# The Seventh National Communication of Malta

## under the United Nations Framework Convention on Climate Change

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

# The Seventh National Communication of Malta
# to the United National Framework Convention on Climate Change

## 2017

**Editor**

James Ciarlo`

**Main Contributors**

Noel Aquilina, Maria Attard, Simone Borg, James Ciarlo`, Paul Pace, Saviour Vassallo

The editor would also like to acknowledge contributions from the following:

Mario Balzan, Catherine Camilleri, Alan Deidun, Aldo Drago, Simon Farrugia, Charles Galdies, Stefano Moncada, Luciano Mulè Stagno, Josianne Muscat, Manuel Sapiano, Paul Joseph Schembri, Joseph Schiavone, Elaine Sciberras, Darrin Stevens, Alex Torpiano, Philip Von Brockdorff.

**Coordination**

Institute for Climate Change and Sustainable Development, University of Malta

Climate Change Unit, Malta Resources Authority

# Table of Contents

## List of Figures

## List of Tables

# 1 EXECUTIVE SUMMARY

*Image Source: euromic (http://www.euromic.com)*

## Introduction

This is the fourth time that Malta is submitting a National Communication under the United Nations Framework Convention on Climate Change (UNFCCC), following the submission of a First National Communication in 2004 and a Second National Communication in 2010. This is also the second time that Malta is submitting such a Communication since its accession to Annex I status under the Convention, the first two submissions having been made as a non-Annex I Party.

### Emission reduction or limitation commitments applicable to Malta

Malta's status under the Convention up to the time it applied for accession to Annex I, and with that accession being conditional to not taking on quantified emission limitation or reduction targets for the first commitment period of the Kyoto Protocol, meant that until 2012 Malta was not subject to an economy-wide greenhouse gas related obligation under the Protocol. This however did not mean that Malta had no obligations to limit or reduce emissions from anthropogenic activities taking place in the country.

In line with, Malta will be contributing its fair share of the EU's unconditional commitment under the Convention to reduce emissions by 20% below 1990 levels by 2020. This is in line with the target inscribed in the amendments to the Kyoto Protocol (the Doha Amendments), that will be jointly fulfilling the second commitment period with the other Union member states; therefore, emissions from the afore-mentioned power plants remain subject to compliance with EU Emissions Trading Scheme provisions, while the Effort-Sharing Decision target is the principal emissions mitigation obligation that the country has until 2020, for all other greenhouse gas emissions.

The major point sources of greenhouse gas emissions in Malta, namely the electricity generation plants have been, since of 2005, subject to the EU Emissions Trading Scheme, whereby they are required to surrender allowances in respect of emissions of carbon dioxide. Emissions of greenhouse gases not covered by the EU Emissions Trading Scheme, are subject to an overall limit under the so-called Effort-Sharing Decision. Under this decision, Malta must limit such greenhouse gases to not more than 5% over emission levels in 2005, by 2020.

The EU is already looking towards the longer-term future, with the 2030 climate and energy framework providing for a 40% domestic reduction target for 2030. Legislative implementation of this goal is currently under discussion at EU level.

## *Greenhouse gas emissions*

*(Refer to Chapter 3 for more detailed information.)*

The preparation and submission of inventories of national greenhouse gas emissions by sources and removals by sinks is an obligation that Malta fulfils in respect of both the Convention and its Protocol, and European Union legislation.

Inventory results for the time-series 1990 to 2015 (the latter being the most recent year for which inventory data submission to the UNFCCC is available) are presented in Table 1-1 (by gas) and Table 1-2 (by sector) and Figure 1-1 (by gas) and Figure 1-2 (by sector). Total emissions in 2015 decreased to 2,230 Gg $CO_2$ equivalent, 6.5% fewer emissions than 1990 levels, when total emissions are estimated to have been 2,385 Gg $CO_2$ equivalent.

Carbon dioxide dominates as the greenhouse gas with the highest level of emissions in Malta. Indeed, emissions of carbon dioxide from all sources, account for 79% of total national emissions (for 2015). Hydrofluorocarbons and methane are a distant second and third, respectively, in level of emissions.

The sector Energy, which includes emissions from electricity generation and transport, is by far the largest contributor to national emissions. This sector accounts for 79% of total national greenhouse gas emissions (for 2015). Indeed, emissions of carbon dioxide from electricity generation and transport also account for the bulk of total national emissions. Emission sources electricity generation and transport warrant particular mention, and policy attention, as they represent the most important source categories in terms of greenhouse gas emissions.

**Table 1-1 Overview of Greenhouse gas emission trends (Gg $CO_2$ equivalent), by gas.**

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| **$CO_2$ (with LULUCF)** | 2,173.68 | 2,363.55 | 2,420.97 | 2,706.17 | 2,640.42 | 2,727.93 | 2,821.85 | 2,484.66 | 2,484.15 | 1,760.04 |
| **$CH_4$** | 154.96 | 145.49 | 173.85 | 212.91 | 179.58 | 167.53 | 165.34 | 155.34 | 171.53 | 178.01 |
| **$N_2O$** | 56.34 | 59.37 | 61.26 | 58.02 | 53.97 | 48.10 | 47.30 | 45.58 | 46.12 | 44.74 |
| **HFCs** | NO, NE, IE, NA | 0.00 | 6.70 | 41.78 | 145.49 | 169.02 | 201.03 | 216.32 | 230.77 | 247.00 |
| **PFCs** | NO, NA | NO, NA | NO, NA | NO, NA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **$SF_6$** | 0.01 | 1.44 | 1.47 | 1.56 | 1.69 | 4.59 | 0.45 | 2.68 | 0.58 | 0.19 |
| **Total** | **2,385.00** | **2,569.85** | **2,664.26** | **3,020.44** | **3,021.17** | **3,117.19** | **3,235.97** | **2,904.58** | **2,933.16** | **2,230.00** |

**Table 1-2 Overview of Greenhouse gas emissions (Gg $CO_2$ equivalent), by sector.**

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Energy** | 2227.95 | 2380.68 | 2430.86 | 2715.60 | 2648.46 | 2735.23 | 2829.73 | 2490.94 | 2490.95 | 1766.43 |
| **Industrial Processes & Product Use** | 7.94 | 9.47 | 15.20 | 49.48 | 152.17 | 179.02 | 206.76 | 223.85 | 235.45 | 248.39 |
| **Agriculture** | 77.13 | 72.38 | 75.03 | 74.51 | 68.91 | 66.50 | 67.24 | 66.99 | 66.31 | 65.90 |
| **LULUCF** | 2.96 | 3.07 | 3.15 | 1.63 | 1.96 | 2.18 | 2.43 | 2.66 | 2.90 | 3.13 |
| **Waste** | 69.02 | 104.24 | 140.02 | 179.22 | 149.66 | 134.26 | 129.82 | 120.13 | 137.55 | 146.14 |
| **Total** | **2385.00** | **2569.85** | **2664.26** | **3020.44** | **3021.17** | **3117.19** | **3235.97** | **2904.58** | **2933.16** | **2230.00** |

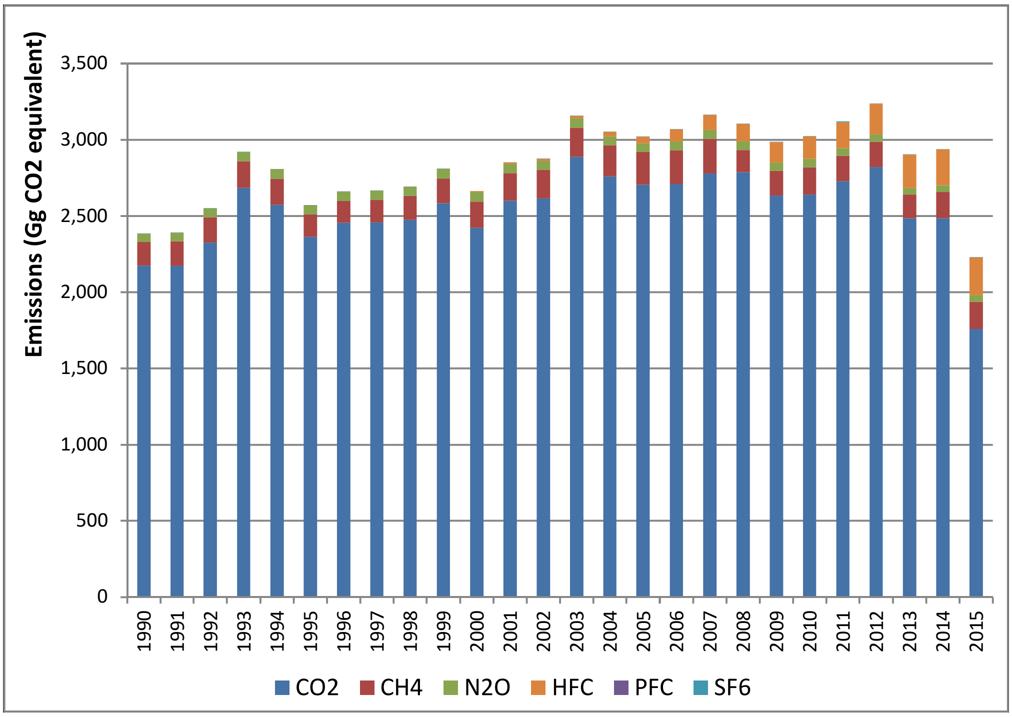



**Figure 1-1 Trends in emissions of greenhouse gases (net emissions for $CO_2$), by gas.**

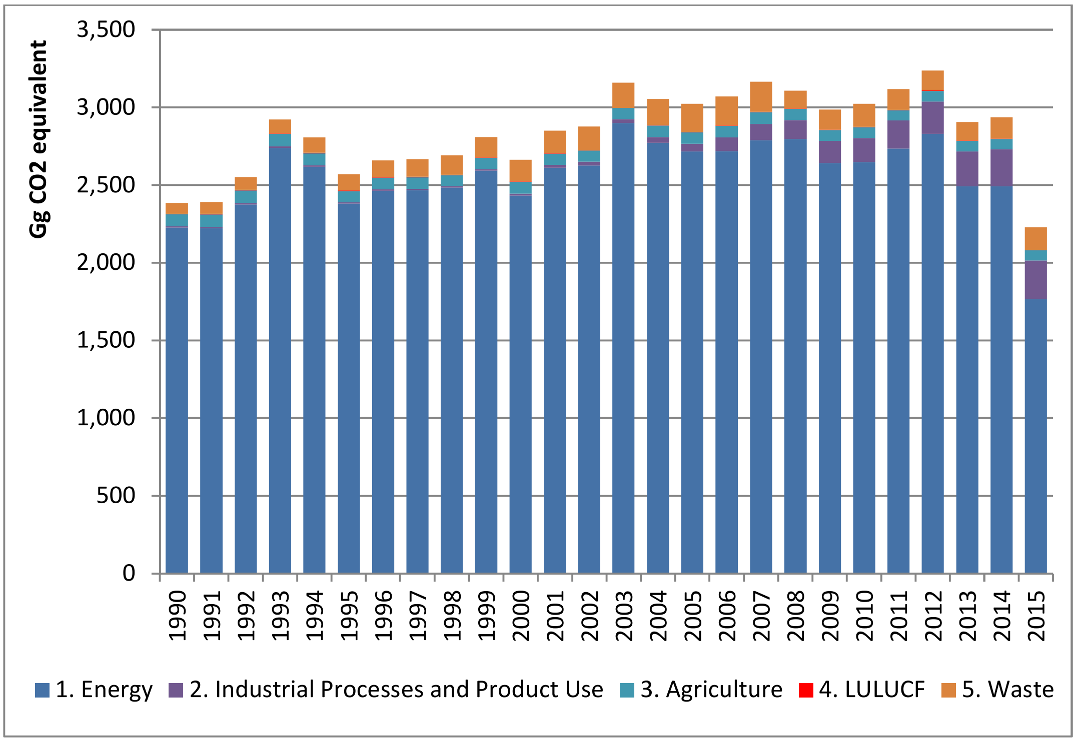



**Figure 1-2 Trends in emissions by sources of greenhouse gases, by sector.**

## *GHG mitigation policies and measures and their aggregate effect*

*(Refer to Chapters 4 and 5 for more detailed information.)*

Greenhouse gas mitigation policy-making in Malta can be said to be a combination of bottom-up sectoral adoption and implementation of measures by stakeholders within the respective sectors, and a growing emphasis on top-down policy processes looking at mitigation from a more holistic, coordinated perspective. It has to be said that European Union climate policy serves as an additional important driver for local mitigation policy.

All sectors relevant to greenhouse gas emissions and removals are addressed by current local policy, albeit one recognizes that the energy sector remains the prime focus of mitigation action, reflecting its status as the most important contributor to national emissions. The policy approach can be summarized thus:

**Table 1-3 Summary of policy approach in respect of greenhouse gases.**

| Sector | Mitigation action focus |
|---|---|
| **Energy consumption** | Submarine electrical connection to European network;<br>Rebates on energy efficient domestic appliances;<br>Distribution of energy saving lamps in the domestic sector;<br>Promotion of solar water heaters;<br>Incentives for the uptake of PV systems;<br>Grant on Purchase of micro wind turbines;<br>Energy savings and RES measures in state schools;<br>Energy saving measures in social housing;<br>Action in the public sector;<br>Energy saving measures in government owned industry;<br>Support schemes for industry, SMEs and the commercial sector;<br>Intelligent metering;<br>Supply of natural gas to fuel existing and future generating plants;<br>Energy Efficiency measures;<br>PV - Grant Scheme;<br>PV - FIT Scheme;<br>PV - Competitive Bidding |
| **Transport** | The introduction of a biofuel 'Substitution Obligation';<br>Introduction of Autogas;<br>Uptake of Electrical Cars;<br>Promotion of E-working and Tele-working;<br>Promotion of Transport Modal Shift towards Public Transportation and Public Transport Reform |
| **Industrial Processes** | Implementation of F-gases Regulation |
| **Agriculture** | Rural Development Programmes;<br>Nitrates Action Plan |
| **Waste management** | Waste Management Plan for Malta<br>Aerial Emissions Works at Maghtab and Qortin Landfills + Capping and Extraction of Gases from managed Landfills;<br>Sant'Antnin Mechanical Biological Treatment Plant;<br>Operation of Urban Wastewater Treatment Plant (UWWTP);<br>Wastewater Sludge Treatment Plant |

The combined effect of the policies and measures discussed and presented in this Communication is represented in the projected emission profiles by sector (Figure 1-3) and by gas (Figure 1-4). Table 1-4 gives a quantified summary of projected emissions. These represent a policy scenario with existing measures, that is, including measures that are being implemented or for which a firm decision to adopt has been taken (end of 2015 as the cut-off date).

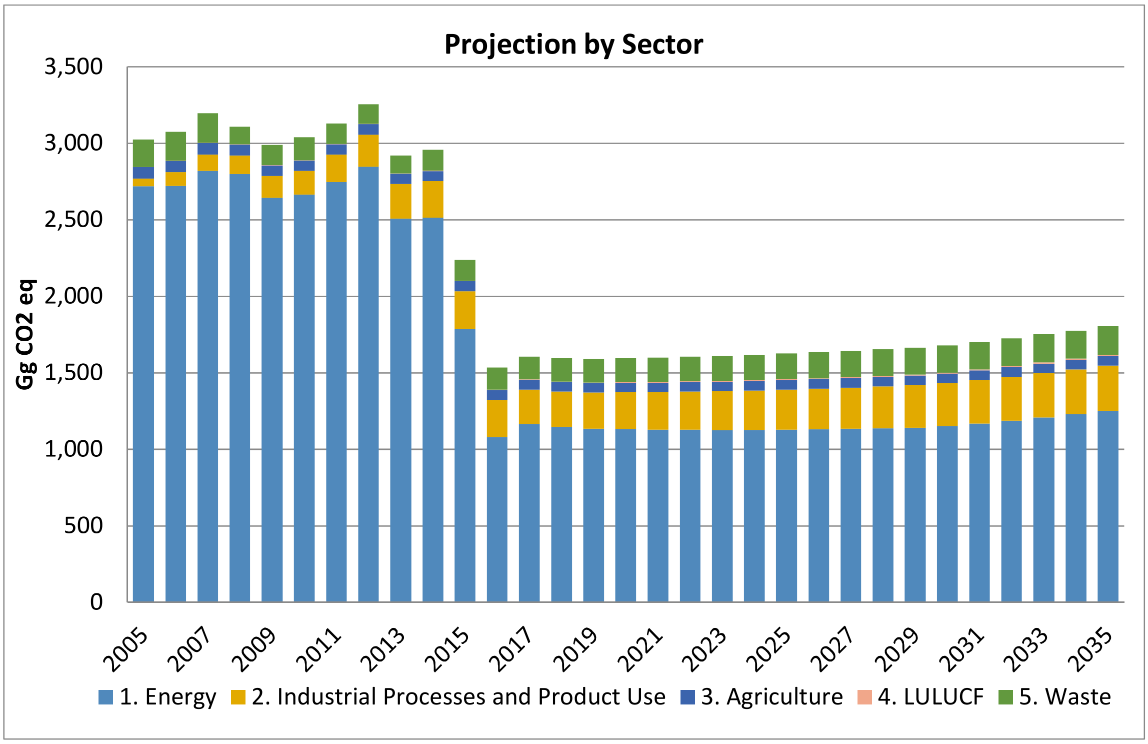



Figure 1-3 Projections (WEM) of total emissions differentiated by sector.

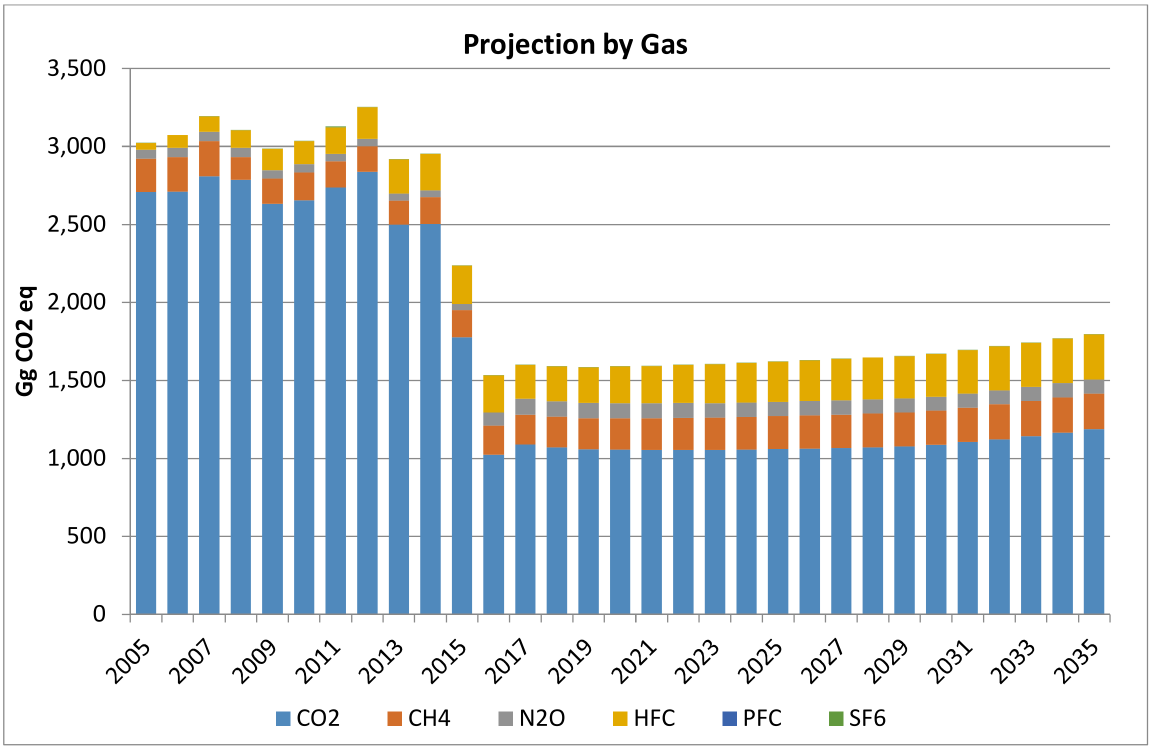



Figure 1-4 Projections (WEM) of total emissions differentiated by gas.

Table 1-4 Emission projections by sector and by gas for the 'with existing measures' scenario.

| WEM | Gg CO2 eq. | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|
| **1.A.1.a Public Electricity and Heat production** | CO2 | 301.74 | 272.33 | 253.70 | 264.84 |
| | CH4 | 7.51 | 6.78 | 6.32 | 6.59 |
| | N2O | 66.99 | 60.46 | 56.32 | 58.80 |
| | | 376.24 | 339.57 | 316.35 | 330.23 |
| **1.A.3.b. Road transportation** | CO2 | 410.79 | 379.87 | 346.53 | 328.43 |
| | CH4 | 1.35 | 1.25 | 1.13 | 1.07 |
| | N2O | 4.06 | 3.75 | 3.43 | 3.25 |
| | | 416.20 | 384.87 | 351.09 | 332.75 |
| **1. Energy** | CO2 | 1,065.78 | 1,066.27 | 1,091.96 | 1,191.70 |
| | CH4 | 9.90 | 9.25 | 8.91 | 9.46 |
| | N2O | 72.21 | 65.51 | 61.20 | 63.72 |
| | | 1147.89 | 1141.03 | 1162.08 | 1264.89 |
| **2. Industrial Processes and Product Use** | CO2 | 3.23 | 3.23 | 3.23 | 3.23 |
| | N2O | 1.14 | 1.14 | 1.14 | 1.14 |
| | HFC | 234.57 | 256.70 | 275.57 | 288.06 |
| | PFC | 0.00 | 0.00 | 0.00 | 0.00 |
| | SF6 | 1.24 | 1.28 | 1.28 | 1.28 |
| | | 240.18 | 262.36 | 281.23 | 293.72 |
| **3. Agriculture** | CH4 | 33.05 | 33.36 | 33.73 | 33.73 |
| | N2O | 28.36 | 28.60 | 28.89 | 28.89 |
| | | 61.41 | 61.97 | 62.62 | 62.62 |
| **5. Waste** | CO2 | 0.39 | 0.39 | 0.39 | 0.39 |
| | CH4 | 156.55 | 168.11 | 177.18 | 185.86 |
| | N2O | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 156.94 | 168.49 | 177.57 | 186.25 |
| **4. LULUCF** | CO2 | 2.84 | 2.81 | 2.81 | 2.81 |
| | | 2.84 | 2.81 | 2.81 | 2.81 |
| **TOTAL with LULUCF** | CO2 | 1,072.23 | 1,072.70 | 1,098.39 | 1,198.13 |
| | CH4 | 199.50 | 210.71 | 219.82 | 229.05 |
| | N2O | 101.72 | 95.26 | 91.24 | 93.76 |
| | HFC | 234.57 | 256.70 | 275.57 | 288.06 |
| | PFC | 0.00 | 0.00 | 0.00 | 0.00 |
| | SF6 | 1.24 | 1.28 | 1.28 | 1.28 |
| | **Total** | **1,609.26** | **1,636.66** | **1,686.31** | **1,810.28** |

## *Vulnerability assessment, climate change impacts and adaptation measures*

*(Refer to Chapter 6 for more detailed information.)*

Table 1-5 to Table 1-7 present an overview of the main findings of modelling of climate change impacts using a state-of-the-art Regional Climate Model. It is recognized that the system used is a significant improvement upon the system used in the Second National Communication, however, substantial research is still required to adapt this new advanced system to the climatic conditions for a small area such as the Maltese Islands.

As a small-island state, Malta is considered as being prone to increased vulnerability to the impacts of climate change, compared to other countries. From a vulnerability assessment perspective, and following-up on work undertaken in this respect for the First and Second National Communications, the following sectors are identified as requiring priority attention when devising adaptation measures: water resources; infrastructure and land use; natural ecosystems; agriculture and fisheries; health; civil protection and vulnerable groups; immigration; and, tourism. Much is already being done; however, more can, and needs to be, done, particularly in the areas of legislation, coordination between national entities, research and integrating climate change considerations into socioeconomic and environmental policies.

**Table 1-5 Summary of modelled annual, seasonal and monthly changes according to the RCP2.6 scenario, in temperature (°C) and change in precipitation (%) (with respect to year 2005) for Malta.**

| Malta RCP2.6 | | Year | Annual | DJF | MAM | JJA | SON |
|---|---|---|---|---|---|---|---|
| **HadGEM2** | Change in Temperature (°C) | 2025 | 1.24 | -0.21 | 1.50 | 2.53 | -2.17 |
| | | 2050 | 1.63 | 0.78 | 2.09 | 2.38 | 1.51 |
| | | 2075 | 1.08 | 0.29 | 0.81 | 1.47 | 1.97 |
| | | 2099 | 1.51 | 0.52 | 1.59 | 2.24 | 1.92 |
| | Change in Precipitation (%) | 2025 | 0.61 | 0.73 | -0.57 | 1.03 | -0.41 |
| | | 2050 | 0.39 | 1.06 | -0.49 | -0.71 | -0.21 |
| | | 2075 | 0.85 | 1.57 | 0.95 | -0.22 | -0.21 |
| | | 2099 | 0.02 | 0.45 | -0.18 | -0.50 | -0.53 |
| **RegCM4** | Change in Temperature (°C) | 2025 | 1.01 | -0.55 | 1.18 | 3.08 | 0.39 |
| | | 2050 | 1.49 | 0.28 | 1.73 | 2.83 | 1.07 |
| | | 2075 | 1.49 | 0.80 | 1.35 | 1.86 | 2.06 |
| | | 2099 | 1.66 | 0.71 | 1.72 | 2.45 | 3.26 |
| | Change in Precipitation (%) | 2025 | 28.21 | 27.49 | -88.02 | -47.11 | 53.85 |
| | | 2050 | 41.05 | 76.22 | -92.37 | 185.23 | -22.15 |
| | | 2075 | 16.98 | 83.50 | 41.77 | 85.53 | -11.93 |
| | | 2099 | 1.36 | 126.43 | -39.55 | 19.20 | -70.62 |

**Table 1-6 Summary of modelled annual, seasonal and monthly changes according to the RCP4.5 scenario, in temperature (°C) and change in precipitation (%) (with respect to year 2005) for Malta.**

| Malta RCP4.5 | | Year | Annual | DJF | MAM | JJA | SON |
|---|---|---|---|---|---|---|---|
| **HadGEM2** | Change in Temperature (°C) | 2025 | 1.24 | -0.21 | 1.50 | 2.53 | -2.17 |
| | | 2050 | 1.63 | 0.78 | 2.09 | 2.38 | 1.51 |
| | | 2075 | 1.08 | 0.29 | 0.81 | 1.47 | 1.97 |
| | | 2099 | 1.51 | 0.52 | 1.59 | 2.24 | 1.92 |
| | Change in Precipitation (%) | 2025 | 0.61 | 0.73 | -0.57 | 1.03 | -0.41 |
| | | 2050 | 0.39 | 1.06 | -0.49 | -0.71 | -0.21 |
| | | 2075 | 0.85 | 1.57 | 0.95 | -0.22 | -0.21 |
| | | 2099 | 0.02 | 0.45 | -0.18 | -0.50 | -0.53 |
| **RegCM4** | Change in Temperature (°C) | 2025 | 1.01 | -0.55 | 1.18 | 3.08 | 0.39 |
| | | 2050 | 1.49 | 0.28 | 1.73 | 2.83 | 1.07 |
| | | 2075 | 1.49 | 0.80 | 1.35 | 1.86 | 2.06 |
| | | 2099 | 1.66 | 0.71 | 1.72 | 2.45 | 3.26 |
| | Change in Precipitation (%) | 2025 | 28.21 | 27.49 | -88.02 | -47.11 | 53.85 |
| | | 2050 | 41.05 | 76.22 | -92.37 | 185.23 | -22.15 |
| | | 2075 | 16.98 | 83.50 | 41.77 | 85.53 | -11.93 |
| | | 2099 | 1.36 | 126.43 | -39.55 | 19.20 | -70.62 |

**Table 1-7 Summary of modelled annual, seasonal and monthly changes according to the RCP8.5 scenario, in temperature (°C) and change in precipitation (%) (with respect to year 2005) for Malta.**

| Malta RCP8.5 | | Year | Annual | DJF | MAM | JJA | SON |
|---|---|---|---|---|---|---|---|
| **HadGEM2** | Change in Temperature (°C) | 2025 | 0.70 | 0.40 | 1.28 | 1.23 | -3.34 |
| | | 2050 | 0.69 | -0.59 | 0.81 | 1.84 | 0.93 |
| | | 2075 | 2.30 | 0.80 | 3.09 | 2.91 | 2.62 |
| | | 2099 | 2.27 | 2.20 | 2.38 | 2.44 | 2.28 |
| | Change in Precipitation (%) | 2025 | 0.52 | 0.80 | 0.21 | -0.32 | 0.09 |
| | | 2050 | 1.12 | 0.60 | 0.10 | -0.47 | 1.21 |
| | | 2075 | 0.16 | -0.28 | 0.20 | -0.23 | 0.13 |
| | | 2099 | 0.43 | -0.01 | 0.07 | 1.66 | 0.30 |
| **RegCM4** | Change in Temperature (°C) | 2025 | 0.94 | 0.20 | 1.86 | 1.79 | -0.24 |
| | | 2050 | 0.95 | -0.94 | 1.15 | 2.76 | 0.80 |
| | | 2075 | 2.31 | 0.02 | 3.82 | 3.55 | 2.08 |
| | | 2099 | 2.70 | 2.13 | 2.30 | 3.29 | 4.16 |
| | Change in Precipitation (%) | 2025 | 47.80 | 138.64 | -48.50 | 115.36 | 97.63 |
| | | 2050 | 57.62 | 46.37 | -43.82 | 199.65 | 135.61 |
| | | 2075 | 3.62 | -31.81 | 20.64 | 94.34 | 57.64 |
| | | 2099 | 20.34 | 16.37 | -31.89 | 55.03 | 61.48 |

## *Financial resources and transfer of technology*

*(Refer to Chapter 7 for more detailed information.)*

Table 1-8 gives a summary of the projects funded through Malta's contributions.

**Table 1-8 Overview of financial contributions to projects for 2013 to 2016. * - For values in 2013 the currency exchange rate 0.74 Euro for 1 USD as on 2 October 2013; the remaining currency exchange rate 0.84 Euro for 1 USD as on 23 November 2017.**

| Recipient country/region/project/programme | Total Amount (€) | Total Amount (USD)* | Type | Sector |
|---|---|---|---|---|
| **2013** | | | | |
| **Kenya - Water Supply** | 12,401 | 15,661 | Core | Water and Sanitation |
| **Ethiopia - Water Supply** | 17,236 | 21,767 | Core | Water and Sanitation |
| **2014** | | | | |
| **Ethiopia - Water Supply Project** | 7,000 | 8,288 | Adaptation | Water Sanitization |
| **Pakistan - Installation of Solar Power back up System** | 7,020 | 8,312 | Mitigation | Energy Generation and Supply |
| **Uganda - Youth Engage: Building Skills and Creating Opportunities for Young People in Njeru Buikwe District** | 16,705 | 19,780 | Mitigation | Energy Generation and Supply |
| **2015** | | | | |
| **Ethiopia - Living Waters Mission Team - Water Supply Project** | 14,000 | 16,583 | Adaptation | Water Sanitization |
| **Uganda - SOS Malta- Building Skills and Creating Opportunties for young people** | 31,773 | 37,636 | Adaptation | Agriculture |
| **Guatemala Foundation - Clean Stoves for Guatemala** | 6,000 | 7,107 | Adaptation | Energy generation, distribution and Efficiency |
| **Scholarships in Climate Action Offered by the Goverment of Malta for Postgraduate Studies at the University of Malta** | 54,180 | 64,178 | Crosscutting | Education |
| **2016** | | | | |
| **Eritrea - Lwanga district, Shinara Nativity School facilities expansion and provision of water** | 20,624 | 24,430 | Adaptation | CRS 14030 |
| **Ethiopia - Konga Town, Water Supply Project for Konga Town** | 21,900 | 25,941 | Adaptation | CRS 14020 |
| **Scholarships in Climate Action Offered by the Goverment of Malta for Postgraduate Studies at the University of Malta** | 54,180 | 64,178 | Crosscutting | Education |

## *Research and systematic observation*

*(Refer to Chapter 8 for more detailed information.)*

The focal point for climate-related research and systematic observation in Malta is the University of Malta where academics from various faculties, institutes and centres within the University are contributing towards increasing knowledge on climate change issues from a variety of perspectives, including scientific and technological, legal and economic. The Malta College of Arts, Science and Technology and the Meteorological Office also contribute towards research and systematic observation activities.

Research on climate-related matters is further spearheaded through the recently launched National Research and innovation Strategy-2020, which makes specific reference to climate change and proposes the setting up of Malta as a centre of excellence in climate change adaptation research. The Maltese government is also assisting capacity building in the area of climate change through the financing of scholarships for post-graduate level studies.

## *Education, training and public awareness*

*(Refer to Chapter 9 for more detailed information.)*

The sphere of formal education is a prime target for educational initiatives aimed at widening awareness on climate change issues. Education for Sustainable Development is now an integral part of the national curriculum. The EkoSkola initiative is an example of good practice that facilitates the dissemination of good environmental (including as it relates to climate action) at various levels of education.

On a non-formal level, the initiative 'Naqqas u Ffranka' ('Save and Reduce') is an example of how education on environmental issues can also be brought direct to the general public.

However, due recognition has to be given to the fact that much remains to be done, not only in understanding to what extent current approaches are really effective, but also to identify the needs of learners and engaging audiences in the learning process.

# 2 INTRODUCTION AND NATIONAL CIRCUMSTANCES

*Image Source: euromic (http://www.euromic.com)*

## 2.1 The submission of a National Communication

The submission of a national communication by a Party to the UNFCCC[1] arises from the requirement for Parties to communicate information on the implementation of the objectives of the Convention[2]:

> "*1. In accordance with Article 4, paragraph 1* [of the UNFCCC], *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;*
>
> *(b) A general description of steps taken or envisaged by the Party to implement the Convention; and*
>
> *(c) Any other information that the Party considers relevant to the achievement of the objective of the Convention and suitable for inclusion in its communication, including, if feasible, material relevant for calculations of global emission trends.*
>
> *2. Each developed country Party and each other Party included in Annex I shall incorporate in its communication the following elements of information:*
>
> *(a) A detailed description of the policies and measures that it has adopted to implement its commitment under Article 4, paragraphs 2 (a) and 2 (b)* [of the UNFCCC[3]]*; and*
>
> *(b) A specific estimate of the effects that the policies and measures referred to in subparagraph (a) immediately above will have on anthropogenic emissions by its sources and removals by its sinks of greenhouse gases during the period referred to in Article 4, paragraph 2 (a)* [of the UNFCCC]."

In addition, the Convention requires Parties included in Annex II to the Convention to report on their efforts in providing "*new and additional financial resources*"[4] to developing country Parties, to "*assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects*"[5] and to "*promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties*"[6].

[1] United Nations Framework Convention on Climate Change, United Nations, 1992.
[2] UNFCCC: Article 12 'Communication of Information Related to Implementation'.
[3] Article 4, paragraphs 2(a) and 2(b) of the UNFCCC require "*developed country Parties and other Parties included in Annex I*" to "*adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs*" and to "*communicate,* [..] *periodically* [...] *detailed information on* [...] *policies and measures* [...] *as well as on its resulting projected anthropogenic emissions by sources and removals by sinks of greenhouse gases*", respectively.
[4] UNFCCC: Article 4 'Commitments', paragraph 3.
[5] UNFCCC: Article 4 'Commitments', paragraph 4.
[6] UNFCCC: Article 4 'Commitments': paragraph 5.

This National Communication is the fourth communication to be submitted by Malta, and the second to be submitted by Malta as an Annex I Party. Malta had previously submitted a First[7] and a Second[8] Communication in 2004 and 2010 respectively, always as a non-Annex I Party to the Convention. The previous Communication, submitted in 2014, served as Malta's 3rd, 4th, 5th and 6th National Communication to the UNFCCC.

## 2.2 Introduction

This chapter serves as a backdrop to the information and discussions presented in subsequent chapters, by providing information on a number of aspects that describe the country in its various facets, as may be relevant to a better understanding of subsequent chapters. Besides an overview of national circumstances, this chapter will also discuss the development of Malta's status under the Convention and how the National Communication and the Biennial Report relate to Malta's particular situation vis-a-vis the Convention and associated treaties.

## 2.3 Malta's status and obligations under international climate treaties and EU climate policy

Malta ratified the UNFCCC in 1994 and the Kyoto Protocol[9] in 2001. These ratifications were made on the basis of non-Annex I status. To this effect, Malta did not immediately take on any quantified emission limitation or reduction obligations under these international instruments; thus, it did not have a quantified target for the limitation or reduction of greenhouse gas emissions for the first Kyoto Protocol Commitment Period (CP1; 2008-2012).

Its accession to the European Union in 2004 meant that Union legislation related to climate action became also applicable to Malta. The overarching legislative framework that implements EU greenhouse gas emission mitigation policy is currently built on three main pillars, namely:

- The ***Monitoring Mechanism***: formerly implemented via Decision 280/2004/EC[10], it has recently been replaced by Regulation (EU) No 525/2013[11]. The monitoring mechanism provides the legislative framework for monitoring and reporting of greenhouse gas emissions from sources and removals by sinks, the formulation, at Member State level of policies and measures, and the monitoring and reporting of the progress achieved in limiting or reducing greenhouse gas emissions through such policies and measures, and for the reporting of other climate-related information. Indeed, this Communication builds

[7] *The First Communication of Malta to the United Nations Framework Convention on Climate Change*, Ministry for Rural Affairs and the Environment, 2004.
[8] *The Second Communication of Malta to the United Nations Framework Convention on Climate Change*, Ministry for Resources and Rural Affairs, 2010.
[9] Kyoto Protocol to the United National Framework Convention on Climate Change, United Nations, 1997.
[10] Decision 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; OJ L 49, 19.2.2004, pg. 1.
[11] 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; OJ L 165, 18.6.2013, pg. 13.

to a certain extent on work undertaken in fulfilling reporting obligations under the Monitoring Mechanism;

- The ***EU Emissions Trading Scheme*** (EU ETS): established through Directive 2003/87/EC[12], this scheme adopts a market-based approach to the reduction of emissions of certain greenhouse gases from certain industrial activities and aviation. The approach is very much pan-European in nature, in the sense that the fundamental principles (e.g. scope), rules and procedures (e.g. permitting requirements; monitoring and reporting of emissions; accounting for emissions; allocation of allowances) and the main underlying quantified elements (e.g. cap of emissions; rates of free allocation vs allocation through auctioning) are common to all participants without distinction on the basis of where they are located.
- The ***Effort-Sharing Decision***: Decision 406/2009/EC[13] sets quantified emission limitation or reduction targets for individual Member States, applied to those emissions not covered by the EU Emissions Trading Scheme, apart from certain exceptions.

These three instruments are further complemented by other sector-specific legislation that either directly address emissions of greenhouse gases from specific sectors, products or activities (e.g. legislation that sets limits on the rate of emissions of $CO_2$ from new vehicles) or indirectly contribute to the limitation or reduction of such emissions as a co-benefit to their primary objective (e.g. renewable energy sources directive). The ultimate aim is to ensure that the EU and its Member States meet their international obligations, particularly those related to targets under the Kyoto Protocol.

An important development for Malta in respect of its climate change policy was the approval, in 2010, of its request (submitted to the Conference of the Parties to the UNFCCC in 2009) to become an Annex I party to the UNFCCC; however, for the remainder of the Kyoto Protocol's CP1, Malta remained without a quantified limit on its national greenhouse gas emissions. This change in status did however signify the intention of the country to step up its level of activity in the international sphere of climate action. This national communication is one outcome of such intent.

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 GHG emissions and removals became more stringent, and in line with the EU's Monitoring Mechanism[14], which included the requirement to report a national GHG inventory on an annual frequency, with set timeframes: 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. It is pertinent to note that Malta is not an Annex II Party to the Convention.

---

[12] 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; OJ L 275, 25.10.2003, pg. 32.

[13] Decision 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020; OJ L 140, 5.6.2009, pg. 136.

## 2.4 Malta and the Paris Agreement

The Paris Agreement, a landmark agreement on Climate Change, was adopted at the 21st Session of the Conference of the Parties (COP 21) to the United Nations Framework Convention on Climate Change (UNFCCC) on 12th December 2015. Malta was amongst the first EU MS to ratify the agreement on 5 October 2016. The deposit was done collectively with the EU and together with six other EU Member States namely; Austria, France, Germany, Hungary, Portugal and Slovakia. Fast-track ratification of the Paris Agreement by the EU in enabled its entry into force on 4 November 2016, which was conditional on ratification by at least 55 parties representing at least 55 % of global emissions.

The Agreement is a multilateral, legally binding agreement, which is already in force and will take effect from 2020. The Agreement aims to *hold the increase in global temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels* through the phasing out of fossil fuels. The Paris Agreement requires all Parties to reduce emissions from fossil fuels through "*nationally determined contributions*" (NDCs) and to scale up these efforts in the years ahead. Malta's NDC forms part of the EU's joint target under the EU Energy and Climate Package, which aims to reduce emissions by 40% from all sectors by 2030. The 2030 climate and energy framework sets three key targets for the year 2030: at least 40% cuts in greenhouse gas emissions from 1990 levels, at least 27% share of energy would come from renewable energy resources and at least 27% improvement in energy efficiency.

The framework was adopted by EU leaders in October 2014. It builds on the 2020 Climate and Energy Package. The 2020 Climate and Energy Package package binds the EU to meet its climate and energy targets for the year 2020, implementing and actually exceeding its commitments under the Doha Amendment to the Kyoto Protocol. The package sets three key targets: a 20% cut in greenhouse gas emissions (from 1990 levels), 20% of EU energy is to be generated from renewables and a 20% improvement in energy efficiency. These targets were set by EU leaders in 2007 and enacted as EU law in 2009. They are also headline targets of the Europe 2020 strategy for smart, sustainable and inclusive growth. It embodies the EU's commitment under the Paris Agreement and is in line with the longer term perspective set out in the Roadmap for moving to a competitive low carbon economy in 2050, the Energy Roadmap 2050 and the Transport White Paper. Parties must also adapt to the effects of climate change. Developed States including Malta must contribute to mobilise 100 billion US dollars a year to assist developing countries to meet their NDCs and to adapt to climate change. All Parties must report regularly on their emissions and on their implementation efforts. In 2018, Parties will take stock of the collective efforts in relation to progress towards the goal set in the Paris Agreement and to inform the preparation of NDCs.

In 2015, Malta as Chair in Office of the Commonwealth Heads of Government Meeting (CHOGM) played a significant role in sustaining the momentum within the International community and particularly among the Commonwealth States, to reach an Agreement in Paris on climate change. A Special High Level Executive Session on Climate Change was held alongside the CHOGM, immediately before the start of the High Level Segment to the 21st session of the Conference of the Parties in Paris. The Special Executive session was widely recognized by Commonwealth States and key players (including President Hollande of France and the UN Secreatry Genera Ban Ki Moon) as an important milestone that contributed to pave the way to achieve consensus at the Paris Conference.

Since the conclusion of the Paris Agreement, Malta as an EU Member State remained proactive in implementing its reduction targets under the Doha Amendment till 2020. It is now working also towards achieving its targets as part of the EU under the 2030 Energy and Climate Framework. Malta is particularly proactive on adaptation to climate change and during its tenure of the

Presidency of the Council of the European Union highlighted both the need for more focus on adaptation to climate change as well as on the relation ship between oceans and climate Change. Furthermore, during said Presidency, Malta was instrumental in moving forward negotiations on the proposals for legislation to implement the 2030 Framework.

## 2.5 Quantified economy-wide emission reduction target

Following accession to the European union, Malta became part of the emission reduction commitment under article 4 of the Convention for the EU for 2020. The accession to Annex I status meant that Malta was inscribed in the list of parties to the Kyoto Protocol that intend to take on a quantified emission limitation or reduction commitment (QELRC) for the second Commitment Period of the Kyoto Protocol (CP2; 2013-2020). As such, the commitment for Malta as listed in the Doha Amendments to the Protocol[15] is of -20% by 2020, compared to 1990 levels. It is the intention of the EU and its Member States to jointly fulfil the commitments set out in the Doha Amendments[16]. Therefore, in practical terms, the target under the so-called Effort-Sharing Decision remains the primary country-level quantified emission mitigation goal for Malta with respect to greenhouse gas emission mitigation, together with applicable compliance obligations for certain local activities under the pan-European approach for emission reduction from industrial activities under the EU Emissions Trading Scheme.

## 2.6 Government structure

Malta has had a relatively short history as a sovereign political entity, having gained independence from Britain in 1964, and becoming a Republic in 1974. In 2004, Malta acceded to full membership of the European Union (EU).

The country is a stable democracy with the main legislative body being the House of Representatives elected by universal suffrage for 5-year terms. Government is headed by the Prime Minister with a Cabinet of Ministers each of which is responsible for a Ministry with a specific portfolio. Departments within these Ministries and a number of Authorities and Agencies support the implementation of government policy.

Climate change has, as a theme, featured as an important element in Ministerial portfolios in recent administrations, and a degree of continued development in national climate policy can be noted. In the current legislature, climate change policy falls under the portfolio of the Minister for Sustainable Development, Environment and Climate Change (MSDEC).

[15] The Doha Amendments were adopted by Parties to the Kyoto Protocol through Decision 1/CMP.8 at the eighth session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol held in Doha, Qatar, in December 2012.

[16] Footnote 4 to the table in part A of the Doha Amendments states that: "*The QELRCs for the European Union and its member States for a second commitment period under the Kyoto Protocol are based on the understanding that these will be fulfilled jointly with the European Union and its member States, in accordance with Article 4 of the Kyoto Protocol. The QELRCs are without prejudice to the subsequent notification by the European Union and its member States of an agreement to fulfil their commitments jointly in accordance with the provisions of the Kyoto Protocol*."

## 2.7 Geographic profile

Malta is an archipelago consisting of three main inhabited islands, namely, Malta, Gozo, Comino, together with a number of other small uninhabited islands (Cominotto, Filfla, St Paul's Islands) and islets situated close to the coastline of the main islands.

The archipelago is situated in the central Mediterranean (Figure 2-1), approximately 90 kilometres from Sicily and 290 kilometres from the North African mainland. Towards, the East, the Straits of Gibraltar are at a distance of almost 1,850 kilometres, while the Suez Canal is around 1,500 km towards the Southwest.

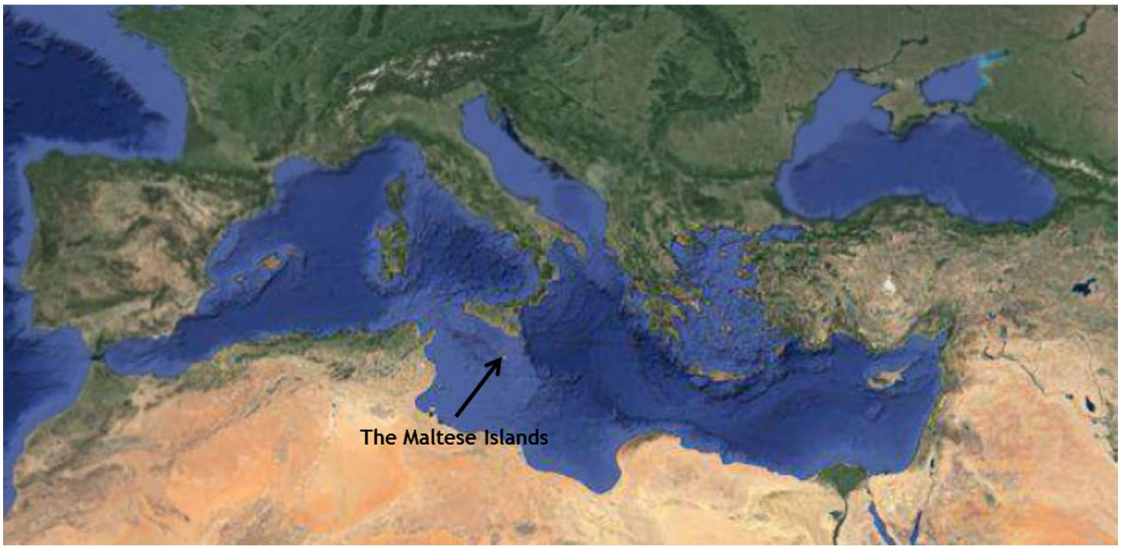



**Figure 2-1 Map of the Mediterranean Sea showing the location of the Maltese Islands. (adapted from Google Maps)**

**Table 2-1 Geographical data for the Maltese Islands (NSO, 2013).**

| | Malta | Gozo | Comino | Total |
|---|---|---|---|---|
| **Area (km²)** | 247 | 66 | 3 | 316 |
| **Shoreline (km)** | 200 | 71 (combined) | | 271 |
| **Max. length (km)** | 27.4 | 14.5 | - | - |
| **Max. width (km)** | 14.5 | 7.2 | - | - |


**Figure 2-2 Map of the Maltese Islands. Valletta, the capital city, is marked by the red dot[17].**

The total area of the Maltese islands is of 316 square kilometres, with a total shoreline of slightly more than 271 kilometres. Table 2-1 presents more detailed geographical data for the Maltese Islands.

Topographically the southern coastline facing the African mainland is dominated by cliffs, with the land sloping down to a low-lying shoreline on the northern coast. The northern areas are marked by low hills, with plains towards the southern parts. The Maltese Islands do not have mountains and there are no rivers.

## 2.8 Population profile

By the end of 2015, the population of the Maltese Islands stood at 434,403 in that year (NSO, 2017), more than double the population a hundred years earlier (Figure 2-3). This gives a population density of around 1,375 persons per km$^2$, one of the highest country population densities in the world.

Distribution of the population across the islands that make up the Maltese archipelago varies. The largest concentration of the population is found in the area around the harbours flanking the capital city of Valletta. The Northern Harbour district (the area to the west of Valletta) and the Southern Harbour district (the area lying to the east and south-east of Valletta, including also the capital city) together form a population agglomeration that accounts for almost half of the total population of the country. The built-up aspect of this part of the country can easily be seen in (Figure 2-2). At the other end of the scale, the islands of Gozo and Comino account for just 7.3% of the total population.

Population density differences between Malta and Gozo are highly contrasting, with the former showing a density of 1,630 persons per km$^2$ while the latter has a density of 459 persons per km$^2$. This also correlates with the extent of built-up area on the two islands.

[17] Adapted from: http://earthobservatory.nasa.gov/IOTD/view.php?id=4933

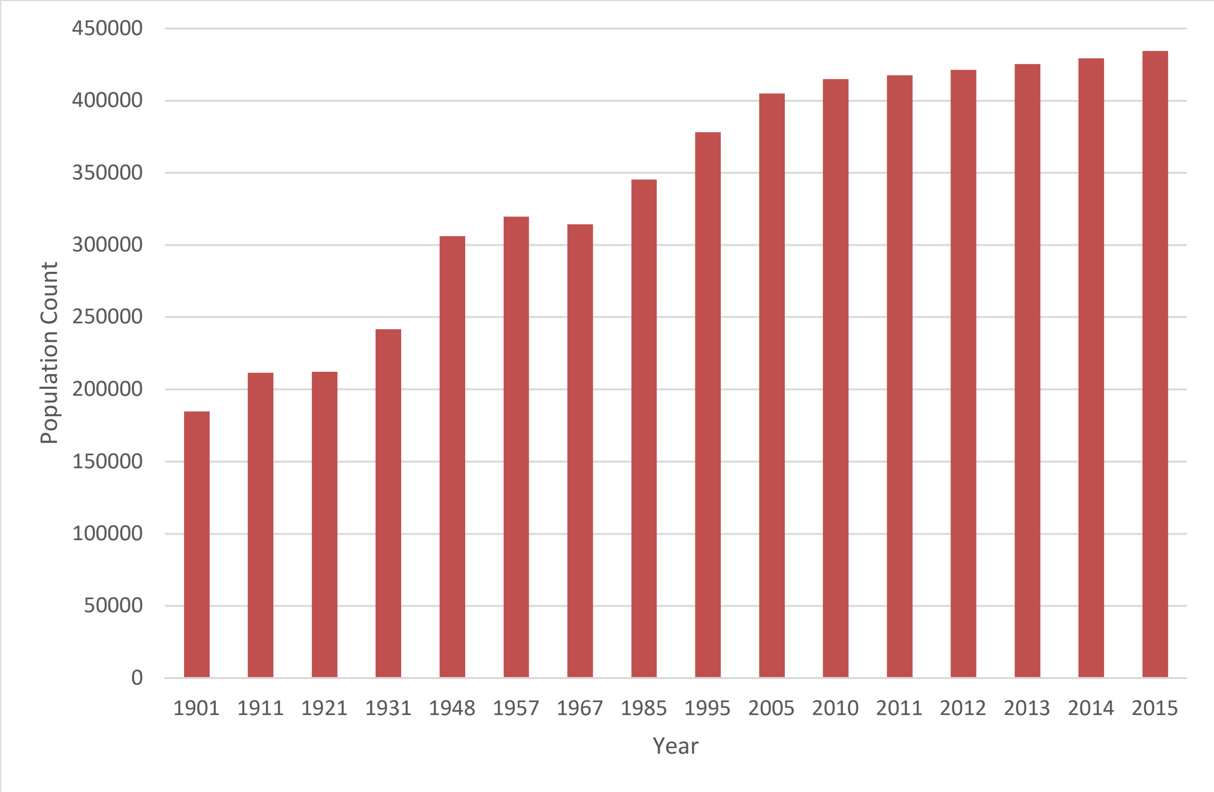



**Figure 2-3 Population growth since 1901 (NSO, 2012; NSO, 2017).**

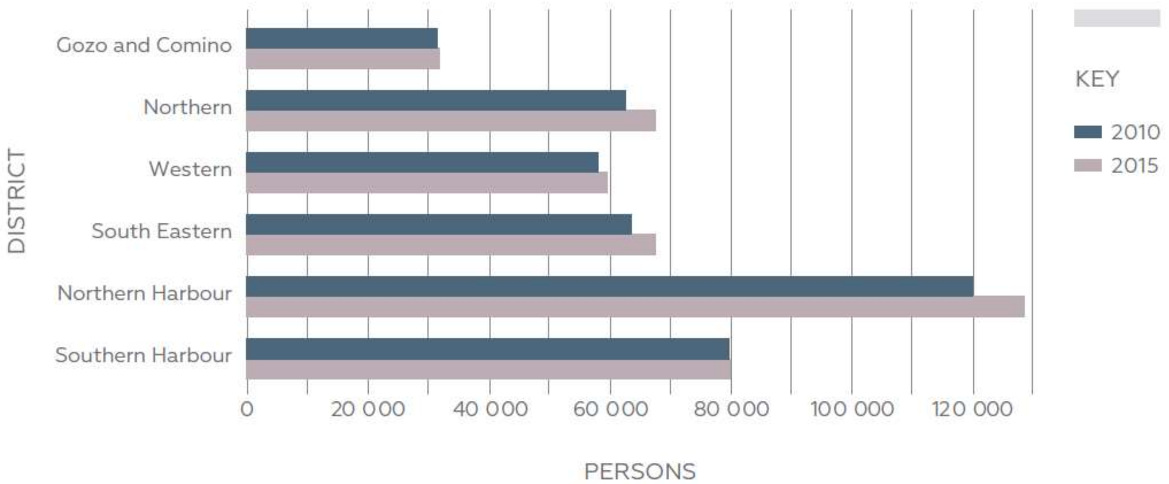



**Figure 2-4 Population by district and selected years (NSO, 2017).**

The population is projected to reach 440,400 persons by 2020 and increase further to 480,700 persons by 2070. The population is also becoming increasingly an ageing one, with current and future population growth trends coupled with increased life expectancy: life expectancy is calculated at 91.1 years for females and 87.2 years for males by 2080 (NSO, 2016).

## 2.9 Climate profile

The climate of the Maltese Islands can be described as typically Mediterranean, with hot, dry summers and relatively mild winters. Values for a number of climatic parameters are provided in Table 2-2. The monthly profiles of mean air temperature and relative humidity are presented in Figure 2-5 and Figure 2-6 respectively. The north-westerly winds are the most common (Galdies, 2011).

**Table 2-2 Mean air temperature, sunshine, wind velocity and total rainfall for the years 2009 to 2013 (NSO, 2013; NSO, 2014).**

| Year | Mean maximum temperature (°C) | Mean temperature (°C) | Mean minimum temperature (°C) | Mean daily sunshine (hours) | Average wind velocity (knots) | Total rainfall (millimetres) |
|---|---|---|---|---|---|---|
| **2009** | 22.7 | 19.1 | 15.5 | 8.4 | 7.7 | 680.4 |
| **2010** | 22.6 | 19.3 | 16.1 | 8.1 | 8.2 | 513.1 |
| **2011** | 22.6 | 18.9 | 15.2 | 8.2 | 7.4 | 591.0 |
| **2012** | 23.3 | 19.6 | 15.9 | 8.7 | 8.0 | 519.2 |
| **2013** | 23.3 | 19.7 | 16.1 | 8.4 | 8.8 | 479.6 |

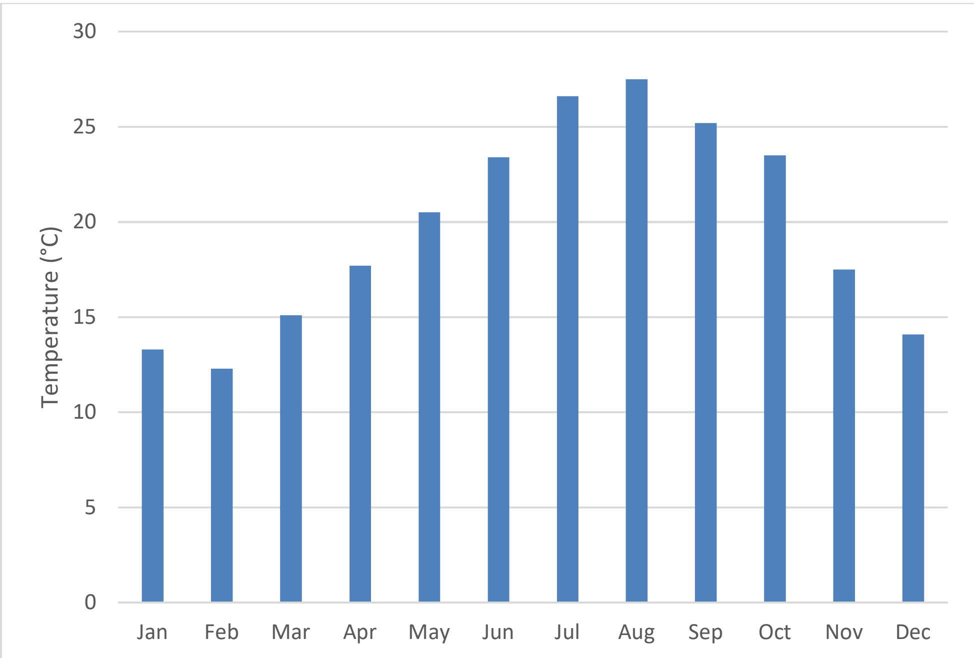



**Figure 2-5 Monthly mean air temperature for 2013 (NSO, 2014).**

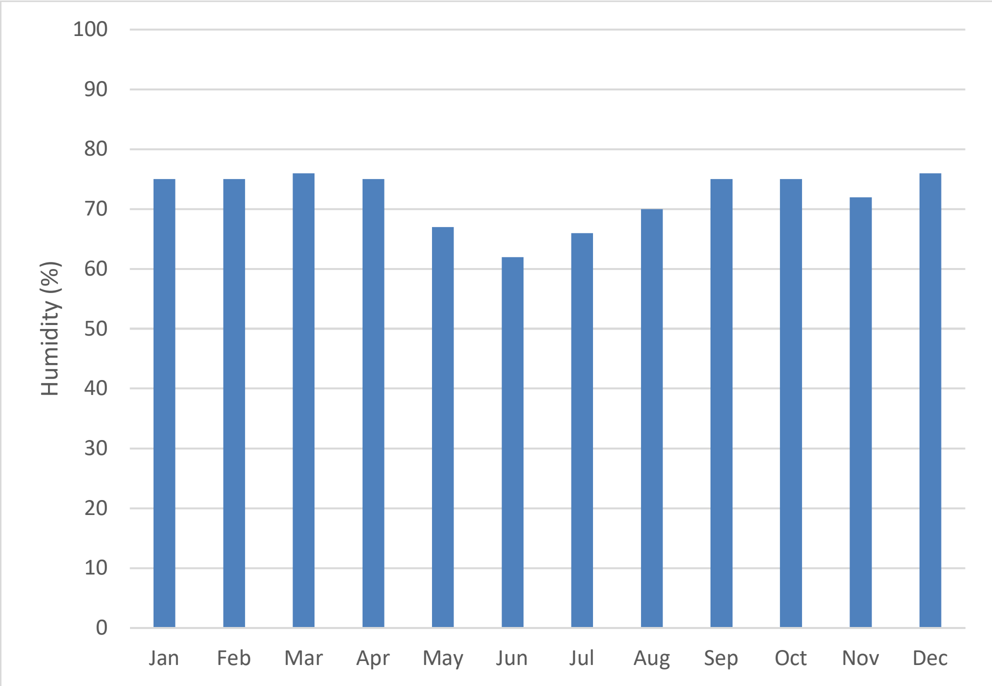



**Figure 2-6 Monthly relative humidity for 2013 (NSO, 2014).**

## 2.10 Economic profile

Historically, agriculture was a very important economic activity in Malta, though one can also note an important element of services-oriented activity, not least due to the presence of established British forces on the islands until the late 1970's, which necessitated a number of ancillary services. Manufacturing and services sectors now both serve as mainstays of the country's economy. The manufacturing has developed into areas such as microelectronics and pharmaceuticals. Apart from traditional activities in tourism, education, health, retailing and banking, the services industry has in recent decades expanded towards higher value-added activities by the financial services sector, more specialised forms of tourism, including in particular, language schools and diving centres, maritime and aviation activity, information technology and gaming. Large scale industrial establishments are few, the largest of which, and the most relevant from a greenhouse gas emissions perspective, being the electricity generation plants (refer to subsequent sections and chapters for more detailed discussions of their relevance in this respect).

Malta's economy has strong trade ties with the European Union. The The trend in Gross Domestic Product (GDP) since 1990 has been relatively consistent in showing continued growth, except for 2009, where the trend was negative, recuperating again in 2010.

Overall, Malta's GDP has grown from €1.899 billion in 1990 to €8.796 billion in 2015 (NSO, 2017). Per capita GDP stood at around €22,686 in 2016 (NSO, 2013), this indicator also showing a steady increase over time.

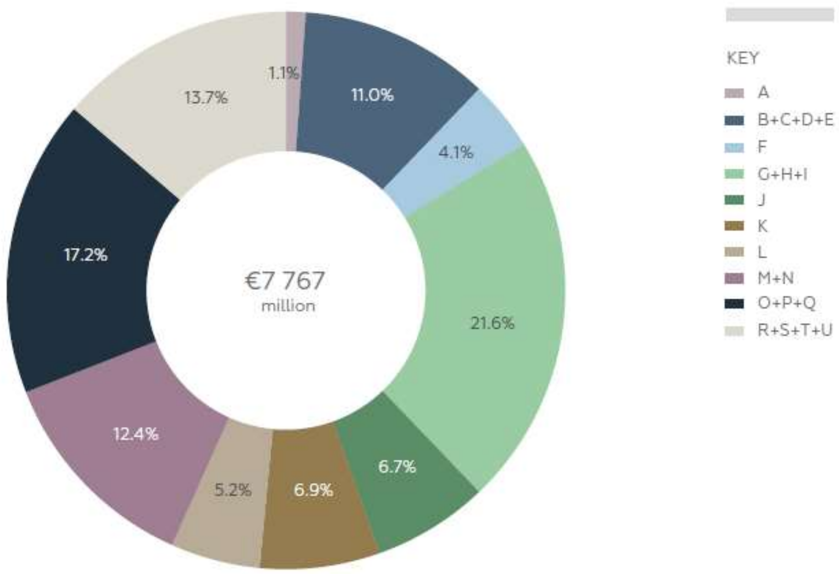



**Figure 2-7 Percentage contribution of economic sectors (by NACE code[18]) to Gross Added Value for 2015 (NSO, 2017).**

## 2.11 Energy

Electricity in Malta has had a chequered history, going as far back as the late 1800's. In fact, electric lighting was demonstrated for the very first time at the Royal Opera House in Valletta in 1882, and later that same year one of the principal squares in the capital city was also illuminated by electric lighting. A year later, the use of electricity for consumers was demonstrated in a private house.

The first power station in Malta started operations in the mid-1890's, with a total capacity of 350 KW, providing electricity to the towns and villages located around the Grand Harbour. The demand for electricity increased, and meeting this demand required substantial developments over the years. These included expansions of existing generating plant at the original power station, the commissioning of new generating plant in a new and more accommodating location (Marsa Underground Station, subsequently replaced by Marsa "B" Power Station), and, for a

[18] NACE Codes:
A: Agriculture, forestry and fishing;
B-E: Mining and quarrying; manufacturing; electricity, gas, steam and air conditioning supply; water supply; sewerage, waste management and remediation activities;
F: Construction;
G-I: Wholesale and retail trade; repair of motor vehicles and motorcycles; transportation and storage; accommodation and food service activities;
J: Information and communication;
K: Financial and insurance activities;
L: Real estate activities;
M-N: Professional, scientific and technical activities; administrative and support service activities;
O-Q: Public administration and defence; compulsory social security; education; human health and social work activities;

period, the installation of electricity generating units in Gozo before it was deemed more viable to serve Gozo's needs from the plant in Malta.

Throughout the period up to the early 1980's, electricity generation was solely dependent on the use of oil. From 1982 until 1995, coal was also used for the generation of electricity at Marsa Power Station. In the 1990's, a new site in Delimara was chosen for a new power station, increasing substantially the generation capacity of the country. This new site has seen a number of extensions, the latest being officially handed over to Enemalta Corporation in late 2012.

Electricity generation has undergone another significant transition in recent years, with the construction of a gas-fired plant at Delimara and the complete shut-down of the generating plant at Marsa Power Station. In parallel to these developments, Malta's system was linked to the electricity grid on mainland Europe, through an interconnection between Malta and Sicily.

**Table 2-3 Electricity statistics for the years 2008 to 2013 (NSO, 2013; NSO, 2014).**

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|
| **Electricity generation (MWh)** | 2,275,892 | 2,167,640 | 2,113,112 | 2,168,553 | 2,268,627 | 2,216,101 |
| **Maximum demand (average; MW)** | 358 | 341 | 328 | 337 | 350 | 343 |

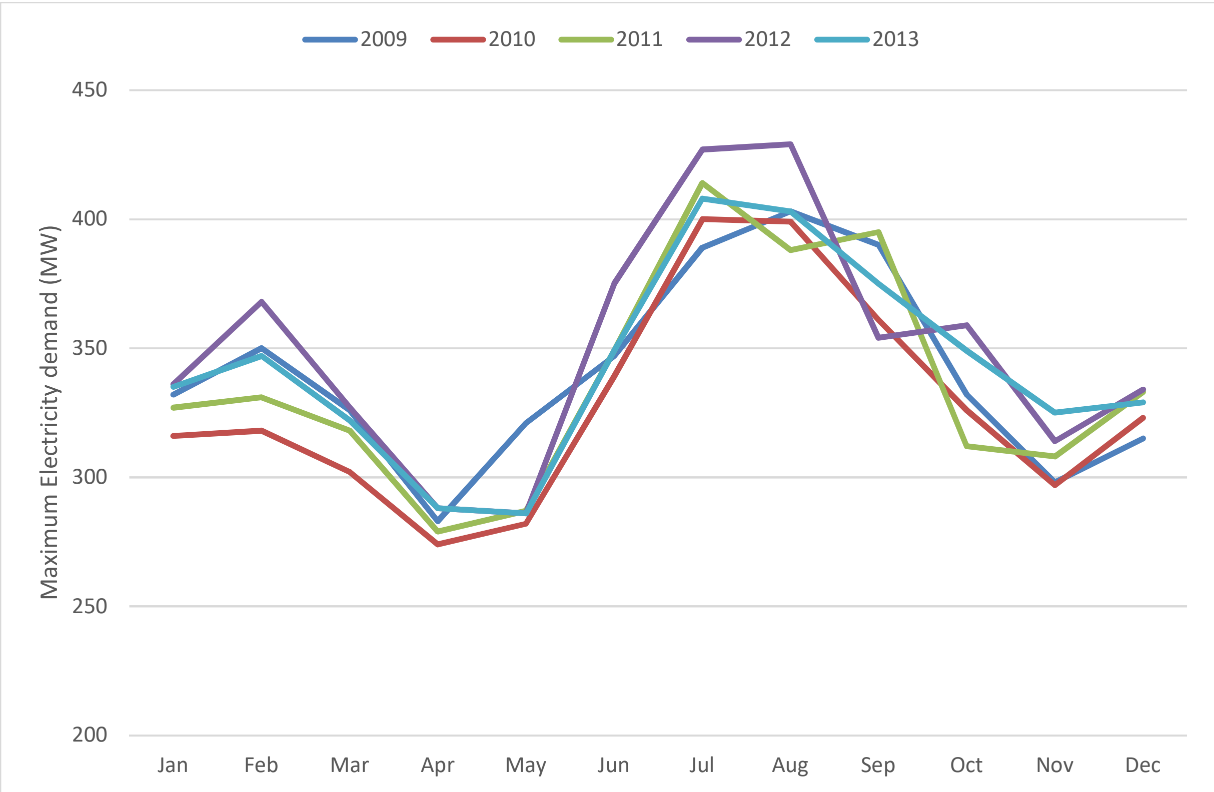



**Figure 2-8 Monthly electricity maximum demand for recent select years (NSO, 2014).**

Disaggregation of fuel consumption by type correlates strongly with the distribution of greenhouse gas emissions from different sectors, as will be discussed in the next chapter. Indeed, fuel consumption for electricity generation dominates over all other uses of fuels, as can be seen in Figure 2-9 for 2013.

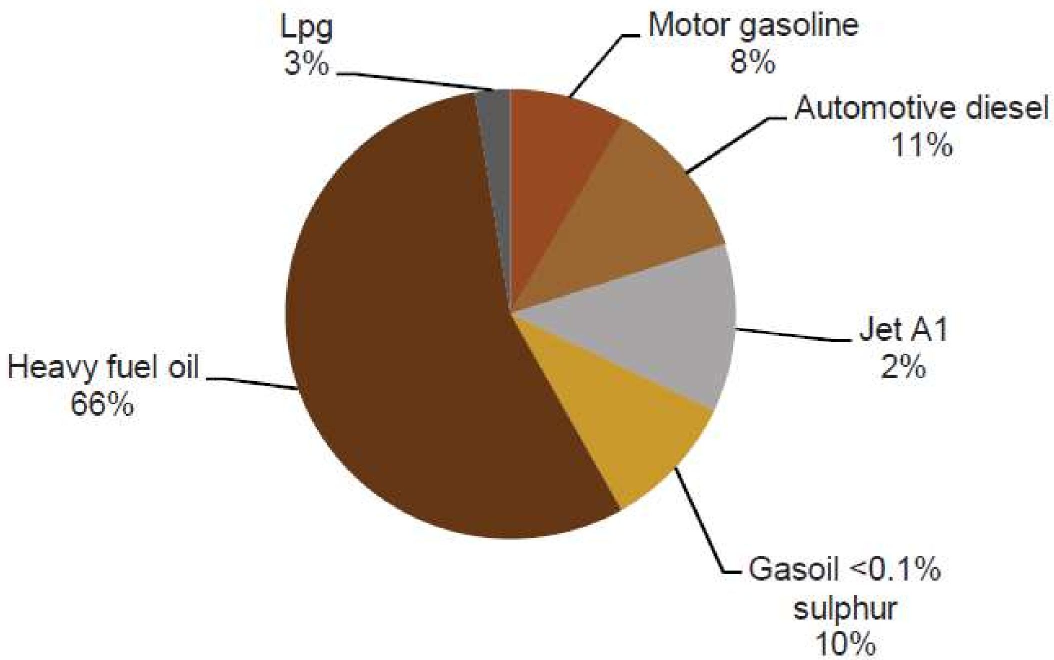



**Figure 2-9 Fuel consumption by type (percent of total) in 2013 (NSO, 2014).**

## 2.12 Transportation

Access to the Maltese Islands from other countries, and vice versa, is limited to sea and air transport. This in itself has important implications also for Malta's economy, dependent as it is on these modes for the importation and export of materials and goods. Tourism, an important contributor to Malta's economy is similarly dependent on arrival and departure of travellers to and from the Maltese Islands either by air or sea. Aviation activities are centred around the sole international airport of Luqa, while two main harbours, the Grand Harbour and Marsaxlokk, provide the main entry points by sea.

Internal transport is mainly based on road transport, with rail systems non-existent. An extensive bus system services the two main islands; however private vehicle ownership and use remains high. The total number of licensed motor vehicles in 2015 was 247,781 (NSO, 2017). This equates to a rate of 799 licensed road vehicles per 1,000 inhabitants in 2015.

A scheduled ferry service provides the only year-round link between the islands of Malta and Gozo. Domestic aviation is limited mainly to intermittent trans-island services provided either by helicopter or light aircraft.

## 2.13 Natural resources

Limestone is one of the few mineral resources that Malta can boast of, used principally by the local construction industry. It has been estimated that in 2006, 1.2% of Malta's total land area was taken up by the hard stone and soft-stone quarries where stone extraction takes place (NSO, 2011).

Water is a fundamental need; however, the sourcing of water is not an easy matter in a country where permanent above-ground water bodies do not exist and where rainfall is rather limited. Most of the naturally occurring freshwater is found in underground aquifers from where it can be extracted via pumping stations and boreholes. Until the late 1960's this was the only manner in which potable water for local consumption was produced. Following a period of a few years where distillation was utilised to a limited extent to complement groundwater extraction, the early 1980's saw the introduction of desalination of sea water (using Reverse Osmosis technology; in itself an energy intensive process, energy consumption estimated at 4.62 kWh/$m^3$ in 2011 (WSC, 2012)) which today accounts for more than half of the production of potable water in the country, through three desalination plants located along the coast of the island of Malta.

In recent years, total annual potable water production in Malta has been at just below 30 million $m^3$, a substantial decrease compared to the peak of more than 50 million $m^3$ seen in 1992-93. In the meantime, a number of groundwater extracting pumping stations and boreholes have had to be shut down due mainly to nitrate contamination or chloride intrusion, putting an even greater onus on desalination plants.

The households sector accounts for the bulk of the demand for water, accounting for almost 70% of total billed consumption.

The Maltese Islands being surrounded by sea, sea salt also deserves a mention in any discussion of local mineral resources. Sea salt continues to be produced using the age-old technique of evaporation of sea water in salt pans, of which a number may be found in coastal areas in various parts of Malta and Gozo.

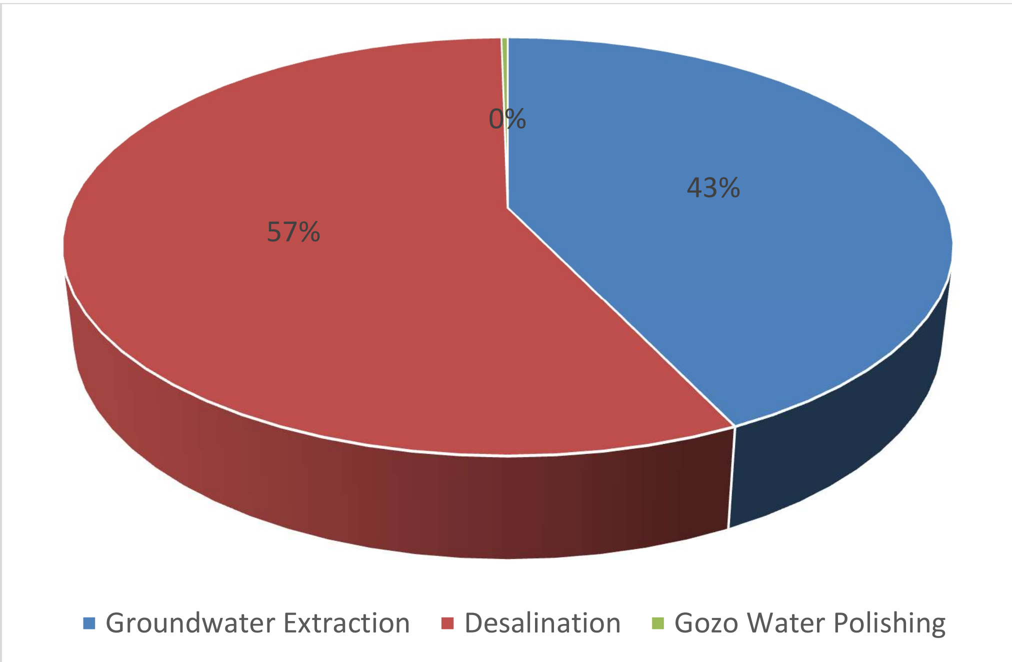


**Figure 2-10 Production of potable water in Malta (% of total) for 2011 (NSO, 2017).**

## 2.14 Waste

Solid waste management was, for a long time, simply a matter of disposal in unmanaged landfills (Magħtab and Wied Fulija in Malta; Qortin in Gozo). In more recent years, the unmanaged landfilling sites have been closed, with rehabilitation work (including landfill gas extraction) now underway in the respective sites. In the meantime, a shift towards waste disposal in managed landfills (Żwejra and Ta' l-Għallis, both in Malta) coupled with greater emphasis on reducing, reusing and recycling and waste treatment, has been at the forefront of solid waste management policy. This has seen a substantial reduction in quantities of municipal solid waste and inert construction and demolition waste being deposited in public landfills.

Waste water management has also seen significant developments over the years. Until some years ago, only a small quantity of wastewater was treated prior to discharge into the sea, in the Sant' Antnin waste water treatment facility, which has been operating for over 30 years.

The construction of new waste water treatment plants in recent years targets the treatment of all sewage prior to discharge into the sea, with the possibility also of diverting treated second-class water for certain uses rather than disposal into the sea. In 2011, the Sant' Antnin plant treated 1.72 million $m^3$ of sewage, with the bulk of the treated effluent utilised for irrigation purposes in agriculture. The Gozo waste water treatment plant, operational as of 2007, treated a total of 1.52 million $m^3$ in 2011, while a more recently commissioned (2008) plant situated at iċ-Ċumnija in the north of Malta treated 2.98 million $m^3$ in the same year. The largest waste water treatment plant is sited at Ta' Barkat, towards the south of the island of Malta; this plant started operations towards the middle of 2011 and in its first part year of operations, treated 12.73 million $m^3$ of waste water. This latter plant is also capable of generating electricity through the inclusion of anaerobic sludge digestion technology in its design, adding to the benefits of the plant in that it can also generate part of the energy it needs to operate (WSC, 2012).

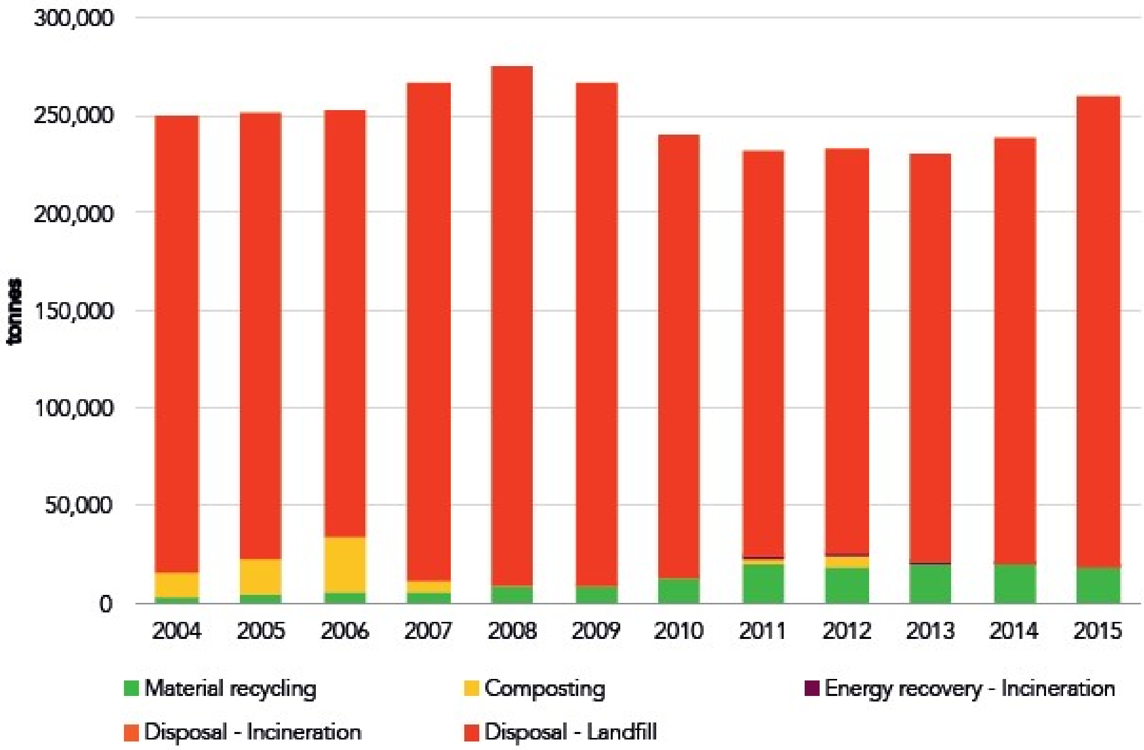



**Figure 2-11 Municipal waste treatment (NSO, 2017).**

## 2.15 Land use, building stock and urban structure

The land use profile of the country shows that more than 22% of total land area is built-up, which together with other urban development (e.g. airport, ports, industrial and commercial sites, mineral extraction sites) accounts for almost 30% of total area of the country (NSO, 2011). Agricultural land accounts for close to 50% of total land area while natural vegetated land accounts for the rest.

The 2005 Census of Population and Housing (NSO, 2007) reported a total stock of 192,314 dwellings, of which 27.6% were vacant[19]. 10 years earlier (census year 1995), the total dwelling stock was determined at 155,202 dwellings, with 23.0% of dwellings vacant (NSO, 1995). While total stock increased by almost 24.0% over the period 1995 to 2005, vacant dwellings increased by 49.0%, contrasting with an increase of under 17.0% in occupied dwellings. It is not expected that the results of the more recent 2011 census will show a substantial improvement in the number of unoccupied dwellings.

Interestingly, while the number of terraced houses only increase slightly over the period 1995 to 2005, the number of flats/penthouses and maisonettes however increased significantly. This reflects a trend in the local construction sector in favour of concentrating residential units in clusters of more than one unit on a single site (thus a preference for flats, penthouses and maisonettes) than used to be the case in the past. This may represent a shift in household choices

[19] Vacant dwellings may also include dwellings used part of the year as second homes or as holiday residences.

in respect of the type of dwellings preferred, reflecting a change in attitudes and lifestyle and a reaction to property prices.

## 2.16 Agriculture

A total of 12,530 holdings were declared during the Agricultural sector census carried out in 2010[20], 98% of which run by sole holders. The majority of 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. 89 % of holdings had less than 2 hectares (ha) of Utilise Agricultural Area (UAA), while the remaining 11 % did not exceed 10 hectares of UAA.

The census of 2010 reported total UAA of around 11 450 hectares in 2010; in 2016, the total UAA amounted to 11,580 ha, of which 9,231 ha were arable land, 1,272 ha were permanent crop area and 1,076 ha were kitchen gardens. 768 ha of the arable land were being used for growing potatoes, 5,440 ha were used for forage plants and 1,837 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. During 2015, more than 40,000 tonnes of vegetables and fruit were produced, with a wholesale value close to €23 million.

In 2010, area irrigated at least once a year was reported at around 2 830 hectares, representing about 25 % of the whole Maltese UAA. One should keep in mind that the extent of the irrigated area varies over the years according to the weather conditions.

In terms of the type of crops, the activity that usually has the largest share of irrigated area is the cultivation of potatoes. According to the 2010 data, its irrigated area was 630 ha, a share of 23 % of the total irrigated area of the country. This is followed by, vineyards (430 ha of irrigated area in 2010, 15 % of total), followed by fruit and berry plantation (8 %), citrus plantations (100ha, 4 % of the total irrigated area), and olive tree plantations (90 ha, 3 % of the total irrigated area).

In Malta, in terms of the volume of water, in 2010 it was estimated that 28.2 million m3 of water were used to irrigate 2 830 hectares of UAA, or approximately 10 000 cubic metres per hectares.

In 2010, 2,740 livestock-related holdings were reported, the great majority of which reported less than 5 Livestock Units (LSU) each. More recent data (2015) shows that 52.7% of farms are registered as sheep farms, followed by goat, cattle and pig. In 2016, livestock in Malta amounted to 935,841 heads, of which 4.3% were pigs, 1.5% cattle, 1.23% sheep and 0.53% goats. In Malta, swine (40,597 heads), poultry (778,086 heads) and rabbit (85,201 heads) are reared mainly for their meat, whereas cattle (14,356 heads), sheep (11,523 heads) and goats (4,971 heads) are grown for their milk. In 2016, the total cattle and sheep milk produced amounted to 43,213,085 kg and 1,671,590 kg respectively.

Livestock populations have decreased significantly compared to 1990 levels, with the exception of 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, $CH_4$ emissions from Enteric Fermentation and Manure Management have also declined.

[20] The European Union Farm structure survey (FSS) collects information on the structural characteristics of the agricultural holdings (land use, livestock and labour force) and is carried out by all European Union Member States every 10 years as an Agricultural census. The Malta Agricultural census 2010 was the first FSS to be carried out by Malta according to European legislation.

## 2.17 Forest

Malta has a very low level of forest coverage, primarily due to the country's small size, high population density, and long history of human habitation, leading to a large human footprint and extensive human usage of the land. The only remaining forest remnants occur in localized pockets, the largest areas of which are the Mizieb and Buskett areas.

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. None of the mentioned woodland areas are utilized for logging or harvesting. Indeed, woodland is protected under Maltese legislation, namely Legal Notice 12 of 200134 'Trees and Woodland (Protection) Regulations'.

Buskett Woodland is the only occurring significant extent of mature woodland in the Maltese Islands, which is a result of afforestation that started during the Knights of St. John's period. A large part of Buskett Woodland is semi-natural woodland with some areas that are managed, particularly the citrus groves found in the area. The land management at Il-Buskett is particularly unique for a Special Area of Conservation 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 through a Private-Public Partnership agreement between the Government and the Environmental Landscapes Consortium, while the Directorate for Parks, Afforestation and Countryside Restoration (PARKS) within the Ministry for Environment, Sustainable Development, and Climate Change is responsible for the woodland.

Miżieb area is part of the Natura 2000 network but is largely privately owned. The site is mainly managed by the area's landowners who use the area for its agricultural value, with a number of landowners being given funds to help in conserving the area. Some invasive alien species have been removed and replaced by the Sandarac Gum tree.

## 2.18 Malta as a contributor to international climate policy

The issue of changing climatic conditions and the consequential threats is not a new phenomenon; however, global political recognition of this problem is a relatively recent occurrence, given strong impetus over 25 years ago by a singular initiative that Malta took within the framework of the United Nations Organization.

It all started with a letter by Professor David Attard, a Maltese academic, published on August 10th, 1988, in The Times (London). Taking note of reports on recent weather conditions, Professor Attard highlighted the "*need for a comprehensive global strategy to protect the weather and climate as part of an effort to ensure that our planet Earth remains fit to sustain human life*." To this effect, he suggested the adoption of a UN resolution declaring the weather and climate to be part of the "*common heritage of mankind*" and that the "*appropriate mechanism be established to protect these natural resources in the interests of mankind*." (Borg, 2009).

Some days after the publication of this letter, the Maltese Government requested the inclusion of an item entitled "*Declaration proclaiming Climate as part of the Common Heritage of Mankind*" in the agenda of that year's session of the General Assembly. On 21$^{st}$ September, 1988, the General Committee of the UN General Assembly agreed to include the item "*Conservation of Climate as part of the Common Heritage of Mankind*" as part of the deliberations of the Assembly, formally introduced on 24$^{th}$ October by the then Minister for Foreign Affairs, Dr Vincent Tabone.

The ensuing discussions on this item led to the adoption of Resolution 43/53 entitled "*Protection of Global Climate for Present and Future Generations of Mankind*", with unanimous support, in the plenary meeting of the General Assembly on 6$^{th}$ December, 1988. Salient points of this resolution include the acknowledgement that "*changes in climate have an impact on development*" and that "*climate change affects humanity as a whole*" and thus should be "*confronted within a global framework so as to take into account the vital interests of all mankind*", and the recognition that "*climate change is a common concern of mankind, since climate is an essential condition which sustains life on earth*".

The resolution also requested the immediate initiation of action that should eventually lead to, among others, "*response strategies to delay, limit or mitigate the impact of adverse climate change*" and recommendations with respect to "*elements for inclusion in a possible future international convention on climate*".

Such a convention became a reality in 1992, with the adoption of the United Nations Framework Convention on Climate Change at the UN Conference on Environment and Development held in Rio de Janeiro, to be followed in 1997 by the adoption of the Kyoto Protocol. The latter came into force in 2005.

# 3 GREENHOUSE GAS INVENTORY INFORMATION

*Image Source: LNG World News (https://www.lngworldnews.com/wartsila-to-convert-maltese-power-station-to-run-on-gas/)*

## 3.1 Introduction

With emissions from anthropogenic sources being considered as a prime culprit in observed changes in climatic conditions, climate change mitigation policy will not effectively deliver on its goals unless a system is available to determine where we are with respect to emissions and removals, and to measure progress towards reaching emission limitation or reduction targets, in a quantified manner and on an ongoing basis - the national inventory is a crucial tool in this respect.

The national inventory of greenhouse gas emissions from sources and removals from sinks (hereafter also referred to as the "national GHG inventory") is elaborated in fulfilment of Malta's reporting obligations under the UNFCCC and Kyoto Protocol, as Annex I Party. The compilation of such an inventory also meets obligations arising from the country's membership in the European Union, principally Regulation (EU) No 525/2013[21], the so-called "Monitoring Mechanism".

This chapter describes the approach currently in place to prepare the national GHG inventory and gives a brief overview of emission trends for the period covering the years 1990 to 2015, including trends by gas and category. 1990 represents the default starting year for presentation of inventories of greenhouse gas emissions and removals. GHG emissions and removals data discussed here are based on the latest available national GHG inventory (MRA, 2017). More detailed information on Malta's GHG inventory, including in-depth discussions of methodological approaches to inventory compilation, may be found in the annual GHG inventory submissions of Malta to the UNFCCC.

### *3.1.1 What is a national greenhouse gas inventory?*

A national greenhouse gas inventory provides a detailed mathematical picture of emissions of greenhouse gases by sources and removals by sinks from anthropogenic activities taking place in a country.

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 GHG species is usually denoted as the Global Warming Potential (GWP). 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 (GWP of methane being 25); 1 tonne of $N_2O$ can be represented as 298 tonnes $CO_2$ equivalents (GWP of nitrous oxide being 298), and so on.

[21] Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism form monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/20014/EC.

Indirect greenhouse gases, also known as precursors, 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); and,
- 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.

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:

- Energy (CRF sector 1);
- Industrial Processes and Other Product Use (IPPU; CRF sector 2);
- Agriculture (CRF sector 3);
- Land Use, Land-Use Change and Forestry (LULUCF; CRF sector 4); and,
- Waste (CRF sector 5).

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.

## 3.2 Greenhouse gas inventory preparation in Malta

Any Annex I Party to the UNFCCC has an obligation to establish a National Greenhouse Gas Inventory System, defined by Decision 20/CP.7[22] 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 (Article 5 of Regulation (EU) No 525/2013).

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 legal requirements is established. As a result, 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[23]. The legal notice (LN 259/2015) forms part of a wider legislative framework being established specifically for

[22] Decision 20/CP.7 'Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol'; FCCC/CP/2001/13/Add.3.

[23] 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.

climate action in Malta, with the main underpinning legal instrument being the Climate Action Act, 2015 (Chap. 543)[24].

The 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 and provides for the formal designation of an inventory agency (IA). Under the same legal notice, the Malta Resources Authority has been designated, through Government Notice No. 1036 of 27th October 2015, as the Inventory Agency. The legal notice gives the Single National Entity overall responsibility for the national inventory system and the mandate to ensure that the national system operates in accordance with relevant decisions of the UNFCCC bodies and with relevant EU legislation. The Inventory Agency is set specific functions relating to inventory preparation and management. The legal notice also establishes rules for the relationship between the Single National Entity and the Inventory Agency on one hand, and data providers on the other. The Minister responsible for climate change is also required to lay before Parliament the annual greenhouse gas inventory.

By virtue of its designation as national Inventory Agency, MRA is responsible for the planning, preparation and management of the national GHG inventory. The Climate Change Unit within MRA performs 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 Common Reporting Format (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.

With the legislative formalisation of the national institutional arrangements via LN 259/2015, the next important step for the national system was the elaboration of documented quality assurance and quality control procedures. Significant progress has been achieved in this respect during the course of 2017, as MRA adopted a quality plan for its inventory processes. The plan builds on the ISO 9001:2015 'Quality Management Systems – Requirements' approach. All business processes required for the compilation of national GHG inventories by MRA have been established, mapped and documented as part of MRA's inventory Quality Management System. The documented quality management system includes an 'Operations & Quality Manual', which defines the overarching quality policy of MRA, sets out a number of quality objectives for the ongoing monitoring and evaluation of performance, and presents high-level responsibilities of all roles within MRA involved in the annual compilation of the national greenhouse gas inventory. A number of Quality System Procedures provide detailed instructions addressing such matters as document control, treatment of non-conformities and competency management. Quality Operational Procedures then cover the entire inventory preparation and management cycle starting with the internal organization of work to dealing with EU and UNFCCC reviews of Malta's inventory submissions. Procedures are accompanied by forms and other controlled documents that ensure good record-keeping on actions taken.

## 3.3 General Trends in Greenhouse Gas Emissions and Removals

This section gives an overview of general trends in total greenhouse gas emissions for Malta, trends of emissions by gas and by sector, and a discussion of the correlation between national emissions and basic national indicators, namely population and Gross Domestic Product.

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

### 3.3.1 Overview of emission trends

Annual national emissions of greenhouse gases over the period 1990 to 2015 are presented in Table 3-1. Emission trends by gas and total annual "with" and "without" LULUCF estimates are also provided in this table. It is pertinent to note that the main focus of the discussion in this chapter is on national emissions and emissions from 'memo items' are included only where this is specifically indicated in the text or captions.

The change in total emissions between the base year (1990) and the latest reported year (2015) for the without-LULUCF estimates show a decrease of 6.53%, while for the with-LULUCF estimates this represents a decrease of 6.54%.

The general trend for the combined emissions (in $CO_2$ equivalent) shows a persistent general increase up until 2012 with a reversal of the trend over the subsequent period of years. With the sector Energy being a dominant contributor to overall GHG emissions in Malta compared to other sectors, it is thus expected that trends for that sector will greatly influence the overall trend. This trend can be more easily observed in Figure 3-1.

**Table 3-1 Total emissions with/without LULUCF for the period 1990 to 2015 (Gg CO2 equivalent).**

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Total (without LULUCF)** | 2,382.04 | 2,566.78 | 2,661.11 | 3018.81 | 3019.21 | 3115.01 | 3233.55 | 2901.92 | 2930.27 | 2226.87 |
| **Total (with LULUCF)** | 2,385.00 | 2,569.85 | 2,664.26 | 3,020.44 | 3021.17 | 3117.19 | 3235.97 | 2904.58 | 2933.16 | 2230.00 |

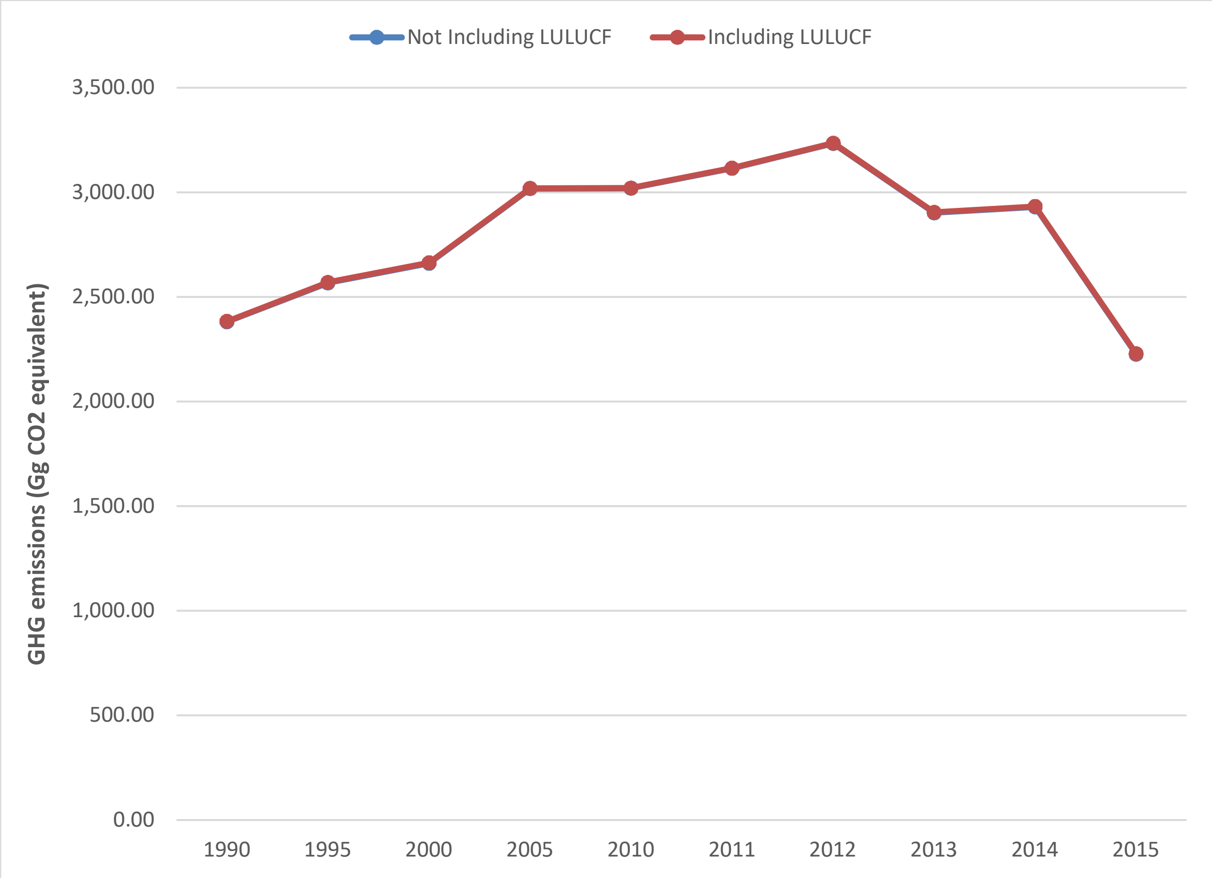



**Figure 3-1 Total Emissions of greenhouse gases, with and without LULUCF, for 1990 – 2015. Note: The difference between these categories is very small and is not clear in the graph.**

The year-on-year increases (or decreases) in the overall emissions (with-LULUCF) are illustrated in Figure 3-2. It reflects the overall trend in total emissions as shown in Figure 3-1, for the years up to and including 2015. As can be seen, most of the year-on-year changes are positive (i.e. year-on-year increases). One may note that despite the large variation in the level of individual year-on-year changes, the general trend is that the year-on-year increases observed in the later years are lower than for earlier years. Indeed, the occurrence of year-on-year decreases in emissions also tends to become more frequent with time.

Substantial decreases in year-on-year emissions can be observed for the years 2012-2013 (-10%) and 2014-2015 (-24%) to the extent that they are also significantly larger than any year-on-year change observed in previous years.

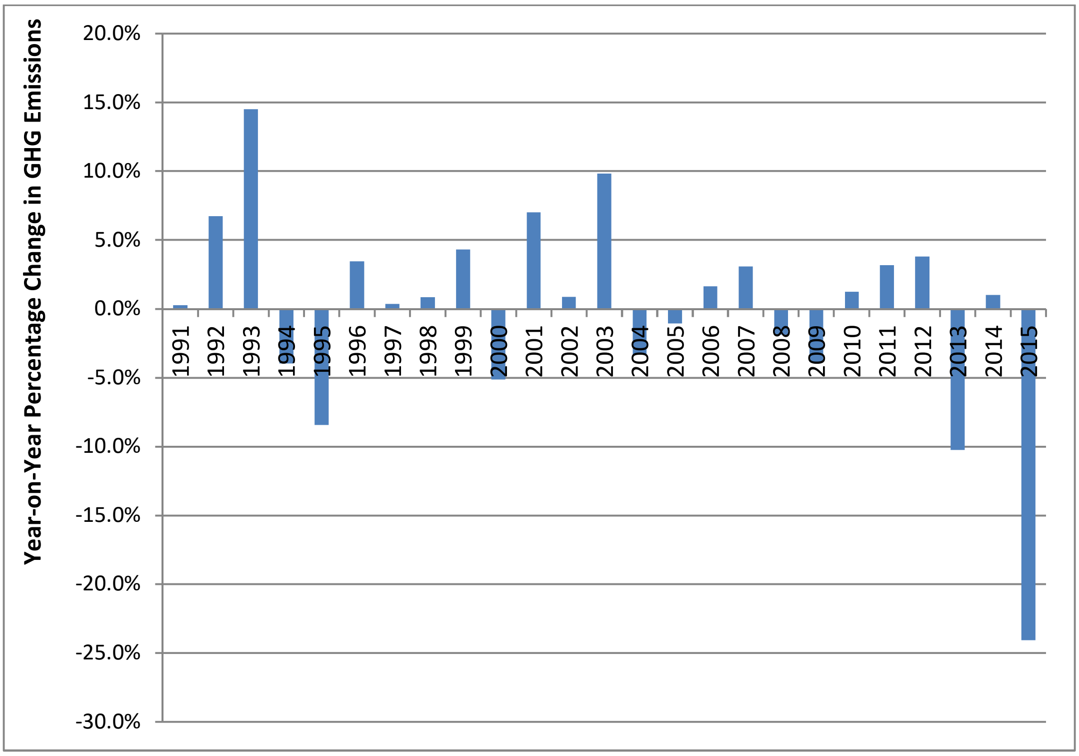



**Figure 3-2 Annual percentage increase or decrease in total greenhouse gas emissions (based on total emissions including LULUCF).**

### *3.3.2 Emission trends and population growth*

A comparison of emissions with the demographic development of a country can serve as a useful indicator of the progress in emissions control over a set period.

Malta's population has seen a sustained growth over the period covered in this discussion, and a concomitant increasing per capita trend in emissions was observed until 2012. However, a marked drop in this trend can be observed for the years 2013 and 2015, as shown in Figure 3-3. This reduction has been reflected in per capita emissions, whereby 2015 has seen the lowest per capita emissions since the base year (1990).

In 1990, the per capita emissions stood at 6.7 tonnes of $CO_2$ equivalent and this increased to 7.7 tonnes of $CO_2$ equivalent per capita in 2012, representing an overall increase of 15%. However, this trend was reversed for 2013 to 2015, with a substantial decrease in total national emissions translating itself into a decrease in per capita emissions; with a 33% reduction in 2015 from the value in 2012. The level of per capita emissions in 2015 is the lowest since 1990 and stood at 5.2 tonnes of $CO_2$ equivalents per capita.

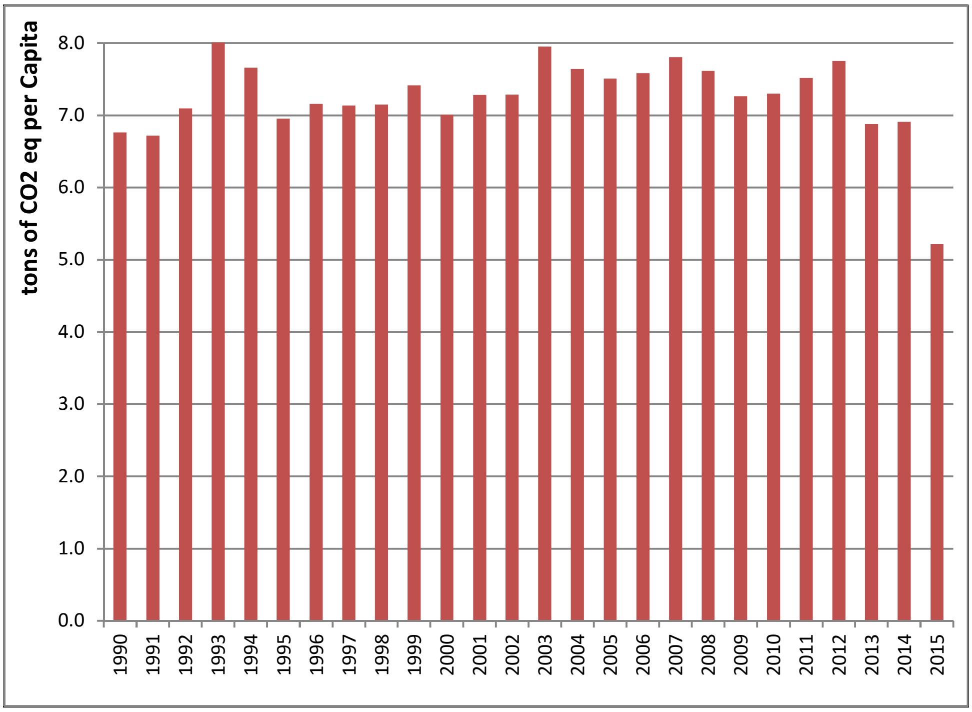



**Figure 3-3 GHG emissions per capita [Source of population data for 1990 to 2015: Eurostat].**

### *3.3.3 Emission trends and economic development*

Another important indicator compares the trend in emissions of greenhouse gases and the economic activity of the country, the latter being represented in terms of Gross Domestic Product (GDP). The relationship between these two parameters, or the 'emissions intensity' of Malta's economy, indicates that the emissions intensity has seen a generally consistent downward trend, as seen in Figure 3-4. This can be interpreted as a decoupling of national greenhouse gas emissions from the country's economic development trends. The continued improvement in the emission intensity trend of the Maltese economy may be due to a combination of reasons, including increased efficiency, from an emissions perspective, of the activities covered by the inventory.

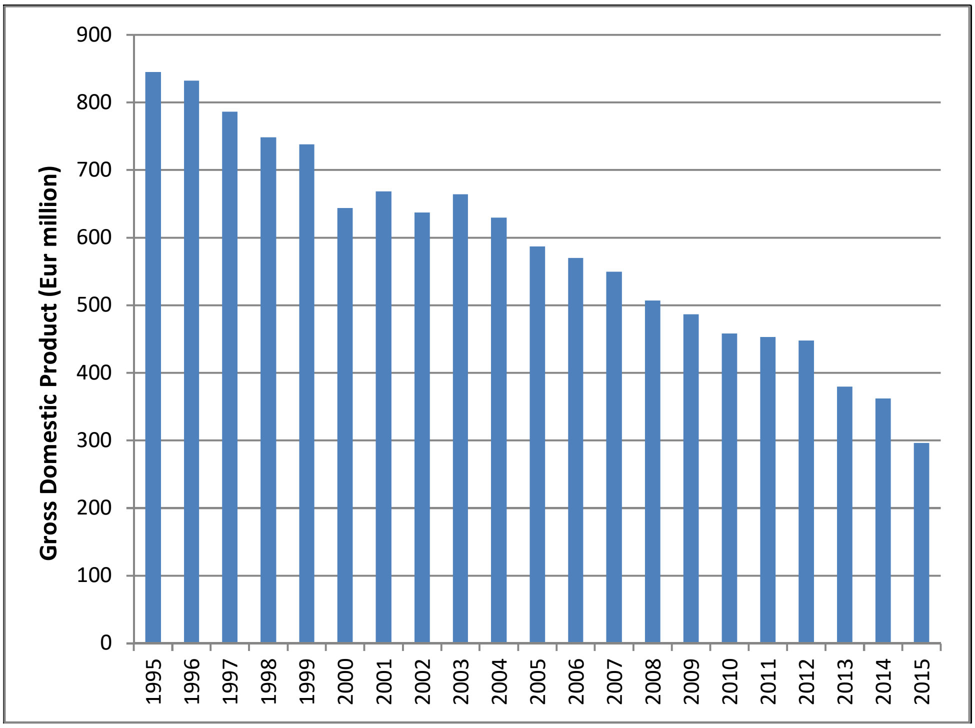



**Figure 3-4 GHG emissions per unit GDP [Source of GDP data for 1990 to 2015: Eurostat].**

## 3.4 Trends in greenhouse gas emissions by gas

This section will discuss emission trends for each gas covered by the national GHG inventory.

### *3.4.1 Overview of emission trends by gas*

Emission trends for each greenhouse gas covered by this inventory are presented in Table 3-2 below. Table 3-3 provides an overview of the changes in emissions between the latest year covered by this inventory and the base year 1990.

Table 3-3 makes very obvious the major contribution that carbon dioxide has in total national emissions. The status of this greenhouse gas as the highest contributor has been maintained throughout the years. This can also be observed in Figure 3-5 and Figure 3-6. The relative contribution of $CO_2$ emissions to total national emissions represents the strong influence that this gas has on the national emissions trends, to the extent that the trend for national emissions runs almost parallel to the trend for $CO_2$ emissions. One does however note that with time, the relative contribution of $CO_2$ has tended to decrease somewhat, especially in more recent years, due to the trend of CO2 emissions *per se* in conjunction with changes in relative contributions of other emitted gases, primarily the substantial increase in the share of emissions of HFCs.

**Table 3-2 Greenhouse gas emission trends by gas for 1990-2015 (Gg $CO_2$ equivalent). [NA – Not Applicable (emissions of that gas cannot occur from a specific activity); NE – Not Estimated; NO – Not Occurring (the activity does not occur in Malta); IE – Included Elsewhere (emissions from an activity are included with those for another activity)]**

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| **$CO_2$ (without LULUCF)** | 2,170.72 | 2,360.48 | 2,417.83 | 2,704.54 | 2,638.47 | 2,725.75 | 2,819.43 | 2,482.00 | 2,481.26 | 1,756.91 |
| **$CO_2$ (with LULUCF)** | 2,173.68 | 2,363.55 | 2,420.97 | 2,706.17 | 2,640.42 | 2,727.93 | 2,821.85 | 2,484.66 | 2,484.15 | 1,760.04 |
| **$CH_4$** | 154.96 | 145.49 | 173.85 | 212.91 | 179.58 | 167.53 | 165.34 | 155.34 | 171.53 | 178.01 |
| **$N_2O$** | 56.34 | 59.37 | 61.26 | 58.02 | 53.97 | 48.10 | 47.30 | 45.58 | 46.12 | 44.74 |
| **HFCs** | NO, NE, IE, NA | 0.00 | 6.70 | 41.78 | 145.49 | 169.02 | 201.03 | 216.32 | 230.77 | 247.00 |
| **PFCs** | NO, NA | NO, NA | NO, NA | NO, NA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **$SF_6$** | 0.01 | 1.44 | 1.47 | 1.56 | 1.69 | 4.59 | 0.45 | 2.68 | 0.58 | 0.19 |
| **Total (without LULUCF)** | 2,382.04 | 2,566.78 | 2,661.11 | 3018.81 | 3019.21 | 3115.01 | 3233.55 | 2901.92 | 2930.27 | 2226.87 |
| **Total (with LULUCF** | 2,385.00 | 2,569.85 | 2,664.26 | 3,020.44 | 3021.17 | 3117.19 | 3235.97 | 2904.58 | 2933.16 | 2230.00 |

**Table 3-3 Emissions of greenhouse gases by gas for the years 1990 and 2015 (Gg $CO_2$ equivalent). [NA – Not Applicable (emissions of that gas cannot occur from a specific activity); NE – Not Estimated; NO – Not Occurring (the activity does not occur in Malta); IE – Included Elsewhere (emissions from an activity are included with those for another activity)]**

| | 1990 | | | 2015 | | | % change 1990-2015 |
|---|---|---|---|---|---|---|---|
| | Emissions | % Share (without-LULUCF) | % Share (with-LULUCF) | Emissions | % Share (without-LULUCF) | % Share (with-LULUCF) | |
| $CO_2$ (without-LULUCF) | 2,170.72 | 91.13 | - | 1,756.91 | 78.90 | - | -19.06% |
| $CO_2$ (with- LULUCF) | 2,173.69 | - | 91.14 | 1,760.04 | - | 78.93 | -19.03% |
| $CH_4$ | 154.96 | 6.51 | 6.50 | 178.02 | 7.99 | 7.98 | 14.8% |
| $N_2O$ | 56.34 | 2.37 | 2.36 | 44.74 | 2.01 | 2.01 | -20.59% |
| HFCs | NO, NA, NE, IE | - | - | 247.00 | 11.09 | 11.08 | --- |
| PFCs | NA | - | - | 0.00 | 0 | 0 | --- |
| $SF_6$ | 0.01 | 0.00042 | 0.00042 | 0.19 | 0.00853 | 0.00852 | 1800% |
| Total (without-LULUCF) | 2,382.04 | | | 2,226.87 | | | -6.51% |
| Total (with-LULUCF) | 2,385.00 | | | 2,230.00 | | | -6.50% |

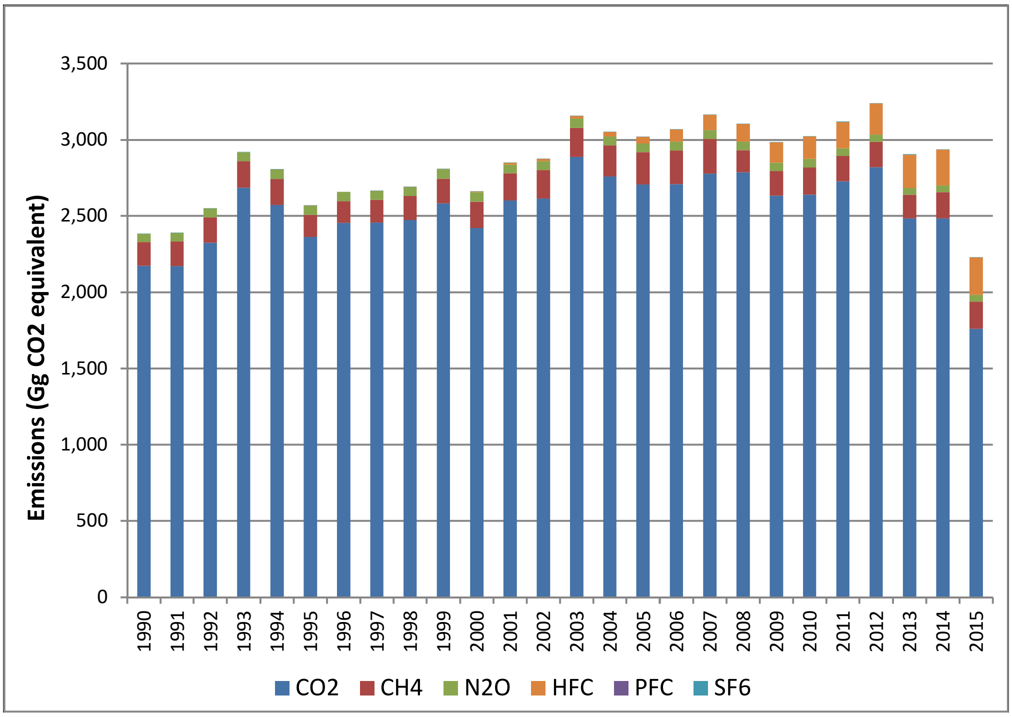



**Figure 3-5 Emissions of greenhouse gases by type of gas, including LULUCF, for 1990 – 2015.**

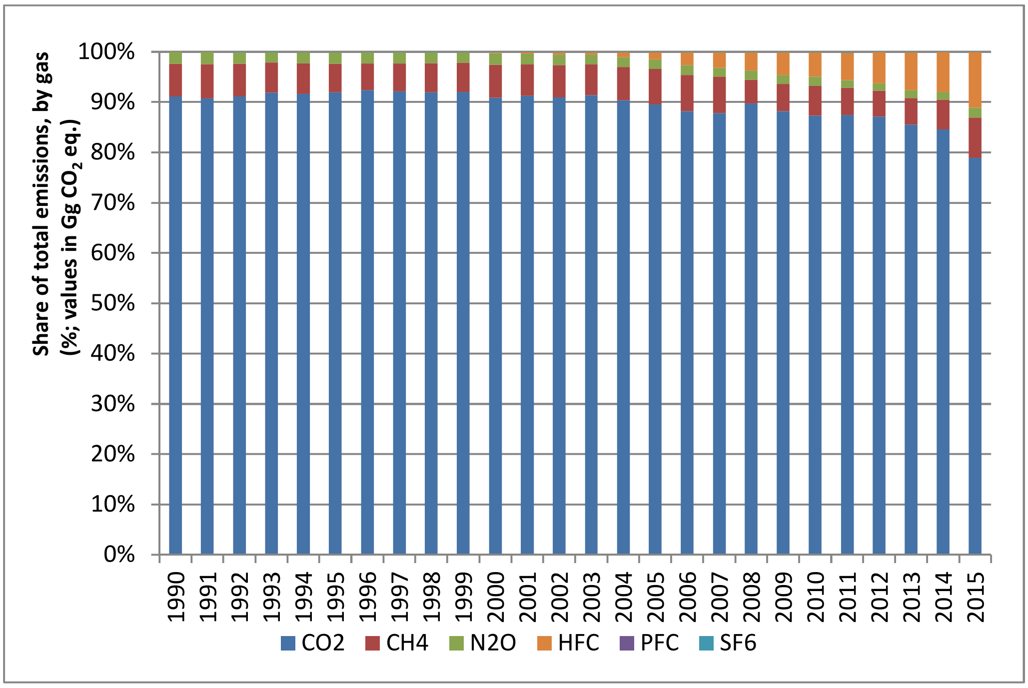



**Figure 3-6 Percentage contribution of each greenhouse gas to total national greenhouse gas emissions (with-LULUCF).**

### 3.4.2 Carbon dioxide

The overall profile of carbon dioxide emissions by sources and removals by sinks is presented in Figure 3-7. It is obvious that emissions far outweigh removals – indeed, removals of carbon dioxide by the LULUCF sector only offset a very minimal amount of emissions of this gas.

Sectorally, the principal contributor to carbon dioxide emissions is the Energy sector (CRF sector 1). Carbon dioxide emissions from this sector account for 99.6% of total gross national carbon dioxide emissions. Within this sector, the source category Energy Industries (1A1) represents the highest overall contribution of carbon dioxide emissions, followed by source category Transport (1A3). Trends are greatly dependent on the relative strength of emitting sources and removal sinks: it is not surprising therefore that the category Energy Industries influences the trend of $CO_2$ emissions to the highest extent.

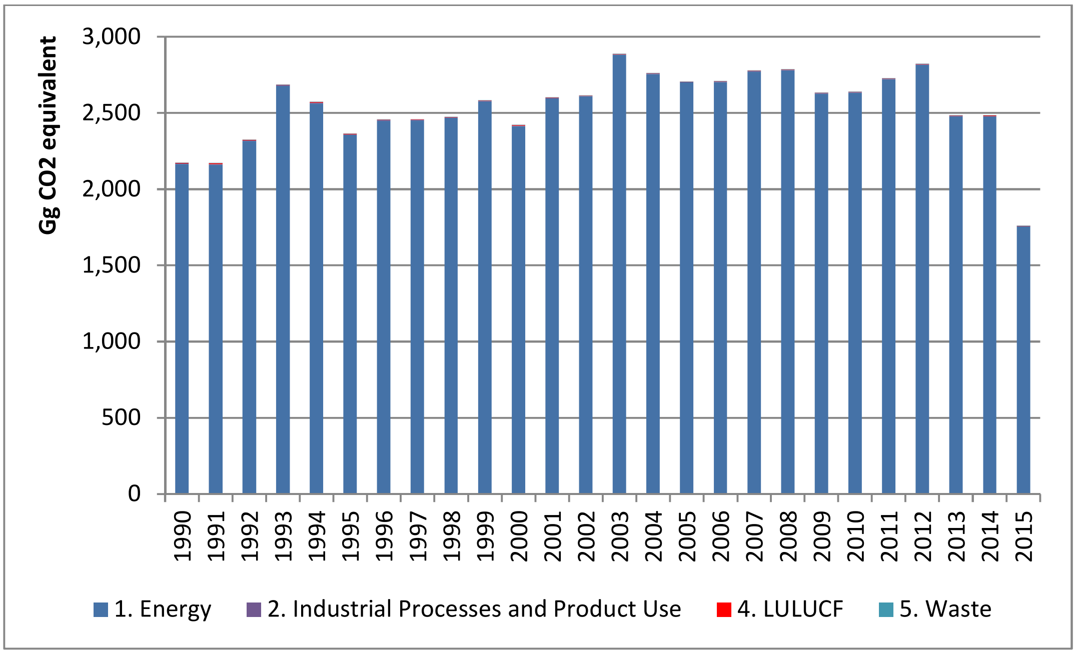



**Figure 3-7 Trends in emissions by sources and removals by sinks for carbon dioxide.**

### 3.4.3 Methane

For most of the period under consideration, methane had the second highest share of national total emissions (in terms of $CO_2$ equivalent). This situation has however changed since 2012, with methane being replaced by HFCs as the class of greenhouse gases with the second highest share of overall national emissions (see Figure 3-6).

Figure 3-8 shows the general trend up to 2007 reflected an increase in emissions of methane; this however has changed in subsequent years. This change is due to the reduction in emissions of this greenhouse gas from the sector Waste (CRF sector 5), as a result of increased flaring of methane in local managed landfilling activities - category Managed Waste Disposal on Land (5A1).

Agriculture is another important emitter of methane through emissions from source categories Enteric Fermentation (4A) and Manure Management (4B). Estimated absolute emissions of methane from this sector peaked in 2000, with estimated emissions in 2015 being the lowest recorded since 1990.

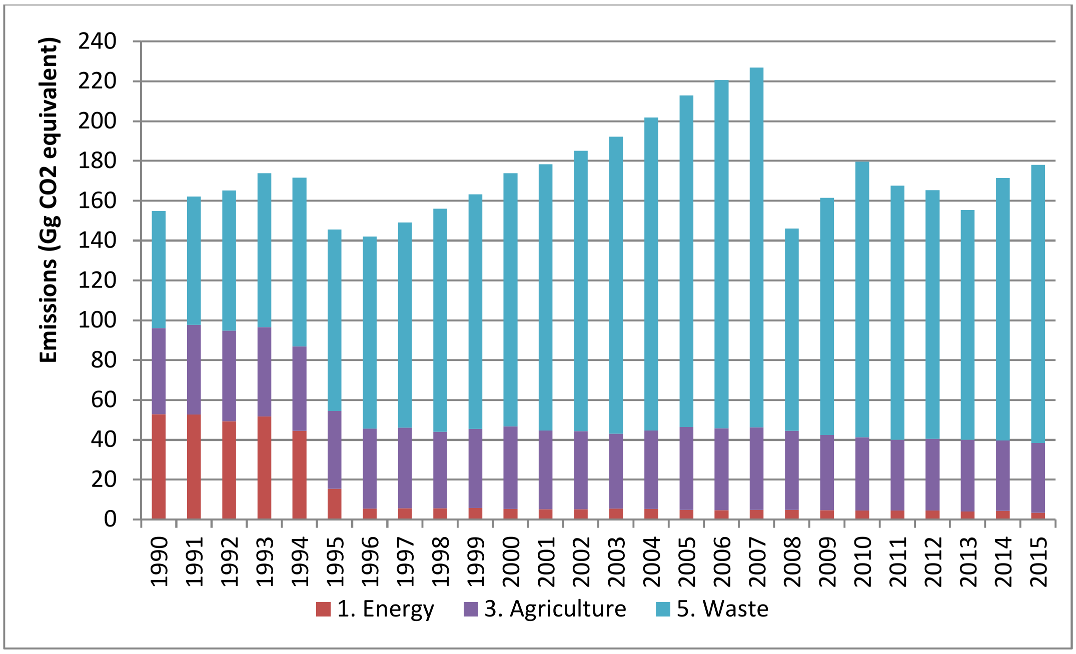



**Figure 3-8 Trend in total and sectoral emissions of methane.**

### 3.4.4 Nitrous oxide

Until 2005, nitrous oxide was the gas with the third highest share of total national emissions (in terms of $CO_2$ equivalent); its share has fallen down in the overall classification over time (Figure 3-6).

Figure 3-9 presents the general trend of nitrous oxide emissions (in Gg $N_2O$). Estimated emissions peaked in 1994. Sectorally, the highest contributor is sector Agriculture (CRF sector 3), with emissions of this greenhouse gas mainly from source category Agricultural Soils (3D), and, to a lesser extent, source category Manure Management (3B). Further contributions to national total nitrous oxide emission are given by sectors Waste (CRF sector 5), Energy (CRF sector 1) and Industrial Processes and Other Product Use (CRF sector 2).

### 3.4.5 Fluorinated greenhouse gases

Whereas for a large part of the period covered by this report, fluorinated greenhouse gas emissions had a minimal share in total national emissions, their contribution increased significantly in more recent years, to the extent that the combined share of such gases (in terms of $CO_2$ equivalent) in total national emissions in 2011 was second highest behind carbon dioxide. The main driving force behind this change is the substantial increase observed for hydrofluorocarbons (see Figure 3-10) with the utilisation of such gases as replacements for ozone depleting substances and increased volumes used in refrigeration and air-conditioning equipment. The high global warming potentials of fluorinated gases further bolster their overall share in total emissions.

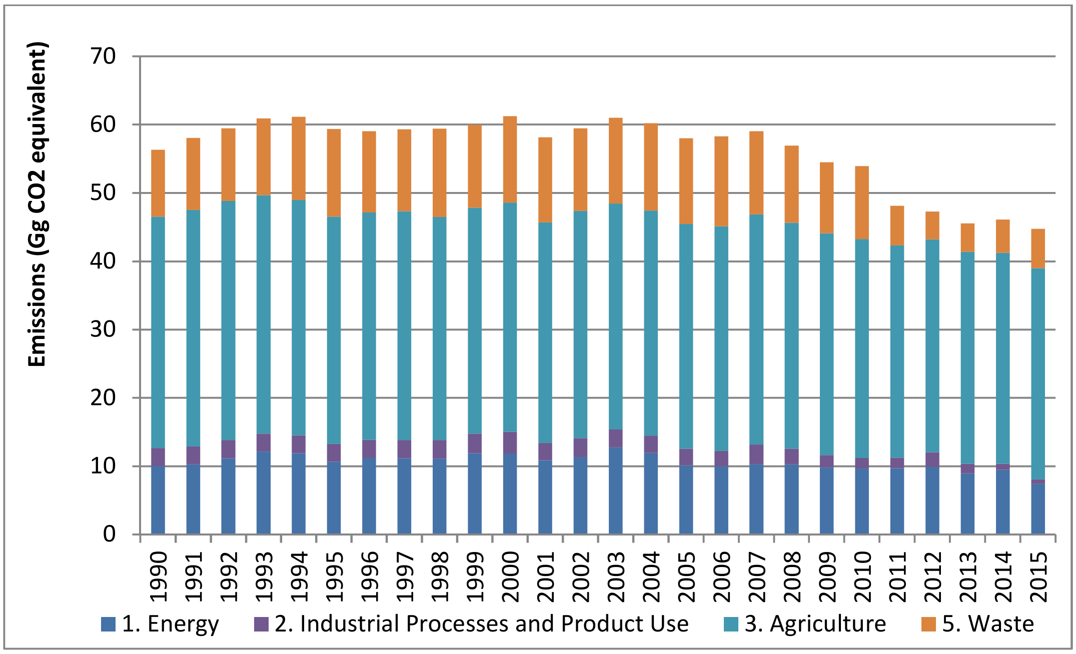



**Figure 3-9 Trends in total and sectoral emissions of nitrous oxide.**

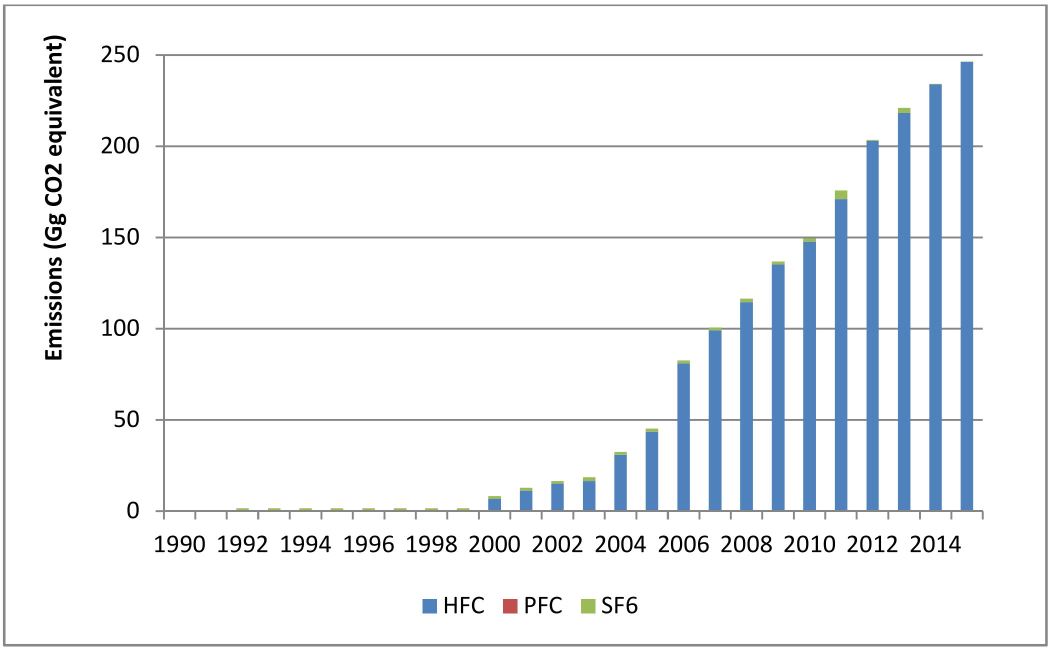



**Figure 3-10 Trends in emissions of fluorinated greenhouse gases.**

### *3.4.6 Indirect greenhouse gases*

Emissions of indirect greenhouse gases are illustrated in Figure 3-11.

Among these four gases, the most significant trends are those of CO and NOx. Both gases show trends that are closely correlated to the trends in activities that result in emissions of such gases, in particular energy generation (category 1A1a) and road transport (category 1A3b).

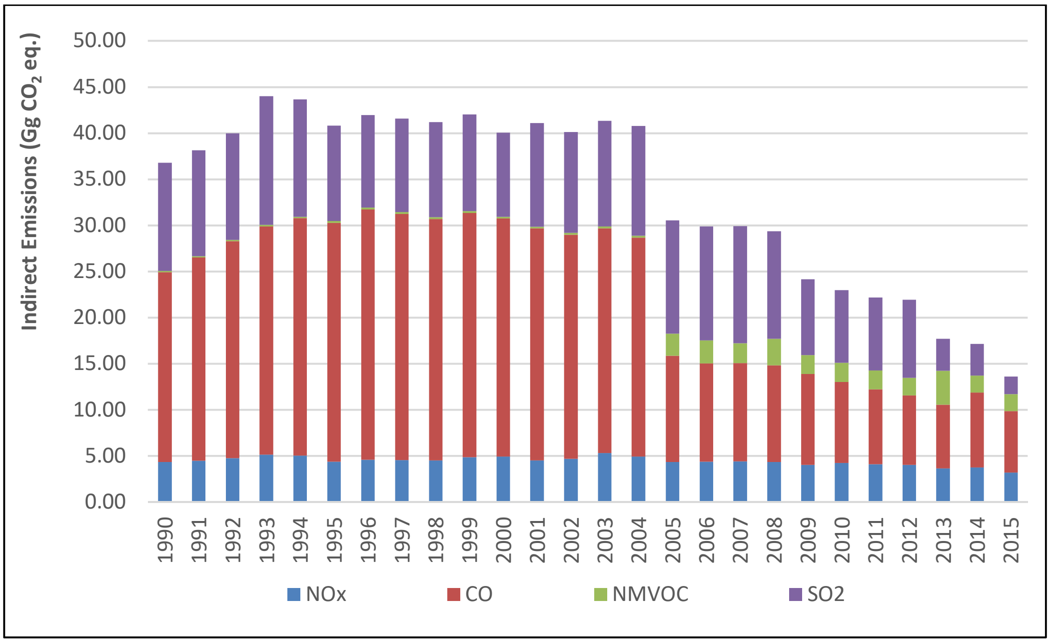



**Figure 3-11 Emission trends for indirect greenhouse gases.**

## 3.5 Trends in greenhouse gas emissions by sector

This section will discuss sectoral trends in greenhouse gas emissions. Greenhouse emissions from all sectors covered by this inventory (except for Memo Items) over the time series concerned are presented in Table 3-4 and illustrated in Figure 3-12.

**Table 3-4 Emissions of greenhouse gases by sector for the years 1990 to 2015 (Gg $CO_2$ equivalent).**

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Energy** | 2227.95 | 2380.68 | 2430.86 | 2715.60 | 2648.46 | 2735.23 | 2829.73 | 2490.94 | 2490.95 | 1766.43 |
| **Industrial Processes and product use** | 7.94 | 9.47 | 15.20 | 49.48 | 152.17 | 179.02 | 206.76 | 223.85 | 235.45 | 248.39 |
| **Agriculture** | 77.13 | 72.38 | 75.03 | 74.51 | 68.91 | 66.50 | 67.24 | 66.99 | 66.31 | 65.90 |
| **LULUCF** | 2.96 | 3.07 | 3.15 | 1.63 | 1.96 | 2.18 | 2.43 | 2.66 | 2.90 | 3.13 |
| **Waste** | 69.02 | 104.24 | 140.02 | 179.22 | 149.66 | 134.26 | 129.82 | 120.13 | 137.55 | 146.14 |
| **Other** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Total (with LULUCF)** | 2385.00 | 2569.85 | 2664.26 | 3020.44 | 3021.17 | 3117.19 | 3235.97 | 2904.58 | 2933.16 | 2230.00 |

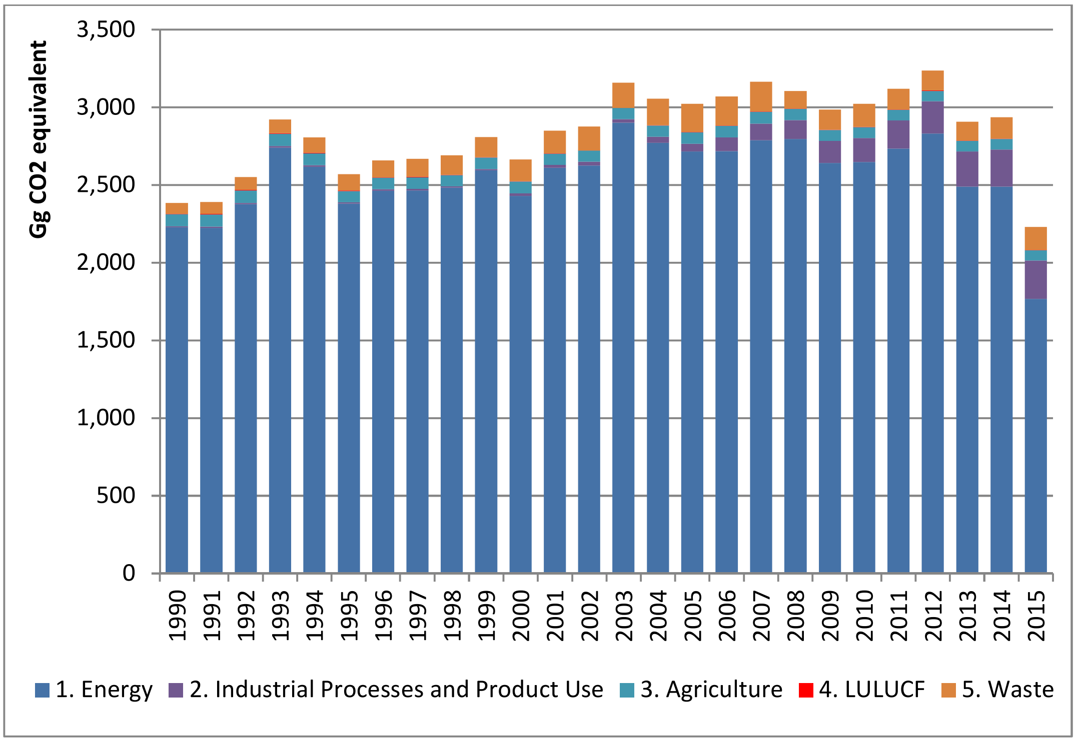



**Figure 3-12 Emission trends by sector.**

The most obvious feature that comes out of Figure 3-3 and Figure 3-12 is the predominance of emissions from the Energy sector in total national emissions. This has been the case throughout the period covered by this report. Indeed, there is a strong correlation between the profile of total national emissions and that of emissions from the energy sector, indicating that the volume of emissions attributed to this sector strongly determines the year-on-year trend in total national emissions. All other source sectors contribute substantially less to overall emissions, while LULUCF is associated with a minor removal effect.

Overall sectoral trends as a percentage change between year 1990 and year 2015 are provided in Table 3-5. After a long period (until 2012) during which the general trend was of increasing emissions, the Energy sector, in recent years, started showing a gradual decrease in overall emissions, particularly evident between 2014 and 2015. This decrease is such that emissions in 2015 are even less than what they were in 1990. The trend in overall emissions for the sector Energy reflects primarily changes in the mix of sources used to meet electricity demand in the country, the impact of which even superseding emission trends for other categories included in this sector (e.g. road transport).

The increase for the sector Industrial Processes and Other Product Use is explained by the substantial increase in emissions of HFCs, as already explained in an earlier section. The overall trend for the sector Agriculture represents a decrease in emissions between 1990 and 2015, though one may observe a number of fluctuations throughout the period. Sector Waste also shows an increase in emissions between the base year and 2015, though fluctuations may also be observed for this sector over the period, not least during the latter half of the time series.

The level of emissions from sector LULUCF can be said to have remained relatively stable over the time series, varying between a minimum 1.23 Gg $CO_2$ (2002) equivalent and a maximum 4.74 Gg

$CO_2$ equivalent (1991). More information on the reasons underpinning the observed sectoral trends can be obtained from the annual submissions of Malta's GHG inventory.

**Table 3-5 Emissions of greenhouse gases by sector for the years 1990 and 2015 and the corresponding change between the two years (Gg $CO_2$ equivalent).**

| | 1990 | % share | 2015 | % share | % change 1990-2015 |
|---|---|---|---|---|---|
| Energy | 2227.95 | 93.42 | 1766.44 | 79.21 | -20.72% |
| Industrial Processes and other product use | 7.94 | 0.33 | 248.39 | 11.14 | 3029.70% |
| Agriculture | 77.13 | 3.23 | 65.90 | 2.96 | -14.57% |
| LULUCF | 2.96 | 0.12 | 3.13 | 0.14 | 5.57% |
| Waste | 69.02 | 2.89 | 146.14 | 6.55 | 111.74% |
| Other | NA | | NA | | NA |
| Total (with LULUCF) | 2,385.00 | | 2,230.00 | | -6.5% |

### *3.5.1 Energy (CRF sector 1)*

The Energy sector is the most significant contributor of greenhouse gas emissions in Malta. Emission trends for this sector, split by sub-sector categories, are presented in Figure 3-13.

In 2015, the category Energy Industries (1A1) accounted for 50.4% of the overall greenhouse gas emissions in the Energy sector as a whole. This category has the greatest influence on the overall energy emission trends and due to the relative importance of the Energy sector, it also influences national emission trends.

The second highest contributor under this sector is Transport (1A3), incorporating Road Transport (1A3b), National Navigation (1A3dii) and Domestic Aviation (1A3aii). Cumulatively, this sector accounts for 35.8% of total Energy sector emissions. Transport is thus another major contributor to the overall national emissions. With the decrease in emissions from the Energy Industries category in recent years, the relative share of the category Road Transport has seen a marked counter increase.

The Manufacturing Industries category (1A2) accounts for 2.4% of the energy sector emissions, while the Commercial/Institutional (1A4a), Residential (1A4b) and Agriculture, Forestry & Fisheries (1A4c) sectors account for 7.7%, 2.5% and 0.9% of the energy sector emissions respectively. The remaining 0.2% are emissions from the 'Other' Sector (1A5) and are attributed to the combustion of fuels for Military purposes.

Emissions from fossil fuel combustion account for all the fossil fuel related emissions, since no fuel oil production, oil refining or coal mining activities, are carried out on the Maltese Islands. Public Electricity Generation over the period under consideration in this Communication incorporated two-point sources, namely the two electricity generation plants (Marsa Power Station and Delimara Power Station) that have been operational up to 2015 and which were run on fuel oil and gasoil. It should be noted that until 1995, bituminous coal was also used for electricity generation in one of these plants. Moreover, flue gas treatment through desulphurisation and $deNO_x$ using bicarbonate and urea from some of the generating plant at Delimara Power Stations has a minor, yet measurable contribution.

A time-series of the carbon intensity in this sector indicates that emissions per unit of electricity generated have substantially declined over the past 3 years due to the installation of more efficient electricity generation turbines and the use of the electricity interconnector with mainland Europe. This trend is illustrated in Figure 3-14 below.

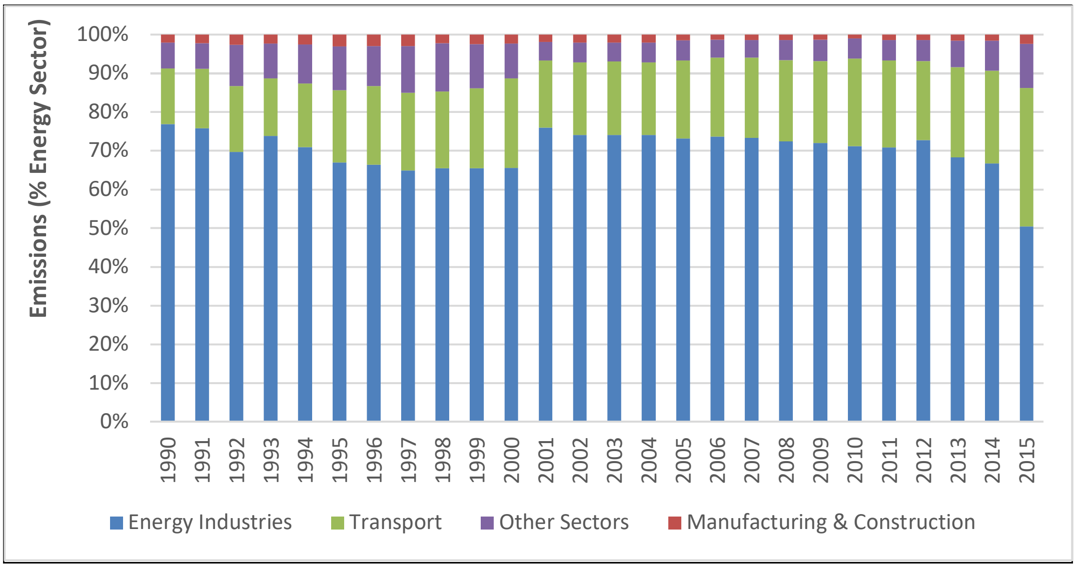



**Figure 3-13 Emission trends in the sector Energy, by source category.**

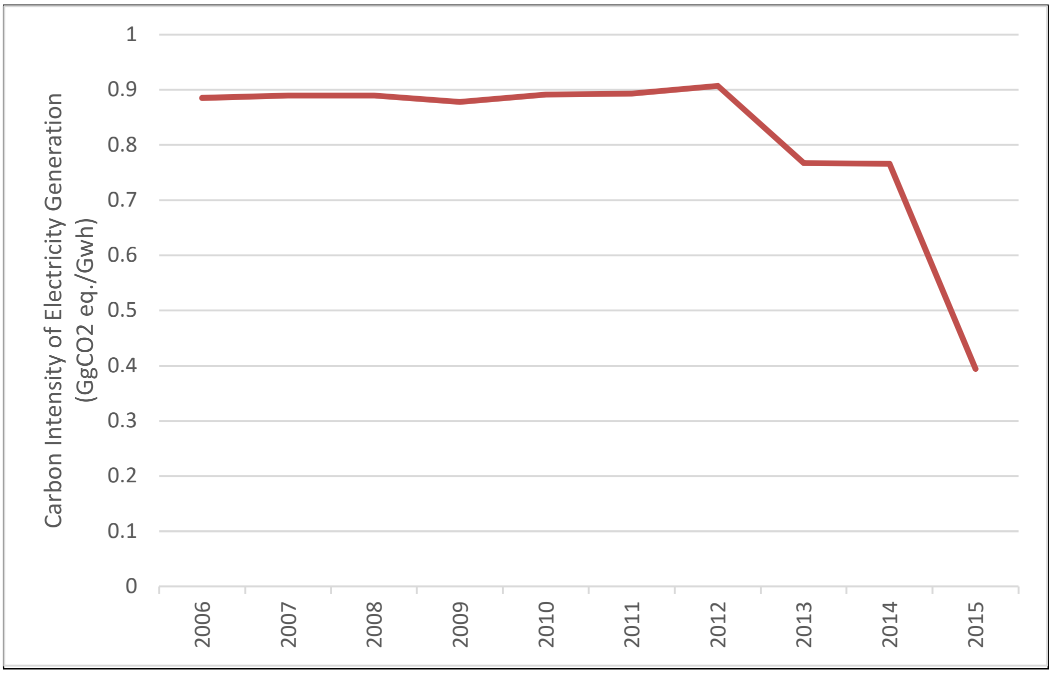



**Figure 3-14 Carbon Intensity of Electricity Generation.**

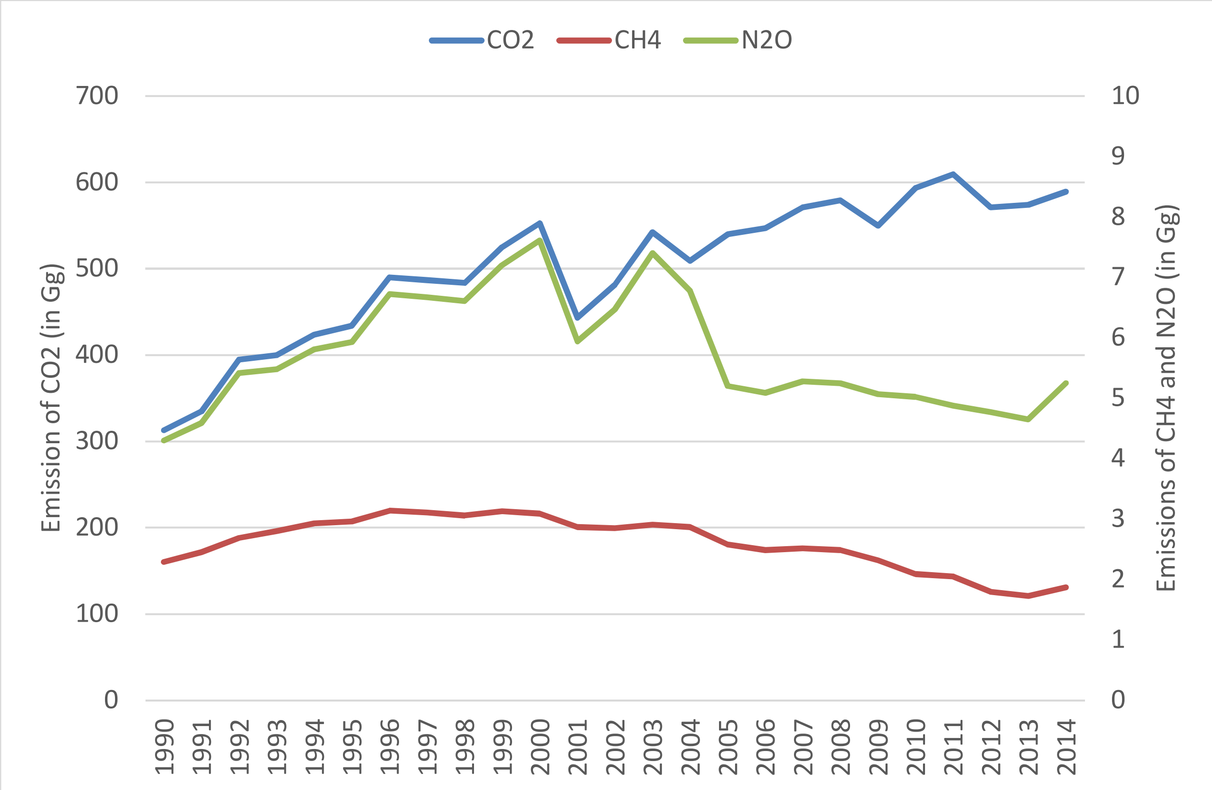



**Figure 3-15 Emissions of direct greenhouse gases (in Gg) for Road Transport from 1990 to 2014.**

As may be observed in Figure 3-13, transport (source category 1A3) is the second highest contributor to overall emission levels in the Energy sector. This source category incorporates emissions from road transport, domestic aviation and national navigation, with emissions from railways not being applicable for Malta. For the transport source category as a whole, emissions of $CO_2$ by far surpass emissions of other gases reported in the national inventory (Figure 3-15).

The transport sector in Malta is dominated by emissions from sub-category Road Transport (see Figure 3-16), with $CO_2$ being the gas that accounts for the bulk of overall GHG emissions for this sub-category. Road transport is also identified as a key source, for 1990 and 2015, in respect of $CO_2$ emissions.

Specific to road transport, the share of the market between petrol and diesel in 2015 was 39% and 58% respectively, 2.4% share of biodiesel (B100 & blended portion) and <1% share for LPG (autogas). Most of the biodiesel is sold 'pre-blended' with diesel following the implementation of the substitution obligation for importers/wholesalers of diesel (EN590) and petrol (EN228) in 2010. The substitution obligation for 2015 requires a minimum of 5.5% of the total energy content of the petroleum placed on the market. This figure is projected to increase by approximately 1% every year until it reaches the 10% RES target[25] in 2020. The trends in emissions follow closely the distribution of market shares for each fuel type as illustrated in Figure 3-17.

[25] As required by Directive 2009/28/EC on the promotion of the use of energy from renewable sources

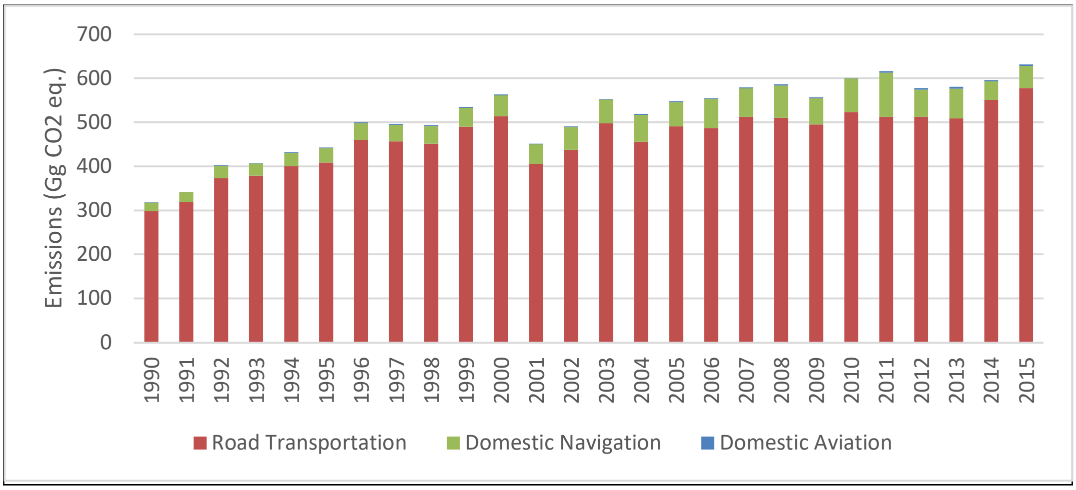



**Figure 3-16 Emission trends in category Transport, by sub-category.**

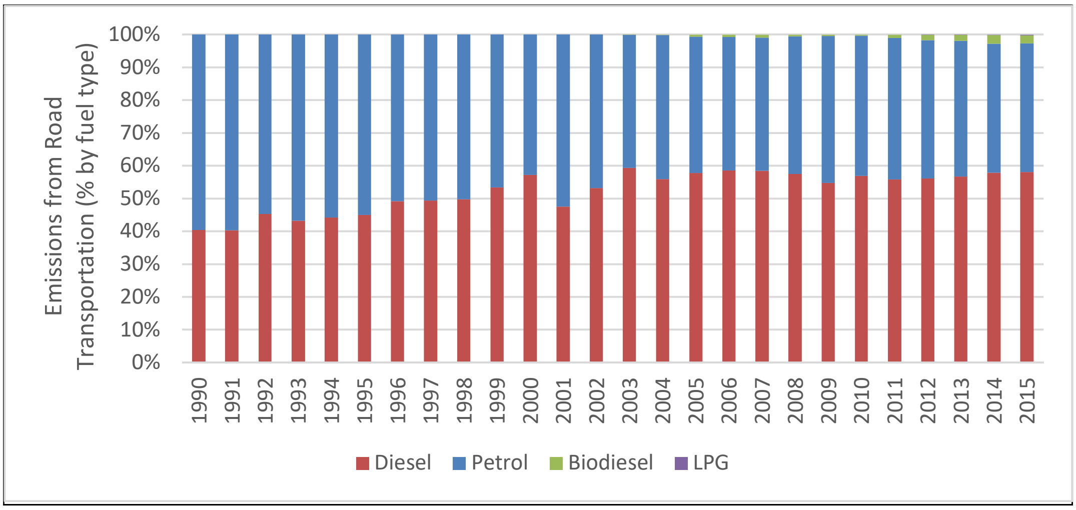



**Figure 3-17 Emission trends in category Road Transport, by fuel type.**

The other two source categories under the Energy sector, namely category Manufacturing and Construction Industries and the category Other Sectors (which includes sub-categories Commercial/Institutional, Residential, and Agriculture/Forestry/Fisheries) are attributed a much lower share of total sector emissions, as can be observed in Figure 3-13.

### *3.5.2 Industrial Processes and Other Product Use (IPPU; CRF sector 2)*

Emissions within this sector comprise direct and indirect greenhouse gas emissions arising from various industrial activities. In Malta, the most relevant sub-sectors comprise the use of fluorinated fluids. When assessing contributions by gas within this sector, in terms of carbon dioxide equivalent, the fluorinated gases contribute to almost 100% of the direct GHG emissions in this sector, especially due to their high global warming potentials.

Figure 3-18 shows direct GHG emissions in this sector increasing continuously over the whole-time series. Emissions of other GHGs in this sector are relatively marginal. A preliminary analysis of the industrial sectors in Malta shows the relative low presence of industrial production of significant GHG source. In the current situation, the vast share of emissions arises from use of products (especially refrigerants and other F-gases) rather than from production processes. In reality a good number of production sub-sectors do not occur in Malta.

The emissions contribution from the industrial processes sector to the total national GHG emissions in Malta amounted to 11.1% in 2015. Figure 3-19 illustrates trends in the indirect greenhouse gas emissions of NMVOC resulting, primarily, from the sub-category Road Paving with Asphalt (2D3).

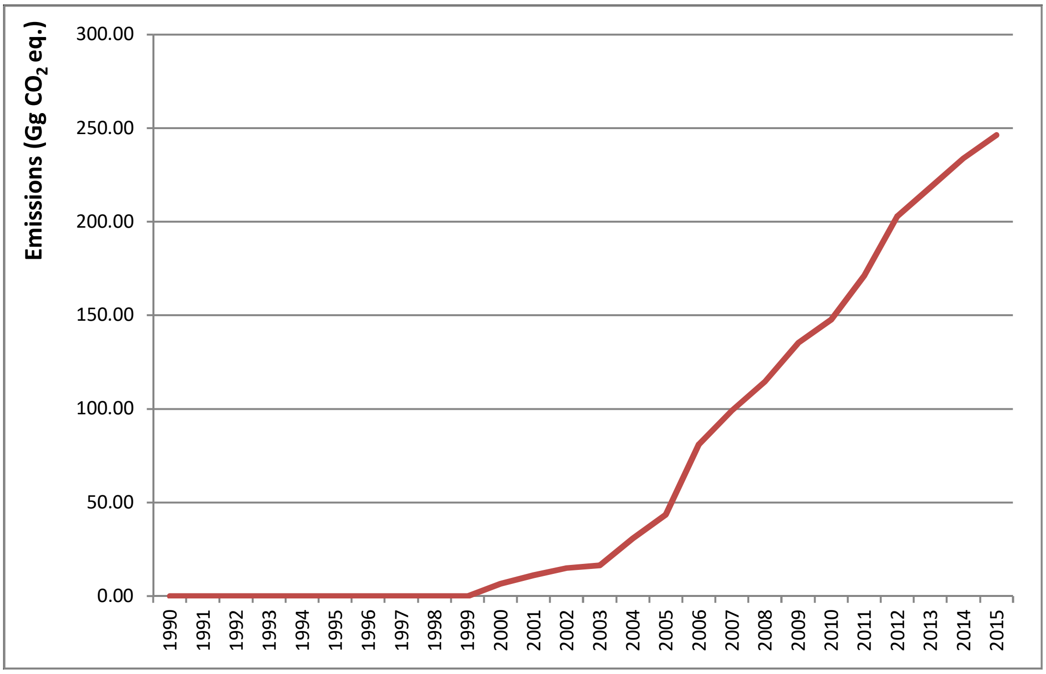



**Figure 3-18 Direct GHG emissions for sector Industrial Processes and Product Use.**

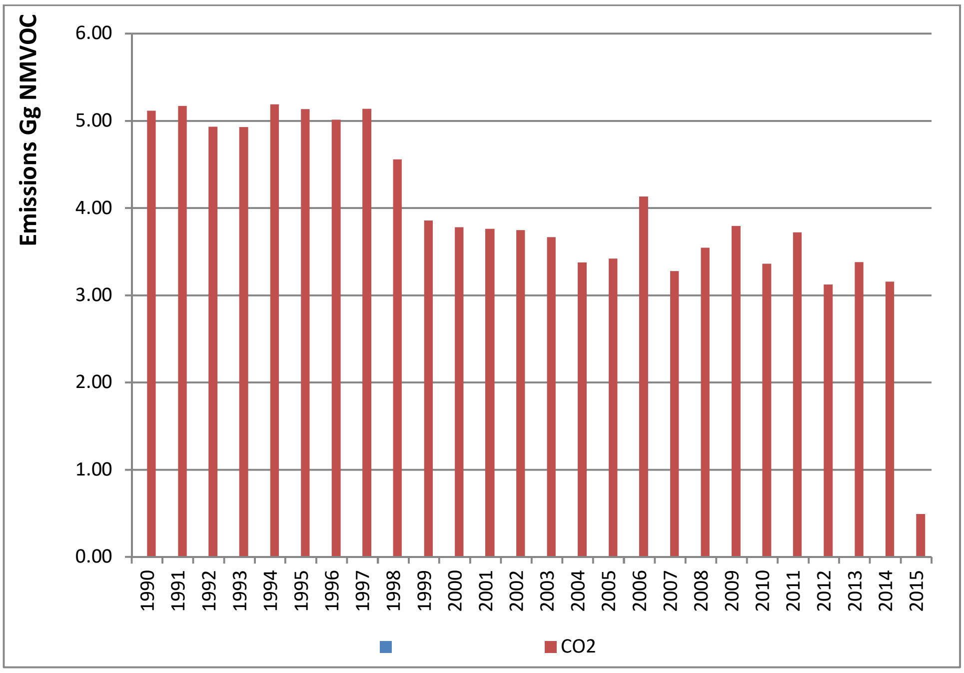



**Figure 3-19 Indirect GHG emissions for sector Industrial Processes and Product Use.**

The share of the emissions from the sector Solvent and Other Product Use in total net emissions of greenhouse gases has always been minimal. The main greenhouse gas accounted for under this sector is nitrous oxide, from its use for anaesthetic purposes (source category 2G3a). With 2015 emissions of this gas from this activity amounting to just 0.004Gg, the share in total national emissions of this sector amounted to less than 0.05%. A downward trend in $N_2O$ emissions can be observed in Figure 3-20. A relatively higher contribution is seen in respect of emissions of NMVOCs from the use of solvents and products containing solvents (source category 2D).

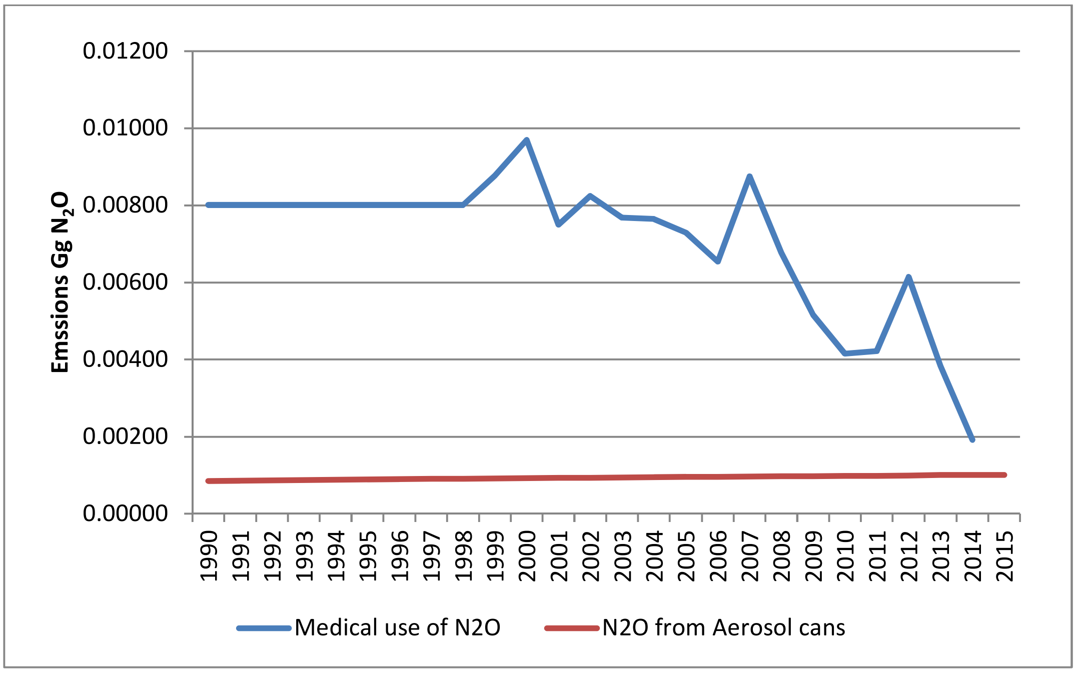



**Figure 3-20 Nitrous Oxide emissions from anaesthetic use and Aerosol cans.**

$SF_6$ 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.

Enemalta plc is identified as the main local user and emitter of $SF_6$ gas from switchgear equipment. Such switchgear equipment is found in the two local power generation plants operated by this organisation (Delimara and Marsa Power Stations, the latter currently on cold standby) and in the Electricity Distribution Network (substations and distribution centres). Other users of $SF_6$-containing equipment include two hospitals (Sir Paul Boffa Hospital and Mater Dei Hospital) as well as a number of private establishments.

### *3.5.3 Agriculture (CRF sector 3)*

Agriculture includes a number of source categories responsible for emissions of either methane or nitrous oxide. Figure 3-21 shows the emissions in carbon dioxide equivalents from the Agriculture sector for the years 1990 till 2015.

Overall, emissions attributed to this sector are on a downward trend, both in absolute terms and in relative terms when compared to the contribution of other sectors.

Agriculture is responsible for $CH_4$ and $N_2O$ emissions resulting from Enteric Fermentation (46.9%), Manure Management (22.3%) and Agricultural Soils (30.8 In 2015, agriculture contributed 20% of the total national $CH_4$ emissions and 69% of total national $N_2O$ emissions.

Three source categories are represented in national GHG inventories compiled by Malta, namely: Enteric Fermentation (source category 3A) with methane emissions; Manure Management (3B) with both methane and nitrous oxide emissions; and, Agriculture Soils (3D) responsible for nitrous oxide emissions.

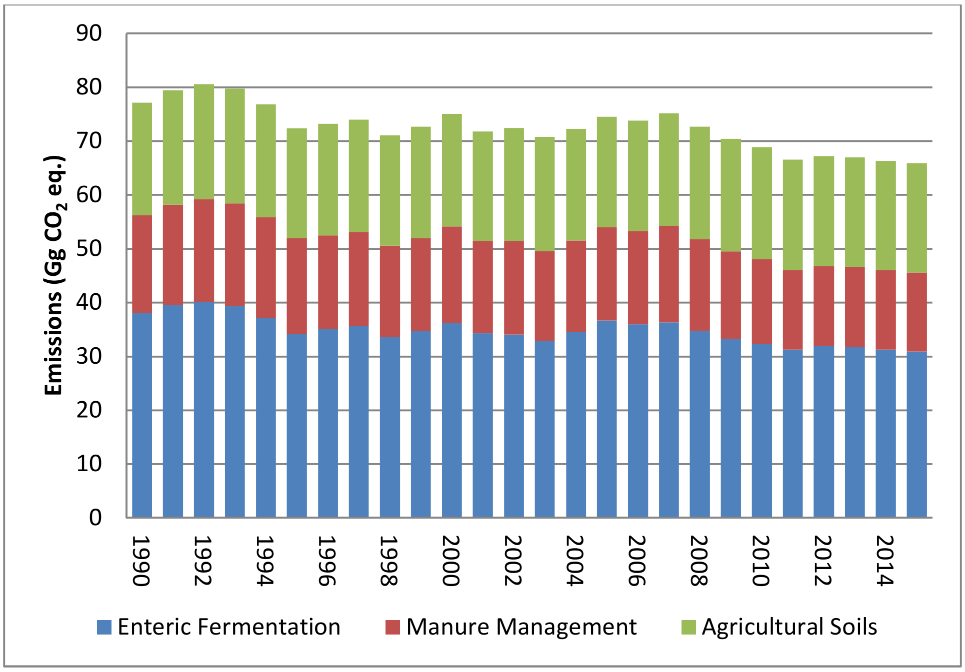



**Figure 3-21 Emissions from Agriculture.**

### *3.5.4 Land Use, Land-use Change and Forestry (CRF sector 4)*

Past national GHG inventory submissions had attributed a net sink effect for the sector LULUCF; however, developments in the methodological approaches utilised for this sector have led to the identification of emission sources within this sector. The sector is now identified as a net emitter, albeit a very small one in absolute terms (Figure 3-22).

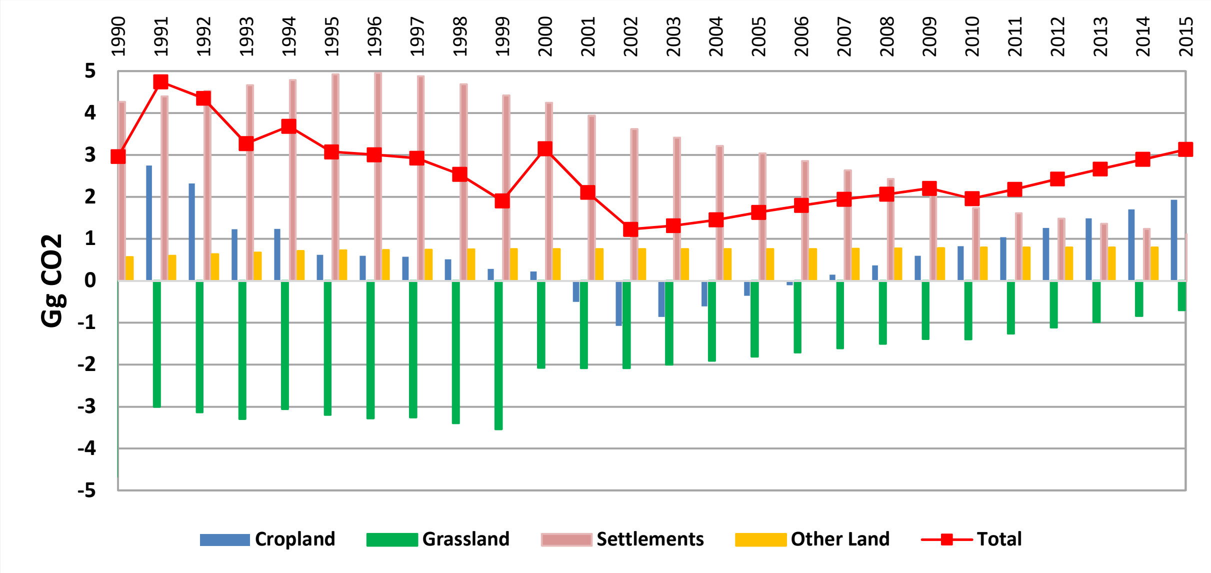



**Figure 3-22 Total CO2 removals and emissions for the LULUCF sector (Forest Land and Wetland categories not shown).**

### *3.5.5 Waste (CRF sector 5)*

In the waste sector, emissions generated from waste management practices over the period 1990 to 2015 are presented. Emission source categories include Solid Waste Disposal (5A), Biological treatment of Solid Waste (5B), Incineration and Open Burning of Waste (5C), and Wastewater Treatment and Discharge (5D).

The waste sector contributed 6.6% to the total national GHG emissions for 2015 with methane emissions having by far the highest share of sector emissions. Within the sector, emissions are mainly attributable to Solid Waste Disposal, specifically disposal on land. A major proportion of emissions within the sector pertain to methane emitted from solid waste disposal operations.

The trend in this sector as presented in Figure 3-23 shows a growth of emissions from this sector throughout the period up to 2007. However, a drastic decrease in emissions is manifest in the years 2008, mainly in sectors 5A (Solid Waste Disposal on Land). The reasons behind this abrupt change can be summarised as the effect of the entry into operation of specific waste management installations. Nonetheless, and despite showing a number of year-to-year fluctuations, emissions from this sector continue to show a general increase over the years following 2009, mainly due to the continuation of landfilling practices.

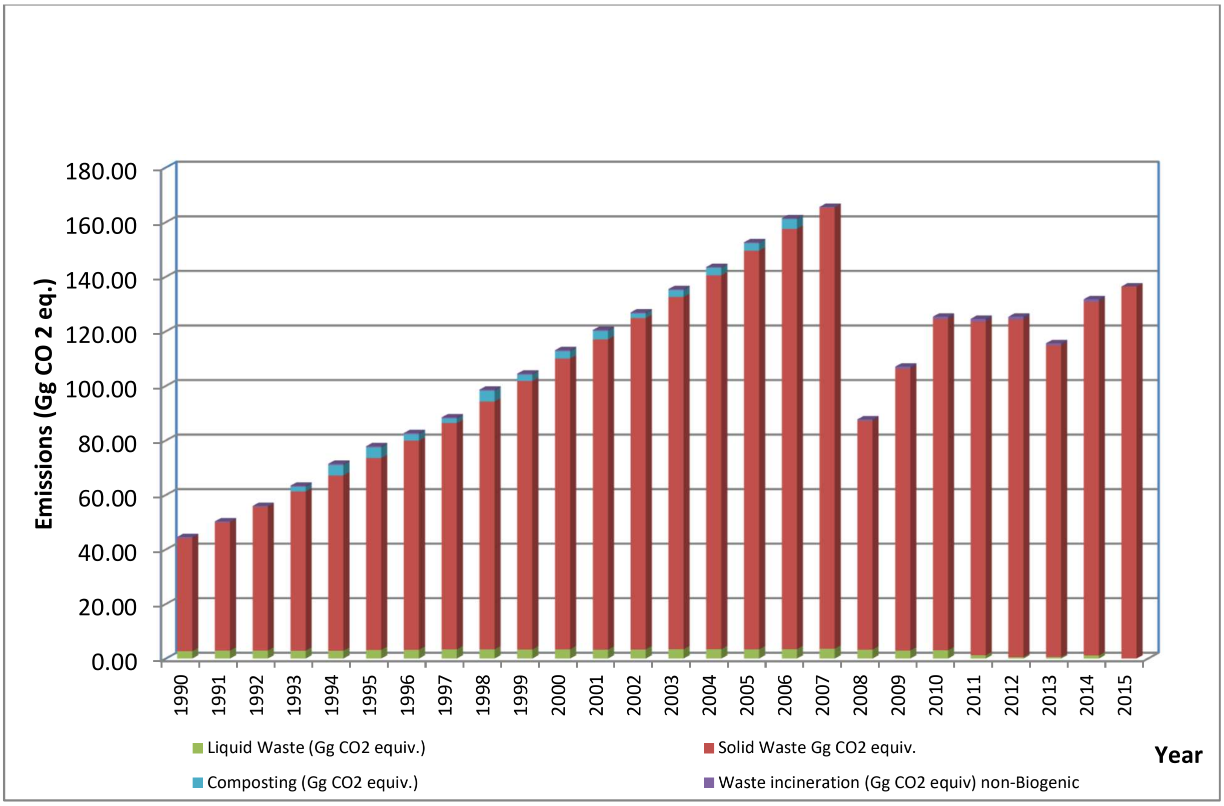



**Figure 3-23 Total GHG Emissions from Waste Management Overview by Activity for sector Waste.**

### *3.5.6 Key category analysis and Uncertainty*

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.

To-date, Malta utilises 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 where possible, on the trend of the inventory. This assessment is usually presented as a listing of all those categories 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.

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

**Table 3-6 Key Category Level assessment.**

| Base Year With LULUCF | | | Base Year Without LULUCF | | |
|---|---|---|---|---|---|
| Energy Industries | Liquid Fuels | $CO_2$ | Energy Industries | Liquid Fuels | $CO_2$ |
| Energy Industries | Solid Fuels | $CO_2$ | Energy Industries | Solid Fuels | $CO_2$ |
| Road Transportation | Fossil fuels | $CO_2$ | Road Transportation | Fossil fuels | $CO_2$ |
| Other Sectors | Liquid Fuels | $CO_2$ | Other Sectors | Liquid Fuels | $CO_2$ |
| Energy Industries | Solid Fuels | $CH_4$ | Energy Industries | Solid Fuels | $CH_4$ |
| Manufacturing Industries and Construction | Liquid Fuels | $CO_2$ | Manufacturing Industries and Construction | Liquid Fuels | $CO_2$ |
| Solid Waste Disposal | Waste | $CH_4$ | Solid Waste Disposal | Waste | $CH_4$ |
| Enteric Fermentation | Farming | $CH_4$ | Enteric Fermentation | Farming | $CH_4$ |
| Domestic Navigation | Liquid Fuels | $CO_2$ | | | |

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.

**Table 3-7 Key Category Trend assessment.**

| **with-LULUCF** | | | **without-LULUCF** | | |
|---|---|---|---|---|---|
| **Energy Industries** | Solid Fuels | $CO_2$ | Energy Industries | Solid Fuels | $CO_2$ |
| **Road Transportation** | Fossil fuels | $CO_2$ | Road Transportation | Fossil fuels | $CO_2$ |
| **Refrigeration and Air conditioning** | no classification | Aggregate F-gases | Refrigeration and Air conditioning | no classification | Aggregate F-gases |
| **Solid Waste Disposal** | Waste | $CH_4$ | Solid Waste Disposal | Waste | $CH_4$ |
| **Energy Industries** | Liquid Fuels | $CO_2$ | Energy Industries | Liquid Fuels | $CO_2$ |
| **Other Sectors** | Liquid Fuels | $CO_2$ | Other Sectors | Liquid Fuels | $CO_2$ |
| **Energy Industries** | Solid Fuels | $CH_4$ | Energy Industries | Solid Fuels | $CH_4$ |
| **Domestic Navigation** | Liquid Fuels | $CO_2$ | | | |

The measure of every quantity that serves as input data for the estimation of emissions and removals in greenhouse gas inventories is subject to some degree of 'uncertainty'. Uncertainty reflects the lack of absolute certainty on the true value of a variable parameter. A greenhouse gas inventory is also prone to uncertainty.

A Tier 1 approach, in accordance with the IPCC Good Practice Guidance is applied to uncertainty assessment for this submission. Overall uncertainty has been estimated at around 2.3%. It is also worth noting that Malta's inventory strives to include all emissions and removals from all known sources and sinks within the whole Maltese territory.

# 4 POLICIES AND MEASURES

*Image Source: Flickr (https://www.flickr.com/photos/shepard4711/6201536739)*

## 4.1 Introduction

The UNFCCC asks Parties to adopt policies and measures aimed at limiting or reducing greenhouse gas emissions by sources, and to enhance the removal effect of sinks. This requirement was furthermore inscribed in EU legislation, with the Monitoring Mechanism obliging all Union Member States to report, on a biennial basis, on policies and measures implemented, adopted or planned to control emissions of greenhouse gases.

This chapter looks at the suite of policies and measures adopted in Malta which directly or indirectly address greenhouse gas emissions and removals. This discussion, and thus also the discussion in the subsequent chapter on projections, presents and reflects the state of play of greenhouse gas mitigation policies and measures as at the end of 2016 (MRA, 2017).

## 4.2 Policy context

The overarching policy context up to 2012 has to be seen in light of the fact that Malta had not taken on any greenhouse gas emission limitation or reduction obligations in the context of the UNFCCC or the Kyoto Protocol. With the agreed extension of the Protocol until 2020, this situation changed, with a target of 20% reduction in overall greenhouse gas emissions, as compared to emission levels in 1990, inscribed for Malta in respect of the Second Commitment Period under the Protocol. This target reflects the overall 20% reduction commitment, compared to 1990, that the EU has made as its contribution towards global efforts to control greenhouse gas emissions until 2020.

The Climate Action Act sets a fundamental basis for climate action in Malta thus: "[i]*t shall be the duty of every person together with the Government to protect the climate and to assist in the taking of preventive and remedial measures to protect the climate*." It goes on to define the duties and obligations of the Government of Malta with respect to climate action, together with guiding principles for the fulfilment of such duties and obligations:

> " [t]*he Government shall, in fulfilling its duties and obligations under this Act:*
>
> *(a) take climate change considerations into account, to the extent possible, in relevant social, economic and environmental policies and actions;*
>
> *(b) take into account its obligations and commitments pursuant to international treaties and its obligations as a Member State of the European Union;*
>
> *(c) take into account the geophysical, social and economic circumstances of Malta;*
>
> *(d) ensure that actions taken are, to the extent possible, the most cost-effective, using best available technologies and best practices as appropriate to Malta;*
>
> *(e) ensure that it takes into account the best available scientific, technological, technical and socio-economic information;*
>
> *(f) ensure that all sectors of society and the economy participate in national climate action, including in relevant decisions;*
>
> *(g) ensure that climate change, environment, conventional and alternative energy policies and measures are designed, developed, coordinated and implemented in the best interests of the environment, the economy, international and European Union obligations;*
>
> *(h) ensure that climate action taken respects the interests of all sections of society, is non-discriminatory and, where relevant, promotes gender equality;*

*(i) ensure that data is collected, processed and interpreted in cognizance of data related to achieving overall international and European Union obligations in other areas;*

*(j) respect and, to the extent possible, safeguard the interests of vulnerable sectors of society, including by taking climate actions that support the eradication of poverty;*

*(k) ensure that climate action taken should promote and enhance the competitiveness of Malta's economy;*

*(l) ensure, to the extent possible, that no conflict exists between policies and measures adopted in respect of climate action and other policies and measures;*

*(m) ensure that it takes precautionary measures to anticipate, prevent or minimize the causes of climate change and to mitigate its adverse effects and that where there are threats of serious or irreversible damage, the lack of full scientific certainty should not be a reason for postponing such measures;*

*(n) ensure that climate action taken contributes to sustainable development;*

*(o) ensure that, where relevant, any beneficial impacts of climate change are harnessed to the benefit of society, the economy and the environment, to the extent that such beneficial impacts can reduce vulnerability and enhance resilience to other adverse impacts of climate change;*

*(p) ensure that, prior to taking any decision, all the consequences of the outcome of that decision throughout the whole life cycle of that outcome are taken into consideration; and*

*(q) ensure adequate information is made available to the public, to facilitate public participation in respect of certain plans and programmes relating to the climate system and ensure adequate access to justice*."

The Act requires the elaboration of a Low Carbon Development Strategy and a National Adaptation Strategy, and provides for regular review and updating of these strategies. It also establishes a Climate Action Board, which shall, among others, supervise the implementation of the provisions of the Act and monitor the fulfilment by all relevant parties of their respective duties under the Act. The Act further establishes a Climate Action Fund, to support climate action in Malta. Powers are given to the Minister responsible for climate action to enact regulations under this Act.

In line with, Malta will be contributing its fair share of the EU's unconditional commitment under the Convention to reduce emissions by 20% below 1990 levels by 2020. This is in line with the target inscribed for Malta under the amended Kyoto Protocol, it must be highlighted that this does not necessarily reflect the actual effort that the country has to make in respect of emissions until 2020. It has been agreed that the EU target under the Protocol will be achieved jointly (under the provisions of Article 4 of the Protocol) by the EU and its Member States. This means that the overall Union target (20% reduction compared to 1990, by 2020) is redistributed within the bloc in a manner that allows for a more cost-effective and flexible fulfilment of the overall commitment than would have been the case if Kyoto Protocol targets as inscribed had to be met by the respective Member States. This redistribution forms the basis of the EU emission mitigation policy framework until 2020, and is provided for thus:

- The continuation of the EU Emissions Trading Scheme, for the period 2013-2020, including the expansion of scope to cover additional categories of industrial activities and gases other than carbon dioxide, an EU-wide approach to establishing the cap on emissions, and a substantially more harmonized approach to the allocation of allowances among the participating installations, including partial allocation by auctioning in accordance with harmonized rules and procedures, and free allocation against sectoral benchmarks determined at EU-level;
- For emissions not covered by the EU ETS, the distribution of the overall EU effort as targets for each Member State, inscribed in the Effort-Sharing Decision, with the determination of each Member State's target reflecting the state's capacity to limit or reduce emissions as indicated by the state's Gross Domestic Product.

The participation of local industrial enterprises in the EU ETS is limited to the electricity generation installations in operation, whose carbon dioxide emissions are subject to the accounting provisions of the Directive. Despite the limited scope of the EU ETS in terms of the number of emitting land-based stationary installations falling within the scope of the scheme, the coverage in terms of emissions is substantial, in 2005 (first year of the scheme) this being equivalent to around 67% of total net national greenhouse gas emissions, in 2014 equivalent to 57% and in 2015 equivalent to 40%. The reduction with time in EU ETS coverage in terms of emissions compared to total national emissions reflects the decrease in contribution of the electricity generation sector towards total national emissions as this economic sector becomes more efficient through major infrastructural and technological developments.

The EU ETS also covers carbon dioxide emissions from aviation activities, albeit the scope has, in practical terms, been limited to emissions from intra-European Economic Area (intra-EEA) flights, under a derogation adopted by the European Union in response to the agreement at the International Civil Aviation Organization (ICAO) on a global market-based measure for international aviation and the ongoing process to draw up and adopt the technical implementation rules for such a global measure (to be known as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)).

The EU ETS is implemented in Malta through subsidiary legislation S.L. 423.50 'European Union Greenhouse Gas Emissions Trading Scheme for Stationary Installations Regulations' and S.L. 423.51 'European Union Greenhouse Gas Emissions Trading Scheme for Aviation Regulations'.

Under the Effort-Sharing Decision, Malta is required to limit emissions not covered by the EU ETS, by 2020, to a level not greater than 5% over emission levels in 2005. Interim targets for the years 2013 to 2019, determined as a linear trajectory in accordance with the provisions of this Decision, also apply. More information regarding the commitment to limit greenhouse gas emissions under this Decision is given in the Chapter 4.

The European Union's 2020 Climate Change and Energy Package, apart from presenting the policy framework for greenhouse gas emission mitigation up to 2020, also revisits previous Union policy in respect of renewable energy sources and energy efficiency. In an effort towards consolidating progress in increasing the share of renewable energy sources and enhancing energy efficiency, the Package establishes relevant targets for each Member State. Thus, under the Renewable Energy Sources Directive[26] Malta is required to reach, by 2020, a 10% share of energy from renewable sources in gross final consumption, including a 10% share of renewable

[26] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC; OJ L 140, 5.6.2009, pg 16.

energy for the transport sector. In respect of energy efficiency, the Energy End-Use Efficiency Directive[27] provides for a target of 9% increase in efficiency by 2016 for Malta.

It is worth remarking here about the more recent developments in European Union policy on climate mitigation. At the October 2014 European Council, the Heads of Government of the EU Member States agreed on a binding EU target of an at least 40% domestic reduction in greenhouse gas emissions by 2030 compared to 1990, which target is to be delivered collectively by the EU in the most cost-effective manner possible, and with all Member States participating in this effort, balancing considerations of fairness and solidarity. This target is the focus of the EU's 2030 climate and energy framework. Negotiations are currently ongoing to adopt the necessary EU legislation to implement this new goal, including a revision of the EU ETS Directive, the enactment of an Effort-sharing Regulation to replace the existing Effort-sharing Decision, albeit maintaining a similar approach as in the Decision in respect of setting specific targets to the individual Member States, and the enactment of a regulation so as to include LULUCF greenhouse gas emissions and removals into the 2030 framework.

## 4.3 Policy-making process

Sectoral policy normally lies within the domain of the ministries, departments, government authorities or agencies under whose remit a particular sector falls. This can be said to form the first level of policy setting that potentially contributes to limiting or reducing national greenhouse gas emissions, through a bottom-up sectoral approach. Individual industrial enterprises, particularly major parastatal organizations whose activities contribute substantially to national emission levels, can also often contribute to such a policy-making approach.

In certain instances, emissions mitigation policy is included as an element of multi-sectoral policy frameworks. To take an example, the National Energy Policy[28] adopted in 2012 mainstreams climate mitigation considerations within the policy framework on the basis of which the country's energy future is being planned. This is an important development in local policy-making, looking at climate change mitigation as an integral part of the national policy process and putting the issue at the forefront of the planning of the country's economic and social development.

More recently, an even more holistic dimension to climate policy has also become prevalent. The 'A Sustainable Development Strategy for the Maltese Islands'[29] of 2006 identified the reduction of greenhouse gas emissions as a priority area that warrants "*foremost attention for the attainment of sustainable development goals in Malta*". In 2012, the 'National Environment Policy'[30] highlighted the reduction of national greenhouse gas emissions as an important national environment policy element.

A further development in local greenhouse gas emission mitigation policy-making was the appointment, for the first time, of an *ad hoc* Climate Change Committee with a mandate to draw up a National GHG Mitigation Strategy[31]. The strategy was the subject of a public consultation process and a parliamentary debate. This initiative can be considered as being a first attempt at

---

[27] Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC; OJ L 114, 27.4.2006, pg 64.
[28] *National Energy Policy*, Ministry for Resources and Rural Affairs, 2012.
[29] *A Sustainable Development Strategy for the Maltese Islands*, National Commission for Sustainable Development, 2006.
[30] *National Environment Policy*, Ministry for Tourism, Environment and Culture, 2012.
[31] *National Strategy for Policy and Abatement Measures Relating to the Reduction of Greenhouse Gas Emissions*, Ministry for Resources and Rural Affairs, 2009.

a more coordinated top-down approach to climate mitigation. Though the strategy focusses very much on energy generation and energy demand, it does go beyond the usual emission-source-oriented approach to emission mitigation planning. Indeed, it explores aspects such as:

- Securing civil society and citizen participation;
- Establishing an institutional framework for climate change and building the appropriate human capital; and,
- Integrating the economics of climate change in policy design and in the identification of abatement measures.

The Climate Action Act, 2015 (Chapter 543) establishes a Climate Action Board, which shall, amongst others, supervise the implementation of the Act, monitor that Malta fulfils its obligations under the UNFCCC and as a Member State of the European Union, advise the Minister on the implementation of the Act, facilitate the adherence to the low-carbon development strategy and adaptation strategy, and annually report to the Minister on the progress being made in the field of Climate Change. The Climate Action Board came into effect on 2 February, 2016.

The Climate Change Unit within the Malta Resources Authority is the body responsible for the compilation of the Policies and Measures (PAMs) and Projections Report with respect to greenhouse gas emission sources and sinks in the various economic sectors.

In order to fulfil its roles relating to policies and measures and projections the Climate Change Unit is developing a multi-sectoral modelling tool that enables the evaluation of policies and measures through the modelling of emission sources and sinks in the various economic sectors and the estimation of emission projections based on macroeconomic factors and on the proposed PAMs up to a policy horizon of 2050.

The multi-sectoral evaluation tool being developed by the Climate Change Unit, together with sectoral models, form an integral part of a national system for reporting on policies and measures and for reporting on projections of anthropogenic greenhouse gas emissions and removals in accordance with the Monitoring Mechanism Regulation. It is important that the modelling tools are developed and operated in a manner that ensures compatibility and comparability, especially in their interactions with each other. To this effect, a common understanding of modelling approaches being adopted, and coordination of efforts by the various interested entities, is deemed of crucial importance.

For this purpose, a Steering Committee has been established under the auspices of the Climate Change Unit within the Malta Resources authority with the aim to facilitate the coordination of activities by the various interested parties relating to modelling of greenhouse gas emissions by sources and removals by sinks. For this purpose, the Steering committee:

- Provides a forum for coordination of activities relevant to the fulfilment of Malta's obligations relating to reporting on policies and measures and projections of emissions by sources and removals by sinks;
- Provides a framework for governance of modelling of greenhouse gas emissions and removals;
- Assists in the continued development of a multi-sectoral modelling tool that explains, analyses and projects emission sources and sinks;
- Assists, as may be necessary, in the development of sectoral modelling tools that may contribute to the fulfilment of obligations relating to reporting on policies and measures and projections, including by providing deliverables which serve as input to the multi-sectoral modelling tool;
- Assists in the integration of existing and future sub-models developed by governmental entities into a national system on reporting on policies and measures and projections,

including by ensuring the proper and effective interlinking between the multi-sectoral modelling tool operated by the Climate Change Unit and the sectoral modelling tools operated by the respective sectoral government entities;
- Streamlines and provides activity data sources from within the various governmental entities;
- Provides support for and guidance to the estimation of projections of emissions and/or removals by the various economic sectors up to a policy horizon of 2050;
- Facilitates the collation of information and data relating to PAMs proposed by the various governmental entities and which have an impact on greenhouse gas emissions and/or removals within the particular policy or regulatory area.

## 4.4 Policies and measures and their effect

This section provides an overview of a number of policies and measures, from a sectoral perspective, that contribute to national efforts to control emissions, and, as far as possible, achieve targets to which Malta is bound under international treaties or regional (principally EU) policy arrangements. More often than not, one will note that policies and measures described are not specifically intended to address greenhouse gas emissions; it is often the case that the reduction or limitation of emissions from the sector or sectors covered by the particular policy or measure is one of a number of co-benefits of the implementation of a policy or measure, albeit an important benefit.

### *4.4.1 Energy: Power Generation*

The National Energy Policy for Malta, published in December 2012, takes into account Malta's economic and social development by encouraging a proactive and flexible approach aimed at overcoming the challenges that define the energy sector whilst seeking to exploit the opportunities that may arise through technological advancement. The National Energy Policy is underpinned by five principles: Energy efficiency and affordability; Security of supply; Diversification; Flexibility; and Sustainability.

These principles give rise to the following policy areas which guide Government action under the National Energy Policy:

1. Energy efficiency;
2. Reducing reliance on imported fuels;
3. Security of supply;
4. Reducing Emissions from the energy sector;
5. Delivering energy economically efficiently and effectively;
6. Ensuring the energy sector can deliver.

In addressing Malta's energy challenges, the National Energy Policy is significantly influenced by several EU energy and environmental policies. The targets set by the relevant EU Directives for Malta are as follows:

- Energy End Use Efficiency: 9% by 2016;
- Renewable Energy Target: 10% of final energy consumption by 2020, which includes a 10% Renewable energy target in transport.

- Indicative National Energy Efficiency target 2020: 264,282 toe (equivalent to 27% of the primary energy consumption in 2020 under a BAU scenario).

The National Energy Efficiency Action Plan (NEEAP) (2014)[32] and the National Renewable Energy Action Plan (NREAP) (2011)[33] published by Government pursuant to obligations arising from the EU energy acquis provide more detailed information on the actions being proposed and implemented to increase energy efficiency, particularly from an end-use perspective, and increase the substitution of conventional energy sources with renewable sources. A shift towards more efficient technologies and the use of lower-carbon fuels in the supply of energy, especially in power generation, will further contribute towards reducing GHG emissions in the energy sector. With the energy sector being by far the highest contributor to national GHG emissions, the implementation of these mitigation measures is expected to lead to a reduction in the national carbon footprint. A further important co-benefit of implementing mitigation measures is a concomitant reduction in emissions of non-$CO_2$ pollutants, particularly those related to air quality. The implementation of measures that impact the energy demand side, such as those related to energy performance in buildings, will further contribute to emissions reduction while saving money for energy consumers.

#### 4.4.1.1 Conventional electricity generation

Malta's electricity sector was, until recently, completely isolated from the European grid. Whilst isolation has been tackled through a 200MW interconnector with Italy, the small size of the Maltese internal market and the location of Malta at the periphery of mainland Europe, remain intrinsic to the nature of this sector. This is acknowledged by Directive 2009/72/EC[34] which, pursuant to Article 44, ensures that Malta benefits from a number of derogations from the full implementation of the Electricity & Gas Directives.

Electricity utilised in the Maltese Islands during 2016 was provided by three main sources; the Delimara power stations, which operated on heavy fuel oil and gas oil, electricity imported through the interconnector and electricity generated by distributed renewable energy plants. The use of heavy fuel oil has been phased out during 2017, when a newly constructed 215MW gas-fired CCGT power plant became operational and the conversion of the 144MW plant at Delimara power station to run on natural gas was finalized

The total nominal installed capacity of the power station, including backup, is 479 MW and the interconnector provides an additional 200MW. Both DPS and MPS fall within scope of the EU Emissions Trading Scheme Directive[35] and the Industrial Emissions Directive[36]. A number of inter-linked technical measures are being implemented or are planned by Enemalta to cater for the future demand on the national electricity infrastructure and reduce the greenhouse gases emitted to ensure that obligations under the EU's Climate Change legislation are effectively met. These measures include the decommissioning of the Marsa Power Station, the installation of new generating capacity at the Delimara plant to enable more efficient generation, and the

[32] A revision of the NEEAP is to be submitted to the Commission in April 2017.
[33] A draft NREAP was issued for public consultation in November 2016.
[34] Directive 2009/72/EC of the European Parliament and the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC.
[35] 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.
[36] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution, prevention and control).

introduction of an electrical interconnector with the European grid which helped Malta to diversify its energy sources. Additionally, work is underway for the realisation of the infrastructure for the provision of a natural gas supply.

Other measures include improvement in the efficiency of the distribution network in line with a long-term distribution plan and demand management measures, such as lower night tariffs for heavy consumers to encourage a more even load distribution and to reduce the widening gap between winter and summer peak load due to the more frequent use of air conditioning.[37]

These measures also help to reduce dependence on one source of energy contributing towards security of supply and reduce the national energy bill, potentially contributing towards strengthening Malta's fiscal situation and enhancing the Country's competitiveness.

#### *4.4.1.2 Intelligent Metering*

In 2008, Enemalta awarded a contract for an automated meter reading system, deploying power line communications technology, to provide the required information for the management of the low voltage networks. This measure will provide the possibility of an increase in the tariff effectiveness and responsiveness to energy market trends.

Smart meters are being installed for every electricity consumer in Malta. This is expected to lead to a reduction in energy consumption by changing consumer behaviour through information on their daily consumption. This project was started in 2009 and originally targeted the replacement of 245,000 meters. This figure eventually rose as a result of new consumers and the installation of PV systems. By the end of 2016, 95% of customer meters were installed.

#### *4.4.1.3 Renewable energy sources*

The Promotion of Energy from Renewable Sources Regulations (S.L. 545.11)[38] establishes the target for the share of renewable energy in the final energy consumption by 2020, including the intermediate trajectory, the obligation to submit the NREAP, the eligible sources of renewable energy and the methodology for calculating the contribution of each renewable source to the target.

As required by Directive 2009/28/EC[39], Malta submitted its first NREAP to the European Commission in July 2010 (MRA, 2010)[40]. This Action Plan outlines measures that Malta intends to adopt to achieve the national targets of 10% renewable energy share of gross final energy consumption and 10% share of renewable energy in transport.

Malta plans to achieve its 2020 renewable energy targets by exploiting solar energy, waste-to-energy conversion plants and biofuel blending substitution obligations. Renewable energy generation relies on numerous small installations distributed across the Maltese Islands. These will

[37] Data provided by Enemalta Corporation.
[38] Directive 2009/28/EC has been mainly transposed into national legislation by the Legal Notice 538 of 2010, the Promotion of Energy from Renewable Sources Regulations. Provisions related to grid connection and access, and dispatch of electricity from renewable sources are found in the Electricity Market Regulations (LN 166 of 2011 as amended).
[39] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.
[40] NREAP was resubmitted in 2011.

be mainly integrated in existing building infrastructures, such as on rooftops, due to Malta's limited space and the conflicting use by other activities.

The introduction of a feed-in tariff for solar photovoltaic systems (PV) has addressed the financial barrier holding back the further penetration of PV systems. The Feed-in Tariffs Regulations (S.L. 545.27) established the feed-in tariffs for electricity generated by photovoltaic installations connected to the grid, including those systems benefitting from a capital grant. The feed-in tariffs introduced in September 2010 replaced the previous net-metering arrangement. The introduction of the feed-in tariff increased the potential for exploitation of the roof space including that of premises with no consumption of electricity and hence with no incentive for net metering. The feed-in tariffs have been revised regularly since 2011 to ensure a reasonable return on investment and avoid overcompensation given that market prices of new systems change.

Over the years, a number of grant schemes on the purchase of a solar water heater that refund part of the capital cost were introduced by Government to encourage households and the business community to invest in these solar technologies. The penetration of solar water heaters in households as at the end of 2015 was 18,216 units with an estimated solar (heat) energy capture of 40.11GWh.

In October 2011, WasteServ Malta Ltd[41] was granted a license to generate electricity for own consumption and export by means of two combined heat and power units (CHP) at Sant' Antnin Solid Waste Treatment Plant. This plant has a total capacity of 1.737MW and is fired by biogas produced onsite by the Mechanical Biological Treatment Plants (MBT) through anaerobic digestion of the organic part of municipal waste. The Malta North MBT, which was inaugurated in February 2016, is expected to process 39,000 tonnes of feed stock derived from solid and liquid manure per year. This waste will be treated in order to recover energy from biogas which is produced naturally from the treatment process.

Wind energy has lagged behind solar energy as a contributor to achieving national renewable energy targets. The projected uptake of micro and medium wind has been negligible. The main reason for this low uptake is the uncertainty about energy yield, the relatively high installation cost and planning permitting issues. A set of planning permitting guidelines[42] was published by the Malta Environment and Planning Authority (MEPA) in 2010 for micro wind turbines with capacities up to 20kW. These guidelines indicate the locations and conditions under which wind turbines up to a capacity of 20kW may be permitted. To-date, the wind turbines that have been approved are for research purpose to assess the environmental impact and yield.

Large scale wind farms, though providing substantial scope for contributing to national energy sourcing, have also encountered difficulties. The NREAP submitted in 2010, projected a significant contribution from wind energy to Malta's target of 10% RES in its gross final energy consumption by 2020. These targets were based on three wind farm proposals. However, subsequent feasibility studies indicated that these projects were not financially and/or environmentally feasible with the current prices and technology. The revised NREAP takes this into account and presents an alternative route to effectively achieve Malta's 10% Renewable Energy Target.

#### 4.4.1.4 Energy end-use efficiency

Since the publication of the 1st NEEAP in 2008 efforts on the promotion of energy efficiency have mainly targeted the residential, commercial (mainly tourism) and industrial sectors. These sectors

[41] WasteServ Malta Ltd is a government-owned company that operates the main publicly-owned waste management facilities in the Maltese Islands.
[42]Planning Guidance for Micro-wind Turbines, May 2010, MEPA. available at: http://www.mepa.org.mt/LpDocumentDetails?syskey= 1242

have also been targeted in the 2nd NEEAP published in 2011 and the 3rd NEEAP published in 2014. Government made substantial investment through support and incentive schemes to achieve the targets set in the Action Plan. The latest NEEAP has been re-designed to look towards the achievement of energy savings of 27% in 2020. It includes estimates of expected savings for the period 2014-2020 as a result of readily quantifiable measures which were included in the previous NEEAPs and which would still result in savings post 2013; end-user measures quantified under Energy Efficiency Directive (EED) Article (7); specific renovation projects which result in net energy savings; and already committed investment in the generation infrastructure. The NEEAP is being updated and a revised plan shall be submitted to the Commission in April 2017.

Malta Enterprise, the Government entity dealing with the promotion of industry has in recent years launched various schemes to incentivize energy efficiency measures in industry and SMEs. In 2016, in collaboration with the Energy & Water Agency, Malta Enterprise launched a scheme to incentivize high efficiency cogeneration. It also plans to launch a new scheme in 2017 which promotes energy efficiency in the Malta's industrial and services market.

Government grants were provided for the purchase of roof insulation, double glazing and energy efficient appliances in the residential sector. The grant on energy efficient appliances subsidized the purchase of A-rated washing machines, dishwashers, air conditioners and tumble dryers and A+ and A++ rated refrigerators. A nearly Zero Energy Plan for Malta has been developed and is pending final approval. This has set targets for the shift towards nearly zero energy new buildings by 2020.

A feasibility study analysing the potential of co-generation and district heating in Malta was carried out as required by Article 14 of the EED. The conclusions showed that an increase of final energy consumption for H&C in Malta is expected by 2030, in particular within the services and industry while in the residential sector, the expected increase will be limited by energy performance requirements for new and refurbished dwellings. Despite the projected increase, the final heating demand will remain relatively low compared to what is needed to create favorable conditions for enhancing CHP and district heating. This expected low thermal demand does not make it financially feasible to install such technologies.

The project to replace public lighting started in 2015 and consisted of retro-fitting street lights in Malta and Gozo. In the case of Malta, street lights were retrofitted in arterial and distributor roads for a total length of 13 km in which 491 lanterns were installed. It is estimated that 424 MWh or 79% of the consumption of the old lanterns is being saved per year. In the case of Gozo, street lights were retrofitted in the whole of the island for a total of 4,897 lanterns. It is estimated that 1.3 MWh or 55% of the consumption of the old lanterns has been saved per year. Both projects were concluded in 2015.

During 2015 and 2016, the Government embarked on an energy efficiency support campaign. Leaflets were mailed to 120,237 households, inviting members of the household to make an appointment for a personalised visit providing advice on energy efficiency and water conservation.

A project intended for Renovating Public Buildings to Increase Energy Efficiency and Reduce Greenhouse gases, started its 1st Phase. This consisted of a number of energy efficient interventions at the St. Vincent De Paul Elderly Residence Campus and at the Siġġiewi Primary School. The energy and resource efficiency interventions under Phase 1 were the following: the decentralisation of a Boiler system and introducing a heating with a LPG system at the St. Vincent De Paul Elderly Residence Campus, together with replacing old equipment with more efficient one; and Retro Fitting of Siġġiewi Primary School with energy and resource intervention. Both interventions were completed in 2015.

A study for futher improvment at St. Vincent De Paul Hospital Residence was commissioned. The study presented a holistic way forward both from the technical and financial aspect, of the technology which can be adopted with the aim of reducing the energetic and resource consumption of St. Vincent De Paul. The study proposed technical solutions, and included a cost benefit analysis of the proposed solutions.

#### 4.4.1.5 Energy-related cross-sectoral measures

Through Commission Recommendation of 9th October 2009 on mobilising Information and Communications Technologies to facilitate the transition to an energy-efficient, low-carbon economy, the European Commission identified a number of ways and concrete actions for the ICT industry to achieve improved energy-efficiency across society and the economy. The recommendations aim at ensuring full coherence of ICT policies with national, local and regional approaches to make the transition to an energy-efficient, low-carbon economy. These include:

- minimum functional specification for smart metering that focuses on providing consumers with improved information on, and improved capabilities to manage, their energy consumption together with the setting up of a coherent timeframe by the end of 2012 for the rollout of smart metering;
- monitoring and management of energy consumption in buildings;
- energy efficient work practices such as teleworking, e-government etc;
- delivering of innovative technologies that reduce wasteful consumption of energy in devices; and
- the adoption and implementation of procurement practices that leverage the strength of public sector demand to promote the dematerialisation of ICT goods and services.

The Government periodically embarks on energy efficiency campaigns intended to educate and disseminate good practices to save energy and water in the home.

In February 2014, Cabinet endorsed Malta's new National Research and Innovation Strategy 2020. This document sets out Malta's research and innovation strategy for the forthcoming seven-year period. Recognising the progress made over the last years and acknowledging that there is still a way to go in achieving the objectives set out in the 2007-2010 R&I Strategic Plan, the ultimate goal of this Strategy remains that of embedding research and innovation at the heart of the Maltese economy to spur knowledge-driven and value-added growth and to sustain improvements in the quality of life.

The Government will ensure energy efficiency funding that will provide support for energy efficiency activities both through national and EU funding initiatives. This has also been identified as a priority under the European Structural and Investment Funds. Directive 2012/27/EC requires the setting up of energy efficiency obligation schemes achieving new savings each year from January 2014 to 31 December 2020. Malta has outlined the measures that will achieve the required savings by 2020.

### 4.4.2 Energy: Transport

The transport sector is the second largest contributor of GHG emissions and produces around 28% of Malta's total emissions[43]. The main contributor is road transport with this category's GHG emissions accounting for 91% of overall transport sector emissions, while national marine transport accounts for around 8%, and domestic aviation account for just 0.6% of total sector emissions.

[43] National Greenhouse Gas Inventory CRF MLT_2017_3_Inventory

This sector is dominated by emissions from road transport, with $CO_2$ being the gas that accounts for the bulk of overall GHG emissions from road transport fuel combustion. Diesel is the principal fuel for national marine navigation and a small portion of petrol is also used. Jet kerosene (Jet A1) and aviation gasoline are used in domestic aviation. As regards road transport, the market is almost equally shared between petrol and diesel.

**Table 4-1 Summary of policies and measures related to Energy consumption (comprising consumption of fuels and electricity by end users such as households, services, industry and agriculture).**

| ***Name of mitigation action***<br>***Objective and/or activity affected***<br>***Brief description*** | | | | | ***Estimate of mitigation impact (not cumulative, in kt CO2 eq)*** | |
|---|---|---|---|---|---|---|
| ***GHGs affected*** | ***Type of instrument*** | ***Status*** | ***Start year*** | ***Implementing entity(ies)*** | ***2025*** | ***2035*** |
| Submarine electrical connection to European network | | | | | | |
| Efficiency improvement in the energy and transformation | | | | | | |
| The implementation of an electrical interconnection to the European energy grid in conjunction with the retention of significant local electricity generation capacity offers greater flexibility in meeting local demand while providing a potential for considerable reduction in the national CO2 emissions through the reduction of local emissions from the main contributor of CO2 emissions. The Interconnector was energised on 24 March 2015, following completion of works and a period of testing and commissioning. Full implementation of the project is expected to be completed in April 2015 following satisfactory completion of further necessary testing. | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Economic | Implemented | 2015 | Enemalta Corporation | 170.51 | 259.79 |
| Rebates on energy efficient domestic appliances | | | | | | |
| Efficiency improvement of appliances | | | | | | |
| Government subsidy scheme on energy efficient appliances to provide financial incentives | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Economic | Expired | 2006 | MRA | not estimated | not estimated |
| Distribution of energy saving lamps in the domestic sector | | | | | | |
| Efficiency improvement of appliances | | | | | | |
| Distribution of energy saving lamps. The Government initiated a scheme whereby each household in Malta was given a voucher that could be redeemed from retailers for 6 free energy saving lamps (CFLs) (per household). | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Economic | Expired | 2009 | x | not estimated | not estimated |
| Promotion of solar water heaters | | | | | | |
| Demand management/reduction | | | | | | |
| The RES support scheme provides financial support to cover part of the investment costs of domestic SWH equipment. Available funds will be allocated according to the type of equipment purchased. | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Economic | Implemented | 2006 | - | 8.579848853 | not estimated |
| Incentives for the uptake of PV systems | | | | | | |
| Demand management/reduction | | | | | | |
| Government grant scheme on the purchase of PVs, and to encourage electricity generation through technologies other than conventional generating plants, the government has launched schemes to promote the installation of renewable the domestic sector and has introduced a feed in tariff. | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Economic | Implemented | 2006 | MRA | 22.22030296 | not estimated |
| Grant on Purchase of micro wind turbines | | | | | | |
| Demand management/reduction | | | | | | |
| A scheme for the promotion of micro wind turbines installed on domestic premise was launched in 2006 and is still on going. | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Economic | Implemented | 2006 | - | 0.06 | 0.058 |
| Energy savings and RES measures in state schools | | | | | | |
| Efficiency improvements of buildings, Demand management/reduction | | | | | | |
| Sun pipes, double glazing, efficient lighting systems, solar water heaters, photovoltaic systems, water conservation systems | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| $CO_2$, $CH_4$, $N_2O$ | Economic | Implemented | 2005 | Foundation for Tomorrow's Schools | not estimated | not estimated |
| Energy saving measures in social housing | | | | | | |
| Efficiency improvements of buildings, Demand management/reduction | | | | | | |
| Energy conservation and inclusion of renewable energy sources in the design and construction of social housing; double glazing, wall insulation, solar water heaters, photovoltaic panels, water runoff collection and use | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Economic | Implemented | 2004 | Housing Authority | not estimated | not estimated |
| Action in the public sector | | | | | | |
| Efficiency improvements of buildings | | | | | | |
| Create environmental awareness within ministries, promote environmentally friendly practices including energy efficiency and renewable energy | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Information | Implemented | 2004 | - | not estimated | not estimated |
| Energy saving measures in government owned industry | | | | | | |
| Efficiency improvement in services/ tertiary sector | | | | | | |
| Optimisation of reverse osmosis process, energy reduction in water transfer and distribution network, energy efficiency at Malta shipyards | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Planning | Implemented | 1995 | Water Services Corporation, Malta Shipyards | not estimated | not estimated |
| Support schemes for industry, SMEs and the commercial sector | | | | | | |
| Efficiency improvement in industrial end-use sectors | | | | | | |
| Grant scheme to promote investments in energy efficient equipment | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Economic | Implemented | 2009 | - | not estimated | not estimated |
| Intelligent metering | | | | | | |
| Demand management/reduction | | | | | | |
| Automated meter reading system to provide required information for the management of low voltage networks. Deployment of automated meter reading systems will increase tariff effectiveness, responsiveness and energy market trends. The eventual implementation of pre-payment and time-of-use tariffs are believed to contribute to reduction in energy demand. | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Information | Implemented | 2009 | Enemalta Corporation | not estimated | not estimated |
| Supply of natural gas to fuel existing and future generating plants | | | | | | |
| Switch to less carbon-intensive fuels | | | | | | |
| The Government is committed to a plan to switch from heavy fuel to natural gas for the generation of electricity at the Delimara Power Station in the shortest possible term. This plan will involve investment by the private sector in a new 215MW Combined Cycle Gas Turbine unit which will be gas-fired as well as an LNG storage and re-gasification terminal. The new diesel engines at Delimara will also be converted to gas. Part of the Delimara plant will be retained as reserve capacity fired by gasoil. It is envisaged that the older generating units at Delimara will be phased out. | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Economic | Implemented | 2016 | Ministry for Energy and Health, Enemalta | 452.99 | 473.62 |
| Energy Efficiency measures | | | | | | |
| Efficiency improvement of appliances, Efficiency improvements of buildings, Demand management/reduction, Efficiency improvement in services/ tertiary sector, Efficiency improvement in industrial end-use sectors | | | | | | |
| Combined effect of energy efficiency measures | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Economic, Information, Planning | Implemented, Expired | 2006 | MRA, x, Foundation for Tomorrow's Schools, Housing Authority, -, Water Services Corporation, Malta Shipyards, -, Enemalta Corporation | 17.48 | 16.81 |

| | | | | | | |
|---|---|---|---|---|---|---|
| PV - Grant Scheme | | | | | | |
| Demand management/reduction | | | | | | |
| PV- Grant scheme | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Fiscal | Implemented | 2014 | SEWCU | 31.18 | 30.01 |
| PV - FIT Scheme | | | | | | |
| Demand management/reduction | | | | | | |
| PV - FIT Scheme | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Fiscal | Implemented | 2014 | SEWCU | 27.88 | 26.84 |
| PV - Competitive Bidding | | | | | | |
| Demand management/reduction | | | | | | |
| PV - Competitive Bidding | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Fiscal | Implemented | 2014 | SEWCU | 38.51 | 37.06 |

A National Transport Strategy, 2050 (NTS) and Transport Master Plan, 2025 (TMP) have been developed to cover all relevant transport modes (land, public transport, sea and air) for the short, medium and long term for Malta. The NTS consists of a vision outlining where Malta wants to be in the long term, the strategic goals, the strategic direction on how to get there and the indicators necessary to measure the progress of this strategy. The TMP builds on the strength of long term vision, goals and guiding principles established in the NTS. The Master Plan sets out the framework and the overall priorities which will guide transport investment in air, sea and land transport sectors over the next 10 years. It also identifies and prioritises low carbon transport measures.

The National Intelligent Transport Systems Action Plan for Malta 2013-2017 (2013)[44] is a synthesis of how Transport Malta (TM) intends to roll out Malta's first major ITS deployment which is split in two phases and spanning over an eight-year time frame. The first phase will take place between 2013 and 2017 while the second phase will be carried out in the following three years, from 2018 to 2020. Phase 1 (2013-2017) of Malta's ITS deployment includes the laying down of the foundation for the national ITS mainframe and open system architecture.

Through this deployment and because of the small and manageable size of the transport network, Malta will be one of the first European countries to have all of its main road network, its transport hubs and termini seamlessly connected in real time at a national level. The roll-out of ITS at national level in the first phase will generate vast quantities of raw travel and traffic data which can be filtered and structured to provide a vital monitoring and assessment tool for transport planners and operators, emergency services, policy makers and control bodies.

The MODUS project will strive to mitigate negative trends in Maltese transport by making public transport more efficient and reliable. The MODUS project is divided into four main components as follows: the Introduction of new accessible bus interchanges that will connect public transport routes; the Launch of a new Park and Ride facility at Marsa; the extension and introduction of new bus priority lanes; and the Introduction of an Intelligent Transport Management System (ITS) that will allow TM to monitor the traffic situation all on Maltese roads in real time. This system will enable TM to respond quickly to congested areas and divert traffic to alternative routes.

The National Strategy for the Introduction of Electromobility in Malta and Gozo (2012)[45] notes the importance of electric mobility and its relevance to land transport in Malta and Gozo. An indicative target of uptake of 5,000 battery electric vehicles (BEVs) by 2020 has been set. This will contribute to the realisation of targets both with respect to air pollution and mitigation of GHG

[44] http://www.transport.gov.mt/admin/uploads/media-library/files/National%20ITS%20Action%20Plan%20for%20Malta%20_2013%20-%202017_.pdf
[45] http://www.transport.gov.mt/admin/uploads/media-library/files/National%20Strategy%20for%20the%20Introduction%20of%20Electromobility.pdf

emissions. The contribution of electric cars is considered as fundamental for Malta to reach its renewable energy target of 10% by 2020.

Making transport in Malta environmentally sustainable is a priority, and the electrification of transport in Malta is one of the main pillars in the transport policy. Through the Malta National Electromobility Action Plan (2013)[46], the uptake of electric vehicles is to be incentivised through a series of measures, one of which is the scrappage scheme which allows a grant for individuals and companies who want to scrap their current car and replace it with a BEV. The government will be leading by example and will gradually be replacing its current vehicle fleet to a more energy-efficient one. The use of electricity in other transport modes including waterborne transport and related maritime infrastructure is also being assessed.

The project Demo-EV "*Demonstrating the feasibility of electric vehicles towards climate change mitigation*" project code: LIFE10 ENV/MT/088 was funded by the EU and the Maltese Government. Demo-EV started in September 2011 and ended in December 2014. Demo-EV sought to introduce and promote the use of electric vehicles in the Maltese Islands by demonstrating the feasibility of battery electric vehicles and sought to contribute towards the attainment of a carbon neutral road transportation system in Malta by putting into practice, testing, evaluating and disseminating a number of actions related to the implementation of electromobility. In this respect, Demo-EV has contributed towards reaching the 2020 Climate Change and Energy targets. It has also implemented the National Air Quality Plan hence, the logo *Go Clean, Go Silent, Go Electric.*

Electric vehicles incentives have been put in place in 2014 and will roll on to 2015. The total budget for these incentives in 2014 was €300,000. For 2015, the allocated grant was €250,000. Also for 2015, the grant was open to private companies and NGOs. The scheme is as follows:

- €5,000 grant for the purchase of a Battery Electric Vehicle (BEV) in conjunction with a scrappage scheme of an ICE vehicle, or
- €4,000 grant for the purchase of a BEV without a scrappage scheme;
- €1,500 grant for the purchase of an Electric Quadricyle.

Electric vehicles are provided with two privileged parking spaces adjacent to each charging pillar. Currently there are 45 public charging pillars in various locations in Malta and Gozo. Electricity is free of charge while charging BEVs on these pillars for a limited period of time.

The years 2007-2009 saw a reversal in the demand growth trend for biofuels, with consumption dropping from 1.75% to 0.68% of diesel (by energy content). In order to reverse this trend, LN 68 of 2011 was published in order to boost the use of biofuels. This introduced a 'substitution obligation'[47] on importers and wholesalers of automotive fuels whereby market players were now obliged to import a minimum amount of biofuel content calculated as a percentage of the total petrol and diesel placed on the market. The percentage was set at 1.5% for 2011, and is expected to rise to 10% by 2020.

Autogas is Liquefied Petroleum Gas (LPG) used as a fuel in a vehicle for the traction of a vehicle. In August 2010, with a view to the introduction of autogas for vehicles on the Maltese market, the Malta Resources Authority (MRA) published the Autogas (Installation and Certification) Regulations (LN393/2010), to lay down the regulations for retrofitting of motor vehicle engines. Accompanying this legislation, the MRA issued Codes of Practice to guide installers on the installation of kits and engineers on the design of autogas service stations.

[46] http://www.transport.gov.mt/admin/uploads/media-library/files/The%20Malta%20National%20Electromobility%20Action%20Plan.pdf

[47] L.N. 68 of 2011 amending the Petroleum for the Inland (Wholesale) Fuel Market (Amendment) Regulations, 2011, (LN 278 of 2007).

In 2008, a teleworking policy was published by Government which took into consideration feedback received from a research project carried out together with the National Commission for the Promotion of Equality (NCPE). The purpose of this policy was to set up a formal framework for the administration of teleworking in the Maltese Public Administration and the policy document outlines the general principles on which teleworking should be administered in the Public Administration of Malta (MPO, 2008). Several employees within the Public Administration entities are undertaking the opportunity to engage in teleworking. This measure could potentially have a significant impact to reduce emissions from daily journeys to work which in Malta are currently mainly dependant on usage of own vehicle.

A number of actions were drawn up by Transport Malta and the central Government in the bid to reduce the fuel use in transport and creating safer road journeys. Vehicle Circulation Fees for more efficient vehicles[48] are calculated depending on the year of registration, based on engine size, year of make, $CO_2$ emissions, particulate matter (PM) emissions and fuel type.

In the past few years, Government initiated a Vehicle Registration Tax System Reform[49] with the aim of having cleaner smaller and new cars on the Maltese roads. In 2009, the registration tax and licensing of vehicles was reformed. Through this reform registration tax and licensing of vehicles are now calculated on carbon dioxide emissions, the length of the vehicle, Euro standard and its value. Incentives are also given to hybrid cars and electric vehicles.

The Government has also taken measures to improve accessibility into the capital city, Valletta, reduce traffic congestion and improve the environment. Such measures include the introduction of Controlled Vehicular Access[50] and the park and ride schemes[51]. While not decreasing the numbers of individuals travelling to Valletta, these efforts have resulted in a substantial drop in private vehicle traffic in and around Valetta in morning peak hours. Between 1998 and 2010, a modal shift of 9.2% towards non-car modes (as opposed to a national shift of 4.4% towards car modes) was recorded. This system was introduced on 1 May 2007. On 1 December 2013, the system was modified to exempt charges on weekday afternoons and Saturdays. While the change in 2013 has seen increased vehicle numbers accessing Valletta, the impact of this change in terms of Modal Shift and Impact on GHG emissions has yet to be determined.

The University of Malta has been implementing a Green Travel Plan[52] for a few years in order to decrease the demand for travel which results from a population of approximately 11,000 students and approximately 4000 members of staff. The University of Malta has been working to improve transport options which include bike purchasing and rental schemes, public transport fund schemes for students and discounts for staff, an online carpooling application and flexibility and teleworking for staff.

A Provision of advisory services on energy efficient driving action is intended to change the attitude and influence behaviour in transport use and will be combined with the information campaign which is aimed to educate the general public on energy efficiency measures in general.

### 4.4.3 Industrial Processes and Other Product Use

In Malta, direct emissions of greenhouse gases from industrial processes and solvent use account for 11% of national GHG emissions[53]. GHGs emitted by this sector are $CO_2$, $N_2O$, HFCs, PFCs and

[48] http://www.transport.gov.mt/land-transport/vehicle-registration-and-licensing/renewal-of-road-licence/licence-fees
[49] http://www.transport.gov.mt/land-transport/vehicle-registration-and-licensing/registering-and-licensing-a-motor-vehicle
[50] http://www.cva.gov.mt/
[51] http://www.transport.gov.mt/admin/uploads/media-library/files/Park%20%20Ride%20-%20Floriana.pdf
[52] http://www.um.edu.mt/iccsd/greentravel
[53] National Greenhouse Gas Inventory CRF MLT_2017_3_Inventory

$SF_6$. Refrigeration and air-conditioning equipment are considered to be the primary source of GHG emissions from this sector. The main measure that is expected to reduce emissions from the sector is the implementation of the F-Gases Regulations, which should also serve to provide more information on the sectoral activity.

**Table 4-2 Summary of policies and measures related to transport.**

| ***Name of mitigation action / Objective and/or activity affected / Brief description*** | | | | | ***Estimate of mitigation impact (not cumulative, in kt CO2 eq)*** | |
|---|---|---|---|---|---|---|
| ***GHGs affected*** | ***Type of instrument*** | ***Status*** | ***Start year*** | ***Implementing entity(ies)*** | ***2025*** | ***2035*** |
| The introduction of a biofuel 'Substitution Obligation' | | | | | | |
| Renewables in transport | | | | | | |
| The use of biofuels up to some years ago had not resulted in a significant decrease in national GHG emissions as its use decreased from 1.75% , by energy, of diesel used in road transport in 2007 to 0.68% in 2009. This triggered the MRA to introduce a substitution obligation on all importers and/or wholesalers of petroleum fuel used for transport. The annual mandatory substitution obligation in 2011 was 1.5% of the total energy content petroleum place on the market. The obligations rises in intervals of 1% to reach 9.5% by 2019 and then 10% by 2020. | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Regulatory | Implemented | 2011 | MRA | 27.51 | 27.93 |
| Introduction of Autogas | | | | | | |
| Low carbon fuels/electric cars | | | | | | |
| The publishing of Legal Notice 393 of 2010, Autogas (Installation and Certification) Regulations under the Malta Resources Authority Act in a bid towards the introduction of autogas for vehicles on the Maltese market and to lay market regulation for retrofitting of engines. Accompanying the Legal Notice the MRA issued Codes OF Practice to guide installers on the installation of kits and engineers on the design of Autogas service stations. The first service station opened in the 2nd quarter of 2012 and by the end of the year four technicians were approved to serve as competent installers. Government is planning to subsidize the retrofitting of vehicles. | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Fiscal | Implemented | 2011 | MRA | 1.185 | 1.999 |
| Uptake of Electrical Cars | | | | | | |
| Low carbon fuels/electric cars | | | | | | |
| The use of electric vehicles is being promoted as an alternative means of transportation. The use and purchase of such vehicles is being encouraged through (i) a decrease in their registration tax and (ii) new owners of M1 electric vehicles may apply for a grant of 25% or €4000 of the purchase price. | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Fiscal | Implemented | 2011 | Transport Malta | 2.015 | 1.782 |
| Promotion of E-working and Tele-working | | | | | | |
| Demand management/reduction | | | | | | |
| In 2008 a teleworking policy was published by government which took into consideration feedback received from a research project carried out together with the National Commission for the Promotion of Equality (NCPE). The purpose of this policy was to set up a formal framework for the administration of telework in the public administration of Malta and the policy document outlines the general principles on which telework should be administered in the Public Administration of Malta. | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Regulatory | Implemented | 2010 | - | 1.139 | 1.923 |
| Promotion of Transport Modal Shift towards Public Transportation and Public Transport Reform | | | | | | |
| Modal shift to public transport or non-motorized transport | | | | | | |
| The Modal shift in the transport sector is mainly driven by the public transport reform. A modal shift of 8% from the use of private cars to use of public transport is being targeted. Government is implementing measures to reform the public transport system as part of the new transport policy and contract has been awarded to a major international transport company to manage and upgrade the national bus system. | | | | | | |
| $CO_2$, $CH_4$, $N_2O$ | Regulatory | Implemented | 2012 | Transport Malta | 41.92 | 40.89 |

**Table 4-3 Summary of policies and measures related to Industrial processes (comprising industrial activities that chemically or physically transform materials leading to greenhouse gas emissions, use of greenhouse gases in products and non-energy uses of fossil fuel carbon).**

| ***Name of mitigation action / Objective and/or activity affected / Brief description*** | ***Estimate of mitigation impact (not cumulative, in kt CO2 eq)*** |
|---|---|

| GHGs affected | Type of instrument | Status | Start year | Implementing entity(ies) | 2025 | 2035 |
|---|---|---|---|---|---|---|
| Implementation of F-gases Regulation | | | | | | |
| Reduction of emissions of fluorinated gases | | | | | | |
| Control and limit F-gas emissions from sectors such as Refrigeration and Air-conditioning. Control through training and certification of technical personnel and reporting of usage, refilling and destruction. | | | | | | |
| HFCs, PFCs, $SF_6$ | Regulatory, Education | Implemented | 2012 | MCCAA | 18.93 | 62.17 |

### 4.4.4 Agriculture

The Agriculture sector accounts for a very small share of national GHG emissions, with a contribution of 3% due to emissions of $CH_4$ and $N_2O$ from enteric fermentation, manure management and agricultural soils.[54] Various policies and measures are being implemented or planned in this sector which should also reduce the GHG emissions profile of the local agricultural sector. Addressing Malta's obligations under the EU legislation, particularly the Nitrates Directive (91/676/EC)[55], $N_2O$ emissions from the use of fertiliser is expected to decrease over time as improved cultivation practices are adopted, mainly through the Nitrates Action Programme. Furthermore, Malta benefited from the European Agricultural Fund for Rural Development, a financial instrument under the reform of the Common Agricultural Policy with the aim of strengthening the EU's rural development policy and simplifying its implementation.

The Rural Development Programme (RDP) focuses on three main cross-cutting objectives namely the environment, climate and innovation. The programme focuses and prioritises climate change mitigation and adaptation by introducing various measures. The RDP identifies five main themes: Water, wastes and energy; Maltese quality produce; Sustainable livestock; Landscape and environment; and Wider rural economy and quality of life.

The Nitrates Directive (Council of the European Communities, 1991) has the general purpose of "reducing water pollution caused or induced by nitrates from agricultural sources and preventing further such pollution" (Art.1). A threshold nitrate concentration of 50 mg/l is set as the maximum permissible level, and the Directive limits the application of livestock manure to land in excess of 170 kg N/ha/yr. This Malta Nitrates Action Programme (NAP) contains the second Action Programme for Malta pursuant to the Nitrates Directive, basically addresses the protection of waters against pollution caused by nitrates from agricultural sources.

### 4.4.5 Land Use, Land-use Change and Forestry

In view of the high population density of the Maltese Islands and the limited land availability, and to a certain extent the local climatic conditions (such as limited rainfall), the potential for further reduction of $CO_2$ emissions through carbon sequestration in vegetation is envisaged to be minimal. The woodland areas of the Maltese Islands total about 200 hectares. Native forest is all but extinct, cut down by early colonisers for wood and to clear the land for agriculture and building. These residual woodland areas are now protected by legislation.

In recent years, afforestation projects have been undertaken, and have had an effect on the area covered by permanent vegetation, particularly trees; however, the $CO_2$ removals have not been estimated, given that data availability is sparse.

[54] National Greenhouse Gas Inventory CRF MLT_2017_3_Inventory
[55] Directive 91/676/EC on the protection of waters against pollution caused by nitrates from agricultural sources.

**Table 4-4 Summary of policies and measures related to Agriculture, Waste management/waste.**

| ***Name of mitigation action*** <br> ***Objective and/or activity affected*** <br> ***Brief description*** | | | | | ***Estimate of mitigation impact (not cumulative, in kt CO2 eq)*** | |
|---|---|---|---|---|---|---|
| ***GHGs affected*** | ***Type of instrument*** | ***Status*** | ***Start year*** | ***Implementing entity(ies)*** | ***2025*** | ***2035*** |
| Establishment of new Mechanical Biological treatment Plant in the North of Malta | | | | | | |
| Waste incineration with energy use, Improved animal waste management systems | | | | | | |
| Treatment of organic waste to obtain energy and divert waste from Landfill; treatment of manure from farms to obtain energy | | | | | | |
| $CH_4$, $N_2O$ | Other | Implemented | 2016 | Wasteserv | 1.79 | 1.79 |

## 4.4.6 Waste

The overall share of greenhouse gas emissions from the waste sector is equivalent to 6% of the gross national emissions. The main gas emitted is methane, which accounted for 96% of the sector's emissions. Disposal of solid waste to land is the largest contributor of GHGs followed by wastewater management. Waste incineration at present (with current facilities) is only a minimal contributor to the sector contributing <5% of the total waste sector[56]. In the past, composting was another minor contributor to GHG emissions from this sector, but the plant carrying out this activity ceased to operate in 2005.

A "Waste Management Plan for the Maltese Islands – A Resource Management Approach 2014 – 2020"[57] was published in January 2014, proposing measures to be implemented over the period 2014 – 2020 to move towards the achievement of national and EU set targets. The Waste Management Plan for the Maltese Islands (2014-2020) provides a roadmap that Malta is envisaging to follow to move waste management in Malta up the waste hierarchy through increased prevention, re-use, recycling and recovery. The Plan deals with waste prevention, which focuses mainly on behavioural aspects, characteristics and habits both of the domestic and the commercial/industrial waste producer and with waste management strategies, focusing on behavioural aspects as well as waste management strategies of generated waste streams.

The Waste Management Plan is aimed at addressing key issues and challenges:

- Low rates of recycling;
- High landfilling rates;
- Unsustainable waste management;
- To break the link between economic growth and waste generation;
- Moving waste up the waste hierarchy;
- Moving towards sustainable waste management through waste prevention, increased recycling and recovery.

[56] National Greenhouse Gas Inventory CRF MLT_2017_3_Inventory

[57] http://environment.gov.mt/en/document%20repository/waste%20management%20plan%202014%20-%202020%20-%20final%20document.pdf

This strategy affects emissions of greenhouse gases and low carbon development by putting forward proposals that will lead to sustainable lower waste generation rates and thereby improve Malta's standing vis-a-vis the waste hierarchy.

#### *4.4.6.1 Solid waste management*

Until early 2004, solid waste was deposited in unmanaged landfills. One of three landfills (Wied Fulija) was closed in 1996, and the other two landfills, Magħtab (in Malta) and Qortin (in Gozo) were closed in 2004.

Although the Magħtab and Qortin landfills are now closed since 2004, they are still sources of GHG emissions due to the waste present in the landfills that slowly decays underground for years after closure. In 2008, landfill gas extraction infrastructure was installed to treat odour and noxious gas emissions from these closed sites in a regenerative thermal oxidiser. The works also involved re-contouring works of the landform to improve stability of the waste mass, control emissions and to rehabilitate the sites for eventual alternative uses. Landfill gas extraction is expected to continue until 2028.

Between 2004 and 2007, municipal solid waste was disposed of in a managed landfill at Ta' Żwejra, and subsequently in the Għallis managed landfill which started operating in the beginning of 2007. These landfills are operated by WasteServ Malta Ltd., a company set up by the Government of Malta in 2002 to organise, manage and operate national waste management systems.

Over the years, the quantity of waste being deposited in landfills has gradually decreased due to improved recycling practices and diverting of degradable waste to the Sant' Antnin Composting Plant, in operation since 1993. Since 2012 the upgraded Sant' Antnin Plant with the aim of improving the technology used and the environmental performance of the plant, to manage waste more efficiently and produce compost while facilitating the recovery of green energy. To this end, the new Sant' Antnin Waste Treatment Plant includes a biological treatment plant for the production of biogas through the anaerobic digestion of biodegradable municipal solid waste. The biogas produced is to be used for the generation of electricity by combustion in a CHP plant, and any excess electricity will be fed to the grid. Furthermore, the excess heat is directed to heat a nearby therapeutical pool.

WasteServ Malta Ltd is planning to reduce, to the extent possible, the amount of waste being deposited in landfills in Malta, and to utilise waste through energy from waste projects. Biodigestion was highlighted as being an ideal solution. A plant constructed in the north of Malta will treat municipal solid waste (MSW) and animal manure. The plant has started operation in 2016.

In 2015, Malta has introduced the 'Organic Waste Pilot project', this project targets nine localities in Malta and the whole region of Gozo. The organic waste is collected through kerbside collection in a specifically colour-coded bag. Its aim is to pre-treat organic waste and subsequently use it for renewable energy generation and to produce a compost digestate. Hence, Malta will continue to shift away from landfilling in favour of more sustainable waste management options.

#### *4.4.6.2 Waste water treatment*

Malta's waste water handling infrastructure consists of two main networks that collect both domestic and industrial waste water as well as some storm water runoff. The sewerage system has been upgraded with the building of three new sewage treatment plants, which process started in 2006 and ended in 2011. Two of the plants came into operation in 2008, while the third became fully operational in 2011.

The Malta South Urban Waste Water Treatment Plant (Malta South UWWTP) is the largest of the three waste water plants constructed under the Government's Infrastructure Programme for the upgrading of the national waste water infrastructure and for achieving compliance with the requirements of the Urban Waste Water Treatment Directive.

The Malta South Urban Waste Water Treatment Plant (UWWTP) features anaerobic sludge digestion facilities with biogas production and reducing the plant's energy demand on the national grid. Biogas produced is combusted in a CHP plant for energy recovery: the electricity output meets a share of the plant's own operating demand, whereas the waste heat is used up in heating up and maintaining the sludge digesters at 37°C.

Malta has commissioned a study to assess the feasibility of introducing a Waste-to-Energy facility in Malta. The study has been completed and its results are currently being taken into consideration to pave out the way forward. The development of such a facility could reduce emissions emanating from landfill waste and increase the extraction/generation of renewable energy from waste whilst potentially presenting an increase in emissions in the initial start-up of the facility, which would need to be taken into account in future projections of emissions. At this stage, the measure is however limited to the study that looks into the possibility of having a waste-to-energy type of facility which apart from being best suited to meet the needs of our local context would be also able to treat a wide range of different waste streams.

**Table 4-5 Summary of policies and measures related to Waste management/waste.**

| ***Name of mitigation action***<br>***Objective and/or activity affected***<br>***Brief description*** | | | | | ***Estimate of mitigation impact (not cumulative, in kt CO2 eq)*** | |
|---|---|---|---|---|---|---|
| ***GHGs affected*** | ***Type of instrument*** | ***Status*** | ***Start year*** | ***Implementing entity(ies)*** | ***2025*** | ***2035*** |
| Aerial Emissions Works at Maghtab and Qortin Landfills + Capping and Extraction of Gases from managed Landfills. | | | | | | |
| Enhanced $CH_4$ collection and use | | | | | | |
| Gas extraction from closed waste dumps to treat odour and noxious gas emissions. The works also involve the recontouring works of the landform to improve stability, control of emissions and aesthetics. Capping and extraction of gases from the engineered non-hazardous waste landfill. Extracted gases to be utilised for power. | | | | | | |
| $CH_4$ | Other | Implemented | 2008 | Wasteserv | 46.25 | 56.1 |
| Sant'Antnin Mechanical Biological treatment Plant | | | | | | |
| Enhanced CH4 collection and use, Improved landfill management | | | | | | |
| Treatment of organic waste to obtain energy and divert waste from Landfill | | | | | | |
| $CH_4$ | Planning | Implemented | 2011 | Wasteserv | 37.02 | 44.01 |
| Operation of Urban Wastewater Treatment Plant (UWWTP) | | | | | | |
| Improved wastewater management systems | | | | | | |
| Treatment of wastewater to obtain energy and reduce untreated wastewater being pumped to sea | | | | | | |
| $N_2O$ | Planning | Implemented | 2011 | Water Services Corporation | 45.65 | 45.56 |
| Wastewater Sludge Treatment Plant | | | | | | |
| Improved treatment technologies, Improved wastewater management systems | | | | | | |
| Treatment of wastewater sludge leading to a reduction of untreated sludge being placed in the landfill | | | | | | |
| $CH_4$ | Other | Implemented | 2012 | Water Services Corporation | 1.55 | 1.88 |

## 4.4.7 Use of market-based measures, including the flexible mechanisms of the Kyoto Protocol

Market-based measures provide an important complement to measures addressing greenhouse gas emissions from a technological or operational perspective. The use of market-based measures as a means of limiting or reducing emissions of greenhouse gases in Malta has already been referred to above (see section 4.2). It is however worth discussing further the participation of local establishments in the EU Emissions Trading Scheme. Furthermore, a brief discussion of the utilisation, or not, of the project mechanisms provided for under the Kyoto Protocol gives a more complete picture of the emission mitigation situation in Malta.

#### *4.4.7.1 The EU Emissions Trading Scheme*

As already noted above, Malta's participation in the EU Emissions Trading Scheme is limited to the electricity generation plants and a number of aircraft operators; no other industrial and economic sectors active in Malta fall within the scope of the scheme. The focus of this discussion will be the power generation plants. The inclusion of local aircraft operators in the EU Emissions Trading Scheme covers only aviation emissions considered not to be part of 'national' greenhouse gas emissions.

The implementation of the EU ETS has been set out on the basis of phases (Phase 1: 2005-2007; Phase 2: 2008-2012; Phase 3 (current): 2013-2020; subsequent phases of 10 years duration each) Allocation of allowances to the existing two power plants for Phases 1 and 2 of the scheme was been provided for by the 'National Allocation Plan for Malta 2005-2007'[58] and the 'National Allocation Plan for Malta 2008-2012'[59] respectively. Both plans provide for full free allocation to the two plants, with the former also providing for an amount of allowances in a reserve for new entrants, which reserve was never utilised and was subsequently cancelled.

Figure 4-1 provides an overview of the trend in total emissions of the two participating plants including as compared to the total allocation given to them in the allocation plans for Phases 1 and 2. The level of actual emissions has always been lower than the allocation, resulting in a substantial surplus of allowances. The surplus for the first period (2005-2007) was eventually cancelled, as envisaged under the allocation plan for that period. The allocation as approved by the European Commission for the second period (the original Phase 2 allocation profile submitted by Malta had to be reduced following the review of the draft plan by the Commission) was felt to be rather strict in the light of projections available at the time. In reality, efficiency (in terms of emissions of $CO_2$ per unit energy generated) did not change significantly over the period of years between 2008 and 2012; other factors, such as limited growth in demand due to the international economic crisis have however, to some extent, contributed to keeping actual emissions significantly lower that had originally been projected.

[58] *National Allocation Plan for Malta 2005-2007*, Malta Environment and Planning Authority, 2004.
[59] *National Allocation Plan for Malta 2008-2012*, Malta Environment and Planning Authority, 2008.

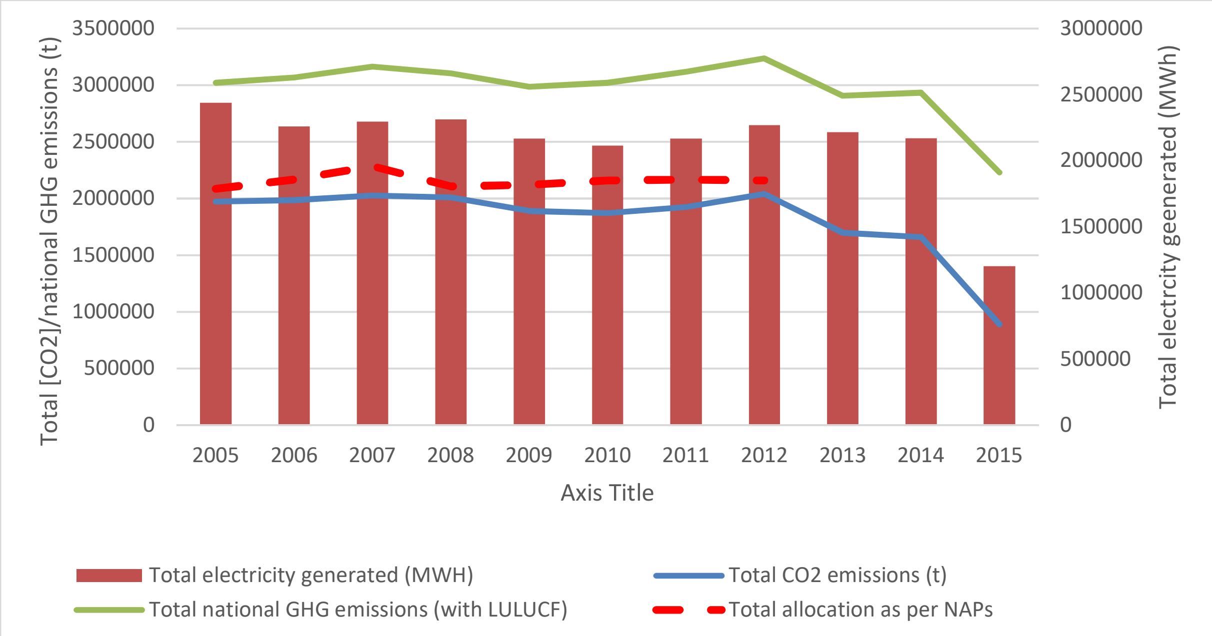



**Figure 4-1 Comparison of annual total emissions for the two electricity generating plants falling within the scope of the EU ETS and the allocation provided for in the two National Allocation Plans of Malta (2005-2007; 2008-2012).**

As of 2013, that is the start of Phase 3, the plants are no longer eligible for any free allocation. Thus, compliance with the surrender obligation for the plants concerned will have to be met by allowances bought on the market and, or, through auctions that are held in accordance with rules set out in subsidiary EU legislation under the EU ETS Directive, through the use of any surplus allowances remaining from Phase 2 and, to the extent allowed by the Directive, by international credits. This represents a cost for every tonne of $CO_2$ emitted – it would thus be in the interest of Enemalta to try and keep emissions as low as possible. To what extent carbon prices are a factor that influences investment in new plant and, or, new sources of electricity that bring about a reduction in overall emissions to be accounted for by the operators of the respective plants may be difficult to determine. However, for sure, the measures already discussed earlier in this chapter will surely contribute to lowering direct compliance costs under the EU ETS.

#### *4.4.7.2 The use of Kyoto Protocol flexible mechanisms and international credits*

There has been no participation in Clean Development Mechanism (CDM), by hosting projects, or in Joint Implementation (JI) projects as either a project host or sponsor. So far, any emission reductions that have taken place or that are projected to occur in Malta under current scenarios have all been or will be due to domestic action and do not constitute offsetting of local emissions by emission reduction activities taking place in other countries. In respect of EU ETS compliance, local participants have utilised international credits as units surrendered to account for reported emissions. This however represents a substitution for the use of allowances, and is limited by EU ETS rules.

Overall, a maximum of around 2 million Assigned Amount Units may be required to ensure Malta's compliance with the 2nd Commitment Period target.

# 5 PROJECTIONS AND THE TOTAL EFFECT OF POLICIES AND MEASURES

*Image Source: Pinterest (https://www.pinterest.com/pin/451978512579440340/?autologin=true)*

## 5.1 Introduction

This chapter provides a detailed analysis of the impact of the policies and measures in reducing GHG emissions over a time period covering 2016 - 2035. A comparative exercise is undertaken between the BAU and WEM scenario for each sector. Subsequently, a comparison at a more aggregated level is carried out, whereby the total projected emissions of the ESD and ETS sectors are compared for the WEM and BAU scenario, respectively.

Efforts continue to be made to update projections of all relevant sectors so as to better reflect the local policy framework and associated actions, with an emphasis on those sectors with a particularly significant impact on overall projected emission trends. These include changes in policy direction, changes in the econometric estimation of a particular sector, the provision of new data and timing in the collection or revisions in the various data streams. This implies that whenever there is a significant update, the probability is that there will be significant movements (either upwards or downwards, as the case may be) in the results as compared to the previous submissions. This issue is further compounded by the small-scale numbers inherent in Malta's absolute emissions; where a small change in a large contributing sector would have a disproportionate impact on the total emissions. It is pertinent to note that the projections presented hereunder reflect those measures that have been reported by the entity responsible for their implementation and which could be quantified in terms of emissions reductions in tons of $CO_2$ equivalent. Hence, those measures that have not been reported or which are inherently unquantifiable, are excluded from the projections. As previously stated, efforts are ongoing to include all those measures that have a quantifiable impact on national GHG emissions.

## 5.2 Projections by sector

### *5.2.1 Energy*

#### *5.2.1.1 Fuel combustion in energy industries*

GHG emissions from electricity generation are the main contributors to national GHG emissions. These emissions follow trends in electricity demand and the supply characteristics (and dispatching) of generation sources. In turn, the major factors influencing electricity demand and which are considered relevant to the assessment of future GHG emissions in this sector are:

- expected growth in economic activity;
- expected developments in electricity retail prices;
- the implementation of electricity efficiency measures.

Changes in weather and climatic conditions can also be expected to have an influence, albeit in the medium to long term. Presently, this effect is difficult to predict and to be included in the modelling framework at this stage.

Figure 5-1 shows the final demand of electricity in Malta between 1991 and 2014. The demand has fluctuated under the influences mainly of GDP growth (representing trends in economic activity) and changes in retail electricity tariffs, amongst others.

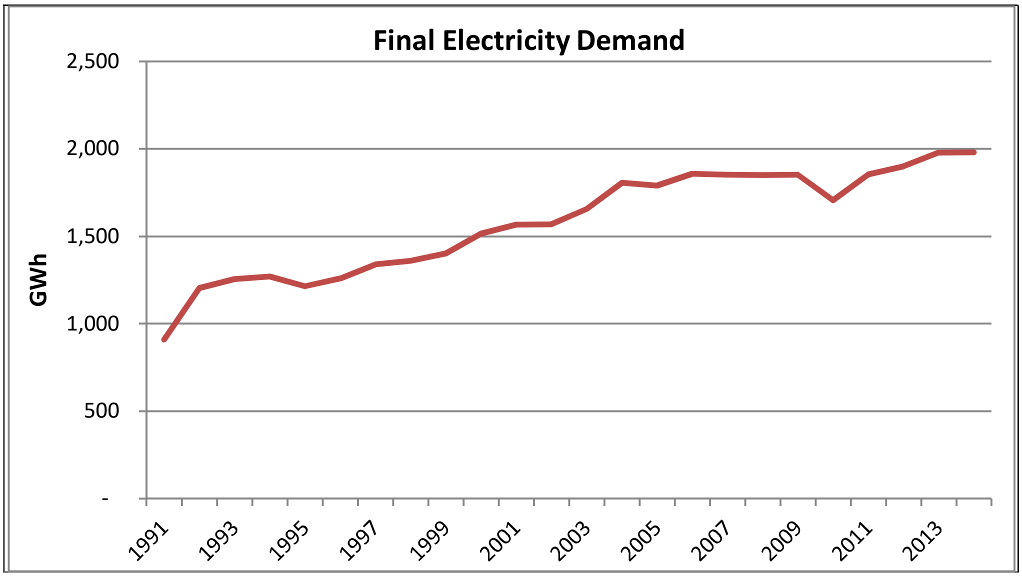



**Figure 5-1 Demand for Electricity in Malta**

Table 5-1 below presents information about the final electricity demand in Malta and its major determinants between 2003 and 2015. The effects of the trend in GDP growth appears to have been offset by the increase in retail tariff prices between 2003 and 2009. The latter effect appears to have been reversed in later years. This information can be synthesized by means of regression analysis with the aim of obtaining the elasticity of demand for electricity with respect to its major determinants.

**Table 5-1 Demand and Main Determinants**

| | Final Electricity Demand (Mwh) | Average Tariff (€/kwh) | GDP volume (2003=1) |
|---|---|---|---|
| 2003 | 1,657,000 | 0.0661 | 1.00 |
| 2004 | 1,789,857 | 0.0644 | 1.02 |
| 2005 | 1,858,474 | 0.0735 | 1.07 |
| 2006 | 1,852,659 | 0.083 | 1.12 |
| 2007 | 1,851,496 | 0.0942 | 1.20 |
| 2008 | 1,852,659 | 0.1107 | 1.28 |
| 2009 | 1,707,284 | 0.1607 | 1.28 |
| 2010 | 1,823,584 | 0.1752 | 1.38 |
| 2011 | 1,865,452 | 0.1751 | 1.43 |
| 2012 | 1,945,699 | 0.1765 | 1.49 |
| 2013 | 1,950,351 | 0.1763 | 1.59 |
| 2014 | 2,005,012 | 0.1668 | 1.76 |
| 2015 | 2,114,334 | 0.1668 | 1.93 |

*Source: Enemalta, Eurostat*

The regression results indicate that the elasticity of final demand to GDP is about 0.8 while the price elasticity of (final) demand is of -0.2. In the modelling exercise, these figures were assumed to remain constant until 2030 and are only affected by the projected impact of the energy efficiency measures.

It is expected that the 2015 to 2020 period will be characterised by the implementation of a number of energy efficiency measures a number of which relate to buildings, industry and the production of water. The impact of such measures between 2015 and 2020 is estimated at 2% of average baseline demand. They are also estimated to reduce the elasticity of demand to GDP from 0.46 to 0.33. The latter value is retained for forecasts beyond the 2020 period, and applied to a situation where GDP growth is expected at an average annual rate of 2.5%, implying a growth in electricity demand of 0.8% per year.

The conversion to greenhouse gas emissions for the forecasted baseline is based on plant performance for 2012, and this is assumed to remain constant in calculating emissions for the baseline. To ensure consistency with national inventory figures for historic emissions and to facilitate the split of projected emissions for ETS and non-ETS sources (that is, to allow for subtraction of like-from-like), data on $CO_2$ emissions from the power plants as recorded in the National Inventory have been used rather than verified annual emissions pursuant to Directive 2003/87/EC.[60]

Savings from the demand-side and RES measures are calculated on the basis of local emissions per MWh specific to that particular year (i.e. both electricity generated at local plants and

[60] Differences in methodological approaches between national inventories and reporting under the EU ETS Directive can lead to discrepancies in reported emissions, though such discrepancies are relatively small.

electricity imported through the interconnection), and hence include the expected reduction in emissions due to the technical measures related to the electricity-generating infrastructure including the interconnection.

Notwithstanding these energy efficiency improvements, the main drop in emissions observed in Figure 5-2 is mostly due to a number of supply side factors, namely the improvement in generation efficiency from the new electricity turbines, the switching to natural gas instead of heavy fuel oil and the utilization of the electricity interconnector.

#### *5.2.1.2 Road transport*

The projections of emissions from road transport have been developed on the basis of the model mentioned in the previous section. There is no differentiation between cars of varying efficiency in respect of emissions per kilometre travelled. However, the total kilometres travelled have been assumed to increase by 0.53% per year between 2015-2020, to subsequently increase by 0.92% per year between 2021 and 2025 and to decrease to 0.35% per year between 2026 and 2030. A second assumption is the improvement in car efficiency of approximately 2% per year over 2010-2030 in-line with the mandatory shifts in favour of higher Euro car standards required by the EU Commission and as indicated in the EU Reference Scenario 2013.

Specific to the measures themselves, it has been assumed that autogas will partially substitute petrol and that the public transport modal shift will gradually increase from 1% in 2012 to 8% in 2019 and then remains constant. Biogenic emissions from biodiesel and the biogenic part of bio-ETBE are not included in the total emissions reported in line with accepted methodological approaches.

Emissions arising from the public transport reform have been calculated on the basis of projected kilometres covered without, as stated in the previous section, differentiating between the efficiencies of the older and newer buses, especially since this is expected to have a larger impact on air quality rather than emissions of greenhouse gases. In view of this methodological approach and the fact that the total distance covered by the current bus system is greater than that covered under the old bus system, the measure has actually been determined to show an increase in emissions in the initial years of operation rather than a reduction. Public transport modal shift is projected to increase from 1% shift in 2012 to 8% shift by 2019, while the projecting of emission savings due to the public transport reform does not differentiate between efficiencies of the old and new bus fleets; the change in fleet is expected to have a more marked impact on air quality rather than greenhouse gas emissions. With this methodological approach, the fact that the new public transport system covers a total route distance greater than the coverage under the previous bus network, an increase in emissions has been projected for the public transport reform measure.

The replacement of 5000 diesel or petrol vehicles by electric vehicles has been included in these projections. However, the effect of this measure depends to a large extent on the nature of the electrical source. Assuming that electricity will be sourced from conventional local electricity generation plant, the effect of this measure is better described as a displacement of an amount of emissions from the transport sector to the electricity industries sector.

### *5.2.2 Industrial Processes and Other Product Use*

The GHGs identified as being emitted by this sector are CO2, HFCs and SF6, as reported in the national inventory under the categories: Soda Ash Production and Use, Carbide Production, Use of N2O for Anaesthesia and Consumption of Halocarbons and SF6. The major action envisaged in this sector is the implementation of the F-Gases Regulation. A measure of this nature is not quantifiable with certainty but has a high probability of influencing in a positive manner the way F-gases are utilised. It is thus assumed that emissions from this sector will eventually stabilise with the implementation of this measure.

### 5.2.3 Agriculture

In agriculture, apart from the effect of policies and measures adopted and implemented, one should also bear in mind the effect of certain trends in the activity itself, which are not necessarily directly linked to specific policies and measures. There is a clear trend towards less land being cultivated due to issues related with scarcity of arable land area. The scarcity of water could possibly further compound such a trend. In animal husbandry, the sector has had to restructure to conform with EU legislation applying to animal welfare, food safety, veterinary and waste management, thus reducing the extent to which this activity is practiced, naturally leading to reductions in emissions, or forcing the implementation of practices that inherently reduce emissions.

The measure that is expected to effect emissions in the WEM scenario is the treatment of manure in the Malta North MBT which is expected to process 39,000 tonnes of cattle and poultry manure. For the evaluation of this measures it is assumed that emissions due to that manure which is treated in the MBT are prevented from Agriculture.

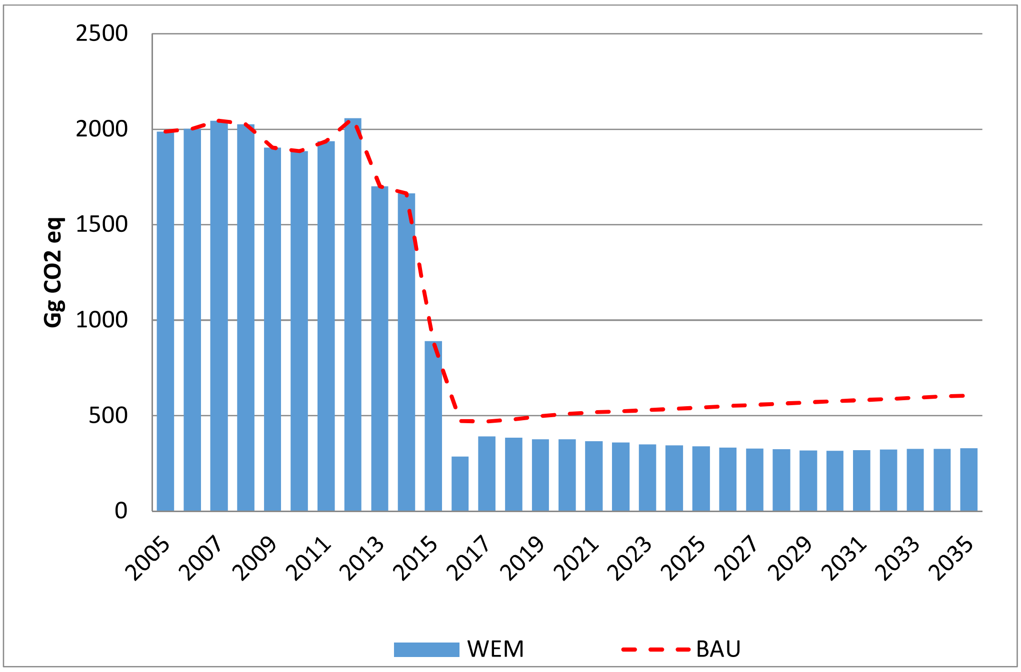



Figure 5-2 Projections of greenhouse gas emissions for electricity generation.

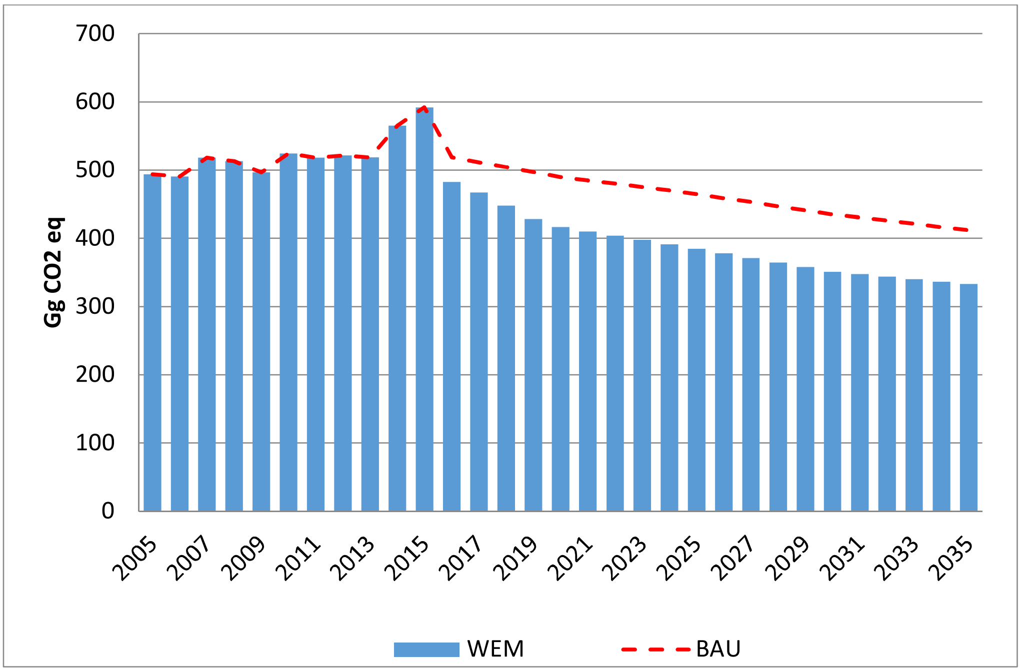



Figure 5-3 Projections of greenhouse gas emissions for road transport.

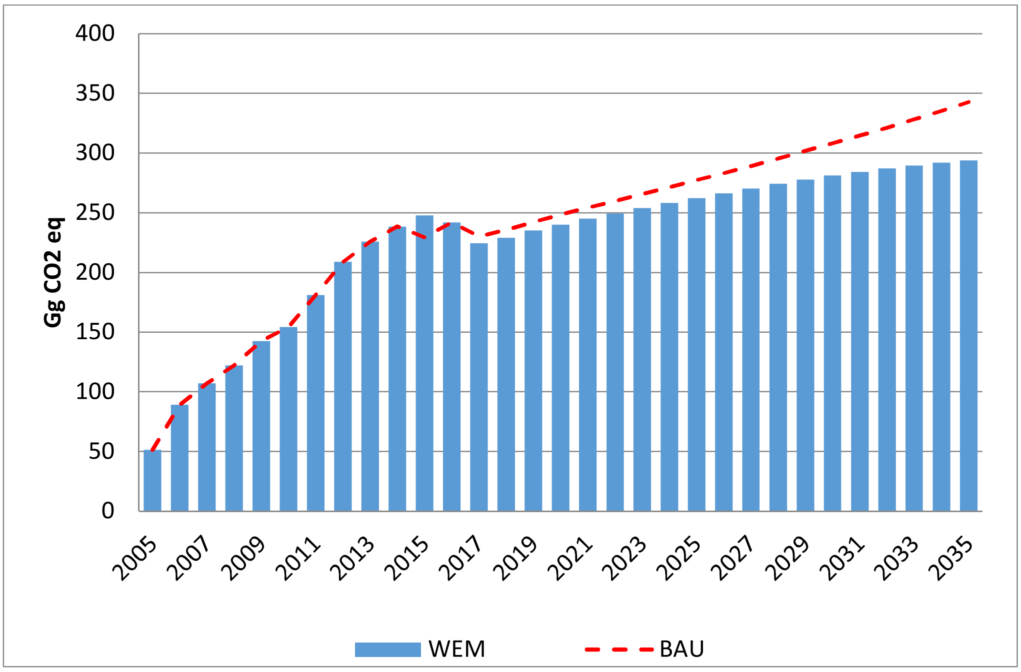



Figure 5-4 Projections of greenhouse gas emissions for industrial processes and product use.

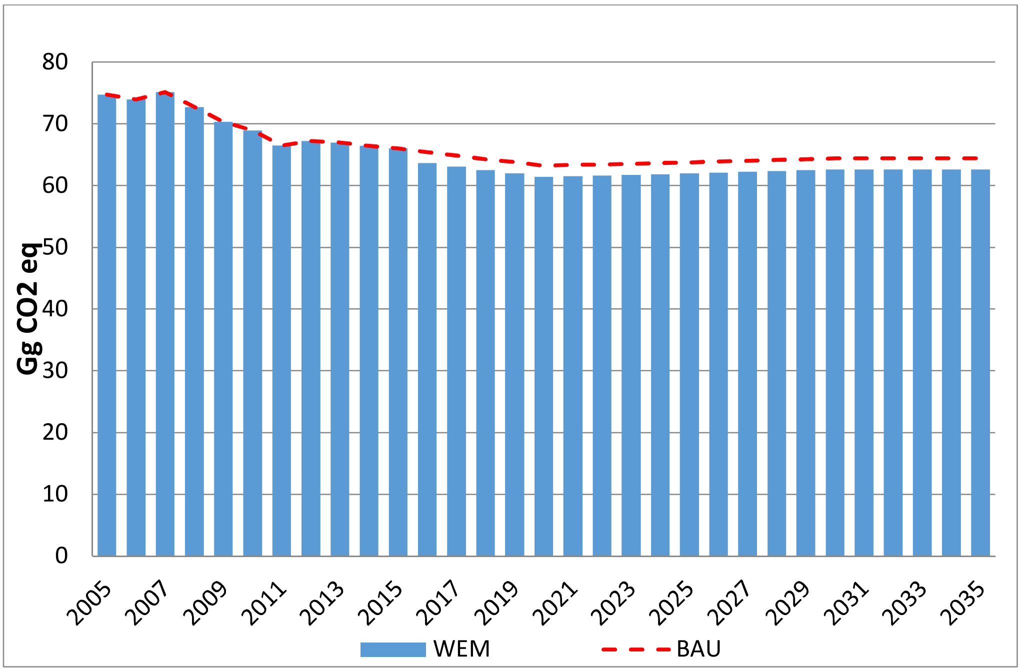



Figure 5-5 Projections of greenhouse gas emissions for agriculture.

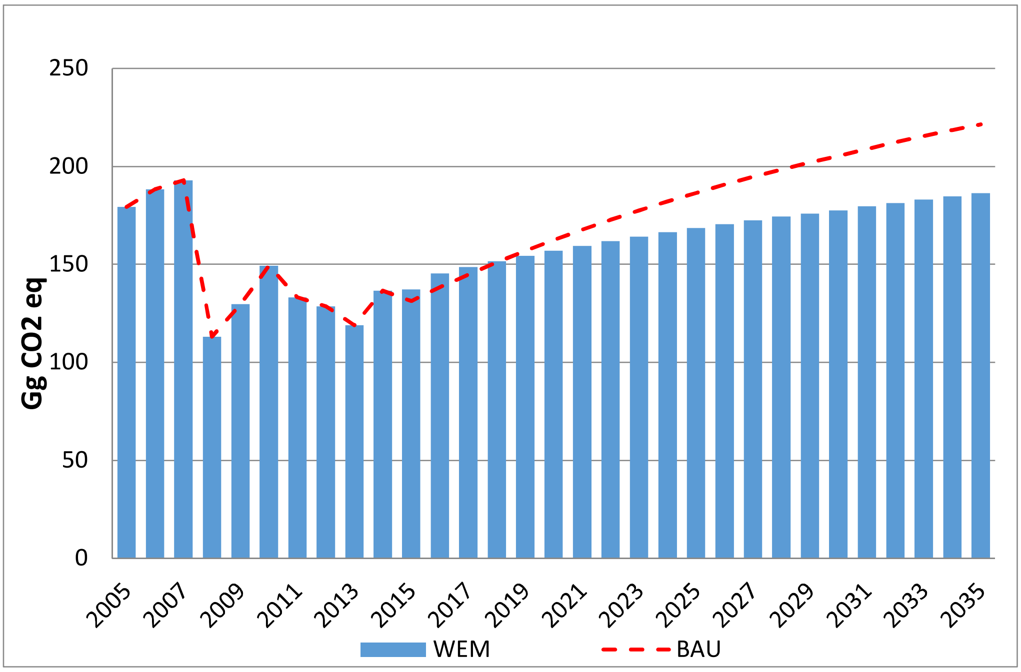



**Figure 5-6 Projections of greenhouse gas emissions for waste.**

### *5.2.4 Land Use, Land-use Change and Forestry*

For the purposes of the WEM scenario, the projected level of emissions expected to remain constant after 2015.

### *5.2.5 Waste*

The projections of emissions from the waste sector have been based on the model described in the previous section. It also builds upon a 'decomposition' model which 'assigns' the expected waste generation to waste treatment plants, incinerator and land-filling, respectively according to their capacity. A number of assumptions have been taken into consideration, including:

- The trend in MSW/Capita and Industrial Waste/GDP are maintained throughout the projected time;
- Degradable Organic Carbon (DOC) and MSW composition remains constant to 2011 values;
- Landfilling amounts do not take into consideration whether the specific active landfill is exhausted or not. It is assumed that all future landfills are managed to the same standard as the landfill currently in use;
- All methane generated from biological treatment of waste is flared and all resulting emissions are considered biogenic.

The actual and projected emissions from the waste sector take into account all measures related to this sector, including both solid and liquid waste. It is projected that the biggest saving will be due to saved methane emissions from landfills.

## 5.3 Assessment of aggregate effects of policies and measures

Table 5-2 shows the emission projections split by sector and by gas for the years 2020, 2025, 2030 and 2035, for the WEM scenario.

The aggregated effect of the policies and measures is illustrated in Figure 5-7 and Figure 5-8. The impact of measures implemented in the electricity generation sector have a significant impact on total national emissions as clearly reflected in the drop in projected emissions from 2015 onwards. This downwards shift in emissions is largely due to the switch to the interconnector, the substitution of heavy fuel oil in favour of natural gas and the switching to more efficient generation turbines.

### Table 5-2 Emission projections by sector and by gas for the 'with existing measures' scenario.

| WEM | Gg CO2 eq. | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|
| 1.A.1.a Public Electricity and Heat production | CO2 | 301.74 | 272.33 | 253.70 | 264.84 |
| | CH4 | 7.51 | 6.78 | 6.32 | 6.59 |
| | N2O | 66.99 | 60.46 | 56.32 | 58.80 |
| | | 376.24 | 339.57 | 316.35 | 330.23 |
| 1.A.3.b. Road transportation | CO2 | 410.79 | 379.87 | 346.53 | 328.43 |
| | CH4 | 1.35 | 1.25 | 1.13 | 1.07 |
| | N2O | 4.06 | 3.75 | 3.43 | 3.25 |
| | | 416.20 | 384.87 | 351.09 | 332.75 |
| 1. Energy | CO2 | 1,065.78 | 1,066.27 | 1,091.96 | 1,191.70 |
| | CH4 | 9.90 | 9.25 | 8.91 | 9.46 |
| | N2O | 72.21 | 65.51 | 61.20 | 63.72 |
| | | 1147.89 | 1141.03 | 1162.08 | 1264.89 |
| 2. Industrial Processes and Product Use | CO2 | 3.23 | 3.23 | 3.23 | 3.23 |
| | N2O | 1.14 | 1.14 | 1.14 | 1.14 |
| | HFC | 234.57 | 256.70 | 275.57 | 288.06 |
| | PFC | 0.00 | 0.00 | 0.00 | 0.00 |
| | SF6 | 1.24 | 1.28 | 1.28 | 1.28 |
| | | 240.18 | 262.36 | 281.23 | 293.72 |
| 3. Agriculture | CH4 | 33.05 | 33.36 | 33.73 | 33.73 |
| | N2O | 28.36 | 28.60 | 28.89 | 28.89 |
| | | 61.41 | 61.97 | 62.62 | 62.62 |
| 5. Waste | CO2 | 0.39 | 0.39 | 0.39 | 0.39 |
| | CH4 | 156.55 | 168.11 | 177.18 | 185.86 |
| | N2O | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 156.94 | 168.49 | 177.57 | 186.25 |
| 4. LULUCF | CO2 | 2.84 | 2.81 | 2.81 | 2.81 |
| | | 2.84 | 2.81 | 2.81 | 2.81 |
| TOTAL with LULUCF | CO2 | 1,072.23 | 1,072.70 | 1,098.39 | 1,198.13 |
| | CH4 | 199.50 | 210.71 | 219.82 | 229.05 |
| | N2O | 101.72 | 95.26 | 91.24 | 93.76 |
| | HFC | 234.57 | 256.70 | 275.57 | 288.06 |
| | PFC | 0.00 | 0.00 | 0.00 | 0.00 |
| | SF6 | 1.24 | 1.28 | 1.28 | 1.28 |
| | **Total** | **1,609.26** | **1,636.66** | **1,686.31** | **1,810.28** |

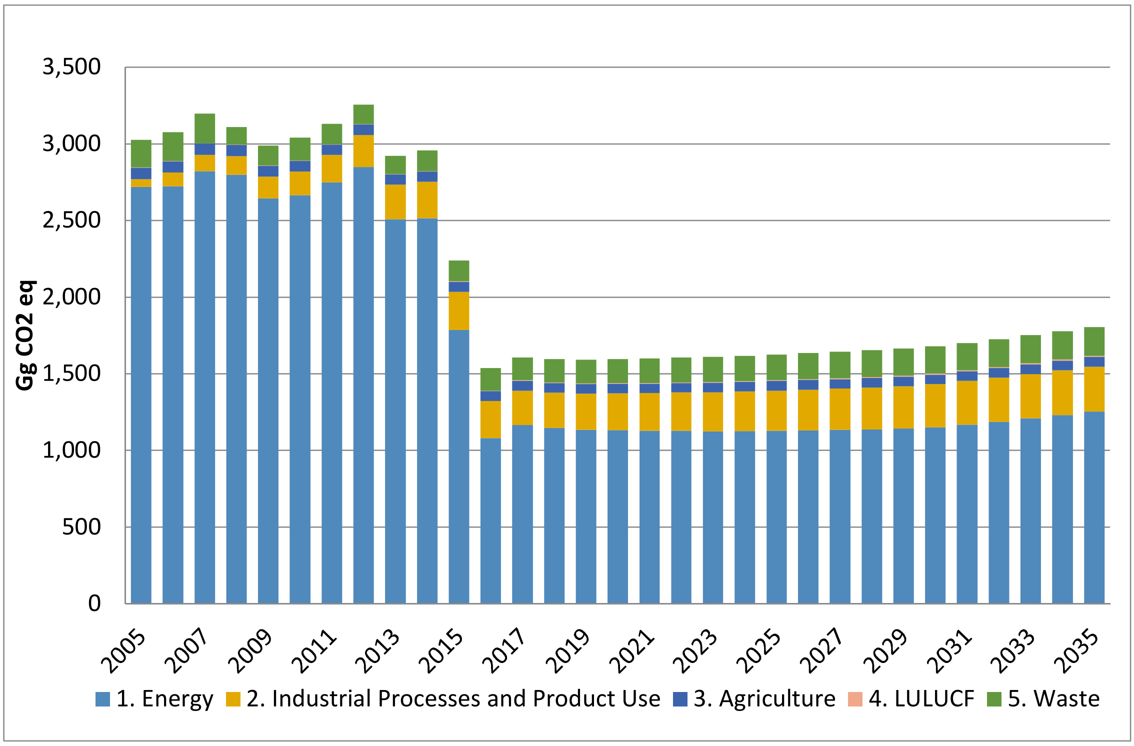



Figure 5-7 Projections (WEM) of total emissions differentiated by sector.

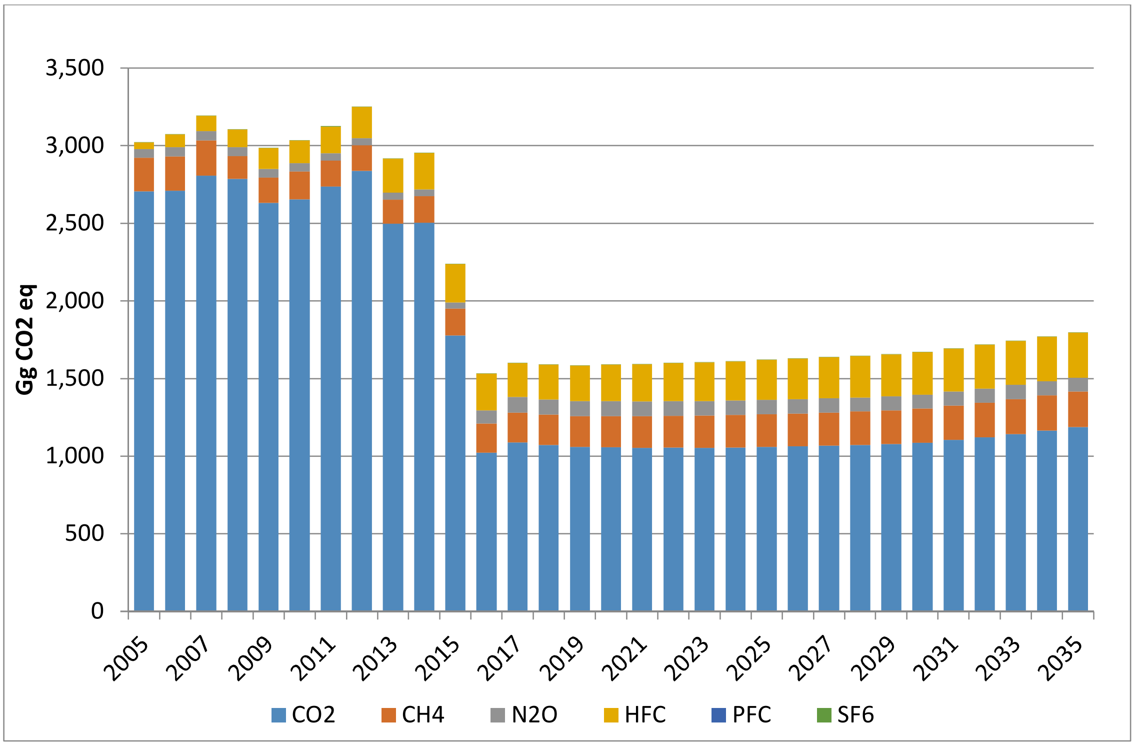



Figure 5-8 Projections (WEM) of total emissions differentiated by gas.

## 5.4 Meeting greenhouse gas emission commitments

Projected emissions are evaluated against emission reduction targets applicable for Malta under the Effort Sharing Decision. This Decision sets a target for Malta limiting emissions to a level not higher than 5% over 2005 levels, by 2020. Furthermore, the Decision establishes a trajectory of interim targets for the years up to 2020, in accordance with the rule that "*each Member State with a positive limit under Annex II* [to the Effort-Sharing Decision] *shall ensure* [...] *that its greenhouse gas emissions in 2013 do not exceed a level defined by a linear trajectory, starting in 2009 on its average annual greenhouse gas emissions during 2008, 2009 and 2010,* [...] *ending in 2020 on the limit for that Member State as specified in Annex II*".

Emissions not falling under the scope of this target include emissions covered by the EU ETS Directive (i.e. $CO_2$ emissions from the power plants), emissions in the LULUCF sector, and $CO_2$ emissions from civil aviation. Emissions from international marine bunkering and international aviation are also excluded. Figure 5-9 below compares the total emissions and projections covered by the sectors falling within the Effort Sharing Decision with the trajectory under this Decision.

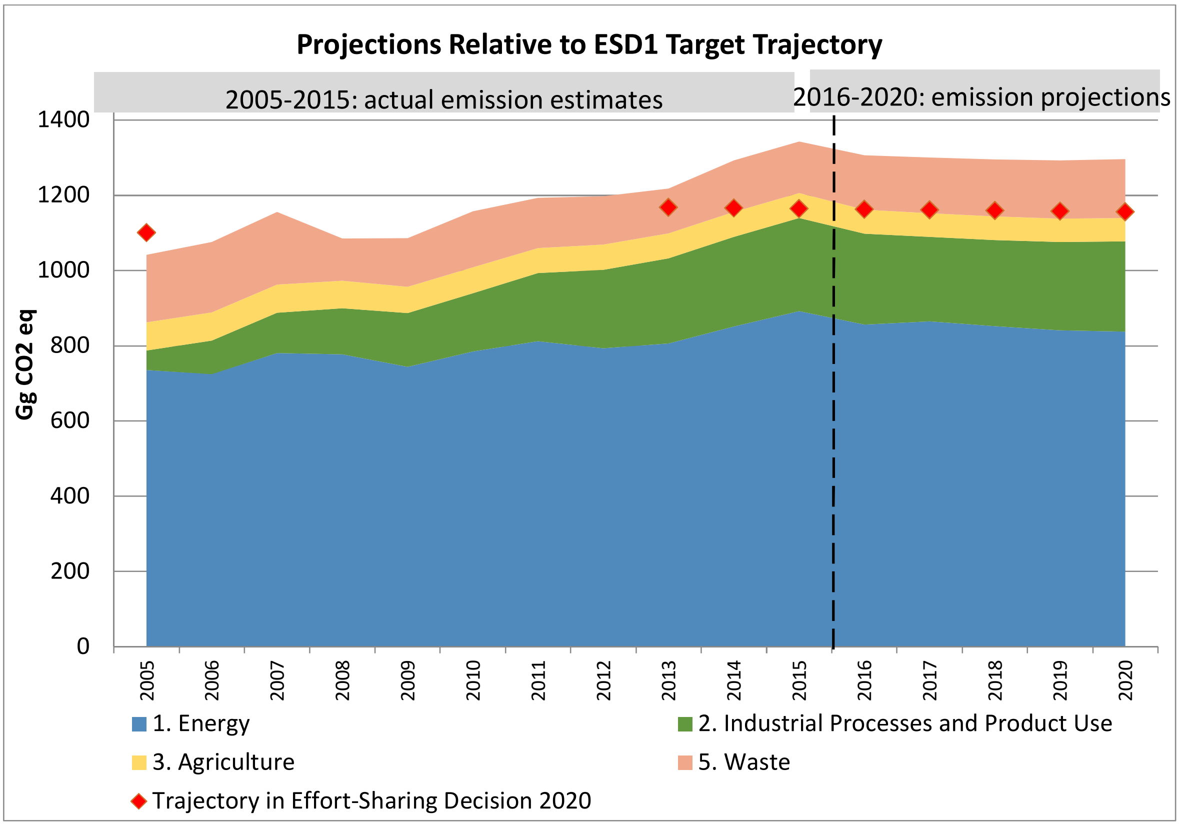



**Figure 5-9 Projections of emissions covered by the Effort Sharing Decision (ESD1).**

As shown in Figure 5-9, Malta is not expected to meet its 2020 target or any of the interim annual binding targets for 2015-2019. Total Effort Sharing Decision (ESD1) emissions are higher than the trajectory targets for all the years. This change in outlook to that reported in the 2015 PAMs report, whereby it was projected that the 2020 target and the interim binding targets would be met, is largely due to a methodological revision of historic GHG emissions, which is part of the ongoing process of ameliorating this data. Since projections are necessarily based on historic emissions, it follows that the relevant projections are revised upwards.

It is pertinent to note that the WEM scenario trajectory is dependent on a number of factors that highlight the particular situation inherent in small countries when considering emission mitigation policies and measures, wherein a single emission source or, the non-implementation of a particular measure, can have a significant impact on the country's emissions with a concomitant impact on its ability to meet quantified obligations, relative to larger countries. For example; the effect of public transport reform discussed above and as modelled in the projections is based on a projected modal shift from private vehicle use to public transport use of approximately 8% of passenger vehicles. A higher modal shift would result in a substantial further increase in future greenhouse gas emission savings from transport. However, the rate of modal shift depends very much on the transport choices made by the individual citizens and visitors to the country, and thus on the willingness of the general public, or the extent to which the public is incentivized, to shift to modes of transport other than private vehicles. Alternative modes of transport have to offer a substantial improvement in mobility in terms of efficiency and time spent travelling, and also have to be significantly more attractive from a cost perspective than passenger vehicles.

Hence, it is being recognised that the availability of better activity data and closer monitoring of implemented measures will play a key role in determining the accuracy of these projections.

An important methodological issue that greatly influences Malta's projections, and therefore, compliance status, is the small order of magnitude represented by Malta's emissions, and even more so, the gap between emissions and targets. The small order of magnitude of absolute emission figures offers a very limited buffer against 'mathematical' impacts of changes to historic data, as can be observed in the figure above whereby the previous positive outlook has been drastically altered due to a revision in historic emissions.

# 6 VULNERABILITY ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

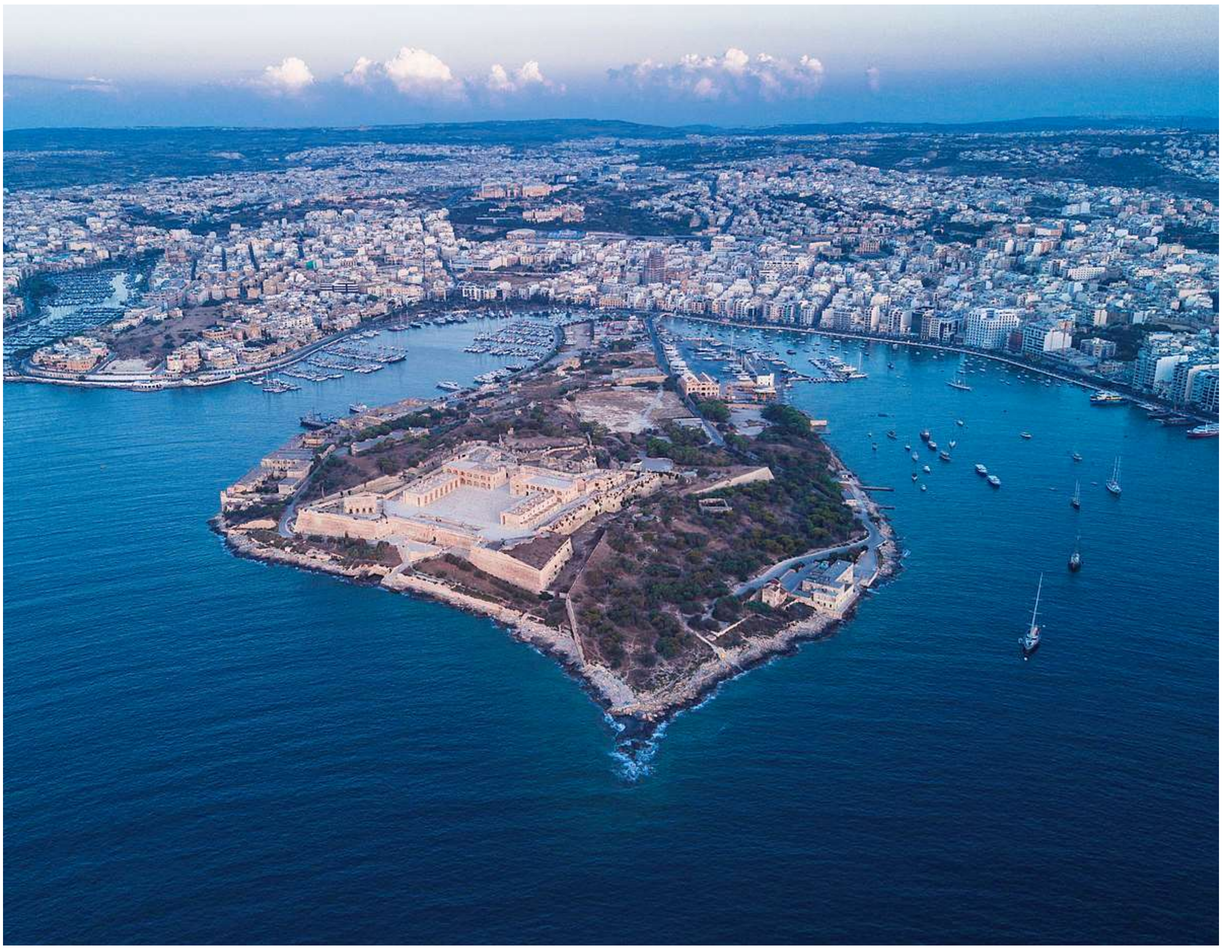


*Image Source: Wikipedia (https://en.wikipedia.org/wiki/Manoel_Island)*

## 6.1 Introduction

Carrying out climate change impact studies requires assessment of vulnerability by identifying changes that are continuously occurring. Modelling such changes applying well defined emission scenarios would be the basis for informed decisions at all levels and across all sectors that will allow a country to adapt and become resilient to climate change.

This chapter discusses ongoing work associated with forecasting climate change and its impacts, provides an assessment of vulnerability and outlines actions being taken to refine the tools needed to project the consequences of climate change.

The IPCC Fifth Assessment Report (5AR; 2013) claims that many aspects of the climate system are showing evidence of a changing climate (Stocker, et al., 2013). Global mean surface temperature has increased since the late 19th century and each of the past three decades has been successively warmer than any previous decade. The globally averaged combined land and ocean temperature data as calculated by a linear trend show a warming of 0.85 (0.65 to 1.06) °C over the period 1880-2012, when multiple independently produced datasets exist, about 0.89 (0.69 to 1.08) °C over the period 1901-2012, and about 0.72 (0.49 to 0.89) °C over the period 1951-2012 when based on three independently-produced data sets. The total increase between the average of the 1850-1900 period and the 2003-2012 period is 0.78 (0.72 to 0.85) °C based on the Hadley Centre/Climatic Research Unit gridded surface temperature data set 4 (HadCRUT4), the global mean surface temperature dataset with the longest record of the three independently-produced data sets. The warming from 1850-1900 to 1986-2005 is 0.61 (0.55 to 0.67) °C, when calculated using HadCRUT4 and its uncertainty estimates. It is also virtually certain that maximum and minimum temperatures over land have increased on a global scale since 1950 (IPCC AR5 Technical Summary, page 37).

It is also certain that the upper ocean (above 700 m) has warmed from 1971 to 2010, and likely that is has warmed from the 1870s to 1971. Global mean sea level has risen by 0.19 (0.17 to 0.21) m, estimated from a linear trend over the period 1901-2010, based on tide gauge records and additionally on satellite data since 1993. It is very likely that the mean rate of sea level rise was 1.7 (1.5 to 1.9) mm/yr between 1901 and 2010. Between 1993 and 2010, the rate was very likely higher at 3.2 (2.8 to 3.6) mm/yr; similarly, high rates likely occurred between 1920 and 1950.

The Fifth Assessment Report observes that, based on historic data, the number of cold days and nights has decreased, and the number of warm days and nights has increased on the global scale between 1951 and 2010. Globally, there is medium confidence that the length and frequency of warm spells, including heat waves, has increased since mid-20th Century. It is likely that heat wave frequency has increased over this period in large parts of Europe, Asia and Australia. Similarly, since the 1950s the number of heavy precipitation events over land increased in more regions.

A summary of observed and projected changes in climatic conditions are provided in Table 6-1.

**Table 6-1 Observed and projected changes in climatic conditions (EEA, 2017).**

| Climate Variable | Observed Change | Projected Change without mitigation |
|---|---|---|
| **Temperature** | Global: Three different long-term observational records show that the global average annual near-surface (land and ocean) temperature in the decade 2006–2015 was 0.83 to 0.89 °C higher than the pre-industrial average. | Global: Further global warming between 0.3 and 4.8 °C is projected for the 21st century, depending on the emissions scenario. The annual average land temperature across Europe is projected to continue increasing faster than global average temperature. |
| | The year 2015 was the warmest on record globally, at approximately 1 °C above the pre-industrial level. The number of warm days have almost doubled since 1960 across | Europe: Since 2003, Europe has experienced several extreme summer heat waves (2003, 2006, 2007, 2010, 2014 and 2015). Such heat waves are projected to occur as often as |

| | | |
|---|---|---|
| | the European land area.<br><br>Europe: European land areas in the decade between 2006 and 2015 have warmed by around 1.5 °C since the pre-industrial age. The years 2014 and 2015 were jointly the warmest years on record in Europe. | every two years in the second half of the 21st century under a high emissions scenario (RCP8.5). The impacts will be particularly strong in southern Europe. |
| **Precipitation** | Precipitation changes across Europe show more spatial and temporal variability than temperature changes. Annual precipitation has increased in most of northern Europe, in particular in winter, and has decreased in most of southern Europe, in particular in summer. Heavy precipitation events have increased in northern and north-eastern Europe since the 1960s whereas different indices show diverging trends for south-western and southern Europe.<br><br>Observations of wind storm location, frequency and intensity have shown considerable variability across Europe during the 20th century. Hail is responsible for significant damage to crops, vehicles, buildings and other infrastructure. | Heavy precipitation events are projected to become more frequent in most parts of Europe.<br><br>Most studies agree that the risk of severe winter storms, and possibly of severe autumn storms will increase in the future for the North Atlantic, as well as for northern, north-western and central Europe.<br><br>Despite improvements in data availability, trends and projections of hail events are still subject to large uncertainties owing to a lack of direct observation and inadequate microphysical schemes in numerical weather prediction and climate models. |
| **Sea Level** | Global mean sea level has risen by 19.5 cm from 1901 to 2015, at an average rate of 1.7 mm/year, but with significant decadal variation. The rate of sea level rise since 1993, when satellite measurements have been available, has been higher, at around 3 mm/year. Global mean sea level in 2015 was the highest yearly average over the record and ~70 mm higher than in 1993.<br><br>Most coastal regions in Europe have experienced an increase in absolute sea level and in sea level relative to land, but there is significant regional variation. Extreme high coastal water levels have increased at most locations along the European coastline. This increase appears to be predominantly due to increases in mean local sea level rather than to changes in storm activity. | Global mean sea level rise during the 21st century will very likely occur at a higher rate than during the period 1971–2010. Process-based models considered in the IPCC AR5 project show a rise in sea level over the 21st century that is likely in the range of 0.26–0.54 m for a low emissions scenario (RCP2.6) and 0.45–0.81 m for a high emissions scenario (RCP8.5). Several national assessments, expert assessments and recent model-based studies have suggested an upper bound for 21st century global mean sea level rise in the range of 1.5–2.0 m.<br><br>The rise in sea level relative to land along most European coasts is projected to be similar to the global average, with the exception of the northern Baltic Sea and the northern Atlantic Coast. |

## 6.2 Expected impacts of climate change

### 6.2.1 Overview of outcomes reported in the 2nd National Communication of Malta and subsequent developments in climate change impact research

The conclusions from projections compiled in the previous National Communication are summarised in Table 6-2 (Aquilina, et al., 2014).

**Table 6-2 The main model results generated using MAGICC/SCENGEN version 5.3 applicable to the region of the Maltese Islands for the years 2025, 2050, 2075 and 2100.** Note that the scenario year is the central year for a climate averaging interval of 30 years.

| | 2025 | 2050 | 2075 | 2100 | Comments |
|---|---|---|---|---|---|
| Increase in Temperature (°C) | 1.1 | 2.0 | 2.6 | 2.8 | Regional Mean |
| Change in Precipitation (%) | –2.4 | –4.4 | –3.7 | –1.8 | Regional Mean |
| Sea Level Rise (cm) | 7 | 14 | 23 | 30 | Global-mean |

Table 6-2 gives the main model results for the region of the Maltese Islands for the years 2025, 2050, 2075 and 2100. These are based on the no-climate-policy emission scenario A1T-MES and were generated using the 14 selected atmosphere-ocean general circulation models. Their use in vulnerability and adaptation studies for the Maltese Islands was recommended although the main problem with the results is associated with the horizontal resolution.

The results presented in this communication are a follow-up of the 3rd-6th National Communication, where a higher resolution regional climate model has been used to provide future projections. The spatial horizontal resolution of the regional climate model used was 20 km, which is a high and suitable resolution for impact assessments, vulnerability and adaptation studies since the Maltese Islands cover a total of 13 cells within a 100 × 100 cell domain area. Some modelling challenges associated with the Central Mediterranean area are still unresolved. RegCM4 is an atmosphere only model and thus cannot be used to give sea-level rise projections.

Table 6-3 provides a summary of the findings from projections of near-surface air temperature using the regional climate model RegCM4 as compared to the global model data (HadGEM2), extracted for Malta [14.5 °N, 35.9 °E], for the emission scenarios: Representative Concentration Pathway (RCP) 2.6, 4.5 and 8.5.

**Table 6-3 Global model (HadGEM2) and regional model (RegCM4) increase in near-surface temperature data extracted for the Maltese Islands for the years 2025, 2050, 2075 and 2099 for emission scenarios RCP 2.6, 4.5 and 8.5 with respect to 2005.** (Driving data for Year 2100 was not available for RegCM4).

| | 2025 | 2050 | 2075 | 2099 | Scenario | Comments |
|---|---|---|---|---|---|---|
| Increase in Temperature (°C) | 1.2 | 1.6 | 1.1 | 1.5 | RCP 2.6 | HadGEM2 |
| | 1.0 | 1.5 | 1.5 | 1.7 | | RegCM4 |
| | 0.7 | 0.7 | 2.3 | 2.3 | RCP 4.5 | HadGEM2 |
| | 0.9 | 0.9 | 2.3 | 2.7 | | RegCM4 |
| | 0.8 | 1.6 | 3.6 | 4.0 | RCP 8.5 | HadGEM2 |
| | 0.9 | 1.8 | 3.6 | 4.5 | | RegCM4 |

Table 6-4 outlines the percentage change in precipitation from the global model data (HadGEM2) and from the regional climate model RegCM4, extracted for Malta [14.5 °N, 35.9 °E], for the emission scenarios RCP 2.6, 4.5 and 8.5. The regional model data indicate changes which are an order of magnitude higher than the global data. This is not something unexpected, although more work is required to increase the reliability of the projections as discussed in Section 6.2.4.

**Table 6-4 Global model (HadGEM2) change in precipitation (%) extracted for the Maltese Islands for the years 2025, 2050, 2075 and 2099 for emission scenarios RCP 2.6, 4.5 and 8.5 with respect to 2005.**

| | 2025 | 2050 | 2075 | 2099 | Scenario | Comments |
|---|---|---|---|---|---|---|
| Change in Precipitation (%)) | 0.6 | 0.4 | 0.8 | 0.0 | RCP 2.6 | HadGEM2 |
| | 28.2 | 41.0 | 17.0 | 1.4 | | RegCM4 |
| | 0.5 | 1.1 | 0.2 | 0.4 | RCP 4.5 | HadGEM2 |
| | 47.8 | 57.6 | 3.6 | 20.3 | | RegCM4 |
| | 0.8 | 0.8 | 0.3 | 0.2 | RCP 8.5 | HadGEM2 |
| | 17.0 | 29.6 | -24.9 | 53.6 | | RegCM4 |

With reference to the Thematic Focus Elements TFE.1 – Water Cycle Change of the 5AR (Stocker, et al., 2013) the changes in precipitation are harder to measure with the existing records, namely because it is difficult to sample precipitation and secondly because it is expected that precipitation will have a smaller fractional change than the water vapour content of air as the climate warms. It appears that some regional precipitation trends are robust, but when virtually all the land is filled using a reconstruction method the resulting time series of global mean land precipitation shows little change since 1900. At present there is *medium confidence* that there has been a significant human influence on changes in precipitation patterns on a global scale, including increases in Northern Hemisphere mid-to-high latitudes.

Changes in the water cycle are projected to occur in a warming climate. Global scale precipitation is projected to gradually increase in the 21st century. Changes in average precipitation in a much warmer world will not be uniform. Mid-latitude regions, like sub-tropical arid and semi-arid regions will *likely* experience less precipitation.

For the Representative Concentration Pathway RCP8.5, drought is relatively uncertain but in the case of the Mediterranean, drying in this region with global temperatures increase is *likely* for several degrees of warming. As indicated in Figure 6-1, the change in precipitation around the Maltese Islands is set to either remain the same or decrease towards the end of the 21st century.

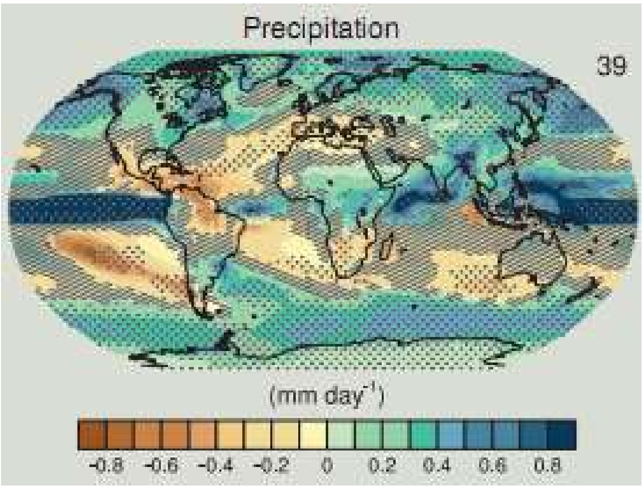



**Figure 6-1 Annual mean changes in precipitation for 2081-2100 relative to 1986-2005 under RCP8.5 [Adapted from Stocker et al., 2013, TFE.1 Figure 3].**

### 6.2.2 Analysis of data with focus on the Maltese Islands

The analysis that follows is based on data obtained from the HadGEM2 simulation. Figure 6-2 illustrates the global mean temperature based on moving averages of monthly means. This plot shows an increasing trend from about 14.5 °C in 2005 up to the mid-century where it reaches about 16 °C, for all scenarios. For the RCP 8.5 the increase in trend will continue till the end of the century. For the second part of the 21st century, with RCP 4.5 the temperature would stabilize at almost 16.5 °C whilst with RCP 2.6 a stabilisation at about 15.5 °C is being projected.

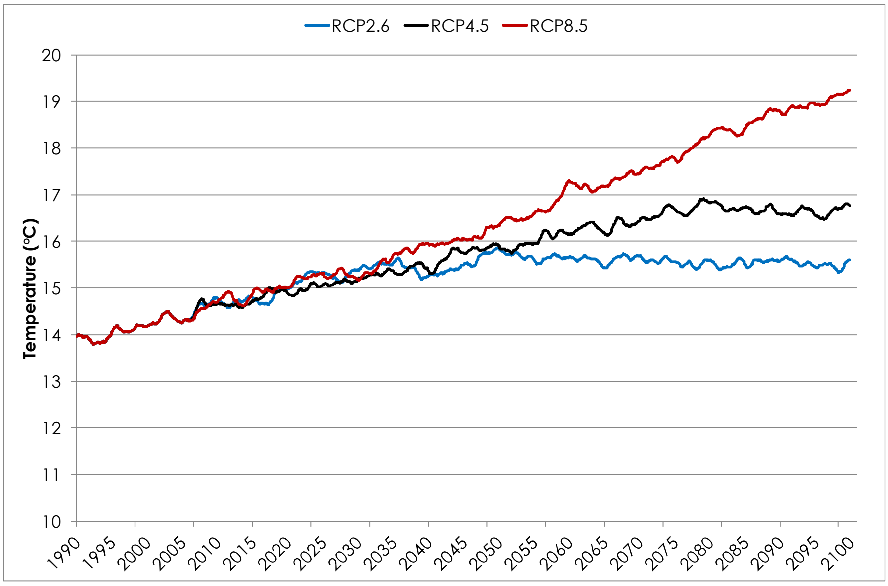



**Figure 6-2 Global mean near-surface air temperature for emission scenarios RCP 2.6, 4.5 and 8.5.**

Figure 6-3 shows projections constructed for Malta [14.5 °N, 35.9 °E], using moving averages of monthly mean values of the Met Office Hadley Centre (additional realizations contributed by the Instituto Nacional de Pesquisas Espaciais) HadGEM2 model data obtained from the CMIP5 data archives[61]. The same dataset was used as driving data for the regional climate model.

[61] http://cmip-pcmdi.llnl.gov/cmip5/availability.html.

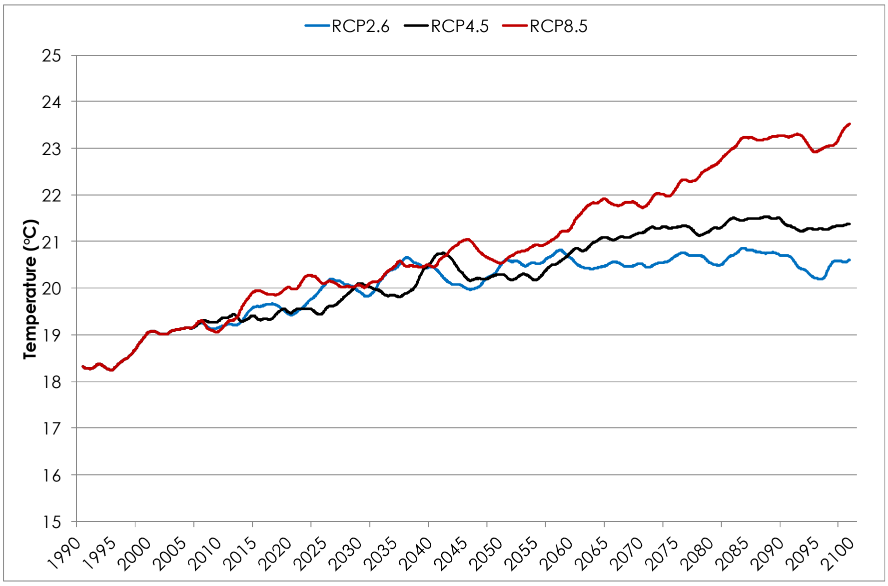



**Figure 6-3 Near-surface temperature projections for the Maltese Islands (1990-2100) based on emission scenarios RCP 2.6, 4.5 and 8.5.**

This simulated data reveals that all three scenarios result in an increase in average temperature for the area of the Maltese Islands, starting from the present-day air temperature (2005) shown at an average of about 19 °C. The main deviation between the three scenarios happens mid-century (around 2050), where the RCP8.5 scenario continues to show a steady increase in the air temperature trend reaching about 23.5 °C by the end of the 21st century, whilst the RCP4.5 and 2.6 scenarios appear to stabilize at approximately 21.5 °C and 20.5 °C respectively. For the Maltese Islands the trends in near-surface air temperatures are in line with what will occur at a global level.

### *6.2.3 Regional climate simulation with focus on the Central Mediterranean region*

The domain shown in Figure 6-4 was defined for the projections to be used in the downscaling simulations run on RegCM4.6.1, hereinafter referred to as RegCM4. The model description and testing were presented upon release in 2012 (Giorgi, et al., 2012). A 100×100 grid cells domain (each of 20 km horizontal resolution) defined by 6 °E to 25 °E and 31 °N to 47 °N was set up. The RegCM4 driving data were the CMIP5 HadGEM2-ES. The scenarios used for these projections were the RCP2.6, RCP4.5 and RCP8. Time series for Malta were extracted from coordinates 14.5 °N, 35.9 °E. The results in this section (Figure 6-5 to Figure 6-7) are based on annual, and seasonal for the years 2025, 2050, 2075 and 2099 compared to the same averages for the year 2005 which is the baseline year.

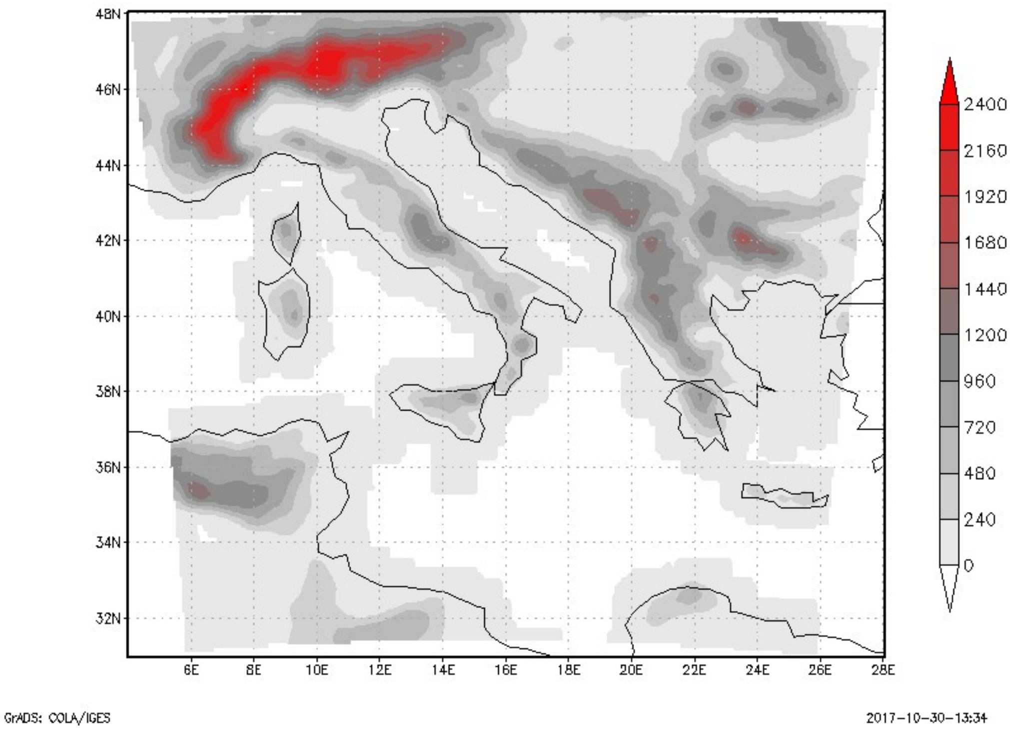



**Figure 6-4 Central Mediterranean domain defined for model runs with RegCM4.**

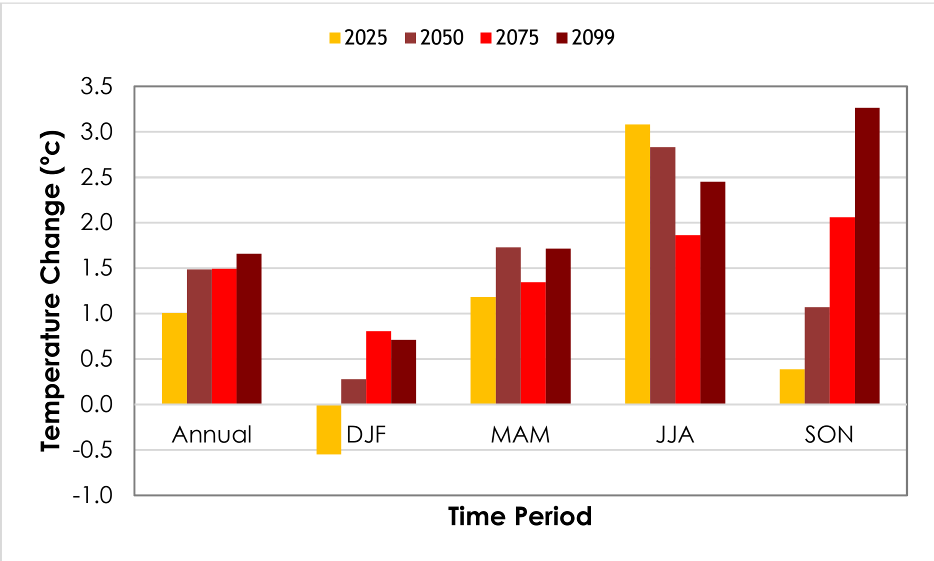



**Figure 6-5 RegCM4 modelled annual and seasonal change in near-surface average air temperature in Malta based on emission scenario RCP 2.6.**

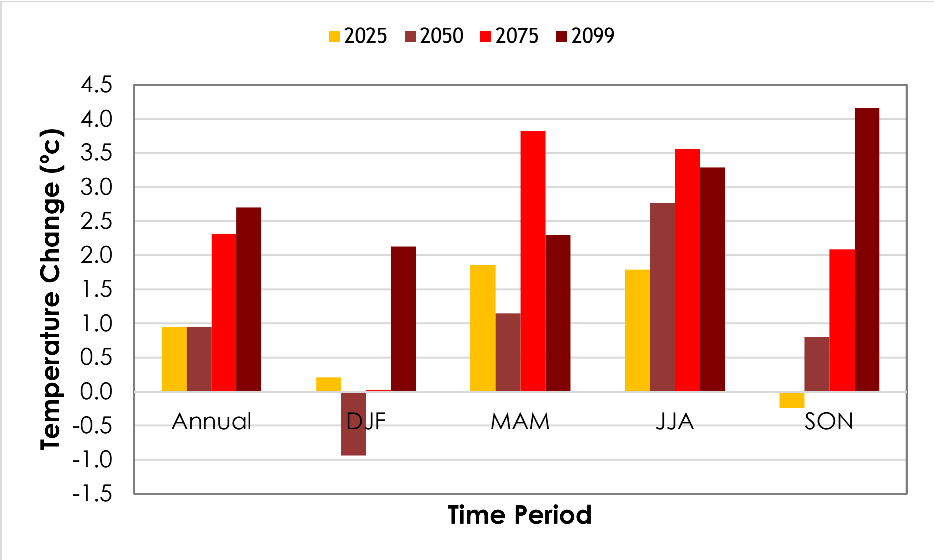



**Figure 6-6 RegCM4 modelled annual and seasonal change in near-surface average air temperature in Malta based on emission scenario RCP 4.5.**

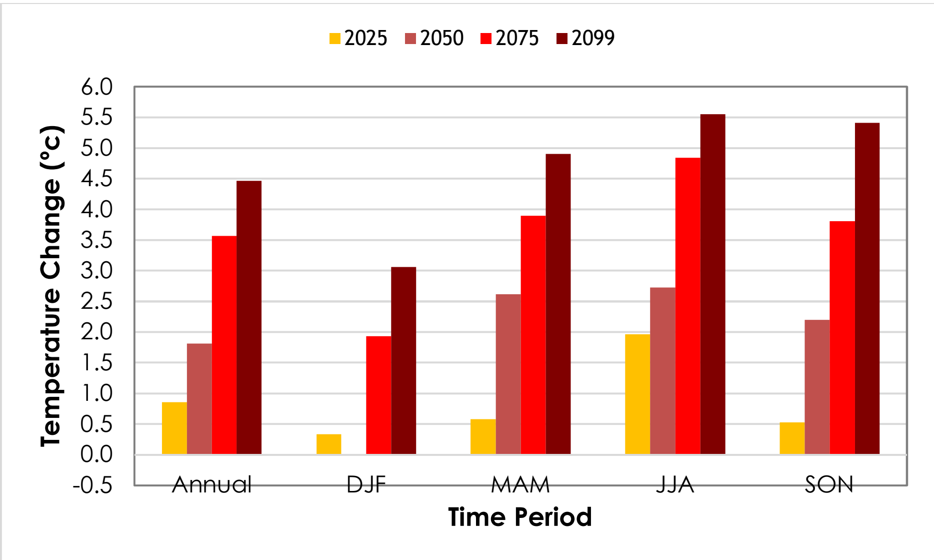



**Figure 6-7 RegCM4 modelled annual and seasonal change in near-surface average air temperature in Malta based on emission scenario RCP 8.5.**

**Table 6-5 Summary of modelled annual, seasonal and monthly changes according to the RCP 2.6 scenario, in temperature (°C) and change in precipitation (%) (with respect to year 2005) for Malta.**

| Malta RCP 2.6 | | Year | Annual | DJF | MAM | JJA | SON |
|---|---|---|---|---|---|---|---|
| HadGEM2 | Change in Temperature (°C) | 2025 | 1.24 | -0.21 | 1.50 | 2.53 | -2.17 |
| | | 2050 | 1.63 | 0.78 | 2.09 | 2.38 | 1.51 |
| | | 2075 | 1.08 | 0.29 | 0.81 | 1.47 | 1.97 |
| | | 2099 | 1.51 | 0.52 | 1.59 | 2.24 | 1.92 |
| | Change in Precipitation (%) | 2025 | 0.61 | 0.73 | -0.57 | 1.03 | -0.41 |
| | | 2050 | 0.39 | 1.06 | -0.49 | -0.71 | -0.21 |
| | | 2075 | 0.85 | 1.57 | 0.95 | -0.22 | -0.21 |
| | | 2099 | 0.02 | 0.45 | -0.18 | -0.50 | -0.53 |
| RegCM4 | Change in Temperature (°C) | 2025 | 1.01 | -0.55 | 1.18 | 3.08 | 0.39 |
| | | 2050 | 1.49 | 0.28 | 1.73 | 2.83 | 1.07 |
| | | 2075 | 1.49 | 0.80 | 1.35 | 1.86 | 2.06 |
| | | 2099 | 1.66 | 0.71 | 1.72 | 2.45 | 3.26 |
| | Change in Precipitation (%) | 2025 | 28.21 | 27.49 | -88.02 | -47.11 | 53.85 |
| | | 2050 | 41.05 | 76.22 | -92.37 | 185.23 | -22.15 |
| | | 2075 | 16.98 | 83.50 | 41.77 | 85.53 | -11.93 |
| | | 2099 | 1.36 | 126.43 | -39.55 | 19.20 | -70.62 |

**Table 6-6 Summary of modelled annual, seasonal and monthly changes according to the RCP 4.5 scenario, in temperature (°C) and change in precipitation (%) (with respect to year 2005) for Malta.**

| Malta RCP 4.5 | | Year | Annual | DJF | MAM | JJA | SON |
|---|---|---|---|---|---|---|---|
| HadGEM2 | Change in Temperature (°C) | 2025 | 1.24 | -0.21 | 1.50 | 2.53 | -2.17 |
| | | 2050 | 1.63 | 0.78 | 2.09 | 2.38 | 1.51 |
| | | 2075 | 1.08 | 0.29 | 0.81 | 1.47 | 1.97 |
| | | 2099 | 1.51 | 0.52 | 1.59 | 2.24 | 1.92 |
| | Change in Precipitation (%) | 2025 | 0.61 | 0.73 | -0.57 | 1.03 | -0.41 |
| | | 2050 | 0.39 | 1.06 | -0.49 | -0.71 | -0.21 |
| | | 2075 | 0.85 | 1.57 | 0.95 | -0.22 | -0.21 |
| | | 2099 | 0.02 | 0.45 | -0.18 | -0.50 | -0.53 |
| RegCM4 | Change in Temperature (°C) | 2025 | 1.01 | -0.55 | 1.18 | 3.08 | 0.39 |
| | | 2050 | 1.49 | 0.28 | 1.73 | 2.83 | 1.07 |
| | | 2075 | 1.49 | 0.80 | 1.35 | 1.86 | 2.06 |
| | | 2099 | 1.66 | 0.71 | 1.72 | 2.45 | 3.26 |
| | Change in Precipitation (%) | 2025 | 28.21 | 27.49 | -88.02 | -47.11 | 53.85 |
| | | 2050 | 41.05 | 76.22 | -92.37 | 185.23 | -22.15 |
| | | 2075 | 16.98 | 83.50 | 41.77 | 85.53 | -11.93 |
| | | 2099 | 1.36 | 126.43 | -39.55 | 19.20 | -70.62 |

**Table 6-7 Summary of modelled annual, seasonal and monthly changes according to the RCP 8.5 scenario, in temperature (°C) and change in precipitation (%) (with respect to year 2005) for Malta.**

| Malta RCP 8.5 | | Year | Annual | DJF | MAM | JJA | SON |
|---|---|---|---|---|---|---|---|
| HadGEM2 | Change in Temperature (°C) | 2025 | 0.70 | 0.40 | 1.28 | 1.23 | -3.34 |
| | | 2050 | 0.69 | -0.59 | 0.81 | 1.84 | 0.93 |
| | | 2075 | 2.30 | 0.80 | 3.09 | 2.91 | 2.62 |
| | | 2099 | 2.27 | 2.20 | 2.38 | 2.44 | 2.28 |
| | Change in Precipitation (%) | 2025 | 0.52 | 0.80 | 0.21 | -0.32 | 0.09 |
| | | 2050 | 1.12 | 0.60 | 0.10 | -0.47 | 1.21 |
| | | 2075 | 0.16 | -0.28 | 0.20 | -0.23 | 0.13 |
| | | 2099 | 0.43 | -0.01 | 0.07 | 1.66 | 0.30 |
| RegCM4 | Change in Temperature (°C) | 2025 | 0.94 | 0.20 | 1.86 | 1.79 | -0.24 |
| | | 2050 | 0.95 | -0.94 | 1.15 | 2.76 | 0.80 |
| | | 2075 | 2.31 | 0.02 | 3.82 | 3.55 | 2.08 |
| | | 2099 | 2.70 | 2.13 | 2.30 | 3.29 | 4.16 |
| | Change in Precipitation (%) | 2025 | 47.80 | 138.64 | -48.50 | 115.36 | 97.63 |
| | | 2050 | 57.62 | 46.37 | -43.82 | 199.65 | 135.61 |
| | | 2075 | 3.62 | -31.81 | 20.64 | 94.34 | 57.64 |
| | | 2099 | 20.34 | 16.37 | -31.89 | 55.03 | 61.48 |

Compared to the last communication, the RegCM4 projections' results summarised in Table 6-5 to Table 6-7 indicate that there will be a slight increase in temperature for RCP4.5 over the next century.

The rate of increase in the average annual temperature projected from 2025 onwards is slightly less than that reported in the last communication for emission scenario RCP 8.5. It is projected that there will be an increase in temperature in September-October-November (SON) but accompanied by a slight decrease in the change of temperature in the remaining months.

### 6.2.4 Developing the local capability to study impacts of climate change

In 2015, the Department of Geosciences was established within the Faculty of Science at the University of Malta. The Atmospheric and Climate Research Group is responsible of the measurement of trace pollutants and modelling activities over the Maltese Islands. Measurements of trace pollutants are taken at the GAW station at Ġiordan Gozo. Modelling activities are ongoing using the community regional climate model RegCM4, in collaboration with the Earth System Physics (ESP) section of the Abdus Salam International Centre for Theoretical Physics (ICTP) that maintains this model. Since then, a PhD student was awarded a local grant (Malta Government Scholarship Scheme: Postgraduate) to contribute to the development of RegCM4 by looking into modelling the radiative forcing impacts of Secondary Organic Aerosols (SOAs).

Apart from being pollutants causing various health concerns, aerosols cause changes in temperature and precipitation because of their effect on radiation and cloud droplets, and hence influence the climate. Observations also suggest that organic aerosols are the most important contributors to light scattering. SOAs are produced by the chemical oxidation of a gaseous precursors and are likely to have an important role in the aerosol-cloud interactions.

The module developed will be implemented in an updated version of RegCM4 after rigorous testing would have been carried out. In this modified configuration, the model would also be useful in the projection of various atmospheric pollutants and hence, project the pollutant influence on climate change; both of which are very important issues within European countries.

Since the last National Communication, the numerical weather prediction model Weather and Research Forecasting (WRF) has been operated and tested to optimise a configuration suitable for small island states which are well known to the scientific community to be very challenging to model especially within the Mediterranean basin.

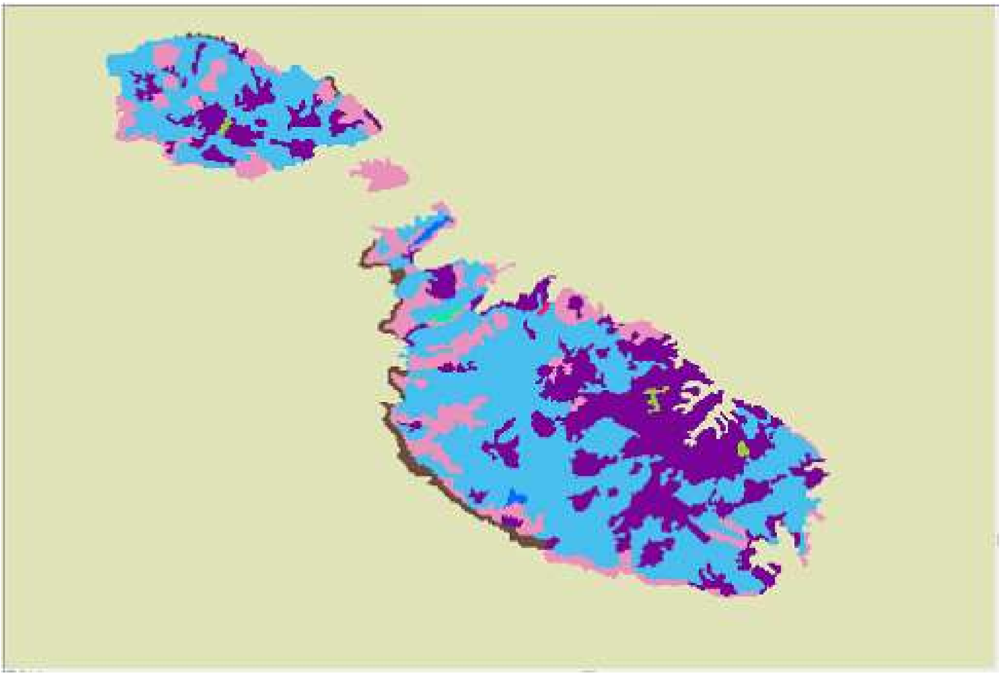


**Figure 6-8 Latest land use categories defined for Malta and used within WRF (Copernicus, 2017).**

**Figure 6-9 Latest high-resolution topography defined for the Maltese Islands to be updated in WRF (EU Open Data Portal, 2017).**

After several tests, it has been identified that the WRF configuration applicable in the central Mediterranean area:

A progressive input of sea surface temperatures is important for islands.

The physics schemes required by WRF in a configuration for small islands need further testing for appreciable improvements in lowering bias in the modelled results.

Land use categories within WRF were modified according to the highest resolution land use database available in the Copernicus land monitoring service, Corine Land Cover, 2012 (See Figure 6-10).

A project is proposed to update the topography of the Maltese Islands in the land surface model which appears to be of utmost importance in the WRF performance for synoptic and local scales using the high resolution European Environment Agency Data Elevation Model data available. (See Figure 6-11).

## 6.3 Vulnerability assessment and adaptation measures

This section provides an analysis of vulnerabilities for Malta as a result of climate change, building upon discussions on vulnerability in the First and Second National Communications submitted by Malta, as well as the National Adaptation Strategy[62] finalized in 2012. The sectors subject to a vulnerability assessment have been chosen on the basis of their being of priority concern for Malta given also the current state of play of these resources and activities. Both the Second National Communication and the National Adaptation Strategy stress the need to focus on priority sectors in the first years and to move on to further study vulnerability in other sectors aiming at a

[62] *National Climate Change Adaptation Strategy*, Ministry for Resources and Rural Affairs, 2010.

comprehensive approach to the extent possible. It is the intention of the Maltese authorities to extend the vulnerability assessment to other sectors in staggered fashion.

The section also provides a cross-sectoral vulnerability assessment apart from the sectoral one. It also assesses vulnerability to climate change for Malta under five main, horizontal headings: the institutional/regulatory, methodological, technological aspects as well as capacity-building. The Second National Communication and the National Adaptation Strategy stress that any efforts to address the sectoral vulnerabilities may fail, if these are not supported by the appropriate framework required for good governance of adaptation to climate change namely, a robust institutional, regulatory, methodological and technological set up that is administered by highly-skilled human resources and supported by the required funding for research and innovation that focus primarily on the local scenario. The cross-sectoral vulnerability assessment identifies also any existing gaps and constraints that are obstructing the implementation of adaptation measures to climate change. These include also logistical and practical difficulties relative to the local circumstances that hinder compliance with the same.

The following major sectors have been identified by Malta as requiring attention when devising adaptation measures due to their current vulnerability, which increases their proneness to risk from climate change:

- Water Resources;
- Infrastructure and Land Use;
- Natural EcoSystems;
- Agriculture and Fisheries;
- Health;
- Civil Protection and Vulnerable Groups;
- Tourism;
- Immigration.

Delving into the individual sectoral needs of the topics was deemed essential under the First and Second National Communication as well as the National Adaptation Strategy to ensure that measures adopted provide the adequate preparedness to the negative effects of climate change. Nevertheless, all sectoral measures need to be screened holistically to ensure coherence, compatibility and equitable burden sharing across them. Adaptation measures that target a stronger and better maintained infrastructure would reduce the negative impacts of extreme weather events, relieve congestion in highly populated areas and render Malta more attractive to tourists and residents alike. Adaptation measures targeting the built environment would promote reduced costs in heating and cooling, protect the built heritage and render the general public more aware on the need to change behavioural patterns to enjoy a healthier environment. Measures to promote the conservation of biological diversity as well as other non-living resources serve to ensure sustainability and preserve the islands' natural heritage. A sound water policy is in itself an indispensable measure that safeguards above all food security and hygiene.

The extent of vulnerability or risks Malta is exposed to, as a result of climate change is directly related to the degree of adaptation measures that are required to ensure preparedness and resilience to the effects of such a phenomenon.

Malta's size and insularity are particularly important in defining the economy in its relation to climate change. The fact that islands contribute insignificant amounts to global emissions does not preclude the Islands from impacts, which will mostly result from the effects of climate change such as drought, the resileince of pests derimental to human, animal and plant health and sea level rise.

Previous Communications produced a summary of vulnerability and adaptation to climate change of small island states which is still relevant today. The factors identified in the Second Communication that increase vulnerability to climate change include:

- high susceptibility to natural phenomena and hazards, often as a result of the significant presence of socio□economic activities in coastal areas;
- extreme openness and high sensitivity to external market shocks, such that small island states would be highly susceptible to climate changes that influence not only them but also other countries;
- high dependence on tourism, a sector that is especially susceptible to climate change;
- high population densities, implying more extreme socio□economic effects over limited areas;
- poorly developed infrastructure, which reduces the scope for mitigation and adaptation;
- relatively thin water lenses that are easily disturbed by changes in climatic conditions.

The limited space and resources and relative isolation, in addition to urgent economic growth and development targets are some of the features of island states to adapt. In the Second Communication a vulnerability index was developed for the production activities as well as for the expenditure activities. The results are reproduced below in Table 6-8 and Table 6-9.

**Table 6-8 A qualitative assessment of climate change vulnerability of production activities. (MRRA, 2010)**

| | Current | | Future | |
|---|---|---|---|---|
| | Economic Weight (%) | Sector Vulnerability | Economic Weight (%) | Sector Vulnerability |
| **Agriculture and fisheries** | 2.5 | 2.4 | 2.0 | 2.3 |
| **Industry** | 20.9 | 1.6 | 17.5 | 2.4 |
| **Distribution** | 11.5 | 2.3 | 9.0 | 2.3 |
| **Transport and Communication** | 10.0 | 2.5 | 10.0 | 2.7 |
| **Financial** | 4.5 | 1.4 | 10.0 | 1.4 |
| **Private Services** | 31.7 | 1.4 | 34.0 | 1.3 |
| **Public Sector (incl. Utilities)** | 18.9 | 2.2 | 17.5 | 2.7 |
| **Overall Production Vulnerability** | **100.0** | **1.8** | **100.0** | **2.0** |
| *Index of Sector Vulnerability<br>0 = None; 1= Negligible; 2 = Moderate; 3 = Strong | | | | |

**Table 6-9 A qualitative assessment of climate change vulnerability of expenditure activities. (MRRA, 2010)**

| | Current | | Future | |
|---|---|---|---|---|
| | Economic Weight (%) | Sector Vulnerability | Economic Weight (%) | Sector Vulnerability |
| **Private Consumption** | 33.9 | 1.7 | 35.0 | 2.3 |
| **Public Consumption** | 11.1 | 1.5 | 7.0 | 1.5 |
| **Investment** | 11.0 | 2.0 | 10.0 | 2.0 |
| **Tourism Exports** | 10.0 | 3.0 | 9.0 | 3.0 |
| **Other Exports** | 34.1 | 1.5 | 39.0 | 1.5 |
| **Overall Expenditure Vulnerability** | **100.0** | **1.8** | **100.0** | **2.1** |
| *Index of Sector Vulnerability<br>0 = None; 1= Negligible; 2 = Moderate; 3 = Strong | | | | |

As demonstrated above the Second National Communication of Malta to the UNFCCC identified various vulnerability and adaptation issues in individual sectors such as health, water resources, migration and demographic changes, biodiversity conservation, waste management, the built environment, telecommunications and transport. These reports on individual sectors supplement an earlier report on 'Technology Needs for Adaptation to Climate Change'[63]. The National Adaptation Strategy built upon the work on adaptation carried out by the Second National Communication. The primary focus of the Strategy was to highlight also the need for awareness on adaptation to climate change and for instilling a sense of ownership across all sectors to mainstream climate change into cross-sectoral and sectoral policies so as to facilitate the implementation of such measures.

The Committee of Experts working on the Adaptation Strategy agreed to focus on two main basic issues namely that the adaptation strategy had to highlight sectors that are already very vulnerable rather than aim to be comprehensive from the outset. Identifying adaptation measures and the required methodologies to implement them, is a learning curve process so the committee preferred to focus first on the sectors that appeared to show highest vulnerability to climate change. Second, the Committee agreed that preparedness must be tailor-made to suit the local scenario since the subjective character of adequate adaptation measures is particular to Malta's geophysical characteristics as a small island nation and to its socio economic and environmental realities. The Committee also identified that there are various types of adaptation measures, namely anticipatory and reactive adaptation, autonomous and planned adaptation. It was also acknowledged that adaptation involves both the public and private sector. The National Strategy on Adaptation examined both the current state of play from a cross-sectoral and sectoral perspective and made several recommendations to address the vulnerabilities that emerged. The recommendations made served to launch a series of initiatives to review the existing state of play and improve the level of preparedness to climate change in a staggered but consistent manner.

This section of this chapter follows upon the work carried out since the launch of the Strategy and first identifies the state of play and then the measures that are being taken and/or proposed to be taken to address adaptation. The section is split into cross-sectoral and sectoral issues for reasons explained above. The cross-sectoral aspect is split into two main categories, the institutional, the regulatory framework and the Technical and Capacity Building Framework. The sectoral part which follows tackles the most salient sectors that have been identified as most vulnerable to climate change. Both the cross-sectoral and the sectoral aspects give first an over view on the current state of play and then report what is currently being done to address vulnerability in relation thereto.

## 6.3.1 Cross-sectoral vulnerability to climate change

### 6.3.1.1 Institutional organization and the regulatory framework

#### (1) STATE OF PLAY

As an Annex I Party, Malta has formulated a National Mitigation Strategy and a National Adaptation Strategy. It is currently working on its Low Carbon Development Strategy (LCDS). A Vision Document for the LCDS has been published, was open for public consultation and is currently being considered for further elaboration and drafting of a final LCDS. Malta has also a cohort of laws that establish emission reduction targets on the sectors that participate in emissions

[63] Mallia A., Xuereb R., Cutajar J., Technology Needs for Adaptation to Climate Change, Working Group VI – Malta's Climate Change Initiative, 2005.

trading, namely power plants and the aviation industry as well as laws imposing targets to generate energy from renewable, including bio fuels as well as energy efficiency in buildings.

In 2015 Malta published a Climate Action Act, which established the Climate Action Board (CAB) and the Climate Action Fund (CAF). The Climate Action Act lays down a legal framework for climate action, which together with the strengthening of the institutional set up can ensure an efficient administrative, policy and legal approach to, mitigation, adaptation and governance measures. The aim of the Act is to mainstream climate change across all sectors and to facilitate cooperation accordingly. It supplements the previously existing administrative Inter Departmental and Inter Ministerial Committees with a legal framework.

Under the Climate Action Act the Government has a duty to protect climate for the present and future generations by developing periodically, updating and publishing national inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases in order to monitor progress towards achieving its quantified emission limitation or reduction commitments pursuant to international treaties and its obligations as a Member State of the European Union. The government is also bound to formulate, implement, publish and update policies regarding measures to mitigate climate change by limiting, and, to the extent possible, reducing anthropogenic greenhouse gas emissions by sources, and by enhancing removals of greenhouse gases by sinks. Government is also bound to formulate, implement, publish and update policies regarding measures to prevent, avoid, reduce, and reduce vulnerability and enhance resilience to the adverse impacts of climate change, and to facilitate adaptation to climate change.

Under the Climate Action Act, the government also has an obligation to promote sustainable management of sinks and reservoirs of greenhouse gases including all terrestrial, coastal and marine ecosystems and promote and cooperate in the conservation and enhancement of sinks and reservoirs of greenhouse gases including all terrestrial, coastal and marine ecosystems.

The added value of the Act lies in the regulatory role it gives to the Minister responsible for climate change, namely the power to publish regulations on climate action governance and adaptation, apart from mitigation. which was already well regulated. Additionally, the CAB has the obligation to monitor implementation of climate action and present it for parliamentary scrutiny. Existing sectoral laws and policies on resource management may already serve to facilitate adaptation to climate change and contribute to ensure resilience in view of the negative impacts of climate change upon natural resources. However, it is clearly apparent that regulating climate adaptation and climate action governance is works in progress. Preparedness requires more in-depth research, to identify the socio economic and environmental impacts at the cross-sectoral and sectoral level so as to address vulnerability to climate change and to implement the requisite adaptation measures.

Furthermore, the Climate Action Act has established as a legal obligation, the formulation of a climate adaptation strategy. The Minister shall, in consultation with other Ministers competent to take cognizance of the matter, and in consultation with civil society, environmental organizations and the general public, prepare a national adaptation strategy, to contribute to the prevention, avoidance, and reduction of the adverse effects of climate change, and to facilitate adaptation to climate change. The CAB is responsible for the transparent monitoring of progress made by the government in reducing vulnerability and enhancing resilience to the adverse impacts of climate change.

In accordance with the Climate Action Act, the national adaptation strategy shall also include information on climate change relating to Malta and on actual and projected impacts of climate change on Malta. The Minister shall ensure that the national adaptation strategy is reviewed and updated periodically, and at least every four years. The Minister shall make available to the public the national adaptation strategy and any updates thereof. The Minister shall lay on the Table of the House of Representatives, the National Low-carbon Development Strategy and the National Adaptation Strategy and their updates, at least once every four years. The Minister shall every year report to the House of Representatives the progress registered in meeting the targets set by the low-carbon development strategy and the national adaptation strategy.

#### 6.3.1.2 International and regional cooperation for adaptation to climate change

Malta aims also to facilitate cooperation between the EU and Mediterranean states in the compilation of data and study of observation systems to enhance climate change resilience in teh Euro Med region. Cooperation may improve data modelling including emission scenarios and climate change impacts scenarios at a local scale as well as monitoring systems.

The EU and the third party Mediterranean states may enhance mutual cooperation by participating in regional capacity-building programmes. It is also essential to include as a regional legal obligation, the publication of information acquired as a result of research conducted or carried out locally to civil society. The Mediterranean states have a legacy to demonstrate to other states that they can overcome their usual political differences and lead by example when it comes to regional cooperation in the field of environmentally related issues.

The Mediterranean Action Plan was the very first regional seas programme to be concluded and has served as a proto type for others. The scenarios regarding the impacts of climate change in the Mediterranean should serve as a alarm bell to prod the Mediterranean states into action. This is an opportunity for both the EU and Mediterranean states to rise to the occasion and to be the first group of states that seek to address climate change adaptation from a regional perspective. The positive repercussions could be various. Such an initiative would serve to strengthen the leadership role the EU strives to maintain in climate change politics, it would demonstrate that it is possible for developing and developed states to agree on legal and policy instruments for adaptation. It could support the multilateral negotiating process to meet the emerging challenges that climate change presents. On an International and Regional level Malta is also committed to cooperate in supporting opportunities for increased technical know-how and capacity building within the European Union, as a Small Island State and through the Union for the Mediterranean so as to outreach similar states with identical vulnerabilities.

Under the Climate Action Act, the Government shall participate, cooperate and support participation in, international and inter-governmental activities and programmes related to climate action. The Government shall promote activities that relate to climate action relevant to the Mediterranean region.

### 6.3.2 Sectoral vulnerability to climate change

#### 6.3.2.1 Water resources

**(1) STATE OF PLAY**

Most of Malta's natural freshwater is stored in underground aquifers, large lens-like bodies of freshwater floating on sea water, stored in porous rocks. This water is renewed when rainwater is absorbed into the ground and percolates into these groundwater bodies. It takes several decades for rainwater to reach Malta's mean sea level aquifer, the largest freshwater reserve on the islands.

Malta is amongst the world's top ten water scarce countries with only around 70 cubic meters of naturally occurring freshwater available per capita, if one considers groundwater (this would rise to around 100 cubic meters if potentially harvestable rainfall runoff is also taken into consideration). The limited water resource makes the country dependent on desalinated water for around 60% of its potable water production.

Climate change may impact the hydrological cycle and subsequently the water quality and availability. The first preliminary assessment of impacts of climate change on water was carried out in 2004 for Malta's First National Communication. The conclusions at the time were that:

- the Maltese Islands are expected to experience a decrease in the national water resources mainly due to increased evapotranspiration rates, and
- alteration in subsurface water movements and sea level rise.

The main parametric differences which were identified to have an impact on the availability of water resources are as follows[64]:

- an increase in the mean annual air temperature of +0.69 °C in 2010 when compared to the climate norm of 1961-1990, showing a maximum increase of +1.2 °C in 2001. The highest maximum temperature increased by +2.0 °C in 2001, while the highest minimum increased by +2.0 °C in 2008;
- rainfall patterns show a relatively high spatial variability over the Maltese territory and no definite trend in the observed precipitation. The most recent study did not analyse the change in seasonal patterns or change in the frequency of thunderstorms;
- the recorded decrease in the mean annual cloud cover over Malta amounts to –0.2 oktas when compared to the Maltese climate norm of 1961-1990;

### (2) VULNERABILITY OF MALTA'S WATER RESOURCES

Water security has always been a challenging issue for civilization on the Islands. This stems from a low availability of natural water and a high population density, and hence, high water demand.. By the end of 1980s, 30% of Malta's energy bill was devoted to desalination and although this figure has gone down to less than 4%. Conversely, the illegal extraction of groundwater has remained to the detriment of this highly vulnerable natural resource. This is an effect of the high-water demand and even if Malta achieves high levels of efficient water use, the demand would still be around twice what nature can provide.

Since becoming a member of the EU in 2004 Malta has strengthened its policy and legal framework regulating water but more remains to be done and since natural water resources will suffer the highest negative impact as a result of climate change[65], water resource management is ear marked as a priority in order to ensure the resilience of this vulnerable and scarce resource.

Climate change can significantly change the status of natural water resources in Malta. As reported in the Second National Communication to the UNFCCC the hydrological cycle can be altered to cause a change in:

- the intensity and frequency of extreme rainfall events (floods and droughts);
- the amount of water available and the demand exerted thereon;
- water quality (e.g. temperature and nutrient content).

Studies have showed that whilst there is no evidence to link climate change to adverse impacts on natural water resources on Malta, the risks of climate change becoming a serious issue in the future are real.

The Second Communication detailed some of the characteristics of the main aquifers in the islands and the potential impact of climate changes. It is in this context that the potential

[64] Data was obtained from the most recent NSO climate study (Galdies, 2011).
[65] See: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch11s11-3.html.

outcomes that might prevail are to be seen to have the following potential effects on water resources in Malta namely:

a) variability in inter annual and intra annual rainfall will have corresponding effects on demand as well on the amount of water potentially available for recharge;
b) seasonal scarcity of precipitation when the water requirements of the agriculture and tourism sectors are highest (normally from June to August) could contribute to increased pressures on freshwater resources;
c) high rainfall intensity events, with shorter durations, will have a lower contributing effect to recharging groundwater resources and increase the generation of storm water runoff;
d) frequent occurrence of low rainfall years when groundwater recharge is likely to be low;
e) frequent occurrence of high rainfall years when runoff is likely to be high (this is dependent on the distribution of rainfall);
f) increased demand for water resources to combat the effects of higher temperatures;
g) higher evapotranspiration rates that will demand increased water volumes for cultivated areas;
h) a potential increase in the salinity of groundwater resources if sea water levels rise with salty water replacing freshwater sources.

The problems that are envisaged to cause lower availability of naturally renewable water resources as a result of changes related to climate are identified with respect to lower annual rainfall volumes, high rainfall intensity, and increased evapotranspiration.

### (1) ADDRESSING VULNERABILITY OF WATER RESOURCES

Malta is taking major steps to adapt the water sector to climate change:

- A comprehensive national Water Catchment Management Plan which mainstreams climate change adaptation obligations[66];
- A holistic approach to water management, by maintaining the quantity and quality and status of ground water sources, via the introduction of an integrated water resources management approach;
- The treatment of wastewater to provide alternative supply of water for industry and agriculture;
- Adoption of sustainable strategies for the management of rain water runoff;
- An assessment of the relationship and risks between climate change/water resources/food security/public hygiene.

Malta has greatly benefitted from the EU's policy and legal framework on water management, which addresses the management of all water resources, particularly through the Water Framework Directive[67]. Maltese water law establishes "*a framework of action*" for the protection of inland surface waters, transitional waters, coastal waters and ground water. Since climate change in the Malta would not only affect the quantity but also the quality of water resources, Maltese water law aims also to:

- address emissions and discharges that affect water, whether via point or diffuse sources, irrespective from where they originate, such as for example from fertilizers and pesticides in soils
- prevent the deterioration of the status of all the bodies of water which is closely linked to the above and

[66] http://energywateragency.gov.mt/en/Documents/2nd%20Water%20Catchment%20Management%20Plan%20-%20Malta.pdf
[67] Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy; OJ L 327, 22.12,2000, pg 1.

- implement the measures necessary to reverse any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity in order to reduce progressively water pollution.

As discussed above, desalination of sea water, and extraction of groundwater, are the main fresh water sources in Malta, and together with rainwater harvesting, and treatment of wastewater, they constitute all the fresh water sources in Malta. Although the energy requirements for desalination have decreased in the last decade, desalination remains an energy intensive process, so the need to address adequate management of groundwater already an over-exploited resource, becomes even more crucial for adaptation in the water sector. The primary drivers of the national water policy and legal framework that supports it, are ensuring the sustainable use of groundwater resources, the improvement in the efficiency of the desalination process, the improvement of rain harvesting methods and the development of treated waters as a New Water resource; enabling national water demand to be met through the conjunctive use of these water resources, whilst ensuring that demand is kept at the highest possible efficiency levels. Government has launched a 'Programme of Measures' in Malta's 2nd Water Catchment Management Plan aimed at achieving the environmental objectives for the water environment required under the EU's Water Framework Directive, and more specifically good quantitative status in all bodies of groundwater by 2021.

This will be achieved through the implementation of the suite of measures developed under Malta's Programme of Measures including the launching of a National Water Conservation Campaign, the achievement of high efficiency levels in water supply distribution, the improved regulation of groundwater use, investment in desalination technology to optimise the energy efficiency of the process, the adoption of upstream sustainable drainage and nature based water retention solutions for the better management of rainwater runoff and the distribution of highly polished treated waters to facilitate their use in lieu of groundwater.

Adaptation measures in the water sector will also address coastal water management, a sector that is significantly vulnerable as a result of climate change both as a habitat and as a zone of intense economic activity. Indirectly the regulation of coastal zone management is also a vital issue for adaptation to sea level rise, although this falls more under the infrastructure sector, as is the case with anti-flooding measures and the regulation of water catchment that is discussed below. Coastal zone waters management is guided by an important set of legal parameters aimed at ensuring a good qualitative status for these waters. The competent authorities are taking the necessary policy and legal measures to ensure that the environmental objectives for coastal water management are met, that any significant and sustained upward trend in the degradation of coastal water quality and the concentration of any pollutant resulting from the impact of human activity in order to reduce progressively pollution of coastal waters is reversed.

#### *6.3.2.2 Infrastructure and land use.*

##### (1) STATE OF PLAY

As a densely populated island state of around 1,400 persons per square kilometre, infrastructure and land use requirements have long been considered as a major competing force against the conservation of natural habitats and eco systems. Land development and planning policies and laws have curbed urban sprawl to some extent but the need for better infrastructure for new developments whether demanded by socio-economic needs or the leisure industry remain subject to a highly polarized debate. As Maltese society becomes more affluent, developers and the government are investing more and more money in state-of-the-art land use and infrastructural projects. The impacts from climate change on the islands including sea level rise, changes in temperature, extreme weather events will have strong negative impact upon the built environment, buildings and infrastructure. A better understanding of these impacts and the associated risks is necessary to plan and develop better the built environment and its supporting infrastructure.

Malta is densely populated, and land resources are scarce. Urban development, agriculture, industrial and commercial activities and quarrying are the main land uses, which add significant pressures on the Maltese countryside. A significant percentage of Malta's urban development also lies on the coast, covering 35% of the coastal zone in Malta and 19% of the coast of Gozo.

Climate change will impact Malta's land use in a number of ways including flooding of coastal areas, drought stress on agriculture, extreme weather events (including flooding) and impacts on structures and infrastructure, secondary impacts on property values and insurance, impact on plants, vegetation and subsequently on human health (Birch Hill GeoSolutions, 2006).

The infrastructure of the Maltese Islands will not be immune to climate change, albeit at different levels depending on its development, resilience and adaptability. The following sectors are discussed in this report: energy, transport, telecommunications, buildings and waste.

### *(A) LAND COVER AND LAND USE IN MALTA*

The last report on land use in Malta was published by the National Statistics Office in 2006 (Table 6-10). This report does not take into account the recent economic growth experienced in the islands, which was complemented with an intensification and growth in development and the building sector, changes to the laws regulating quarries (and their rehabilitation) and changes to the rural development guidelines, all having the potential to contribute to changes in land use in the islands.

According to Table 5-8, agriculture accounts for almost half of Malta's land area (47.5%) whilst natural vegetation areas account for almost 20% of the land cover. The urban area, including industrial parks, airport and port areas cover an area of equivalent to 28% of the land.

The major changes in land cover were experienced prior to the introduction of formal planning in the early 90s. Following the setting up of a planning authority the loss of agricultural/naturally vegetated areas to buildings slowed down..

The pressures of the different activities on the land are very evident and the challenges for planners will require a structured approach to ensure sustainability.

More importantly with respect to climate change are the parts of the coast which have been over developed throughout the years. The 2002 Coastal Strategy Topic Paper prepared by the Malta Environment and Planning Authority identified these uses as predominant around the coast: tourism and recreation; settlement; agriculture, aquaculture; fisheries; shipping; mineral extraction; infrastructure; and, industrial estates.

**Table 6-10 Land use in Malta (2006) (NSO, 2011).**

| Description | $Km^2$ | % of total area |
|---|---|---|
| Agriculture with significant area of natural vegetation | 149.93 | 47.5 |
| Airports | 3.72 | 1.2 |
| Complex cultivation patterns | 10.71 | 3.4 |
| Coniferous forest | 0.67 | 0.2 |
| Built-up area | 70.39 | 22.3 |
| Dump sites | 0.41 | 0.1 |
| Green urban areas | 1.81 | 0.6 |
| Industrial or commercial units | 8.11 | 2.6 |

| | | |
|---|---|---|
| Mineral extraction sites | 3.86 | 1.2 |
| Mixed forest | 1.43 | 0.5 |
| Non-irrigated arable land | 0.59 | 0.2 |
| Port areas | 2.32 | 0.7 |
| Salines | 0.25 | 0.1 |
| Sclerophyllous vegetation | 49.69 | 15.8 |
| Sparsely vegetated areas | 8.11 | 2.6 |
| Sport and leisure facilities | 3.09 | 1.0 |
| Vineyards | 0.27 | 0.1 |
| **Total** | **315.35** | **100.0** |

In July 2015 the Government of Malta approved and published the Spatial Plan for Environment and Development (SPED), superseding the previous Structure Plan for the Maltese Islands which guided planning and land use development in the islands since the inception of planning in the early 90s. The SPED identifies the challenges of climate change and climate change adaptation, particularly related to changes in weather patterns and the rise in sea level, and the subsequent threats to water sources, vulnerable ecosystems and emissions.

In its spatial framework it also identifies Climate Change as a thematic objective: to control greenhouse gas emissions and enhance Malta's capacity to adapt to climate change. Nine specific measures are identified under this thematic objective.

1) Supporting the implementation of Malta's Energy and Water Policies.
2) Supporting the implementation of the National Mitigation Strategy and National Adaptation Strategy.
3) Requiring the integration of small scale renewable energy infrastructure into the design of buildings, particularly in public, industrial and commercial sectors.
4) Promoting renewable energy sources and zero carbon modes for transport.
5) Directing large scale solar farms to areas as identified in the proposed Solar Farm Planning Policy.
6) Promoting energy efficiency in the design of buildings.
7) Ensuring that development plans and proposals contribute to national targets for GHG reductions and mainstream climate change adaptation measures.
8) Directing development away from areas which are prone to significant risk of flooding with the exception of interventions required to manage these areas.
9) Improving public/collective transport as a high priority adaptation measure for Climate Change.

*(B) THE INFRASTRUCTURE IN MALTA*

Specific infrastructure identified in the previous Communications have also been assessed for their vulnerability. Within this coastal zone lie also some of the most important infrastructures for Malta. In the case of energy, the islands are dependent on a national grid with all the electricity requirements generated locally in one power plant at Delimara, located within Marsaxlokk Bay (in the south of the island). An electricity interconnector with Sicily started operating in April 2015 delivering electricity to the islands from the European mainland.

The Interconnector comprises a 120-kilometre high voltage alternating current (HVAC) system capable of bidirectional flow of electrical power, transferring 200MW of electricity. In Sicily, the Interconnector is linked to the Italian network at 230kV at the Terna substation in Ragusa. The submarine cable lands in Malta at Qalet Marku, Bahar ic-Caghaq and transmits electricity to the distribution network at 132kV through a nearby Enemalta terminal station at Maghtab. Besides the electricity copper power cables, the submarine cable between the two islands also includes two fibre optic clusters. Enemalta use this capacity to transmit the data required in the operation of the Interconnector's monitoring, protection and control systems. All equipment installation and cable jointing works in Malta and in Sicily were completed by the end of December 2014. Testing of all systems commenced in January 2015. During the same month, Enemalta plc and Enel Trade signed a framework five-year agreement to use the Interconnector for the importation of electricity from Italy. The project was part-financed through the European Union's European Energy Programme for Recovery (EEPR).

The recent shift from fuel oil to gas, achieved through the building of a new power station and gas facilities, have reduced Malta's dependence on oil and related emissions. The interconnector with Sicily has also ended the isolation of Malta's energy grid.

Fuel storage is still carried out at the following installations (each of which have an active Environmental Permit application which is being processed, and are still being used for the storage and transfer of fuel):

- 31st March 1979 at Birzebbugia (*due to be dismantled and decommissioned*);
- Wied Dalam Depot;
- Has-Saptan underground installation;
- Ras Hanzir underground installation; and
- Aviation fuel installation at the Malta International Airport.

Malta has over 2,600 km of road, mostly built to supply the growing demand for private mobility. This infrastructural situation has also encouraged significant use of the car, to the detriment of the public transport services which have lost patronage and continue to struggle and compete for road space alongside increasing congestion. Congestion has been identified as a major external cost of the transport system in the islands with cost rising to €118 million in 2012. A study commissioned by the European Commission Representation in Malta and conducted by the University of Malta portrayed a very high cost associated with growing car dependence, in particular costs associated with congestion, accidents and climate change adaptation (see Table 6-11) (Attard, et al., 2015).

**Table 6-11 External Costs of Transport by Category (2012) (Attard, et al., 2015).**

| Accidents | Air Pollution | Climate Change Adaptation | Noise | Congestion | **Total** |
|---|---|---|---|---|---|
| **€83.9 million** | €14.3 million | €46.8 million | €11 million | €117.9 million | **€274 million** |

Some of the major link roads in the network have been constructed in low lying areas (valleys) which are naturally prone to flooding and will be impacted by sea level rise. The increase in the number of surfaced roads (and therefore run-off following rain) compound the flooding problem by removing any absorption ability of the ground during rain events. Msida, Birkirkara, Balzan and Qormi are some examples of areas which will require considerable investment to remove the flooding threat. A preliminary study published in 2015 show the extent of impact flooding will have on the road network in low lying areas, as well as the areas around the coast which could be affected by sea level rise, including the main road infrastructure of the islands alongside critical port and other structures along the coast (Attard, 2015). The percentage of arterial roads prone to flooding was estimated at 10 per cent, whilst 6 per cent of distributor roads and 7 per cent of rural roads would be prone to flooding.

In 2012 Government embarked on a €56 million flood relief project partly funded by the European Union, to intercept rainwater through a series of underground tunnels and the replacement and reorganization of culverts and bridges. The project is also aimed at replenishing the national water reserve with a further 700,000 $m^3$ of water a year.

Malta has three main gateway terminals which allow it to connect to other countries. The Malta International Airport was constructed between 1989 and 1991 and has two runways, nine dedicated aircraft parking areas, and extensive car, coach, taxi and car-hire parking space. It also offers now on its site a business centre built to attract business to the area.

The Grand Harbour Freight and Sea Passenger Terminals and the Valletta Cruise Liner Terminal are located close to the urban areas whilst the Malta Freeport is located in Marsaxlokk Bay and supports mainly container movements. Inter-island communication is through the Ċirkewwa and Mġarr Harbours which provide the necessary infrastructure for the existing ferry service operating between the two islands. The coastline is also dotted with small harbours and landing infrastructure for fishing vessels, pleasure crafts and large yachts.

These infrastructures play an important role for the future development of the island. Preliminary investigations (Figure 6-12) show a potential impact of sea level rise on these infrastructures (Attard, 2015). Additional studies and risk assessments are required to ensure their continued operations in the long term.

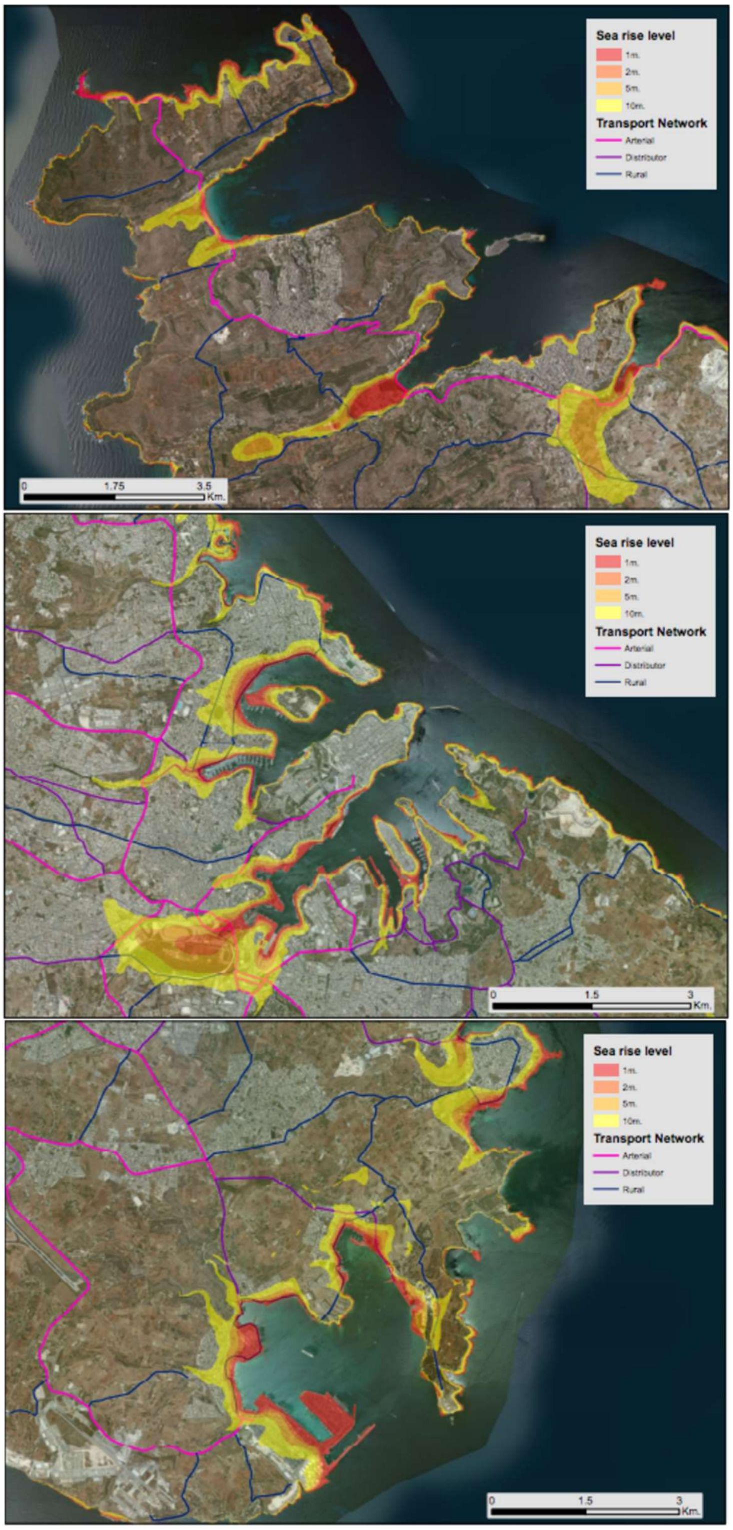



Figure 6-12 Sea level rise scenarios along the main island's coastline (Attard, 2015).

Malta's waste is managed through WasteServ a Government owned company set up for the purpose of promoting and facilitating waste management. The infrastructure includes an engineered landfill, a waste treatment plant, a thermal treatment facility, over 400 bring-in sites and five civic amenity centres. In 2017 concerns over the capacity of the landfill have been raised with Government currently drafting new laws enforcing recycling in an attempt to reduce the amount of waste to landfill.

Between 2011 and 2012 Malta inaugurated its sewage recycling plants in Malta and Gozo. Malta was the first Mediterranean country to treat all of its sewage before dumping it into the sea. The plant at Ta Barkat (Malta) also produces one megawatt of electricity per hour.

Buildings in Malta are significantly exposed to chemical and wind erosion, mostly due to the fact that the buildings are mostly constructed using soft globigerina limestone. There is extensive evidence of erosion caused by chemical pollutants in rain. This is particularly important for heritage protection.

Malta is blessed with a relatively large built heritage which includes amongst other three UNESCO World Heritage Sites (Valletta, Ħal Saflieni Hypogeum and six megalithic temples). These require costly and constant protection and maintenance.

## (2) VULNERABILITY TO CLIMATE CHANGE AND ITS IMPACTS ON LAND, LAND USE AND THE INFRASTRUCTURE

### (A) *CLIMATE CHANGE IMPACTS ON LAND*

The predicted sea level rise and increase in extreme weather events pose a serious threat to coastal population, particularly high-density ones. The impacts range from inundation, coastal erosion (including loss or movement of beaches), and damage cause by storm surges, waves and high winds. Extreme weather events will also impact part of Malta's coast made up of fragile Blue Clay at sea level.

The data related to sea level rise presented above points towards the need for more analysis to reduce uncertainty. However, there is agreement that sea level rise will occur and a certain degree of adaptation will be required.

The previous Communications identified a number of vulnerabilities associated with sea level rise, particularly related to coastal development, but also to protected areas, ports, infrastructures and roads. The most obvious ones are summarized in Table 6-12.

**Table 6-12 Summary of land use vulnerability from climate change (adapted from (MRRA, 2010)).**

| **Land use vulnerability** |
|---|
| Low lying transport infrastructure in the North of Malta. |
| Any land reclamation projects near the coast which the Government is currently considering. |
| Low lying coastal areas that have been modified over the years through development on the coast, and which will be prone mostly to storm surges. |
| A total land area of 1.11 Km$^2$ (0.36% of land area) will be affected by a sea level rise of 50 m. |
| Beaches will be particularly affected as they might be obliterated, reduced in size or, in the case of new beaches, replenishment will be very costly. |
| Increased rain intensity leading to more flooding in some urban areas, with some needing to eventually relocate to alleviate the problem. |
| Loss of soil and nutrients for agriculture from intense rain events. |

| |
|---|
| Longer drought periods can lead to desertification, in particular the areas under dryland production. |
| Increase in wind gusting intensity will also affect the increasingly tall buildings which are being constructed mostly near the coast. |
| Extreme weather events, including the incidences of heavy hailstorms and thunderstorms will affect road surfaces, rubble walls (for the retention of soil in fields), retaining walls and power lines. |
| These impacts on agriculture, buildings and infrastructure will have a secondary impact on property values and insurance. |

Coastal zone density was studied by the Malta Environment and Planning Authority in 2005 and showed an increased density of 5 to 26% between 1990 and 2004. The developments were mainly tourism and recreation (Figure 6-13).

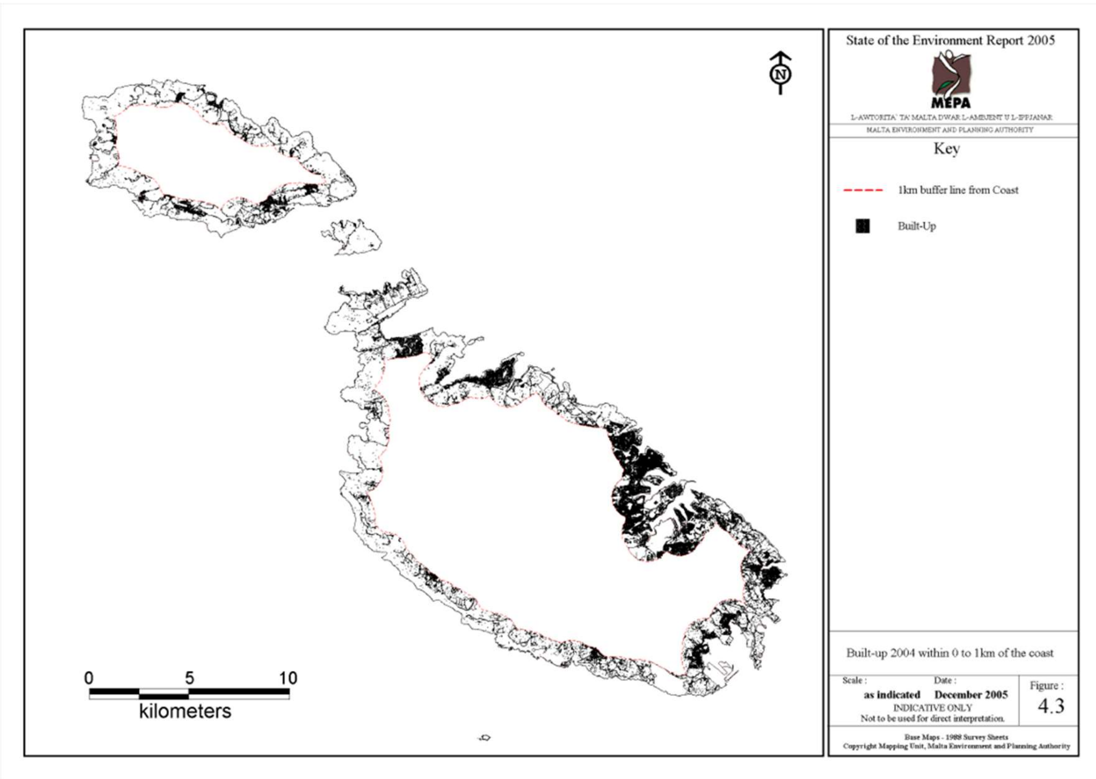



**Figure 6-13 Built-up areas within 0 to 1 km of the coast (2004). (MEPA, 2006)**

(B) *CLIMATE CHANGE IMPACTS ON THE INFRASTRUCTURE*

With the current projections for increase in temperature, changes in precipitation patterns and sea level, there is a threat on infrastructures which can impact other aspects of society. Damage from storms, increased energy demands due to extreme weather, as well as threats to low-lying infrastructure from sea level rise are amongst the more obvious vulnerabilities identified for infrastructure.

In terms of energy, climate change will have a direct effect on both supply and demand. Decreased precipitation and heat waves are also expected to influence negatively the cooling process of thermal power plants. During heat waves and extreme weather, peaks of cooling and heating will affect the demand and distribution of electricity in the islands.

Transport and telecommunication infrastructure are mostly affected from increased frequency and intensity of extreme weather events. Telecommunication infrastructure, if not underground is vulnerable to high winds, whilst exchange stations might be affected by extreme weather damage. Power outages and surges impact heavily on hardware.

As previously described transport nodes and links, such as ports, airports, bus interchanges and stops and roads are impacted by weather events which may lead to closure, but also damage over time. Excess heat causes also damage to infrastructure, such as thermal expansion on road surface, airport tarmac and concrete structure along the transport network. As reported previously this impact will shorten the life of infrastructure, increasing cost and potential structural failure during extreme events. The low-lying links in the road network, situated close to the coast are vulnerable to flood damage and inundation. This is particularly critical for the islands core and comprehensive TEN-T Network (Figure 6-14).

In 2017 Transport Malta published its Transport Strategy 2050 and Transport Masterplan 2025. The Transport Strategy includes a reference to the risks associated with climate change and the need to assess the potential impact of climate change and adaptation. The Masterplan identifies the need for further studies and sets a number of measures including:

**Measure 2.8.2.1** Establish the share of greenhouse gasses from transport that would fairly contribute to climate change targets and monitor progress of this Masterplan in line with these targets.

**Measure 2.8.2.2** Assess the impact of climate change and sea level rise on transport infrastructures.

**Measure 2.8.2.3** Incorporate climate change considerations at the planning and design stage to reduce retro-fitting costs.

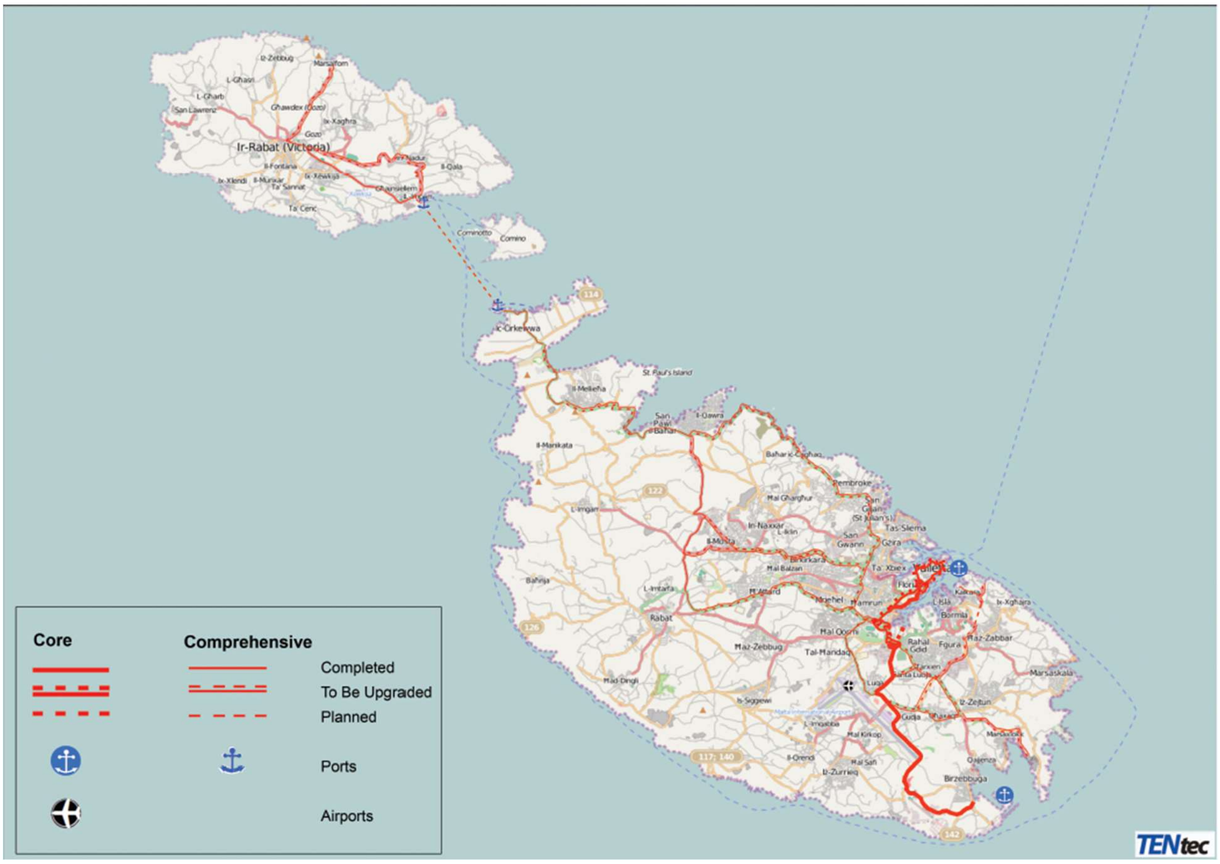



**Figure 6-14 Malta TEN-T Core and Comprehensive Network as identified by the TEN-T Regulations 1315/2013 (European Commission, 2014).**

Climate change has also the potential of impacting on waste management, particularly affecting facilities which handle waste. These include the changes to site hydrology and temperature which could affect landfill degradation rates, leachate production and composition; increased side disamenity; increased disruption of supporting infrastructure; and increased disruption to transport infrastructure due to flooding and the delivery of waste. These impacts are most evident for facilities like the Għallis landfill site and the thermal facility at Marsa.

Despite all efforts in the last two decades to introduce waste management, there are still very few studies that look at the vulnerability of the waste sector to climate change.

### (3) ADDRESSING VULNERABILITY OF THE INFRASTRUCTURE AND LAND USE

Adaptation measures must address infrastructural issues both with respect to land use in general and also to ensure preparedness to climate change within the built environment. Mainstreaming climate change adaptation measures in development planning and land use policy is still a priority area, which will help identify any specific legal requirements for the building industry as a means to adapt to climate change. Any adaptation measures that need to be implemented are likely to be closely related to mitigation measures such as energy conservation in buildings. Furthermore adaptation measures could involve the revision of civil property rights to ensure that any measures adopted do not impinge on neighboring properties and vice versa.

Closely linked to land use and infrastructure adaptation, is the need for developing financial instruments to address socio economic implications such as property value and insurance. Property value may slump as a result of floods or sea-level rise. Although the first priority is to eliminate proneness to flooding and prevent loss of life and property by revising building policies in flood prone areas, the required financial instruments must be available to compensate for losses incurred on the part of the private and public sectors. In this context Malta is taking adaptation measures by:

- Carrying out a preliminary assessment to identify the areas within the Malta River Basin District which are prone to flood risk;
- Assessing the signficance of this flood risk in valleys and coastal areas;
- Mapping the areas which are prone to flood hazard and assets and humans at risk in these areas;
- Taking adequate and coordinated measures to reduce this flood risk;
- Reinforcing the rights of the public to access this information and to have a say in the planning process;
- Establishing flood risk management plans focused on prevention, protection and preparedness, notably by coordinating the implementation of the flood risk management plans and river basin management plans;
- Synergizing public participation procedures in the preparation of these plans making them available to public.

Malta followed the requirements of the Floods Directive (2007/60/EC) and a Preliminary Flood Risk Assessment Report was prepared and published in May 2013. It established the potential risk of flooding in the islands both from weather events and rising sea level. In this preliminary assessment the areas already experiencing flooding were identified (Figure 6-15). Future adaptation will be required to protect land and property from flooding events.


**Figure 6-15 Areas of Malta affected by surface water flooding (MRA, 2013).**

The Planning Authority and the Environment and Resources Authority (previously the Malta Environment and Planning Authority) are implementing the regulatory framework relating to the maintenance and preservation of valleys via a thorough review of the status of existing storm water reservoirs, soak ways, and dams.

The government shall continue to carry out studies between 2014-2021 to assess the technical, environmental and financial viability of the application of different upstream sustainable urban drainage solutions.

Adaptation measures continue to be mainstreamed into certain legal instruments such as in the Environment Impact Assessment (EIA) applicable for land development projects on a large scale and also a Strategic Environment Assessment (SEA) of certain public plans, policies. These two types of legal instruments provide the required opportunity to ask developers to take into consideration adaptation measures for climate change. In this manner developers would include adaptation to climate change when identifying key issues, significant actions, alternatives and impacts to be considered in an EIA or SEA.

### 6.3.3 *Natural ecosystems, agriculture and fisheries*

#### (1) STATE OF PLAY

(A) *TERRESTRIAL AND MARINE ECOSYSTEMS*

Malta is characterized by a rich natural heritage of both indigenous and endemic species. Scientific evidence suggests that climate change will impact ecosystem through the loss of bio-diversity, shifts in the distribution of species, habitat destruction, increased salinization, changes in species composition, reduction of groundwater resources, increased desertification and fires, and a potential fertilizing effect. All terrestrial flora and fauna groups are vulnerable to these impacts.

The impacts on the marine ecosystem on the other hand include changes in faunal and floral diversity, spread of alien species, epidemiological outbreaks, changes in hydrodynamics and water circulation, coastal erosion and loss of habitat. Close to 100 non-indigenous marine species have to date been recorded from Maltese waters, across different taxa, including fish, molluscs, crustaceans, macrophytes (algae and seagrasses), sponges and corals. One of the most important resource in the Mediterranean Sea, the Neptune seagrass, *Posidonia oceanica*, is particularly vulnerable to these impacts.

Malta's geographic characteristics define its morphology, soils and vegetation. Maltese soils have a relatively high pH level (7.0-8.5) and are affected by salinity from sea spray, resulting in additional stresses on vegetation. The natural vegetation of the Islands has evolved to withstand these conditions however changes in the climate will affect the natural vegetation negatively.

(i) *Terrestrial Ecosystems:* Malta is home to some any different species. Schembri et al. (1999[68]) grouped Malta's terrestrial habitats into three categories[69]:
- Steppic communities, garrigue, maquis and Mediterranean sclerophyllous woodland;
- Saline marshlands, sand dunes, transitional coastal wetlands and coastal fringe;
- Communities of disturbed grounds and afforested areas.

(ii) *Freshwater Ecosystems:* Malta is characteristically dry with limited freshwater sources. Many springs are used for irrigation and the very few that still flow carry water during the wet season. Freshwater habitats are therefoer few and support extremely rare and often specialized (and occasionally endemic) biota.

(iii) *Marine Ecosystems:* These are divided into the littoral (those part of the rocky or sandy shore that are regularly covered and uncovered by sea water) and the sub-littoral (permanently submerged shore). As mentioned previously, one of the most important marine resource in the Maltese Islands and the Mediterranean are the *Posidonia oceanica* meadows, which generally occur at a depth of 5 to 45m.

Already many species have been identified as under threat or are in decline. This is due mostly to development in the rural and marine areas, the introduction of alien species, polluting discharge and the exploitation of wildlife. The combined action of multiple stressors on marine benthic communities is of special concern. For instance, in coastal areas popular for recreational boating purposes, frequent anchoring coupled with the intrusion by the non-indigenous seagrass *Halophila stipulacea*, has already been documented. The Blue Lagoon on the island of Comino is a case in point.

As discussed above the competition between landuse for anthropogenic needs and the conservation of natural habitats has left an indelible mark on the Maltese natural landscape and

[68] Schembri P.J., Baldacchino A.E., Camilleri A., Mallia A., Rizzo Y., Schembri T., Stevens D.T. and Tanti C.M., *Living resources, fisheries and agriculture* in State of the Environment Report for Malta, 1998, Environment Protection Department, Ministry of the Environment.

[69] Further information available in Malta's reports to the CBD (Convention on Biological Diversity);
Fourth report available at: https://www.cbd.int/doc/world/mt/mt-nr-04-en.doc;
Fifth national report available at: https://www.cbd.int/doc/world/mt/mt-nr-05-en.pdf.

ecosystems. The agricultural and fisheries sector have also experienced significant impacts upon the terrestrial and marine environment. More recently, the formulation of management plans for natural ecosystems which incorporate even agricultural use as well as integrated marine spatial planning that involves also the fisheries sector, has drawn the previously polarised factions closer together. The Environment and Resources Authority has published 22 site management plans for Natura 2000 sites (Table 6-13 and Figure 6-16)[70].

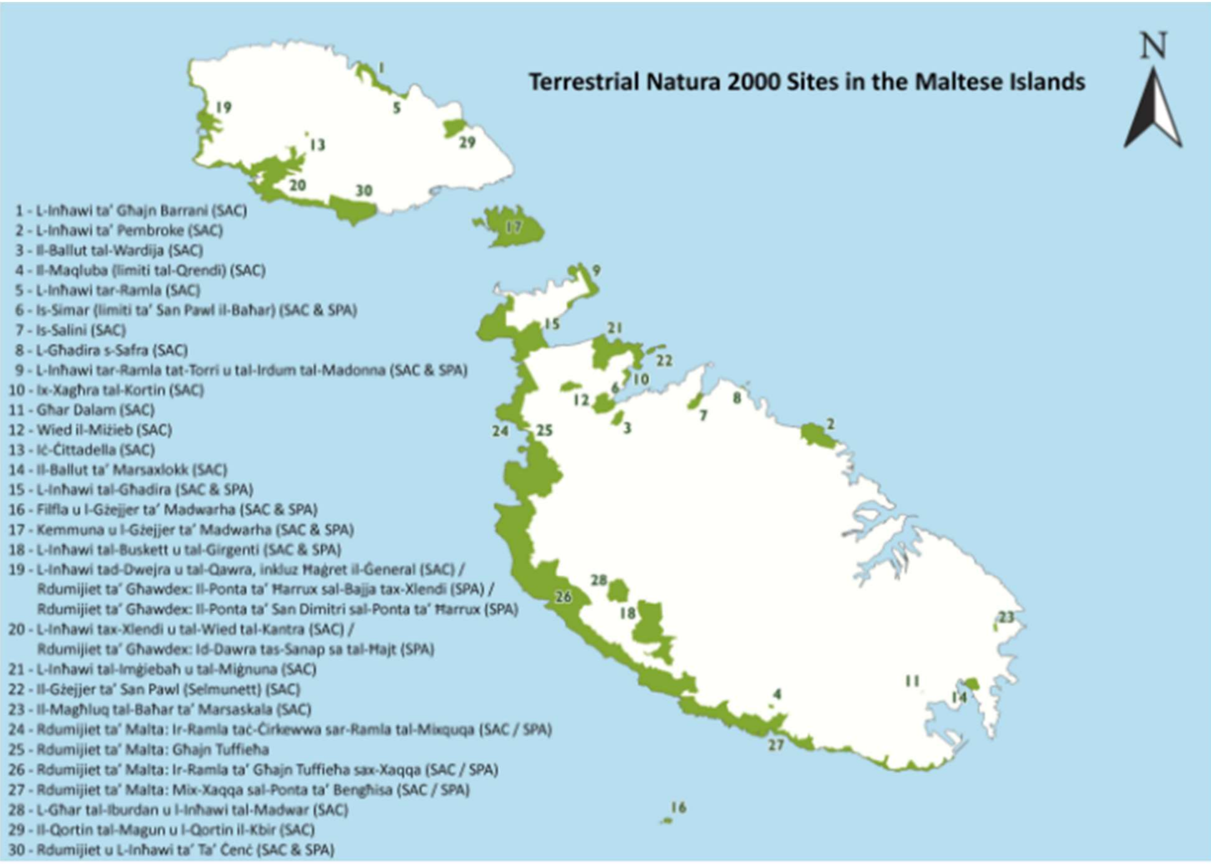



**Figure 6-16 Terrestrial Natura 2000 Sites in the Maltese Islands[71].**

[70] Terrestrial and freshwater management plans and conservation orders: https://era.org.mt/en/Pages/Natura-2000-Management-Planning.aspx;
Freshwater habitats: https://era.org.mt/en/Pages/Water-Catchment-Management-Plan.aspx;
Marine Programme of Measures: https://era.org.mt/en/Pages/MSFD-Programme-of-Measures.aspx;
The National Monitoring Programme: https://era.org.mt/en/Pages/MSFD-Monitoring-Programme.aspx.
MPAs (marine protected areas): https://era.org.mt/en/Pages/Natura-2000-Management-Planning-for-marine-sites-in-Malta--Gozo.aspx;
National Reports on the Implementation of the EU Habitats Directive: http://cdr.eionet.europa.eu/mt/eu/art17/.
[71] Environment and Resources Authority: https://era.org.mt/en/Pages/Natura-2000-Management-Planning.aspx

Table 6-13 Terrestrial Natura 2000 Sites in Malta[72].

| Site | Description |
|---|---|
| **L-Inħawi ta' Għajn Barrani** | Vision Fiche |
| **Il-Maqluba (limiti tal-Qrendi)** | Vision Fiche |
| **L-Għadira s-Safra** | Vision Fiche |
| **Ix-Xagħra tal-Kortin** | Vision Fiche |
| **Għar Dalam (limiti ta' Birżebbuġa)** | Vision Fiche |
| **Iċ-Ċittadella** | Vision Fiche |
| **Filfla u l-Gżejjer ta' Madwarha** | Vision Fiche |
| **Il-Gżejjer ta' San Pawl (Selmunett)** | Vision Fiche |
| **Il-Ballut ta' Marsaxlokk** | Management Plan |
| **Il-Ballut tal-Wardija** | Management Plan |
| **Il-Magħluq tal-Baħar ta' Marsaskala** | Management Plan |
| **Il-Qortin tal-Magun u l-Qortin il-Kbir** | Management Plan |
| **Is-Salini** | Management Plan |
| **Is-Simar (limiti ta' San Pawl il-Baħar)** | Management Plan |
| **Kemmuna u l-Gżejjer ta' Madwarha** | Management Plan |
| **L-Għar tal-Iburdan u l-Inħawi tal-Madwar** | Management Plan |
| **L-Inħawi ta' Pembroke** | Management Plan |
| **L-Inħawi tad-Dwejra u tal-Qawra/Rdumijiet ta' Għawdex: Il-Ponta ta' Ħarrux sal-Bajja tax-Xlendi/Rdumijiet ta'Għawdex: Il-Ponta ta San Dimitri sal-Ponta ta Ħarrux** | Management Plan |
| **L-Inħawi tal-Buskett u tal-Girgenti** | Management Plan |
| **L-Inħawi tal-Għadira** | Management Plan |
| **L-Inħawi tal-Imġiebaħ u tal-Miġnuna** | Management Plan |
| **L-Inħawi tar-Ramla** | Management Plan |
| **L-Inħawi tar-Ramla tat-Torri u tal-Irdum tal-Madonna** | Management Plan |
| **L-Inħawi tax-Xlendi u tal-Wied tal-Kantra/Rdumijiet ta' Għawdex: Id-Dawra tas-Sanap sa tal-Ħajt** | Management Plan |
| **Rdumijiet ta' Malta: Għajn Tuffieħa** | Management Plan |
| **Rdumijiet ta' Malta: Ir-Ramla ta' Għajn Tuffieħa sax-Xaqqa** | Management Plan |
| **Rdumijiet ta' Malta: Mir-Ramla taċ-Ċirkewwa sar-Ramla tal-Mixquqa** | Management Plan |
| **Rdumijiet ta' Malta: Mix-Xaqqa sal-Ponta ta' Benghisa** | Management Plan |
| **Rdumijiet u L-Inħawi ta' Ta' Ċenċ** | Management Plan |
| **Wied il-Miżieb** | Management Plan |

[72] Environment and Resources Authority: https://era.org.mt/en/Pages/Natura-2000-Management-Planning.aspx

(B) *FISHERIES AND AQUACULTURE*

Fisheries depend on a number of environmental factors governing the supply of young stock, feeding and predation conditions, as well as processes such as migrations of fish populations over multiple territorial waters and high seas. Malta's fisheries sector is small and contributes very little to the economy, including a small working population (1.0%) depend on fishing for their livelihood including the aquaculture sector. Particular fish remain under threat, despite data not being collected for 80% of species of commercial importance. The Second Communication reports hake, mullet and Bluefin tuna stocks to be under threat whilst stocks of anchovy, pilchard and swordfish are within safe biological limits.

(i) *Marine Capture Fisheries:* It is evident from Table 6-14, that landings from marine capture fisheries in Malta are dominated by tuna, lampuki (dolphin fish) and swordfish. There are of course seasonal differences for each species. Whilst the landings for lampuki occur mainly between August and December, the landings for swordfish occur throughout the year with the peak fishing period between May and August. Other landings such as shrimp originate exclusively from trawling which takes place throughout the year with quantities decreasing during winter months due to unfavourable weather.

**Table 6-14 Fish Landings (in tonnes) by key species (NSO, 2016).**

| Species | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **Dolphin Fish (Dorado)** | 430 | 194 | 137 | 275 | 173 |
| **Blue-fin Tuna** | 131 | 81 | 121 | 80 | 79 |
| **Swordfish** | 331 | 307 | 229 | 338 | 299 |
| **Shrimp** | 44 | 42 | 33 | 20 | 17 |
| **Stone Bass** | 15 | 9 | 11 | 10 | 10 |
| **Dog Fish** | 26 | 27 | 38 | 25 | 26 |
| **Bogue** | 13 | 23 | 21 | 17 | 18 |

(ii) *Aquaculture:* Since the late 1980s the aquaculture industry has operated in the islands focusing efforts on finfish (Sea Bass and Sea Bream) in offshore cages and subsequently Tuna through penning. Much of the fish is exported to European and Asian markets. Table 6-15 shows the Aquaculture Annual Production for the years 2009-2014.

**Table 6-15 Aquaculture Annual Production (in kg) 2009-2014 (NSO, 2016).**

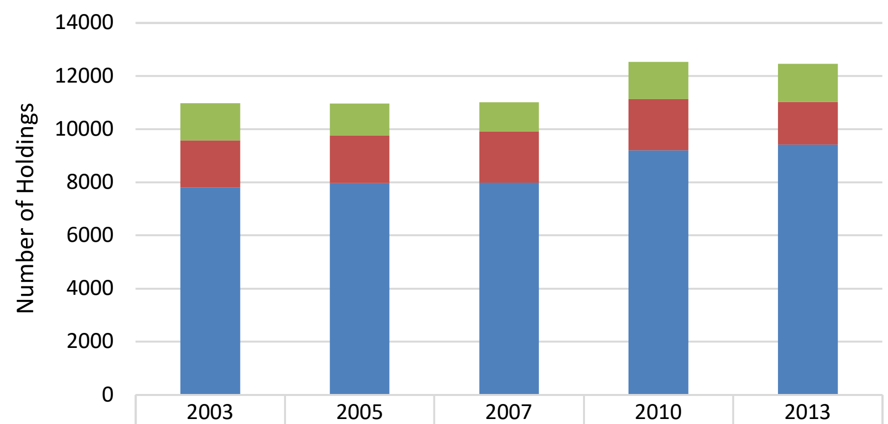
| Species | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Tuna** | 3,441,000 | 4,955,000 | 1,759,000 | 3,470,000 | 6,123,000 | 5,451,000 |
| **Sea Bass** | 93,000 | 102,000 | 54,000 | 126,000 | 127,000 | 190,000 |
| **Sea Bream** | 1,984,000 | 175,000 | 2,159,000 | 2,604,000 | 2,550,000 | 2,704,000 |
| **Other** | 101,000 | 69,000 | 100,000 | 806,000 | 277,000 | 261,000 |

### (C) *AGRICULTURE*

The agricultural system is dependent on climate for heat, light and water and processes such as the supply and demand of irrigation water, plant diseases and post manifestations are also dependent on climate. The predicted changes in the climate of Malta will certainly affect agriculture. This section provides an insight into the agricultural sector in the Maltese Islands and identifies potential impacts of climate change. Agriculture accounts for almost half of Malta's land area whilst forests account for less than 1%.

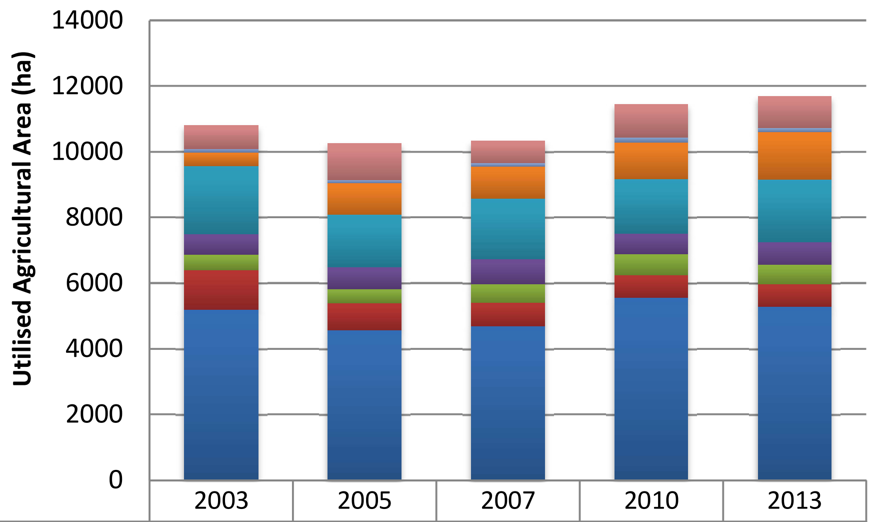
The number of holdings in 2013 amounted to 12,466 with a total of 11,689 hectares of Utilised Agricultural Area (NSO, 2016). Agricultural holdings reduced by 69 between 2010 and 2013. The losses were experienced in the number of holdings of one and less than 2 ha (Figure 6-17). There was also an increase in the hectares of utilised agricultural area, following a decline during the period 2003-2007 (Figure 6-18). It is also evident that the growth of particular crops changes from year to year.

In 2013 there were a total of 19,066 employed in the agricultural sector. This sector was dominated by men (79%) and mostly employed as part-time farmers (93%). Previous Communications reported urban sprawl as the major threat to agricultural land, as well as other issues such as abandonment of agricultural land, farm intensification, and fragmentation of land ownership. Of direct relevance to climate change impacts are factors that could lead to further land abandonment, flooding and sea level rise. An assessment of climate change impacts need to take into account the extent of impact and the socio-economic impacts on the sector.




| | 2003 | 2005 | 2007 | 2010 | 2013 |
|---|---|---|---|---|---|
| ≥ 2 ha | 1418 | 1197 | 1105 | 1395 | 1,431 |
| 1 -< 2 ha | 1767 | 1782 | 1923 | 1931 | 1,607 |
| 0 -< 1 ha | 7802 | 7982 | 7990 | 9208 | 9427 |

**Figure 6-17 Number of agricultural holdings by size for 2003 to 2013 (NSO, 2016).**




| | 2003 | 2005 | 2007 | 2010 | 2013 |
|---|---|---|---|---|---|
| Fallow Land | 696 | 1115 | 676 | 1007 | 959 |
| Other areas | 107 | 93 | 89 | 157 | 121 |
| Kitchen Gardens | 423 | 968 | 987 | 1123 | 1458 |
| Market Gardening | 2083 | 1594 | 1851 | 1661 | 1909 |
| Vineyards | 615 | 661 | 751 | 614 | 683 |
| Permanent Cropping (excl. Vineyards) | 465 | 429 | 570 | 637 | 581 |
| Potatoes | 1207 | 820 | 712 | 701 | 689 |
| Forage | 5197 | 4575 | 4690 | 5553 | 5290 |

Figure 6-18 Size of utilizable agricultural area by type of crop for 2003 to 2013 (NSO, 2016).

### (2) VULNERABILITY OF NATURAL ECOSYSTEMS, AGRICULTURE AND FISHERIES

(A) *NATURAL ECOSYSTEMS*

The major threat to Malta's biodiversity lies in the fact that many terrestrial and marine species are rare, under stress or in decline. This makes species highly vulnerable to climate change. Also, the Mediterranean is one of the regions most sensitive to climate change and shelters 4-18% of the world marine biodiversity (Perez, 2008).

Some of the impacts are summarized below in Table 6-16.

**Table 6-16 Climate change impacts and vulnerability for terrestrial and marine ecosystems. (adapted from (MRRA, 2010)).**

| | |
|---|---|
| **Terrestrial Ecosystems** | **Loss of biodiversity and increased risk of extinction**<br>- Studies in Europe and about the Mediterranean project a 30-40% extinction risk for species beyond 2050 if unable to disperse, and as a result of climate change (Thomas, et al., 2004).<br>- Species populations in Malta are already small which could push many taxa to extinction.<br>- All terrestrial flora and fauna are considered vulnerable to climate change.<br><br>**Shift in the distribution of species**<br>- Changes in temperature, precipitation and sea level will affect ecosystem boundaries.<br>- Climate change might also affect habitat.<br>- All terrestrial flora and fauna will be affected by distributional shifts.<br><br>**Sea level rise**<br>- Inundation of low-lying areas can obliterate habitats, push migration inland (where this is possible), and increase salinization which in turn will affect the sea-level aquifer and will favour halophytic vegetation.<br>- Coastal areas are most vulnerable habitats, including some already protected sites such as Natura 2000 sites, Special Areas of Conservation and Specially Protected Areas[73]. A full list of vulnerable habitats was produced for the Second Communication.<br><br>**Temperature increase**<br>- Temperature increases will favour species with a higher affinity to subtropical climates.<br>- Warming and drying is most likely to induce species-range shifts, with migration rates exceeding the capacity of many endemic species to do so.<br>- Higher temperatures are predicted to decrease species richness in freshwater ecosystem across SW Europe. Some spread of pests and disease causing organisms can also occur.<br>- Warming will impact phenology (timing of seasonal activities).<br>- Water availability will change as temperatures rise and increasing the demand for water.<br>- Desertification and fires will severely impact terrestrial ecosystems.<br><br>**Decrease in precipitation**<br>- Water availability will reduce due to a decrease in rainfall, leading to a loss of hydrophilic species and increase in soil salinity.<br>- Droughts will occur.<br>- Potential sea water contamination of the groundwater from over abstraction, affecting also the populations of migratory birds residing in inland wetlands.<br><br>**Effects of $CO_2$ emissions**<br>- A fertilization effect causing greening of the Mediterranean. |

[73] Currently a total of 190 sites are protected in Malta covering an area of over 13,500hectares (MEPA website, n.d.).

| | |
|---|---|
| **Marine Ecosystems** | **Temperature increase**<br>- Temperature anomalies can dramatically change faunal diversity in the Mediterranean.<br>- Higher sea temperatures also facilitate the spread of alien species. This might dislocate species and possibly affect the food web.<br>- Warming has already led to the shift in Mediterranean species (Perez, 2008).<br>- Climate change might also favour epidemiological outbreaks as pathogens are temperature sensitive.<br>- A number of consequences have already been documented as a result of increasing sea temperatures in the Mediterranean.<br><br>**Changes in coastal hydrodynamics**<br>- Any changes to coastal currents will impact littoral and sub-littoral communities and *Posidonia oceanica* meadows.<br><br>**Changes in deep water circulation**<br>- This may strongly reduce spring phytoplankton blooms and export production to the deep layers.<br>- Low oxygen areas (hypoxia or anoxia) in bottom waters might affect bays and inlets.<br><br>**Increase in sea level**<br>- Changes will affect the distribution of benthic and pelagic organisms.<br>- Inundation will affect the zonation patterns on rocky shores in an upward shift.<br>- Sea level rise may affect seagrass meadows by exposing them to more wave action and swell leading to erosion and loss of habitat.<br><br>**Increase in the intensity of rainfall events**<br>- Increase in sea water turbidity and decrease in salinity.<br>- *Posidonia oceanica* (L.) Delile is particularly vulnerable to turbidity and reduced water transparency. Specific areas around the islands with meadows will be affected by turbidity (Marsalforn, San Blas, Ramla l-Ħamra, Mellieħa Bay, St Paul's Bay and Salina Bay.<br><br>**Increase in $CO_2$**<br>- Acidification will result from the increase in the concentration of dissolved carbon dioxide.<br>- Organisms such as corals, most molluscs and sea urchins will face greater prospects of erosion.<br>- There are still uncertainties related to the impact of increased $CO_2$. |

(B) *FISHERIES AND AQUACULTURE*

The climate trends described earlier and the uncertainties over their impacts expose the fisheries sector to a high risk of collapse. Climate change impacts have a direct and indirect effect on fish stocks (Brander, 2007) as stated earlier in the section on marine ecosystems. The previous Communications already made reference to the trend in Maltese waters for both subtropical Atlantic species and Lessepsian immigrants to increase their occurrence with time, although this may be due to other reasons apart from a general warming of the sea, including heightened shipping and recreational boating traffic (Ulman, et al., 2017) and higher volumes of imports within the largely unregulated tropical aquarium industry (Weigle, et al., 2005).

The aquaculture industry on the other hand is vulnerable to climate change impacts mainly from:

- stress due to increased temperature and oxygen demand and decreased pH;
- extreme weather events with the consequent destruction of facilities;
- loss of stock, loss of business, and mass scale escape with the potential to impact on biodiversity;
- increased frequency of diseases and toxic events;
- sea level rise and conflicts of interest with coastal defence systems; and
- an uncertain future supply of fishmeal and oils from capture fisheries.

Other impacts include vulnerability to disease and reduction in genetic diversity of the wild stock in the event of escapes from aquaculture farms during extreme weather events. Previous Communications also reported some potential positive impacts such as increased growth rate and food conversion efficiencies, increased length of growing season, and range expansion.

### (C) *AGRICULTURE*

Decreasing water resources, loss of biodiversity and air pollution are increasing sensitivity to climate change and reducing resilience in the agricultural sector. Locally these are compounded by fragmentation of land holdings, with 73% of the land holdings being less than 1 hectare in size. Other factors include pressure to develop agricultural land, an aging farming community and insufficient capital investment.

A preliminary evaluation on the economic vulnerability and potential for adaptation to climate change show moderate to strong impacts on agriculture. No detailed studies however exist on the quantification of impacts of climate change in the agricultural sector in Malta, and similar to the previous Communications much of the conclusions presented in this section are drawn from findings in other European and Mediterranean countries. This report confirms the original findings and supports the conclusion that issues identified above will be further exacerbated in the future. These include:

- reductions in overall crop yield;
- reductions in cereal production in the southern Mediterranean;
- further deterioration of the water quality in Malta's aquifers as a direct results of sea level rise will decrease the quality of the soil and harm crops.

Table 6-17 reports on the impacts expected on important components within agriculture in the islands.

**Table 6-17 The impacts expected on important components within agriculture in Malta. (adapted from (MRRA, 2010)).**

| | |
|---|---|
| **Impact on Soils** | Soil erosion is expected to increase due to the intensity of rainfall. This is dependent on measures adopted to protect soils such as rubble walls, vegetation cover and so on.<br>Soil fertility might be affected by heavy downpours, as well as logging of soils, especially in low lying areas, and through leaching. |
| **Impact on Potato** | Increases in atmospheric $CO_2$ leads to higher yields of potato, however this was not sufficient to recover the losses made through increased temperatures.<br>There is a potential for potato pests and diseases to increase as a result of climate change. |
| **Impact on Vineyards** | Largest impacts from increases in temperature and distribution of rain.<br>Accelerated ripening due to increasingly warmer temperatures, has serious consequences for precocious varieties.<br>Malta's vineyards will suffer particularly during drought periods. |
| **Impact on Livestock** | Increases in air temperature may affect behavioural or physiological functions of livestock.<br>Most of Malta's farms are not equipped with cooling devices and a reduction in produce, brought about by warmer temperatures is possible.<br>A global reduction in availability, quality and price of grain will affect Maltese farmers since they import all feeds for livestock. |
| **Impact on Agriculture Infrastructure** | Heavy rainfall will affect critical infrastructure such as rubble walls and greenhouses.<br>Rate of absorption of rainfall will decrease as heavy storms will fill reservoirs and wells fast but not for long.<br>Lengthening of the dry season will force farmers to irrigate more, increasing the pressure on the aquifers and exacerbating the existing problem of illegal extraction from boreholes. |
| **Alteration of Insect and Disease Distribution** | The range and distribution of pests is affected by changes in temperature, wind and humidity.<br>Whilst milder winters might increase the incidence of pest outbreaks, higher temperatures and longer periods of warm weather will allow proliferation of insect pests.<br>Use of pesticides to control pests in itself can harm agriculture. |

#### (3) ADDRESSING VULNERABILITY OF NATURAL ECOSYSTEMS, FISHERIES AND AGRICULTURE

Adaptation measures addressing natural ecosystems are very challenging to devise. The vulnerability of biodiversity and the negative impact which various human activities have upon natural habitats will only be further exacerbated as a result of climate change. Unfortunately, however the species may be unable to adapt to change so quickly so the best way to address adaptation measures in this context is to strengthen legal and policy measures aimed at the conservation of species and their habitat in order to ensure resilience in this sector. The discussion under the previous section has identified how the authorities aim to protect natural habitats even by curbing further development outside urban areas.

Closely linked to this issue is the better management and the sustainable exploitation of natural resources by the farming and fishing communities. Adaptation measures by farmers and fishermen would also lead to better resilience for natural ecosystems since they would be strengthening the conditions for a favourable conservation status. An intensive revision of existing laws and policies in the coming years aims to promote soil conservation to identify the action needed to ensure a high level of soil protection[74]. The conservation of soils is an obligation Malta has even within the context of the United Nations Convention on Desertification which requires it to adopt certain conservation measures with respect to soils against the negative impacts of climate change. Adaptation measures for Malta under the agricultural and fisheries sector include also the assessment of various veterinary laws, plant health laws, fisheries and agriculture related laws to assist this sector to adapt to climate change. As agriculture is one of the sectors that is likely to register severe impacts, the revision of applicable national laws would identify the most adequate policy and legal instruments that can be used to prepare this sector for adaptation and if considered necessary, supplement it with new laws, policies and plans. The same applies to fisheries, where the effects of climate change upon migratory fishing patterns is relatively unknown.

Adaptation measures under this sector also aim to combat the introduction of pests and diseases as result of climate change. The introduction of alien species will affect not only the fisheries and agro-industry but also the natural habitats. Adaptation measures in this sector include establishing rules for the marketing of vegetative propagating and planting material and conditions for the grant of permits for the importation and transport of any plant material, plant pest, or other organisms for the purposes of scientific research or otherwise, subject to such terms and conditions as may be established to safeguard public health, agriculture, and/or the environment.

National agricultural policy promotes appropriate action to maintain Maltese agro-ecosystems through the management of agricultural landscapes given the central role they play in contributing to overall resilience to climate change. Such policy also aims to strengthen information and advisory support on climate-related matters to farmers and agricultural workers which is considered as essential for nurturing motivation and preparedness to adapt.

### *6.3.4 Health issues, civil protection and immigration.*

#### (1) STATE OF PLAY

Malta enjoys very high health standards not least because of its benevolent climate. Extreme high summer temperatures accompanied by months of dry weather or freak heavy rainfall demonstrate various effects upon human, plant and animal health, food hygiene and mortality rates especially amongst the elderly. Furthermore, irregular migration from third states, which Malta may be subjected to, can in part and circumstantially associated with food and water security issues in States already afflicted by drought and conflict, possibly having Climate change as an underlying factor,

(A) *HEALTH AND CIVIL PROTECTION*

[74] See (COM(2006) 232) Proposal for a Directive of the European Parliament and of Council establishing a framework for the protection of soil.

Many climate change concerns are linked to human health and the state of our environment has a direct impact on human wellbeing. The gradual warming of the planet, as well as increased heavy storms and longer period of droughts will affect many aspects of human health such as air quality, water and food quality, shelter and freedom from disease in the case of vector borne diseases. At a global level, the World Health Organisation have identified five major health consequences of climate change including malnutrition as a result of the decline in agriculture, death and injury as a result of extreme weather events, water scarcity and impact on health, and the spread of infectious diseases (WHO website, n.d.). In most cases the most vulnerable are the elderly, disabled, children, ethnic communities and people on low income.

A recent study (Akerlof, et al., 2010) included amongst others the Maltese perception of impacts of climate change on health (Figure 6-19). The study provided an insight into better engagement with individuals about the issues of climate change and has provided for the first time an insight into the perceived relationship between climate change and human health in Malta.

Currently in Malta, there are seasonal patterns associated with mortality, with more deaths occurring in the cold winter months. This variation is more pronounced in deaths of those aged 65 years and over. Low ambient temperatures, while often not the underlying cause of death, contribute to death in older people. In those aged 65 years and over, 60.2% of all deaths between January and March of 2012 (vs. 46.1% of all deaths between April and December of 2012) were due to circulatory disease (DHIR, 2013).

Diseases of the circulatory system and neoplasms accounted for the vast majority of deaths, accounting for 40.1% and 26.9% respectively in 2013 (Figure 6-20). Ischaemic heart disease, other heart diseases (including heart failure) and cerebrovascular diseases were the leading causes of death. There were 1298 deaths due to diseases of the circulatory system, a decrease of 298 deaths from the year 2012. Diseases of the circulatory system were the leading cause of death and appear to be accounting for an increasingly larger proportion of the total number of deaths (40% of all deaths in 2013 vs. 46.7% in 2012) (DHIR, 2015).

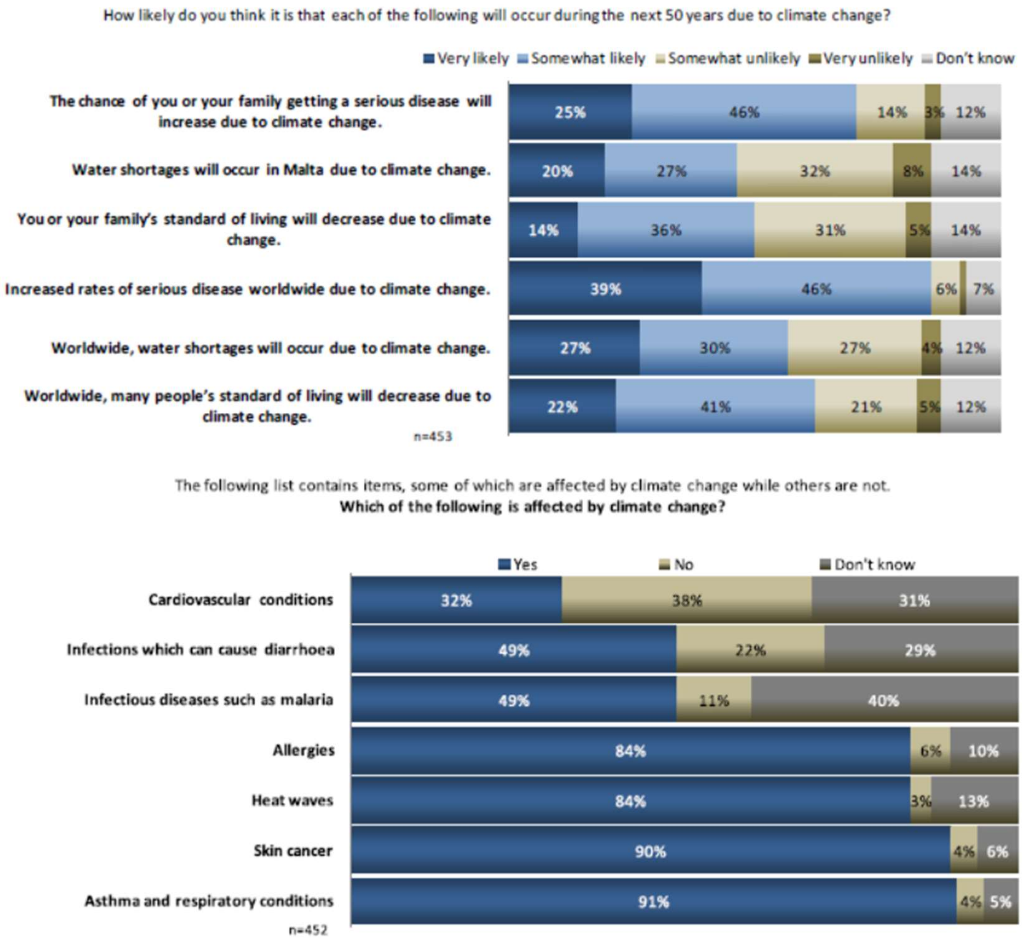



**Figure 6-19 Maltese perceptions of likelihood of health risks resulting from climate change (Akerlof, et al., 2010).**

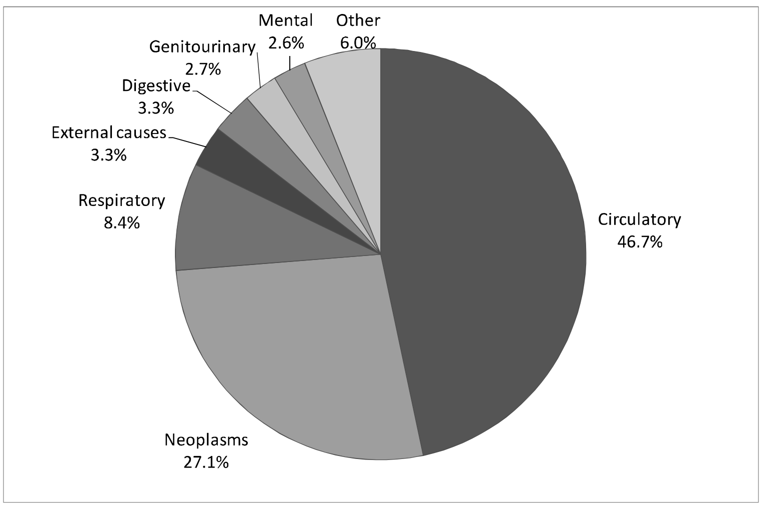



**Figure 6-20 Commonest causes of death using broad categories (DHIR, 2013).**

## (2) VULNERABILITY ON HEALTH, CIVIL PROTECTION AND MIGRATION

### (A) *HEALTH AND CIVIL PROTECTION*

Temperature increases will certainly impact the number of heat-related deaths, even though there are studies that link increases in mortality from respiratory and cardiovascular diseases, as well as from external causes with increased temperatures. However, the major concern is for elderly; however, infants and young children are at a greater risk that then average adult to suffer from heat stroke and death under extreme temperature conditions.

Malta's population projections point towards an increase in the number of elderly people (Figure 6-21). An ageing population becomes vulnerable to climate changes with higher exposure to system collapse particularly the stress of increased cases for beds in the current health care system.

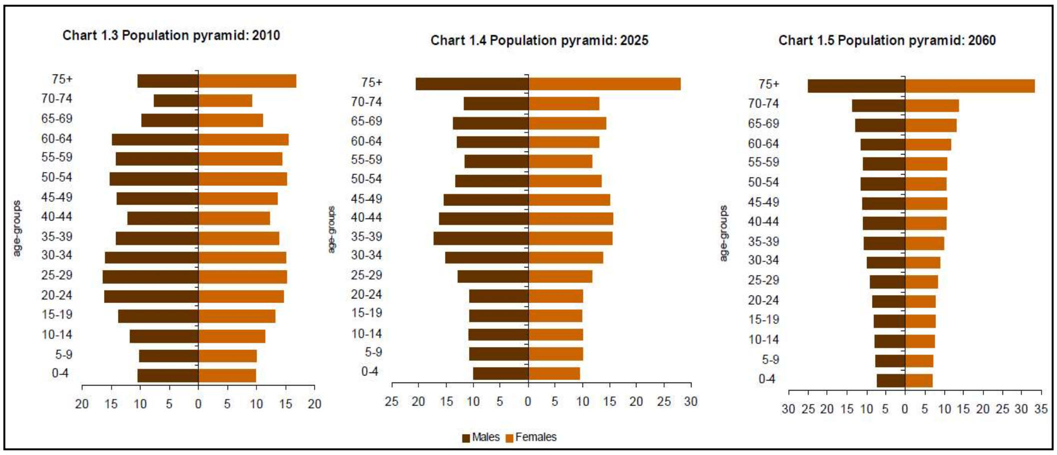



**Figure 6-21 Population projections for Malta 2010-2060. (NSO, 2012)**

High temperatures and reduced precipitation have implications on the natural and built environment, which in turn might affect human health. Water quality as well as quantity becomes a particularly critical issue, especially in the case of Malta. There are also implications for food safety with studies showing that 25% of cases of salmonellosis in Malta were related to increased temperatures (Gatt, 2009).

Changes in seasons might also affect the pollination processes likely to affect those suffering from allergenic diseases or respiratory conditions.

Previous Communications stated that the impact of climate change on vector-borne diseases is uncertain and each vector would be affected in a different way. The introduction of the Asian Tiger Mosquito (new species for the islands) has already been studied, however further investigation will be required to determine their impact in various climate change scenarios.

The changing severity of storms will undoubtedly affect the risk of death or injury. Coastal flooding and flash floods from heavy rainstorms are also a concern in some areas of the islands. An indirect affect would also be the damage caused by extreme weather events and storms to the health care infrastructure or access to hospitals, clinics, pharmacies and so on.

Particular sectors will also be affected through increased occupational health and safety concerns, for example construction workers and those working in the primary industries (agriculture, fisheries) and exposed the high temperatures, rainfall and extreme weather events.

Children remain particularly vulnerable and are sensitive to changes, not only in temperature but also in air quality, affecting amongst other functions the pulmonary functions of the young. The

ISAAC study looked at the distribution of wheezing children in Malta between 1994 and 2002 and found already that the prevalence of wheezing in the 5-8-year-old age group increased between the period 1994 and 2002 (Fsadni, et al., 2012). Further investigation into the causes and the possible impact from climate changes would be required to assess the vulnerability of these young children.

(B) *MIGRATION*

Malta's main challenge with respect to migration is the limited land and space resources. With an already high population density and pressure on resources such as water, increase in the number of illegal immigrants to the islands might represent a potential problem.

All climate change scenarios presented in the report, and related to warming temperatures, precipitation and sea level rise are potential issues and when interfaced with demographic shifts might cause considerable stresses on the economy of the islands. Previous Communications had also put forward a potential of a reverse trend where due to climate changes population moves north to the detriment of the islands future population and resources.

**(3) ADDRESSING VULNERABILITY OF PUBLIC HEALTH, CIVIL PROTECTION AND IMMIGRATION**

The Health Authorities with the support of the World Health Organization have been conducting research on climate and health related issues in Malta for quite some time. The authorities have announced the taking of adaptation measures by assessing and identify options required to strengthen the continuous and rigorous surveillance of infectious diseases and their vectors; for the undertaking of a proper risk assessment, for the identification of measures to reduce the possibility of outbreaks of climate change related vector-borne diseases, and to ensure that, in the event that an outbreak does occur, a plan is in place to control the outbreak as early as possible. The Health Authorities continue to assess and determine the local entomological expertise required for the relevant identification and mapping of distribution of vectors that carry disease and to take appropriate measures to address arising gaps.

Food safety is also a crucial issue in the linkages between health and adaptation. Consequently Health Authorities continue to maintain and where appropriate strengthen programmes directed to reduce the potential risk on food safety, given that the projected climatic scenario for the Maltese islands is likely to have an adverse effect on food safety with the subsequent risk of food-borne illness. The intention is to establish and where these already exist strengthen, early warning systems in place, in particular for heat waves, extreme weather and flooding events. Public education campaigns on adaptation, particularly among vulnerable groups continue to focus on health issues. Local research indicates that the public is more willing to change their lifestyle and to be supportive of climate change policy if it is presented as a health issue.

Adaptation measures aim to address also civil protection in general. Vulnerable groups would inevitably be highly affected by climate change. Contingency plans for adaptation to climate change are being considered as an option to address climate change effects upon public health, surges in irregular migration and civil protection in general. At this point in time the authorities are undertaking the preliminary ground work that would serve to identify a variety of risks and ensure preparedness in order to:

- address the negative impacts envisaged as a result of climate change particularly upon vulnerable groups;
- assess socio-economic implications, which increased insurance covers for risks resulting from the likely impacts of climate change;

- identify financial guarantees and incentives amongst the various stakeholders in all sectors;
- intensify awareness and promote a change in behavioural patterns to improve adaptation to climate change;
- increase awareness of climate change impacts within the government, industry, and community sectors will support cultural change transitions that are required for the adoption of more climate change friendly technologies, designs, and operations by public and private operators;
- Carry out further research with the support of multilateral and regional institutions on the effects which climate change will have upon irregular migration.

### 6.3.5 Tourism

#### (1) STATE OF PLAY

Voted as having one of the best climates in the world Malta, tourism is Malta's main economic driver. Record tourist numbers have been the norm these last five years as the country has become a much-prized tourist destination. Malta enjoys a benevolent climate all year round, it has a formidable historical heritage, a unique culture due to its strategic location in the Mediterranean and its multicultural history. It is safe and politically stable and very well geared for the outdoor life. Malta's appeal for the discerning tourist is on the rise. It is also a very popular tourist destination among divers because of its pristine marine habitats.

Inbound tourist trips from January to December 2016 reached nearly 2.0 million, an increase of 10.2 per cent over the same period in 2015. Italian and British tourists dominate the tourist population in the islands with tourists from Germany and France also arriving in high numbers. Cruise liner passengers also registered an increase with 626,082 arriving in 2016, a rise of 4.3% over 2015. Over 74% of the cruise liner passengers came from EU Member States.

The direct contribution of Travel and Tourism to GDP in Malta stood at 14.1% of the total GDP in 2016. The total contribution on the other hand stood at 26.7% of the total GDP of the islands for 2016 (World Travel and Tourism Council, 2017).

#### (2) VULNERABILITY OF TOURISM SECTOR

The impacts of climate change upon tourism are largely unknown and still subject to rudimentary research that needs to be intensified to ensure the sectors resilience. Furthermore, the tourism sector is likely to find niche opportunities that may arise due to more favourable climatic conditions in what are now considered to be the low season months.

#### (3) ADDRESSING VULNERABILITY IN THE TOURISM SECTOR

In order to tackle issue related to climate change the Malta Tourism Authority introduced eco-certification for new hotels which includes mandatory and voluntary criteria which are aimed at reducing greenhouse gas emissions and reducing energy consumption[75]. Sustainable transport modes including walking and cycling are supported by the National Tourism policy (European Commission, 2013).

The 2012-2016 Tourism Policy for the Maltese Islands identifies climate change as one of the environmental drivers of the national framework, however the more recent 2015-2020 National

[75] http://www.mta.com.mt/eco-certification

Tourism Policy fails to take into account climate change impacts and the vulnerabilities of the sector (Ministry for Tourism, 2015).

Furthermore, in 2016 Malta signed the Casablanca Declaration on Tourism and Climate Change which aims to undertake measures to assess and monitor the impact of tourism on climate change in the region and to mitigate as much as possible the impacts of climate change on touristic development.

# 7 FINANCIAL RESOURCES AND TRANSFER OF TECHNOLOGY

*Image Source: archilovers.com (http://www.archilovers.com/projects/185985/castille-square.html)*

## 7.1 Introduction

Despite it being a small country with constrained financial capabilities, and despite not being an Annex II Party to the Framework Convention on Climate Change, Malta has started to also contribute financial and capacity support for climate action in developing third countries, including support resulting in the transfer of technologies and know-how. This chapter discusses the efforts made, using examples of projects that have been supported during the years 2011 and 2015. Malta is not a Party included in Annex II to the Convention and is therefore not obliged to adopt measures and fulfil obligations as defined in Article 4, paragraphs 3, 4, and 5, of the Convention.

## 7.2 Support through public finances

Support to developing countries between 2013 and 2016 has been primarily focussed on grants by the government for specific projects related to climate change mitigation or adaptation activities. During 2015, a total amount of €105,953 (US$125,559[76]) was disbursed on projects in Ethiopia, Uganda, and Guatemala. A similar sum of money was granted in 2016 for projects in Ethiopia and Eritrea. This funding of projects serves as the country's contribution to the pledge made by developed country Parties during the Conference of the Parties to the UNFCCC held in 2009 in Copenhagen, to provide new and additional resources to support mitigation and adaptation activities in developing countries. The collective pledge of US$30 billion for the period 2010 to 2012 is often referred to as Fast Start Finance.

In 2015 and 2016, part of the finances was allocated to a Climate Action Scholarship intended to bring students from third world countries to study in Malta. Unfortunately, no eligible students were found for these scholarships in these years. In 2017 however, four students from Palau, Botswana, Grenada, and Zambia, were awarded a Climate Action Scholarship (€18,060 each) for Masters programmes in Built Environment, Sustainable Energy, and Sustainable Development (two students took up the latter).

Projects were selected through a call for project proposals. Following the assessment of eligibility of proposed projects by a purposely constituted adjudication board, the government formalized the financial support through agreements with the respective organizations.

A summary of projects sponsored through grants given by Malta from 2013 to 2016 is given from Table 7-1 to Table 7-4. Subsequent sections provide more detailed information on the individual projects.

[76] For the purposes of this discussion, the currency exchange rate 0.84 Euro for 1 USD as on 23 November 2017.

**Table 7-1 Provision of public financial support: contribution through bilateral, regional and other channels in 2013. * - For tables in the report the currency exchange rate 0.74 Euro for 1 USD as on 2 October 2013.**

| Recipient country/ region/project/programme | Total Amount (€) | Total Amount (USD)* | Status | Funding Source | Financial Instrument | Type | Sector |
|---|---|---|---|---|---|---|---|
| **Kenya - Water Supply** | 12,401 | 15,661 | Provided | ODA | Grant | Core | Water and Sanitation |
| **Ethiopia - Water Supply** | 17,236 | 21,767 | Provided | ODA | Grant | Core | Water and Sanitation |

**Table 7-2 Provision of public financial support: contribution through bilateral, regional and other channels in 2014. * - For tables in the report the currency exchange rate 0.84 Euro for 1 USD as on 23 November 2017.**

<table>
<tr><th>Recipient country/ region/project/programme</th><th>Total Amount (€)</th><th>Total Amount (USD)*</th><th>Status</th><th>Funding Source</th><th>Financial Instrument</th><th>Type</th><th>Sector</th></tr>
<tr><td>Ethiopia - Water Supply Project</td><td>7,000</td><td>8,288</td><td>Committed</td><td>ODA</td><td>Grant</td><td>Adaptation</td><td>Water Sanitization</td></tr>
<tr><td colspan="8">Living Waters Mission Team: the project will provide access to clean water through four water points to a community of 4000 members. The water source is on top of a mountain which is at a distance of some 4,000m from the church. A 10,000 litre collection tank will sit in the middle grounds in the church compound and will have one water point. The middle ground tank will feed another there water points scattered in the valleys. In their application it is stated that the aim is to reduce the time and energy cost for fetching water.</td></tr>
<tr><td>Pakistan - Installation of Solar Power back up System</td><td>7,020</td><td>8,312</td><td>Committed</td><td>ODA</td><td>Grant</td><td>Mitigation</td><td>Energy Generation and Supply</td></tr>
<tr><td colspan="8">CAM Youth: the project entailed the installation of a solar power back-up system that ensures constant and regular power supply at the Joseph De Piro Middle School for Girls in Asif Town II, Lahore. This implementation ensured that the school benefits from a constant and regular power supply so that students in classrooms may have adequate lightning during winter, when it is usually dark even during the day. This set-up also made possible ventilation through classroom ceiling fans in spring and summer when the temperatures typically reach over 45 °C.</td></tr>
<tr><td>Uganda - Youth Engage: Building Skills and Creating Opportunities for Young People in Njeru Buikwe District</td><td>16,705</td><td>19,780</td><td>Committed</td><td>ODA</td><td>Grant</td><td>Mitigation</td><td>Energy Generation and Supply</td></tr>
<tr><td colspan="8">The project targets capacity building and training of skills for young people living in bad conditions. This training focused on teaching agriculture and crafts skills.</td></tr>
</table>

**Table 7-3 Provision of public financial support: contribution through bilateral, regional and other channels in 2015. * - For tables in the report the currency exchange rate 0.84 Euro for 1 USD as on 23 November 2017.**

| Recipient country/ region/project/programme | Total Amount (€) | Total Amount (USD)* | Status | Funding Source | Financial Instrument | Type | Sector |
|---|---|---|---|---|---|---|---|
| **Ethiopia - Living Waters Mission Team - Water Supply Project** | 14,000 | 16,583 | Committed | ODA | Grant | Adaptation | Water Sanitization |
| The project will provide access to clean water through four water points to a community of 4000 members. The water source is on top of a mountain which is at a distance of some 4,000m from the church. A 10,000 litre collection tank will sit in the middle grounds in the church compound and will have one water point. The middle ground tank will feed another there water points scattered in the valleys. In their application it is stated that the aim is to reduce the time and energy cost for fetching water. Protecting the open spring source will also reduce the number of communicable diseases and resulting deaths. This will be coupled with an education campaign by the sisters on the importance of health, hygiene and sanitation. The project will also reduce the work load of the women and the children, especially the girls who should be in school but remain back at home to assist in household chores; amongst them fetching water every day. (Lead - Mr Wallace Buttigieg Scicluna) | | | | | | | |
| **Uganda - SOS Malta- Building Skills and Creating Opportunties for young people** | 31,773 | 37,636 | Committed | ODA | Grant | Adaptation | Agriculture |
| The overall project objective is to contribute to building skills and capacity of young people living in poverty in Uganda, in order to enable them to improve their quality of life through better opportunities for income generation. The specific objective will be to train young people in the Buikwe District with technical and non-formal skills related to integrated agriculture and candle making. It is foreseen that through the development and provision of a comprehensive theoretical and practical 32-week training course, we will provide the young people with skills to develop income generating opportunities. Additionally, training will be provided in setting up and running social enterprise, thereby contributing to the sustainability of the practical training given. The training will also provide key skills in leadership and confidence building which will in turn enable the young people to engage in their communities. (Lead - Ms. Claudia Taylor-East, Ms Graziella Schiavone) | | | | | | | |
| **Guatemala Foundation - Clean Stoves for Guatemala** | 6,000 | 7,107 | Committed | ODA | Grant | Adaptation | Energy generation, distribution and Efficiency |
| This project will facilitate the production and installation of 100 clean burning wood stoves in low-income households within the community of Izabel, Guatemala. Many women suffer from health problems due to the way they cook using an open fire. The project aims to produce ONIL cook clean stoves which have completely changed the way of life in areas in central America. (Lead - Ms. Marika Zammit, Mr. Andre Zammit) | | | | | | | |
| **Scholarships in Climate Action Offered by the Goverment of Malta for Postgraduate Studies at the University of Malta** | 54,180 | 64,178 | Committed | Other | Grant | Crosscutting | Education |
| The Ministry for Sustainable Development, the Environment and Climate Change, provided direct funding to the University of Malta to coordinate and administer a Master of Science or Master of Arts by research focusing on climate action including adaptation, mitigation and governance. (Lead - International & EU Office, University of Malta) | | | | | | | |

**Table 7-4 Provision of public financial support: contribution through bilateral, regional and other channels in 2016. * - For tables in the report the currency exchange rate 0.84 Euro for 1 USD as on 23 November 2017.**

| Recipient country/ region/project/programme | Total Amount (€) | Total Amount (USD)* | Status | Funding Source | Financial Instrument | Type | Sector |
|---|---|---|---|---|---|---|---|
| **Eritrea - Lwanga district, Shinara Nativity School facilities expansion and provision of water** | 20,624 | 24,430 | Disbursed | ODA | Grant | Adaptation | CRS 14030 |
| Nativity School is a primary and junior secondary school located in Eritrea. The project aimed at the creation of a Multipurpose Hall and a study room with electricity available through solar energy. The project also covered the construction of a water reservoir and installation of a solar system for pumping water from the well. This would improve teaching and learning conditions and also provide better sanitation | | | | | | | |
| **Ethiopia - Konga Town, Water Supply Project for Konga Town** | 21,900 | 25,941 | Disbursed | ODA | Grant | Adaptation | CRS 14020 |
| The project provided access to clean water through 3 water points in Konga, Ethiopia. This reduced intestinal parasites, HIV, hepatitis B, typhoid amongst others. This project was coupled with an education campaign on health, hygiene and sanitation. The project had the aim of reducing the workload of women and children who would have more time for education. The project had a 15,000 litre water tank next to a water source on a mountain top. It was expected that having in place clean potable water would significantly reduce diseases and decrease mortality rate. | | | | | | | |
| **Scholarships in Climate Action Offered by the Goverment of Malta for Postgraduate Studies at the University of Malta** | 54,180 | 64,178 | Committed | Other | Grant | Crosscutting | Education |
| The Ministry for Sustainable Development, the Environment and Climate Change, provided direct funding to the University of Malta to coordinate and administer a Master of Science or Master of Arts by research focusing on climate action including adaptation, mitigation and governance. (Lead - International & EU Office, University of Malta) | | | | | | | |

# 8 RESEARCH AND SYSTEMATIC OBSERVATION

*Image Source: ISEP (https://search.isepstudyabroad.org/University/Detail/0e233d83-c5a7-4ff9-a3f5-497752af3462*

## 8.1 General policy on research

### *8.1.1 Climate research policy context*

Research policy in Malta falls under the responsibility primarily of the Malta Council for Science and Technology (MCST), as well as the Ministry for Education. These bodies are responsible for national research funding and student grant schemes (scholarships) respectively. In their choice of funding areas, they drive directly and indirectly the national policy on research. Over the recent years the Ministry for Environment, Sustainable Development and Climate Change has also initiated scholarship grants for climate change research for third world country nationals studying at the University of Malta.

The National Research and Innovation Strategy 2020[77] approved by Cabinet in 2014 looks at building critical mass and capacity in select areas, giving the country a competitive edge. The Mission of this strategy is to provide an enabling framework for achieving this vision, building on past achievements as well as lessons learnt along the way. This Strategy and its implementation do not, by themselves, provide all the building blocks of a knowledge-based economy but are a crucial step towards this. The achievement of this stated Mission depends on putting in place the necessary 'building blocks', identified as the three goals of:

1. A comprehensive R&I support ecosystem – The achievement of this goal would be an important building block towards Malta's transformation to a knowledge economy as it would facilitate innovative ventures to take shape and flourish. This support ecosystem would be independent of thematic specialisations, thus providing a baseline level of support for all players and embedding flexibility to support any new specialisation areas which emerge over time.

2. Investing in a stronger knowledge base – The achievement of the second goal is to be seen as a longer-term investment, the fruits of which may or may not be reaped within the timeframes of this Strategy. This goal balances the overarching orientation of this Strategy towards close-to-market R&D and innovation by building capacity and excellence in the earlier stages of the R&D process. Given the magnitude of investments required and resource limitations, priority should be focused on identified thematic specialisations.

3. Smart, flexible specialisation – This goal targets the establishment of a knowledge-based economy by prioritising its achievement in a number of thematic areas. It is a very innovation-oriented approach which however does not exclude the involvement of research activities. In addition, the prioritisation of long-term investments in a stronger knowledge base in identified thematic areas serves to embed stronger foundations over the longer term, thus consolidating the knowledge base of these thematic areas.

An area of research identified in the strategy remains climate change adaptation:

> *"7.3 Capacity building for excellence in climate change adaptation*
>
> *Climate change and adaptation to it are major global concerns. However climate change impacts can be highly diverse and depend on, inter alia, geographical, hydrological and economic specificities. It is therefore important for Malta to invest in understanding climate change impacts within the local context in order to be able to adequately adapt to the changing environment by informing policy as well as business responses. Evidence-based adaptation to climate change is therefore necessary for long-term economic growth, competitive advantage, efficiency gains and cost savings. Investment in research into climate change adaptation is therefore identified by the present Strategy as an area of focus for building multidisciplinary*

[77] http://mcst.gov.mt/policy-strategy/national-research-innovation-strategy/

*research capacity and strengthening international cooperation, thus building a path towards excellence in this area. Given the existing (albeit somewhat fragmented) high degree of expertise in various facets of climate change adaptation, the time is ripe for Malta to consolidate its expertise, augment and valorise it through the development of a centre of excellence on climate change adaptation."*

### 8.1.2 Actions to support research

The previous Malta Government Scholarship Schemes (2006-2013) were replaced by the Endeavour Scholarship scheme[78] (2014 to date) in support of Master and PhD scholarships.

The increased focus of such funding programmes on issues relating to climate action will not only support scholarship but will also channel research in this important area of study. These include a Scholarship in Post Graduate Studies to study Adaptation and Resilience to Climate Change, a Scholarship in Post Graduate Studies to Develop a Low Carbon Economy, and a Scholarship in Post Graduate Studies on Good Governance of Climate Action.

### 8.1.3 Scholarships in Post-Graduate Studies at the University of Malta on Climate Action - offered by the Government of Malta to Students from Developing States

#### 8.1.3.1 The Purpose and Aim of this Initiative

The Scholarships are being offered as part of the Government of Malta's commitment under the Climate Finance Package to provide support for capacity building in developing States. Whilst capacity building is often associated with infrastructural projects, Malta believes that the formation of professionals within a community is the most essential step in this process of emancipation from an excessive and long-term dependence on external expertise. Consequently, the Government of Malta wishes to provide assistance to developing states on an equally fundamental aspect of capacity building, namely the empowerment of human resources in developing States through funding scholarships for academic learning and research at the post graduate level.

A total of Nine scholarships in post graduate studies are being offered for students seeking to enroll in Post-Graduate Studies at the University of Malta commencing in October 2017. Further scholarships will be offered over a span of three to four consecutive years. Each scholarship will focus on one of the three key areas recognized as essential pathways for ensuring effective climate action on a national level. It will also include aspects from the other two remaining pathways as related to focus area to ensure a multidisciplinary approach. These three pathways span across various disciplines and are essential for all States, irrespective of their geophysical realities or economic situation.

These pathways are:

- mitigation of climate change and the development of a low carbon economy;
- identifying risks and vulnerability to adapt to climate change and enhance resilience; and
- good governance of climate change.

The scholarships offer students from developing States the opportunity to focus their studies and research according to their national needs and realities. A number of developing states are already exploring methodologies on how to build a better future in view of the impacts of climate change. The formation of young professionals in this field will directly support the growth and consolidation of these home-grown initiatives. The aim of these scholarships donated by the

[78] https://education.gov.mt/en/education/myScholarship/Pages/ENDEAVOUR%20Scholarship%20Scheme.aspx

Government of Malta will serve to complement other national climate action projects and provide the opportunity to educate academically and train professionally, young people from developing States on how to manage mitigation, adaptation and governance of climate change. The scholarships will help to:

- address skills mismatches and gaps in local expertise;
- empower local communities to build a tailor- made knowledge base;
- identify the appropriate tools and options for the local scenario to address and adapt to climate change; and
- provide a powerful medium for the formation of a sense of national identity, economic stability and community regeneration.

#### 8.1.3.2 Climate Action

Malta is an ideal meeting point for researching climate studies, not only because of the relevant academic expertise it has acquired in these sectors, but also because its size and other geophysical conditions render it a living laboratory. Although it is an Annex I Party under the UNFCCC Malta is not a major net emitter yet it is likely to be amongst the most vulnerable States that will be effected by climate change. Malta has taken salient preventive and precautionary measures to address this challenge by adopting policy and legal measures that promote a low carbon economy. It is steadily working to enhance resilience to the effects of climate change. It has a robust legal and policy framework that facilitate intersectoral governance of climate action. Malta has committed itself to ambitious climate action whilst continuing to develop its economy. Malta has in fact been successful in decoupling economic growth from its consumption of fossil fuels. It has managed to increase its GDP to 260% whilst decreasing its green house gas emissions by 55% since 1990 levels.

The academics of the University of Malta have played a vital role in guiding the government of Malta to adopt the necessary measures for climate action. The University of Malta has acquired a wealth of experience in identifying policy, legal, administrative and institutional capacity building measures that serve to fulfill Malta's obligations in climate action as a small island nation in the Mediterranean and as a member of the European Union. On the one hand Malta's Mediterranean dimension highlights its need to address climate change urgently so as to ensure resilience in one of the zones predicted to be worst effected by climate change. On the other hand, as a member State of the European Union, Malta has implemented inter disciplinary climate action measures that form part of the most developed and researched regime on the subject.

#### 8.1.3.3 The Scholarships

##### *Scholarship in Post Graduate Studies to study Adaptation and Resilience to Climate Change*

The international community's endeavours to address climate change include adapting to its effects. Adaptation entails reducing the local risks of climate change by identifying national vulnerabilities in order to secure resilience. In this manner, climate action that promotes resilience would enhance both the sustainable use of natural resources and national, regional as well as global peace and security. Resilience to climate change depends upon the empowerment of local communities with the infrastructure, skills and tools to manage their own natural resources. Furthermore, sustainable management includes the development of conservation and management techniques that are suited to local materials, traditions and skills, in order to ensure that they may be replicated and sustained with the least possible dependence on externally-devised solutions.

There are a number of distinct similarities between Malta and developing states requirements in addressing adaptation to climate change. For this reason, the training and expertise offered by the University of Malta is highly relevant to the developing states' context. These common characteristics should also facilitate the creation of long-term synergies between the University of Malta and other universities in developing states.

The MSc by research programme[79] is a three-semester full-time research programme comprising a taught study-unit to which 5 ECTS credits are assigned and a dissertation study-unit to which 85 ECTS credits are assigned. The taught study-unit will be chosen in consultation with the Faculty, to be relevant and complementary to the dissertation research.

Students may propose a research proposal in one or more of the following:

1) The water and agriculture nexus under the influence of climate change;
2) Building resilience to counteract water scarcity;
3) Building the necessary capacity in water resources for good governance;
4) Enhancing the adaptive capacity of river basins for sustainable water resources management; and
5) Developing water policy frameworks for developing regions.

### *Scholarship in Post Graduate Studies to Develop a Low Carbon Economy*

As a member of the European Union, Malta is proud to be legally committed at a multilateral, European and domestic level to reduce emissions of greenhouse gases in order to mitigate climate change. Malta's determination to switch to a low carbon economy is characterized by a vision, based on the long-term, socio-economic, and environmental benefits of greenhouse gas emissions reduction.

Academic studies to promote a low carbon economy however are not limited to energy generation issues alone. They must provide also a holisic perspective taking into account other sources of greenhouse gases from a variety of sectors such as transport, land use, agriculture, waste generation and industrial processes. National action plans and strategies to increase energy efficiency, particularly from an end-use perspective, and to promote renewable energy sources are an essential policy making tool without which States risk making the wrong choices and adopting fragmented and piecemeal approaches that are neither holistic nor cost effective.

The student is to acquire a skill set that she or he can apply in their home country to make a real difference with respect to climate change mitigation, and without the need for equipment that may not be available upon return to the home country. The student will gain an understanding of the role that access to energy services plays for development and learn how the existing or targeted energy needs could be achieved through renewable and least-carbon-intensive energy regimes. The study will thus take its starting point at current regional or national situation, take expected economic and population growth into account, and test scenarios how future energy demand can be met as cost-effectively as possible, while minimizing the region's carbon footprint. The student will learn how to assess the potential of all relevant renewable energy sources from accessible data bases and how to proceed by relating to existing data in case exact data is missing for the region. The student will be introduced to relevant software packages and use them to relate the studied region's renewable energy potential to the prevalent or expected energy demand by modelling the energy mix that provides for adequate energy security while keeping costs and energy-related greenhouse gas emissions at a minimum. At the end of the study the student will be able to adequately communicate with policy makers; explain and interpret the

[79] A more detailed description of the course structure may be viewed at:
http://www.um.edu.mt/ben/overview/PRMSCBENFTR0-2014-5-F
The detailed course bye-laws may be viewed at:
http://www.um.edu.mt/__data/assets/pdf_file/0004/99805/MSc-BuiltEnv-BL-2010.pdf

study's result and recommendations; point out which data would have to be acquired in better quality to improve the accuracy of the model results; and to adjust the study whenever circumstances should change in the future or a different region is to be investigated[80].

## *Scholarship in Post Graduate Studies on Good Governance of Climate Action*

The implementation of mitigation and adaptation measures referred to above cannot function well unless there is the required institutional capacity to promote sound policy making and adequate regulatory instruments. As climate action is essentially multidisciplinary, it requires coherence and mainstreaming across the board particularly within the public sector. National authorities should set in place the required institutional networking with a clear delineation of roles to ensure fair and equitable effort sharing for climate action in all sectors, the formulation of adequate regulatory instruments, streamlining administrative practices to ensure that private sector's involvement is not overburdened by unnecessary bureaucracy. Good governance aims to ensure that all sectors will be under pinned to set up:

- the required institutional capacity to monitor, review and verify green house gas emission reduction targets;
- assess resilience according to national risks and vulnerabilities to formulate adequate adaptation measures;
- secure better implementation for climate action measures and ensure the necessary forward planning; and
- identify niche opportunities for business investment to counter climate action.

Climate change has been one of the most dominant and contentious political issues over these last two decades. Assailed by skepticism on one side and hailed as the most serious threat facing humankind on the other side, the climate debate has generated a wealth of scientific research, landmark economic studies like the 2007 Stern Review as well as complex legal instruments both at the national and global level. As policy makers strive to understand the socio-economic implications of predicted scenarios, politicians are caught between the polarised views of skeptical or overly concerned stakeholders who either accuse them of creating unnecessary burdens or of being too passive in dealing with human-induced climate change. Thankfully, there is a more plausible approach to climate politics, appropriately termed as "climate action". Some governments have made the effort to push for climate governance from a holistic and realistic perspective that is not limited solely to environmental issues.

Climate action is linked first and foremost to low carbon development, sustainable resource management, capacity building opportunities and other aspects that strike at the very resilience and competitiveness of States in today's world. Decoupling economic growth from the increase in fossil fuel energy generation as part of a climate change mitigation strategy bears many advantages. Similarly, adapting to the predicted effects of climate change involves implementing sustainable natural resource management that is deemed already essential in present times. Furthermore, adaptation to climate change according to the different scenarios presented by the scientific experts of the IPCC, is essentially a good governance exercise, which carries out risk and vulnerability assessments in order to ensure sustainable development, preparedness and therefore enhance resilience as well as present innovative, niche opportunities. Within this context, many governments have embarked on devising strategies and action plans to address climate change mitigation and adaptation. Nevertheless holistic governance of

[80] A detailed description of the course structure may be viewed at: http://www.um.edu.mt/ise/programme/PMSCSSEFTR3-2015-6-O
The detailed course bye-laws may be viewed at: http://www.um.edu.mt/__data/assets/pdf_file/0018/191034/MSc-Sustainable-Energy-BL-2013.pdf

climate action and its linkages with sustainable development remains an area of research that is largely unexplored.

Good governance in this respect includes an assessment of the required institutional and legal framework to support mitigation and adaptation policy measures. This MSc by Research involves a horizontal as well as a sectoral assessment. Whilst the horizontal assessment would aim mainly at enhancing the interdisciplinary nature of an institutional set up to facilitate coherent governance and enhance civilian information, participation and right of review; the sectoral assessment undertakes a painstaking exercise to identify whether existing legislation governing resource management is lacking in securing resilience and sustainablity and which amendments need to be adopted to facilitate adaptation.

The research would aim to identify how if endowed with the appropriate legal and institutional framework, climate change measures would also serve to identify the intrinsic value of natural resources and the vital role they play in the wealth, resilience, competitveness and general well-being of States[81].

### *Funding for the Scholarship*

Funding by the Government of Malta covers, wholly or partially, various expenses that would be presented to the awardee. These include, payment of the University of Malta tuition and enrolment fees, healthy insurance, reimbursement for visa expenses, and one return journey to the home country. The scholarship also provides a monthly subsistence allowance to be used towards accommodation, living, transport and academic expenses, and any other expenses that may arise.

## 8.2 Research and systematic observation activities - overview

The interest in Climate Research and its effects has been steadily increasing throughout the years. Numerous research groups within the University of Malta have lead this development together with other institutions such as the Met Office and the Malta College of Arts, Science and Technology (MCAST). While many institutions conduct research, a number also contribute to Systematic Observation of climate-related parameters. A summary of these institutions and the nature of their contribution can be found in Table 8-1.

At a local level, Malta contributes at a EU level towards the Copernicus program. Copernicus is a European Union Programme aimed at developing European information services based on satellite Earth Observation and in situ (non-space) data**.** The Copernicus program is a source of free, open and reliable data. Malta's contribution to the program is as follows:

1. Malta is an official member of both the Copernicus Committee and the Copernicus User Forum;
2. Malta forms part of the Copernicus Network Relay. The Maltese Copernicus Relay comprises the Planning Authority, the Malta Council for Science and Technology and the Malta Environment Resources Authority;
3. Malta also forms part of the Copernicus Academy. The Physical Oceanography Research Group (PO-Res.Grp) at the UoM contributes towards the use of CopernicusMarine Environment Monitoring Service (CMEMS) and the update of CMEMCS data by local users;

[81] A more detailed description of the course structure may be viewed at:
http://www.um.edu.mt/iccsd/overview/PMSCSSDFER0-2015-6-O
The detailed course bye-laws may be viewed at:
http://www.um.edu.mt/registrar/regulations/faculties/isd/msc-su-dev-bl-2010

4. Malta holds quarterly space governance meetings whereby the contributions from local entities to the space sector, including the Copernicus program, are discussed.

**Table 8-1 Overview of Maltese Institutions that contribute to Research and Systematic Observation.**

| Institution | Research/Systematic Obs. |
|---|---|
| **UNIVERSITY OF MALTA** | |
| ***Department of Geosciences - Faculty of Science*** | |
| Climate Research Group | Research |
| Atmospheric Pollution Research Group | Systematic Observation |
| Physical Oceanography Research Group | Systematic Observation |
| ***Department of Biology – Faculty of Science*** | |
| Marine Ecology Research Group | Research |
| ***Faculty of Arts*** | |
| Department of Geography | Research |
| ***Faculty of Economics, Management and Accountancy*** | |
| Department of Economics | Research |
| ***Faculty of the Built Environment*** | Research |
| ***Faculty of Laws*** | |
| Environmental and Resources Law Department | Research |
| ***Forum on Legal Issues for Adaptation to Climate Change*** | Research |
| ***Centre for Environmental Education and Research*** | Research |
| ***Institute for Climate Change and Sustainable Development*** | Research |
| ***Institute of Earth Systems*** | Research |
| ***Islands and Small States Institute*** | Research |
| ***Institute for Sustainable Energy*** | Research |
| ***Institute for European Studies*** | Research |
| **THE MALTA COLLEGE OF ARTS, SCIENCE AND TECHNOLOGY (MCAST)** | |
| Applied Environmental Sciences Research Group | Research |
| Energy Research Group (MCAST Energy) | Research |
| **MET OFFICE** | Systematic Observation |

## 8.3 The role of the University of Malta in spearheading climate research

The University of Malta is the primary institution to develop and support research in the area of climate change. The setting up of the University Climate Change Platform (CCP) in 2012 and the establishment of the Institute for Climate Change and Sustainable Development[82] in 2013 have provided an environment for better coordinated research activities within the different faculties, institutes and centres of the University.

The aim of the Platform is indeed to bring together the various bodies involved in research on climate change issues in the University[83]. The CCP's main objectives are (a) to facilitate collaboration between University of Malta entities and individual academics interested in climate change issues and (b) to promote research and teaching initiatives relating to climate change. The Platform provides various facilities to encourage such collaboration and promotion of research, including (a) periodical issue of a newsletter that reports on CC-related activities by University entities; (b) information about research and teaching activities, as well as participation in climate-change related conferences by University entities and individual academics and (c)

[82] www.um.edu.mt/iccsd
[83] https://www.um.edu.mt/islands/climate

promotion and showcasing of research conducted by University of Malta entities and individual academics.

The activities of a wide range of bodies working under the auspices of the University of Malta are described here, providing a case study of the role of this academic institution in spearheading research in Malta in the various facets of climate change. Aspects of systematic observation of climatic conditions and parameters related to climate change are also described. The section does not purport to provide a detailed resumé of research and systematic observation work that has been, and continues to be, undertaken, but rather provides an overview of the broad extent of work relating to climate change issues that is taking place within the University, reflecting also the complex nature of the topic.

### *Climate Research Group, Department of Geosciences - Faculty of Science*

The Climate Research Group[84] (CRG) forms part of the Department of Geosciences at the University of Malta and focusses on the understanding of the structure and variability of the climate system, especially within the Mediterranean region.

The CRG operates a numerical weather prediction (NWP) model called WRF and a regional climate model (RCM) called RegCM4 on a super computer cluster (ALBERT) at the University of Malta. With these facilities the Department of Geosciences is offering research opportunities from undergraduate to post-doctoral levels. Furthermore, contribution to the international scientific community will be given through new experiments, testing and developing components of the models.

The research interests of the group include:

- Development of chemistry of an aerosol module in a RCM;
- Implementation of code for new chemical reactions in a RCM;
- Improvement of RCM performance over small islands;
- Regional analysis of meteorological extremes;
- Optimising NWP predictions over Small Islands.

Ongoing research includes a post-doc project on the validation of the chemical module developed within this group to calculate the radiative effects of secondary organic aerosols in a RCM in collaboration with the International Centre for Theoretical Physics (ICTP) in Trieste. An MSc project has commenced to optimise a NWP to account for the urban heat island and study how this is affected by proximity to the sea in small island states.

The CRG has also been active in outreach activities with a series of public talks, television and newspaper interviews, and the design of new study units for a new undergraduate course offered by the Department of Geosciences at the University of Malta.

### *Department of Geography - Faculty of Arts*

The Department of Geography is involved in research in a number of broad areas. Of particular interest to climate change is the research concerning Coastal Zone Management and sea level rise which has also seen the completion of a number of postgraduate dissertations in this field over the years[85].

[84] http://www.um.edu.mt/science/geosciences/climate
[85] http://www.um.edu.mt/arts/geography

## *Department of Economics – Faculty of Economics, Management and Accountancy*

Besides offering specific study units covering environmental issues and the application of Cost Benefit Analysis to assessing external costs and benefits, the Department of Economics has conducted research on the external costs of transportation[86] in conjunction with the Institute of Climate Change and Sustainable Development, and on carbon emissions of plug-in vehicles[87]. Dr Philip von Brockdorff, Head, Department of Economics co-authored both studies. The latest relevant research being conducted by Dr von Brockdorff and Dr Ian Cassar, from the same Department, is an estimation of emissions multiplier for economic sectors using input output methodology.

## *Faculty of the Built Environment*

The Faculty of the Built Environment has at least three Departments that contribute to areas related to climate change. Probably, the most important is the Department of Spatial Planning and Infrastructure, which works, inter alia, on water governance, water resources, and waste management, all of which are important themes of sustainable development within our industry. They have run at least two editions of a specialist M.Sc. course in Sustainable Infrastructure, and will be hosting a Developing World student who has won a Scholarship in Climate Action, offered by the Government of Malta. Her research will focus on Building Resilience for Water Resources, and will focus on the issues relevant to her home, which is the island state of Palau in the South Pacific.

The Department of Environmental Design, is interested, inter alia, in energy efficiency of buildings and embodied energy in construction materials, among others. It undertakes research on various aspects of environmental performance of buildings, including passive design of buildings, ventilation and movement of air inside and around buildings, natural and artificial lighting, and acoustics. It has offered specialist M.Sc. courses in Environmental Design, and has now launched an M.Sc. in Sustainable Building Design.

The Department of Civil and Structural Engineering has worked in the use of waste material in the construction industry, and one member of staff has recently submitted a patent based on nearly eight years of work, focussed on the re-use of globigerina waste to produce artificial stone components.

In addition, the Department of Architecture and Urban Design has recently completed a Life Plus project on Green Roofs, focussed on the solar protection offered by such systems, on their contribution to storm water flooding mitigation, and to increased bio-diversity, which has also led to a National Standard on Green Roofs being promulgated. The Department of Conservation and Built Heritage has also participated in projects related to the impact of Climate Change on heritage assets.

The Department of Construction and Property Management is also working on waste materials in the construction industry, and on the life cycle of buildings, with a view to reducing waste. Members of the department have participated in a number of European projects dealing with lifetime engineering, sustainability in construction and life cycle analysis. Research focuses primarily on life cycle assessment, materials and durability and energy efficiency and lifetime engineering.

For the last seven years, the Faculty has been working on a major ERDF funding proposal, which has the objective of building a prototype resource-efficient building on campus. This building will act as a live laboratory, and will provide the research infrastructure for topics, ranging from the

[86] https://ec.europa.eu/malta/sites/malta/files/docs/body/study_on_traffic_online.pdf
[87] http://www.sciencedirect.com/science/article/pii/S2213624X17301396

use of grey-water in buildings, the use of deep saline water extraction, the performance of renewable energy devices designed by the Institute of Sustainable Energy, the potential use of micro-grids in buildings, and a range of other important studies, which have relevance to Climate Change. The building will also act as a demonstration building for the industry, and for the public. In other words, it will also be a tool for the preparation of society for climate change mitigation measures.

### *Environmental and Resources Law Department - Faculty of Laws*

The Environmental and Resources Law Department[88] was set up in 2010 and focuses on lecturing, tutoring and research at under graduate and post graduate level in:

- Environmental law;
- Law relating to sustainable development and sustainable resource management;
- Development Planning law;
- Climate change law;
- Occupational Health and Safety Law;
- Food Safety Law;
- Heritage law; and
- Aspects of policy making related thereto.

The decision to set up this new Department within the Faculty of Laws was prompted by the vast developments in the legal framework addressing these topics on a national, European and international level. The particular relevance for Malta of having an academic department dedicated particularly to environmental and resources law within the highest education institution in the country is borne out by the fact that the environmental (including climate change) *acquis communitaire* is the second largest chapter in the whole EU *acquis* to which Malta is bound as a member state of the Union; and this does not include other legal areas addressing topics that are closely related to environmental and climate change considerations, such as energy. The Department participates regularly in national and international conferences addressing climate change issues and its research focuse on the linkages between climate action and sustainable development. It has contributed to climate law and policy research at the undergraduate, masters in law and also other postgraduate levels.

### *Forum on Legal Issues for Adaptation to Climate Change*

An initiative of significant importance to which the University is contributing is the Forum on Legal Issues for Adaptation to Climate Change. This forum of European academic legal experts was jointly set up in 2010 by the University of Malta and the Catholic University of Leuven and is based at the University of Malta. Its mission statement is to serve as a place of discussion, continuing education and advice on developing a legal framework for adaptation to climate change in the EU and beyond. The Forum is committed to support the European Commission's Directorate General on Climate Action (DG CLIMA) in its work on adaptation to climate change.

Membership in this Forum includes academics from universities or academic institutions in five European Union states. The Forum is co-chaired by Dr Simone Borg (University of Malta; Ambassador to Malta on Climate Change) and Prof Dr Kurt Deketelaere (University of Leuven)

[88] http://www.um.edu.mt/laws/env-resources.

and has an advisory board made up of key people from the University of Malta and DG CLIMA that also includes Mr Michael Zammit Cutajar who has served as Executive Director of the UNFCCC Secretariat, Special Advisor on Climate Change to President of the European Commission Manuel Barroso and as Ambassador to Malta on Climate Change. The University of Malta offers the logistical set up and hosting of the Forum on its campus, including all conferences, as well as the contribution of its academics specialised in the field of adaptation to climate change. The University of Leuven as joint founder of the Forum contributes, through its Institute for Environmental and Energy Law, its expertise on climate change issues and its global legal network.

### *Centre for Environmental Education and Research*

The Centre for Environmental Education and Research[89] (CEER) offers opportunities for Education for Sustainable Development (ESD2) to empower citizens to actively participate in environmental decision-making fora and in initiatives that promote good quality of life for all. CEER provides a focal point for coordinating ESD2 initiatives, increasing the opportunity for ESD2 research, making scientific and technological research results more accessible and facilitating resource transfer and capacity building in Malta and the Euro-Med region.

The Centre is involved in research in the area of ESD2 and climate change. Academic staff of CEER have published on the subject, including articles in international journals on areas such as youth and environmental and climate change knowledge, attitudes and behaviour.

An online teaching module on climate change was also developed by the CEER under the EU funded project RADC (Raising Awareness for Development Cooperation). The CEER also coordinated a three-year EU funded project called Global Action Schools where Climate Change was one of the main themes that the project focussed upon. The project was aimed at exploring how small changes in the day-to-day running of schools can have a positive impact on life in developing countries, and to link learning to the role that students can play in creating a fairer and more sustainable world.

CEER is currently also involved in two 3-year EU funded projects: (a) EduChange that addresses climate change through innovative place-based education and blended learning; and (b) PEERMENT that aims to promote peer mentoring among educators on pedagogical issues related to ESD2 and climate change.

### *Institute for Climate Change and Sustainable Development*

The Institute for Climate Change and Sustainable Development (ICCSD) was set up in 2010 as the Institute for Sustainable Development. It later took over the responsibilities for the interdisciplinary research area of Climate Change. The Institute supports the network of academics interested in working on interdisciplinary research in area of sustainability and climate change. To date the Institute offers Masters and Ph.D. programmes. It conducts research in various fields related to sustainable mobility and transport and climate change. It tackles also research related to waste and cleaner technology. The Institute is involved in local and international research and contributes regularly to publications on various topics of research. It attracts a number of academics from different fields to collaborate on specific aspects of study, primarily related to sustainability fields (including climate change)[90].

[89] http://www.um.edu.mt/ceer.
[90] Information on the programmes, research and outreach are available at www.um.edu.mt/iccsd

## Institute of Earth Systems

In 2010 the University approved the setting up of the Institute of Earth Systems (IES)[91] which brought together the former International Environment Institute and the Institute of Agriculture.

The IES conducts research on climate and related trends at both local and regional level. Subthemes include the understanding of regional past and current climate, impacts of climate change on biodiversity, health and infrastructure. It has built a knowledge-base to assist students and researchers to perform studies on climate change and its impacts on many sectors. Below is a salient list of research themes.

- Improve and use climate and weather prediction models;
- Document and assess impacts from extreme weather and climate change on sectors such as health, agriculture, tourism, aviation, biodiversity, and coastal environment;
- Gauge climate change literacy, beliefs and communication of climate change impacts;
- Reconstruct past climates from pollen records in sediments.

## Islands and Small States Institute

The Islands and Small States Institute (ISSI)[92] promotes research and training on economic, social, cultural, ecological and geographical aspects of islands and small states. The Institute has climate change as one of its areas of interest and is involved in a number of research initiatives. Furthermore, its academics have been involved in climate change research at an international level for a number of years, including Prof. Lino Briguglio as the only Maltese academic to-date involved in the work of the IPCC. Through his involvement in Working Group II of the IPCC, as a lead author for the chapter on Small Island in the Third, Fourth and Fifth assessment reports, and thus formed part of the team that was awarded the Nobel Prize to the IPCC in 2007.

The Islands and Small Institute hosts the CCP[93] of the University of Malta, which is coordinated by Dr Stefano Moncada. The CCP facilitated the creation of two databases in the area of climate change, the first summarising all the study units, featuring climate change, taught at the University of Malta, and the second that provides an up-to-date list all the publications in the area of climate change, published by researchers from the University of Malta. The CCP organises research seminars on climate change mitigation and adaptation, including: - 'Climate Change Mitigation and the Co-Benefits of a Low Carbon Economy in Malta' (3rd November 2016); - 'Climate Change and Disaster Risk Reduction: Trends and Economic Challenges in Malta' (23rd November 2016); - 'Managing Extreme Events: Health System Preparedness for Climate Change' (6th of April 2017); 'Assessing and seizing sustainable trade opportunities in specific Green Economy sectors' (24th November 2017). The social media accounts of the CCP (Facebook and Twitter) are constantly updated, and are used to disseminate information about climate change, including research, undertaken both at the University of Malta and abroad.

The ISSI is an official World Health Organisation (WHO) research collaborating centre, and within the existing health platform, coordinated by Dr Natasha Azzopardi Muscat, there are key research areas that focus on the public health aspects of climate change, especially costs and preparedness of health systems to the negative impacts of climate change.

## Institute for Sustainable Energy

[91] http://www.um.edu.mt/ies
[92] http://www.um.edu.mt/islands
[93] https://www.um.edu.mt/islands/climate

The Institute for Sustainable Energy[94] (ISE) is the primary centre for study and research in renewable energy in Malta. It performs research in renewable energy, organizes courses at all levels and aims to assist in the development of National Energy plans through studies in the use of new and renewable energy sources and methods of energy conservation. Its interest in climate change is thus primarily from a mitigation perspective, looking at alternative means of sourcing energy. ISE research areas include Solar materials and systems, wind energy, energy storage, energy in buildings, geothermal energy, energy economics and policy.

#### *Institute for European Studies*

The Institute for European Studies[95] is a multi-disciplinary teaching and research institute which was awarded the Jean Monnet Centre of Excellence in 2004. The Institute is engaged in various research and publication activities in European integration studies and is a member of the Trans-European Policy Studies Association (TEPSA), EPERN (European Parties Elections and Referendums Network), EADI (the European Association of Development Research and Training Institutes), PADEMIA (the Erasmus Academic Network on Parliamentary Democracy in Europe), the European Consortium for Political Research (ECPR), and the two Euro-Mediterranean networks, EuroMeSCo (the Euro-Mediterranean Study Commission) and FEMISE. The Institute is also a member of the Council for European Studies (hosted at Columbia University).

The Institute for European Studies engages in climate change research at Ph.D., M.A. and B.A. levels, as well as innovative research undertaken by members of the academic staff. The research, and systematic observations, in the area of climate change undertaken by the Institute are mostly in the disciplines of political science and economics. More specifically, observations were collected on how the EU climate change policies have been performing vis-à-vis the international commitments to mitigate GHG emissions. Furthermore, research has also assessed the performance of GHG emission reduction targets at national level, specifically looking at Malta's aims in the area of renewable energy targets, highlighting institutional and financial barriers to respect the targets.

A further area of economic research looked at climate change in the field of development policy, observing how the EU development and co-operation policy, including the disbursement of Overseas Development Assistance (ODA), both at EU and national level, have addressed climate change adaptation and mitigation efforts. This specific research has focused on developing countries in the Horn of Africa (one of the key areas of origin of migration for Malta), and Small Island Developing States (SIDS).

### *8.3.1 The Malta College of Arts, Science and Technology (MCAST)*

#### *Applied Environmental Sciences Research Group*

The MCAST Applied Environmental Sciences Research Group (AESReG) was set up to carry out applied research in the fields of environmental sciences and sustainability. The group is based at the newly built facilities of the MCAST Institute of Applied Sciences, which offers fully-equipped laboratories for training and research.

The team works on agro-environmental issues, including the reduction of the carbon footprint, carbon sequestration, and biodiversity for sustainable agriculture as part of a strategy to promote resilience and as an adaptation to climate change. In particular, the reduction in crop

[94] http://www.um.edu.mt/iet
[95] http://www.um.edu.mt/europeanstudies

productivity and quality, and the deterioration of the conditions for crop production have been identified as negative impacts of climatic change that are highly likely to impact on the Maltese agricultural sector by the National Climate Change Adaptation Strategy (2012)[96]. The research team has developed a strong experience in measures that enhance biodiversity and which provide agricultural benefits through synergies with crop production.

With the Mediterranean region being identified as one of the most vulnerable regions to the impact of climate change on ecosystems and human well-being, the research group is a pioneer in the implementation of research on ecosystem services and nature-based solutions in Malta, and within the region, and has been involved in related projects since the research group's inception. Recent research by the group has investigated the link between ecosystems and the delivery of ecosystem services that lead to benefits to society in Malta, for example through carbon sequestration, improved local climate regulation and air quality regulation. The AESReG collaborates with national authorities and with international partners in a number of projects that use multidisciplinary techniques to assess and map ecosystems and their contributions to human well-being.

### *Energy Research Group (MCAST Energy)*

The MCAST Energy specialises in global and regional solutions by innovative devices in emerging technologies, systems level integration to policy engagement for better community. The breadth of energy research at MCAST includes device fabrication and on-site testing, energy economics and policy, efficient buildings, power systems, renewables and transportation. The group specialises in applied research techniques including but not limited to optimisation, decision making and life cycle analysis.

On the basis of research in these areas, the MCAST Energy team have participated in a number of European projects dealing with the development and demonstration of smart grid systems, energy and water systems integration and management, renewable energy and technologies. Research focuses primarily on a future-proof active smart Micro-Grid system optimisation and water and energy systems integration in a single and efficient system. The overarching objectives are to capitalise on the availability of local and large renewable energy resources and adapting them for solutions to sustainability in terms of electric power demand and supply.

Members of the MCAST Energy have also assisted in setting up new projects dealing with sustainability in the energy market, in particular, PV integration, on-site testing and monitoring. Members are also involved in research related to impacts of PV integration on low voltage (LV) networks with collaboration of Enemalta PLC. Also, due to a newly assembled organic/perovskite photovoltaics laboratory research are focused will on scalability of perovskite solar cells and organic photovoltaic (OPV) coating processes.

Recently MCAST Energy organised the National Energy Day Conference and has also hosted 'The 10th International Summit on Stability of Organic and Perovskites Solar Cells' (ISOS-10 '17). The group has a growing research portfolio including two MCST funded projects[97] , an MCST FUSION funded project, six COST Action Projects[98], and actively participating in various other industrial and international collaborations. Strategic partnerships of MCAST Energy include Enemalta PLC, Water and Energy Agency and Energy Advice (Lithuania). MCAST Energy offers also executive courses, Masters by Research and in collaboration with The University of Manchester split-site PhDs.

[96] https://www.gov.mt/en/Government/Publications/Documents/MSDEC/National%20Adaptation%20Strategy.pdf
[97] www.3dmicrogrid.com & www.edgewise.ubi.pt.
[98] stablenextsol.eu, cost-rely.eu, www.cost.eu/COST_Actions/ca/CA16114, http://www.cost.eu/COST_Actions/ca/CA16235, http://www.cost.eu/COST_Actions/ca/CA16232, & http://www.cost.eu/COST_Actions/ca/CA16222.

## 8.4 Systematic observation

### 8.4.1 Systematic Observation activities at the University of Malta

#### *Atmospheric Pollution Research Group, Department of Geosciences - Faculty of Science*

The Atmospheric Pollution Research Group, which is now part of the Geosciences Department, was set up in the mid-1990s and actually started functioning officially in October 1996. An old lighthouse (still functioning) on the North-western tip of Gozo was chosen as the measurement station since this is exposed to the prevailing North Westerly winds. The initiative for the establishment of the group came from the Nobel laureate Professor Paul Crutzen who considers the Mediterranean a very important "cooking pot" for atmospheric chemistry in the Northern hemisphere.

The Giordan lighthouse has a history of meteorological data logging. From April 1877 to April 1981 weather observations were taken four times daily. These were recorded in logbooks and included the following meteorological parameters: direction and force of wind, air temperature, air pressure, and eye-witness observations of the state of weather and remarks (ex. visibility and general description – blue skies, rain, clouds, lightning)[99].

The Giordan Lighthouse was designated a Global Atmosphere Watch (GAW) Station in 2001. The GAW programme is a partnership involving 80 countries and its mission is to make reliable observations of the chemical composition and physical characteristics of the atmosphere, both on a global and regional scale. Its aim is to provide reliable long-term observations that are relevant for understanding atmospheric chemistry and climate change[100].

All data from this station is made available to the WMO community which then contributes to the annual publication of results. This constitutes a detailed record of climate variability with details of greenhouse and aerosol trace gas pollutants contributing to this climate change.

In 2010, the Giordan Lighthouse station, together with the premises at the University of Malta Gozo Campus, have been upgraded and refurbished using ERDF. The ERDF 078 project included instruments to measure trace gases and GHGs as well as aerosols. Moreover, further instruments were added through the VAMOS SEGURO project as part of the Italia-Malta 2007-2013 Cross-Border Cooperation Programme. The new monitoring equipment acquired through these projects is extremely sensitive and is housed in a temperature controlled laboratory[101].

Nowadays, trace gases, aerosols, volcanic ash and Aerosol Optical Depth are measured together with the meteorological parameters. Studies conducted by researchers of the Atmospheric Pollution Research Group further reveal the increasing temperature trend being experienced by the Maltese Islands (see Figure 8-1). It is to be noted that there is a gap in the data set between 2009-2010 for both relative humidity and temperature since the station was being refurbished and the new equipment was being installed. There was also another gap in relative humidity data during 2006 due to sensor malfunction.

---

[99] Azzopardi, F. (2016). Regional dispersion of pollutants with special reference to Etna emissions as measured at Giordan Lighthouse GAW station. Ph.D thesis, University of Malta.
[100] www.wmo.int
[101] Azzopardi, F. (2016). Regional dispersion of pollutants with special reference to Etna emissions as measured at Giordan Lighthouse GAW station. Ph.D thesis, University of Malta.

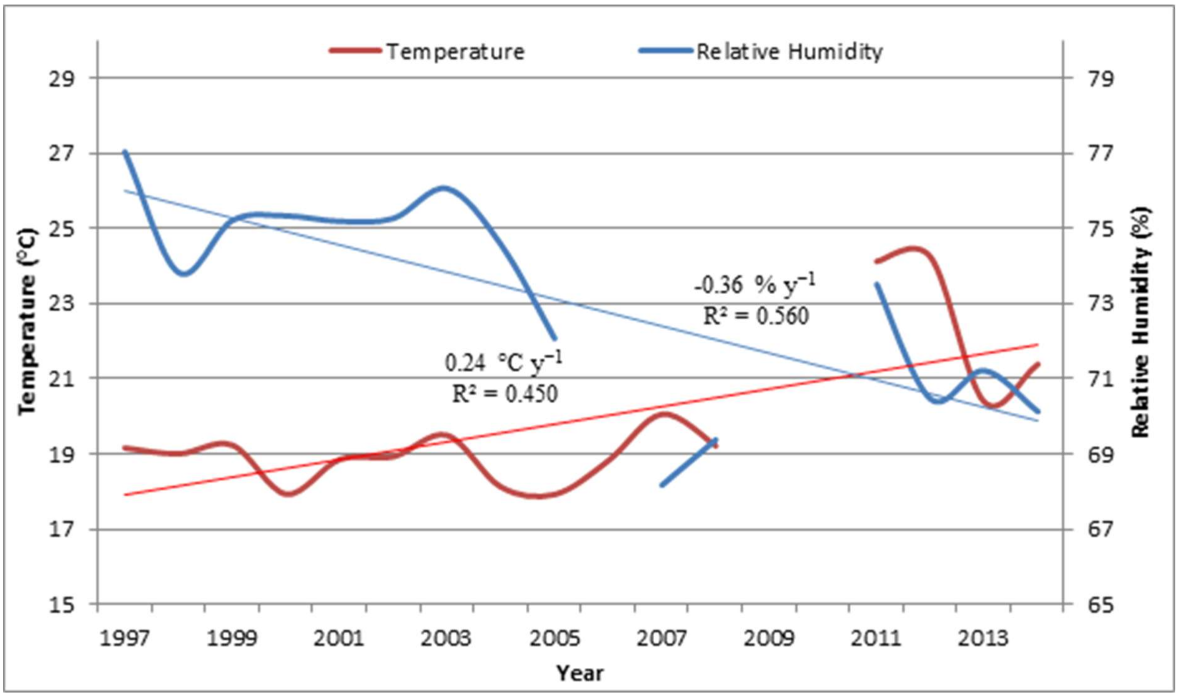



**Figure 8-1 Mean annual temperature and relative humidity between 1997-2014. Temperature shows a positive trend of 0.24 °C y−1 whilst relative humidity shows a decreasing trend of 0.36 % y−1.**

### *Physical Oceanography Research Group, Department of Geosciences – Faculty of Science*

The Physical Oceanography Research Group (PO-Res.Grp; previously Physical Oceanography Unit, PO-Unit) within the Department of Geosciences undertakes oceanographic research, in a holistic perspective, including operational observations and forecasts, specialised data analysis and management, with extensive participation in international cooperative ventures. The PO-Res.Grp has mainly endeavoured to promote activities in operational oceanography by the installation and maintenance of permanent sea monitoring systems, and the provision of meteo-marine forecasts. Observations include atmospheric parameters, sea level, currents and waves in both delayed and operational mode; forecasts for the same parameters are issued daily for the Central Mediterranean area and in the vicinity of the Maltese Islands on the services website[102].

The PO-Res.Grp also acts as a national oceanographic data centre and promotes the IOC/IODE (Committee on International Oceanographic Data and Information Exchange) products and activities in Malta. A main contribution in this field is the online national oceanographic database forming part of the Malta Blue Pages.

Under the direction of Prof. Aldo Drago, the PO-Res.Grp has strengthened its activities, know-how and capability through the participation in several EU funded regional and pan-European scientific projects. The Group has participated in several INTERREG projects, which resulted in the setting up of an HF radar observing system furnishing routine hourly updates in the form of 2D maps on the sea surface currents and sea state conditions in real-time in the stretch of sea between Malta and Sicily.

[102] www.capemalta.net

Prof. Drago is involved in MonGOOS (which is linked to the GCOS), the Mediterranean Regional Alliance for GOOS (ex. MedGOOS for which he served as Executive Secretary for many years). The PO-Res.Grp is a member of the MonGOOS, and Prof. Drago is vice chair of the WG on applications. The PO-Res.Grp relays some of the data to MonGOOS, but all the data is accessible directly from the online systems.

The Physical Oceanography Group is also currently undertaking local projects involving data collection for the environmental management of protected areas. This involves the use of drone technology for mapping of litter. KAPTAN, a smartphone application, was developed within the CALYPSO project and provides a service to mariners based on meteo-marine observations and forecasts[103]. The CALYPSO Data interface[104] provides data viewing and download of HF radar datasets in the Malta-Sicily Channel.

The main effort in relation to climate change studies consists of long term routine observations, in particular of sea level by the station in Portomaso, meteorological data collected by the weather station in M'Xlokk and the heat flux station at the University campus. This complements the operational short-term forecasting of marine (T, S, currents, waves) and atmospheric conditions for the Central Mediterranean area and the Malta shelf areas, which also provide the basis for climatological datasets in the long term.

One of the best documented impacts on the composition of marine biotic communities of climate change/global warming is the heightened success of invasion by non-indigenous marine species within new areas outside their native range. Whilst the drivers behind the increased mobility of species between different biogeographical realms largely reside with an increase in shipping, boating, aquaculture, offshore platforms and the aquarium industry, climate change is implicated in the increased probability of survival and proliferation of the exotic species in the newly-invaded areas.

Citizen science is the collaboration between scientists and the general public as volunteers to gather and/or analyse data relating to phenomena in the natural world which, due to a number of attributes, are difficult to monitor through conventional scientific methods. The operational monitoring of marine alien species is a perfect candidate for citizen science given the challenging disparate nature of sightings/records of such species in our waters.

Against this background, in January 2017, the citizen science campaign Spot the Alien Fish[105], was launched by the Department of Geosciences at the University of Malta and the IOI. This campaign sought to capitalise on the lessons learned from the implementation of the Spot the Jellyfish campaign, translating into a larger campaign poster, printed on both sides and in a laminated, splash-proof format to allow its seaside deployment. A total of thirty-six fish species are featured on the campaign poster, with an arrow underscoring the origin of each fish species (west, through the Straits of Gibraltar for species of Atlantic origin, or east, through the Suez Canal, for Lessepsian species). Since the inception of the campaign, two previously-unrecorded fish species were recorded from Maltese nearshore waters – the Guinea angelfish (*Holacanthus africanus*) and the Azure damselfish (*Chrysiptera hyanacea*), with two individuals of the former species being caught by recreational fishermen and one individual of the latter species being recorded on video by a SCUBA diver. Numerous reports of additional non-indigenous fish species, most notably *Fistularia commersonii, Siganus luridus, Seriola fasciata* and *Cephalopholis taeniops*, were submitted through the campaign portal, assisting administrators in tracking population trends for these species, whilst the second record for Maltese nearshore waters of the African moonfish (*Selene dorsalis*) also emerged through this marine citizen science campaign.

[103] The same services are also available online on www.capemalta.net/calypso/kaptan
[104] www.capemalta.net/calypso
[105] www.aliensmalta.eu

Venomous and toxic fish species are also highlighted on the same poster. In both marine citizen science campaigns, the public is solicited to also submit reports of unidentified species not necessarily included within the campaign posters and to retain, if possible, the individuals in question, if caught, either in a frozen state (in the case of fish) or in a bucket full of seawater (in the case of jellyfish) for subsequent collection by the campaign administration team. The submission of good-quality photos to accompany sighting reports is also encouraged within both campaigns. The two campaigns are regularly promoted with important national stakeholders, including snorkelers, SCUBA diving clubs, sailing clubs, angling and recreational fishing (e.g. spearfishing and spinning) clubs and professional fishermen, whilst a prominent online presence is maintained through the submission of regular posts on the two campaign social media *ad hoc* groups/pages.

### *Marine Ecology Research Group, Department of Biology – Faculty of Science*

The Marine Ecology Research Group (MERG) has carried out research[106] for the Mediterranean Science Commission's (*Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee (CIESM)*) 'Tropical Signals' project[107], as part of a systematic research observation programme carried out by 21 research teams from 15 different Mediterranean countries to detect, monitor and understand the effects of climate warming on Mediterranean marine biodiversity using representative biological indicators of change. The entry and spread of non-indigenous species in the Mediterranean has been linked to a changing marine environment. Consequently, monitoring such species, using common biological monitoring protocols across all participating countries, is an important component of the Tropical Signals project. MERG was given the role to implement such research in Malta under the auspices of the Programme, building on its track record of research on species and habitats in Maltese waters.

Apart from implementing the monitoring surveys, MERG has carried out two fundamental tasks in this respect as part of the programme:

- An inventory of alien species[108] and range-expanding[109] species reported from Maltese waters to act as a baseline for future comparisons; and,
- An extensive survey of the scientific and other literature and of authenticated but unpublished reports of newcomer[110] marine species recorded from the Maltese Islands and surrounding waters.

From this review[111] it resulted that up to the start of the 'Tropical Signals' programme (early 2008), 39 authenticated newcomer species and another nine unconfirmed ones, had been recorded from Maltese waters. Of the accepted records, 25 had become established[112], while 14 were

[106] Information compiled from information courtesy of Schembri P,J., Department of Biology, Faculty of Science, University of Malta.
[107] http://www.ciesm.org/marine/programs/tropicalization.htm.
[108] Species or infraspecific taxa, inclusive of parts, gametes or propagules, that may survive and subsequently reproduce and spread outside of their historically known range (geographical area occupied naturally) and beyond their natural dispersal potential (due to minor climatic oscillations) as a result of deliberate or accidental introduction by humans; (synonymous terms: non-native, non-indigenous, allochthonous, foreign, exotic, immigrant, imported, transported, adventives).
[109] Species that have recently arrived in a given area by natural dispersal from a neighbouring area in which they are native, without the intentional or unintentional intervention of humans.
[110] Alien and range-expanding species are collectively referred to a 'newcomer species'.
[111] Sciberras, M. & Schembri, P. J. (2007) A critical review of records of alien marine species from the Maltese Islands and surrounding waters (Central Mediterranean). *Mediterranean Marine Science* 8(1): 41-66.
[112] Species present as reproducing and self-perpetuating populations in the wild.

either casual[113] or questionable[114]. The most represented groups were molluscs (14 species), fish (13 species) and macrophytes (seagrasses and large seaweeds; 10 species). Six species were classified as invasive in Maltese waters[115].

Analysis of when each of the newcomer species was first reported from the Maltese Islands, and of their known or probable mode of arrival, showed that since the early 1990s, there has been an increasing trend in the number of marine newcomer species reported, with more than half the species being recorded since 2001 (Figure 8-2).

Since the start of the 'Tropical Signals' programme additional non-indigenous and other newcomer species have been reported from Maltese waters by workers from the Marine Ecology Research Group and by others[116]. Up to February 2016, the total number of newcomer species in Maltese waters (that is, alien and range-extending species) amounted to 80. Eight of these (9% of all newcomers) are considered to have extended their range naturally and hence do not fall under the definition of 'alien species', which are those introduced directly or indirectly through human agency.

Of the species considered aliens (or putative aliens but with uncertain origin), the dominant taxonomic groups are Mollusca (21 species), Actnopterygii (fish, 15 species), Crustacea (8 species), and Rhodophyta (7 species). Some 40% of alien introductions have occurred via unknown pathways; the rest were primarily introduced via shipping (24%), followed by 'secondary dispersal' (19%), and aquaculture and the aquarium trade (8%). 'Secondary dispersal' refers to species introduced in Maltese waters through dispersal from areas where they are considered alien (hence human-mediated). Eight species (10% of the total newcomer species) are considered to be invasive: the aliens *Caulerpa cylindracea*, *Lophocladia lallemandi*, *Womersleyella setacea*, *Brachidontes pharaonis*, *Percnon gibbesi*, *Fistularia commersonii*, and *Siganus luridus*, and the range extender *Sphoeroides pachygaster*.

Summing up what is known so far, it seems that a few species have been introduced deliberately and many more have been accidentally introduced by human activities, and that for the latter there appears to be a correlation with increasing marine traffic to Malta and the Central Mediterranean. Other species, mainly warm-water Atlantic and Indo-Pacific ones, first established populations in the western and eastern Mediterranean respectively, and then spread to the Central Mediterranean, including the Maltese Islands, under their own steam or assisted by shipping. The rate of entry of newcomer marine species in Maltese waters seems to be increasing with time (Figure 8-2), a phenomenon that may possibly be facilitated by the general warming trend of Mediterranean surface water that has been ongoing for the past few decades.

This research is ongoing. Apart from implementing the 'Tropical Signals monitoring programme in the Maltese Islands, and researching alien and other newcomer species and their impacts, MERG also maintains a database of such species reported from Maltese waters and authenticates all records as well as reviews past records in the light of new knowledge. Through this work, additional species since the last published review (2015) have been added, the establishment status of some species has been revised, past errors of identification have been corrected, and newly established species that have the potential to become invasive are being actively monitored.

[113] Species only recorded once or twice and have not established breeding populations.
[114] Species for which insufficient information exists to decide if they are established or casual.
[115] Species whose population has undergone a very rapid growth phase and which may affect the diversity or abundance of native species and the ecological stability of the ecosystem.
[116] Evans, J.; Barbara, J. & Schembri, P.J. (2015) Updated review of marine alien species and other 'newcomers' recorded from the Maltese Islands (Central Mediterranean). *Mediterranean Marine Science* 16(1): 225-244.

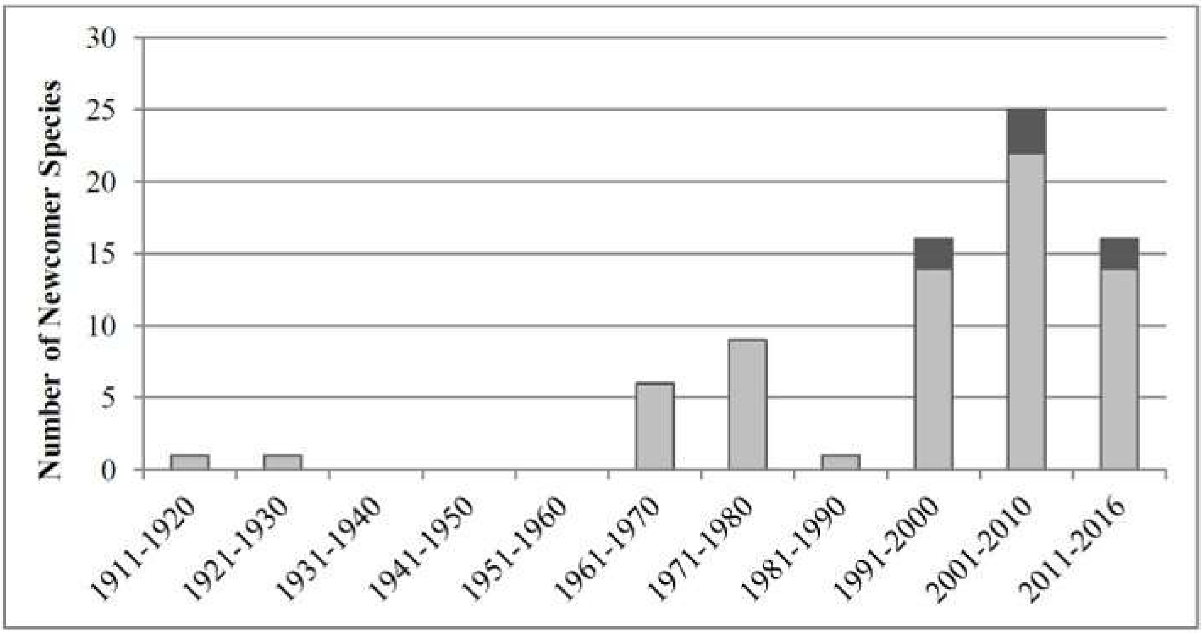



**Figure 8-2 The increasing trend in arrival of newcomer marine species in Maltese waters as indicated by the number of new records of such species per decade since 1910 (except for the period 2011-2016, which only covers five years). Light shading represents alien species and dark shading represents range-extending species [Marine Ecology Research Group, unpublished ©2017].**

### *8.4.2 Met Office*

Since 1945 the Met Office have been compiling and monitoring temperatures, precipitation, and winds. At a later date, the solar radiance, and various other aspects of meteorological importance were also included. The Met Office has its own Data & Quality unit to ensure a more complete and comprehensive data is gathered for different specific needs other than those available for daily reports. As the National Meteorological Office for the Maltese Islands, the Met Office forms part of the WMO global observing system. Monthly coded messages are produced and normally broadcast in the first week of the month. These are based on the Monthly climate extremes and means.

The Met Office also compiles a number of statistical data for internal research and also shares this research with various local and international entities. At the moment the Met Office is invested in the research of storms.

# 9 EDUCATION, TRAINING AND PUBLIC AWARENESS

*Image Source: ISEP (https://search.isepstudyabroad.org/University/Detail/0e233d83-c5a7-4ff9-a3f5-497752af3462)*

## 9.1 Introduction

The current analysis of Education, Training and Public Awareness initiatives reflects the UNECE's emphasis on shifting "*the focus away from solely transmitting information towards facilitating participatory learning*"[117]. Consequently, an educational process that promotes the adoption of sustainable lifestyles (i.e. ESD2) should have the following characteristics that interact with each other to provide a holistic learning experience:

- Learning content that presents a critical review of issues that are relevant to the learners' experiences.
- Pedagogy and learning environments that promote active learning through exploratory, action-oriented and transformative approaches.
- The development of core competencies that enable learners to act for sustainability.
- Empowering learners to transform themselves and society.[118]

This chapter explores the ESD2 initiatives related to climate change that follow the dimensions listed above, albeit the initiatives addressing all dimensions are noticeably limited in number. The chapter provides a follow-up to the initiatives reported in the NC6.

## 9.2 Examples of good practice

From the last report, there has been a consolidation of efforts aimed at providing ESD2 initiatives related to climate change. The formal sector has once again been the most 'productive' sector in this regard, with the non-formal and informal sectors registering an increase in initiatives. However, these latter initiatives tend to be rather sporadic and not part of a well-thought educational strategy with clear intended learning outcomes.

Most of the climate change education, training and public awareness initiatives have a tendency to transcend traditional boundaries and adopt a trans-sectoral approach. This approach reduces unnecessary duplication of initiatives and makes the best use of resources (particularly human).

### *9.2.1 Formal education*

The formal education sector is characterised by structures that are conducive to the development of educational programmes.

Topics related to climate change have continued to feature in various educational programmes – from primary right through tertiary education and in diverse subject areas. The nature of the topics is still predominantly scientific/technological closely followed by economic and legal aspects of the phenomenon. The impact of climate change on health is marginally addressed and the predominant perspective nurtured is that climate change is essentially an environmental issue requiring technological and legal solutions. There has been an emergence of a social perspective of climate change – this perspective is gaining momentum as it provides an opportunity to look into how the diverse aspects of climate change are interrelated, thus promoting a more holistic analysis of the phenomenon.

Local and international research and innovation projects related to climate change have continued to increase significantly at the University of Malta and the MCAST. These projects, mainly

[117] UNECE (2005). *The UNECE Strategy for Education for Sustainable Development*. Retrieved from http://www.unece.org/fileadmin/DAM/env/documents/2005/cep/ac.13/cep.ac.13.2005.3.rev.1.e.pdf

[118] UNESCO (2014). *Roadmap for Implementing the Global Action Programme on Education for Sustainable Development* Paris: UNESCO. Retrieved from http://unesdoc.unesco.org/images/0023/002305/230514e.pdf

scientific and technological in nature, are mainly related to energy generation, water conservation and traffic. The ICCSD and the CEER are academic entities within the University of Malta that have particular relevance to Education, Training and Public Awareness about climate change. The ICCSD was set up to facilitate research, knowledge transfer and networking in sustainable development or climate change particularly re issues related to mitigation and adaptation strategies. It has also spearheaded initiatives on the promotion of sustainable transport at the University of Malta. CEER was specifically set up to promote ESD2, based on the dimensions outlined earlier, in different educational sectors and with different audiences. One of CEER's main engagements in the community is the co-ordination of the EkoSkola programme[119] (see below).

In a relatively recent initiative, the Government of Malta offered three Scholarships in Climate Action for postgraduate studies at the University of Malta to students from developing States. This is part of the Government's commitment, under the Climate Finance Package, to provide support for capacity building in developing States by providing students from these countries with the opportunity to focus their studies and research on their national needs and realities. The scholarships focus on the following pathways for ensuring effective climate action on a national level:

- mitigation of climate change and the development of a low carbon economy;
- identifying risks and vulnerability to adapt to climate change and enhance resilience; and
- good governance of climate change.[120]

In compulsory education, the inclusion of ESD2 as a cross curricular theme in the National Curriculum Framework[121] in 2012 was a major step forward in ensuring curriculum space where issues related to climate change could be explored. Since then, the intended learning outcomes for ESD2 were identified[122], but there still needs to be the development of specific guidelines about the integration of ESD2 within all the curriculum areas. This development is the direct responsibility of the Educational Officer for ESD2 appointed in 2015. Seminars and workshops aimed at reaching this goal have been organised for various subjects.

In the meantime, the Eco-Schools programme (known locally as EkoSkola) continued to develop into the largest ESD2 network on the Island, with more than 82% of the total student population (from kindergarten to post-secondary schools) participating in the programme. The Eco-Schools programme is an international programme involving more than 16 million students from 67 different countries and is acknowledged by UNESCO as the largest global ESD2 network. EkoSkola is essentially a programme that empowers students to adopt an active role in environmental decision-making and action in their school and in their community. Since the last report, climate change was a frequently recurrent theme in the activities addressed in EkoSkola, mainly because of the UNFCCC in COP21 in Paris. This mainly consisted in lessons focusing on aspects of climate change; information meetings to the community; the growing and eventual planting of trees as a way to reduce $CO_2$ content; conducting energy audits at school and in households; and organising walking busses.

During the last months of 2015, students from State, Church and Independent primary and secondary schools that form part of Nature Trust Malta's ESD2 programmes: EkoSkola, Learning About Forests (LEAF) and Young Reporters for the Environment (YRE); participated in a number of events designed to place student voices and actions, centre stage in our nation's efforts to

[119] https://www.ekoskola.org.mt/uploads/2016/11/Newsletter-51.pdf

[120] *Scholarships in Climate Action offered by the Government of Malta for Postgraduate Studies at the University of Malta.* Retrieved from: https://www.um.edu.mt/__data/assets/pdf_file/0017/303155/climateactionscholarshipsuniversitofmalta2017.pdf

[121] Ministry for Education and Employment (2012). *A National Curriculum Framework for All*. Retrieved from: http://curriculum.gov.mt/en/Resources/The-NCF/Documents/NCF.pdf

[122] Learning Outcomes Framework. *Education for Sustainable Development.* Retrieved from: http://www.schoolslearningoutcomes.edu.mt/en/pages/education-for-sustainable-development

promote sustainable development. The events included: EkoSkola Young Citizens' Summit; CHOGM People's Forum; A Voice for the Commonwealth Child; The EkoSkola-CHOGM Students' Exhibition; The EkoSkola-CHOGM Commitment Grove; and Imagining a Children's Forum for CHOGM 2017.

As part of a series of events on "From Climate Change to Climate Action" organised by the Malta-EU Steering and Action Committee (MEUSAC) and the European Commission Representation in Malta, EkoSkola organised a Young People's Summit on Climate Change issues on October 28th, 2015. The students' recommendations were collated into a declaration (*The voice of present and future generations about Climate Change*) that was presented to the Minister for the Environment, Sustainable Development and Climate Change and the Ambassador for Malta on Climate Change Issues. In their declaration, the EkoSkola students made numerous pleas to:

- improve the traffic situation;
- promote use of alternative forms of energy;
- protect our limited water reserves;
- ensure the care of our trees;
- reduce waste; and
- improve environmental education outside of schools.

This declaration was later presented during another meeting, *From Climate Change to Climate Action*, involving various diplomats: the goodwill Ambassador of France for the preparation of the COP21 Conference; the Ambassador of the United States of America to Malta; the Ambassador of the People's Republic of China to Malta, the High Commissioner of the Republic of Ghana to Malta; and the Ambassador of the Arab Republic of Egypt to Malta.

Following the COP21 meeting, another Young People's Summit was organised on 26th April 2016 to suggest specific actions that politicians and other decision makers need to adopt in order to put Climate Change as a priority on Malta's national agenda. The ensuing student deliberations were collated into a declaration that was approved by the attendees and presented at the 12th EkoSkola parliamentary session held on 2nd June. Concern about climate change has for the past years featured very prominently in the EkoSkola's agenda. Three parliament sessions were specifically dedicated to Climate Change where students had the opportunity to showcase concrete actions they are taking in their school communities.

More recently, another Young People's Summit with the theme: Caring for our Seas was organised on the 4th October 2017 so as to precede two important conferences about the sea: Our Ocean (5th-6th October) and the European Marine Science Educators Association (EMSEA) Conference (7th-10th October) occurring in Malta. The themes explored were: Climate change; Protection of marine life; Marine litter; and Promoting wellbeing of communities – particularly those whose life is intimately related to the sea. As in previous editions of the Summit, in line with Nature Trust – FEE Malta's policy of promoting the voice of young people in decision making fora, the students' recommendations and concerns were collated into a declaration. A copy of the declaration was:

- forwarded to Madame Federica Mogherini, High Representative of the European Union for Foreign Affairs & Security Policy and Vice-President of the European Commission, by the journalist Ms Vanya Walker-Leigh during the Our Ocean Conference. The declaration also ended up on the conference's website[123];
- read by students during a public meeting entitled: *Laudato Si`: Interfaith and Secular Perspectives on Care for Creation* organised by the Interdiocesan Environment Commission and Nature Trust – FEE Malta as part of the activities marking the Season of Creation 2017; and

[123] https://ourocean2017.org/other-press-releases

- presented by students during the EMSEA Conference. The students also answered several questions raised by the delegates, mostly involved in marine education and research.

Following EkoSkola's success story in seamlessly infusing ESD2 in schools through a bottom-up whole-school approach has also promoted schools in adopting two other international programmes: Learning about Forests (LEAF) and Young Reporters for the Environment (YRE). LEAF is an outdoor learning programme promoting awareness and knowledge about the key role forests play for sustainable life on our planet, particularly their role in combating climate change. YRE aims to empower young people to take a stand on local sustainable development issues (such as climate change) they feel strongly about and to give them a platform to articulate these issues through the media of writing, photography or video.

The Catch the Drop Campaign – HSBC Water Programme has been very active in schools in promoting awareness about water conservation issues. Schools participating in the EkoSkola programme have integrated this campaign in the Action Plans and used the funds provided to improve the school's water catchment and management infrastructure.

### *9.2.2 Non-formal and Informal education*

Initiatives in this sector have been relatively low except for some occasional action taken up by NGOs or companies (as part of their CSR) characteristically involving clean ups and/or tree planting. However, these initiatives tend to be sporadic and lack adequate follow-up. What follows are some notable examples:

The Interdiocesan Environment Commission has been traditionally active in trying to develop values that promote sustainable lifestyles by issuing regular opinion papers about sustainability issues; conducting training sessions in the community; and providing consultancy and support to parishes wishing to reduce their carbon footprint.

The MEUSAC and the European Commission Representation in Malta and the MSDEC organised a series of meetings under the theme "From Climate Change to Climate Action" aimed at reaching out to various sectors of the Maltese society. These meetings included: "*Risk Management and Climate Change - Opportunities and Challenges for the Financial Sector*"(organised on the 15th October 2015 for the financial sector); "*Climate Change Action at the Local Level*" (organised on the 13rd October 2015 for NGOs and the general public); Young People's Summit on Climate Change (reported above); "*Addressing Local and Global Climate Action Challenges Ahead*" (organised on the 30th October 2015 for academics and Malta Council for Economic and Social Development members); and "*COP21 and its Aftermath*"(organised on the 3rd November 2015 for diplomats, politicians, NGOs and the general public).

## 9.3 Hurdles to education targeting climate change

As outlined in NC6, the commitment of individuals and organisations towards climate change continues to be the main driving force for climate change action in the field of Education, Training and Public Awareness. Although there is consensus of the ESD2's importance in bringing about desired behavioural changes, its inclusion in national policies and initiatives is still mainly as an afterthought. This report reiterates the main hurdles to climate change education, training and public awareness:

- a belief that any expert in a particular field of sustainable development is automatically an educator for sustainable development irrespective of the fact that s/he has not been trained in ESD2 methodologies;

- an ingrained opinion that behavioural change can be obtained just by imparting knowledge about the required behaviour;
- investing huge resources in awareness raising that is seen as a point of arrival rather than a point of departure;
- confusing "communication campaigns" (whose remit is short-termed) with "educational campaigns" (whose impact is long-term);
- imparting knowledge that is predominantly monodisciplinary and science/technology oriented, irrespective of the fact that a true understanding of the dynamics of climate change requires an interdisciplinary and systemic approach;
- targeting educational campaigns at children and disregarding adult education;
- treating the "public" as one homogeneous audience, thus failing to identify the diversity and complexity of roles within society; and
- adopting a one-size-fits-all methodology that does not address the diverse needs of citizens and fails to engage them in the issue at different levels.

The issues highlighted above are symptomatic of a top-down approach to education characterised by the transmission of other people's priorities, knowledge, values and thinking to passive learners. What is needed are enabling and transformative pedagogies that identify the learners' needs and actively engage them in their learning. Learners are thus transformed into inquisitive, reflective, experienced and critical thinking individuals – the basic unit of a sustainable society. Another essential aspect that is frequently disregarded is the need to evaluate whether educational campaigns achieved their intended objectives or not … and what lessons were learned from the experience.

Malta would surely make headway in climate change education, training and public awareness campaigns once the need for the expertise of ESD2 professionals in acknowledged and tapped.

## 9.4 Looking forward

Furthermore, NC6 highlighted the need to develop a holistic National Strategy for ESD (NSESD). The process was initiated in 2016 with the development of a consultation document to identify the rationale and guiding principles of the strategy. This was achieved by consultations with various interest groups and organisations that can be loosely grouped under the following seven target groups:

- Government organisations and Authorities
- Environmental / Development organisations
- Opinion makers
- Mass Media and the Arts
- Education organisations
- Influence groups (Business, Professional and other groups)
- Civil Society

The NSESD document[124] was revised on the basis of the public consultation exercise. The next phase is the initiation of further discussions with the interest groups to compile an NSESD Action

[124] Consultation document: https://www.um.edu.mt/__data/assets/pdf_file/0003/275673/NSESD-PublicConsultationDocument-Final.pdf

Plan that identifies specific targets and actions to be taken, sets deadlines and lists agencies/organisations responsible for the implementation. The NSESD Action Plan will also include specific guidelines for periodic monitoring, evaluation and review of the strategy.

# References

Akerlof, K. et al., 2010. Public perceptions of climate change as a human health risk: Surveys of the United States, Canada and Malta. *International Journal of Envrionmental Research and Public Health*, Volume 7.

Anon., 2010. Frontex attributes substantial drop in illegal migrants to Europe this year to economic ills. *Times of Malta*, Issue 7 October 2010.

Aquilina, N. et al., 2014. *The Third, Fourth, Fifth and Sixth National Communication of Malta: under the United Nations Framework Convention on Climate Change,* s.l.: The Malta Resources Authority on behalf of the Ministry for Sustainable Development, Environment and Climate Change.

Attard, M., 2015. The impact of global environmental change on transport in Malta.. *Xjenza Online – Journal of The Malta Chamber of Scientists,* 3(2), pp. 141-152.

Attard, M., Von Brockdorff, P. & Bezzina, F., 2015. *The External Costs of Passenger and Commercial Vehicle Use in Malta,* s.l.: University of Malta - European Commission Representation in Malta.

Birch Hill GeoSolutions, 2006. *Climate Change Adaptation for Land Use Planners,* s.l.: Birch Hill GeoSolutions.

Borg, S., 2009. *Malta's Initiative on Climate Change.* s.l.:Ministry of Foreign Affairs and the Ministry for Rural Affairs and the Environment.

Brander, K., 2007. Climate Change and Food Security Special Feature: Global fish production and climate change. *Proceedings of the National Academy of Sciences*, 104(50).

Ciarlo`, J., 2011. *Investigating relationships between Oscillation Patterns around Europe and their influence on aerosol transport using regional Climate Model (RegCM4), MSc dissertation,* s.l.: University of Malta.

Copernicus, 2017. *Copernicus: Land Monitoring Service.* [Online]
Available at: http://land.copernicus.eu/

de Haas, H., 2011. Mediterranean migration futures: Patterns, drivers and scenarios. *Global Environmental Change*, 21(1).

DHIR, 2013. *Annual Mortality Report, 2012,* s.l.: Directorate for Health Information and Research.

DHIR, 2015. *Annual Mortality Report. National Mortality Registry. Malta..* [Online]
Available at:
https://deputyprimeminister.gov.mt/en/dhir/Documents/annual_mortality_report_2013.pdf

EEA, 2012. *Climate change, impacts and vulnerability in Europe 2012. An indicator based report.,* s.l.: European Environment Agency.

EEA, 2013. *Annual European Union greenhouse gas inventory 1990-2011 and inventory reprt 2013 - Technical report No 8/2013,* s.l.: European Environment Agency.

EEA, 2017. *Climate change, impacts and vulnerability in Europe 2016: An indicator-based report,* s.l.: European Environment Agency.

EU Open Data Portal, 2017. *Digital Elevation Model over Europe (EU-DEM).* [Online]
Available at: https://data.europa.eu/euodp/data/dataset/data_eu-dem

European Commission, 2013. *Annual Tourism Report, Malta.* [Online]
Available at: file:///Users/mariaattard/Downloads/annual%20tourism%20report%202013%20-%20Malta.pdf

European Commission, 2014. *Scandinavian – Mediterranean Corridor – Malta Core and Comprehensive Network, TENtec.* [Online]
Available at: http://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/site/index_en.htm

Fenech, S., 2013. *Evaluating the different schemes for studying wind fields with WRF-LES, BSc(Hons) dissertation,* s.l.: University of Malta.

Fonseca, M., 2001. The geography of recent immigration to Potugal. In: *The Geography, Environment and Development in the Mediterranean.* s.l.:Sussex Academic Press.

Frontex , 2010. *FRAN Quarterly Update, Issue 1, January-March,* s.l.: FRONTEX.

Fsadni, P. et al., 2012. ISAAC Malta: Changes in geographical distribution of wheezing children in Malta between 1994 and 2002. *Journal of Asthma and Allergy*, Volume 5.

Galdies, C., 2011. *The Climate of Malta: statistics, trends and analysis 1951-2010,* s.l.: National Statistics Office - Malta.

Gatt, A., 2009. *Infectious Disease Prevention and Control,* s.l.: National Seminar on Health Effects of Climate Change, Malta.

Giorgi, F. et al., 2012. RegCM4: model description and preliminary tests. *Climate Research,* Issue 7-29, p. 52.

Mallia, A., Briguglio, M., Ellul, A. & Formosa, S., 2002. Physical Background, Demography, Tourism, Mineral Resources and Land-Use. In: *State of the Environment Report, 2001.* s.l.:Environment Protection Department, Ministry of the Environment.

MBB, 2012. *EU LIFE+ Investing in Water Project - Project Portfolio,* s.l.: Malta Business Bureau.

MEPA website, n.d. *Protected Areas - National.* [Online]
Available at: www.mepa.org.mt/impnatareas-pas-nat

MEPA, 2006. *State of the Environment Report, 2005,* s.l.: Malta Environment and Planning Authority.

Ministry for Gozo, 2012. Naqqas u Ffranka: Eco-Gozo home consultancy visits. *Let's Gozo: it's all about Gozo*, Issue 6.

Ministry for Tourism, 2015. *National Tourism Policy (Draft). Malta.* [Online]
Available at: http://mhra.org.mt/wp-content/uploads/2015/08/TOURISM-POLICY-2015-2020.pdf

MRA, 2010. *Malta's National Renewable Energy Action Plan ,* s.l.: Malta Resources Authority.

MRA, 2013. *National Greenhouse Gas Emissions Inventory for Malta 2013 - Report 4/2013,* s.l.: Malta Resources Authority.

MRA, 2013. *Preliminary Flood Risk Assessment Final Report May 2013..* [Online]
Available at:
http://www.preventionweb.net/files/33946_33946preliminaryfloodriskassessment.pdf

MRA, 2017. *Malta's Report on Policies and Measures and Projections - May 2017,* s.l.: Malta Resources Authority.

MRA, 2017. *National Greenhouse Gas Emissions and Removals Inventory for Malta: Annual Report for Submission under the United Nations Framework Convention on Climate Change and* *the European Union Monitoring Mechanism,* s.l.: The Malta Resources Authority on behalf of the Ministry for Sustainable Development, the Environment and Climate Change.

MRRA, 2010. *National Climate Change Adaptation Strategy,* s.l.: Ministry for Resources and Rural Affairs.

MRRA, 2010. *The Second Communication of Malta to the United Nations Framework Convention on Climate Change,* s.l.: Ministry for Resources and Rural Affairs.

NSO StatDB, n.d. *StatDB.* [Online]
Available at: www.nso.gov.mt
[Accessed 9 November 2013].

NSO, 1995. *Census of Population and Housing 1995, Volume 6: Dwellings,* s.l.: National Statitics Office - Malta.

NSO, 2007. *Census of Population and Housing, 2005, Volume 2: Dwellings,* s.l.: National Statistics Office - Malta.

NSO, 2011. *Demographic Review - 2010.* s.l.:s.n.

NSO, 2011. *Malta in Figures, 2011,* s.l.: National Statistics Office - Malta.

NSO, 2012. *Agriculture and Fisheries, 2010,* s.l.: National Statistics Office - Malta.

NSO, 2012. *Agriculture and Fisheries, 2011,* s.l.: National Statistics Office - Malta.

NSO, 2012. *Census of Population and Housing, 2011 - Preliminary Report,* s.l.: National Statistics Office - Malta.

NSO, 2013a. *Solid Waste Management in Malta, 2004-2011,* s.l.: National Statistics Office - Malta.

NSO, 2013b. *Energy Consumption in Malta: 2003-2012,* s.l.: National Statistics Office.

NSO, 2013. *Malta in Figures.* s.l.:s.n.

NSO, 2013. *Malta in Figures, 2013,* s.l.: National Statistics Office - Malta.

NSO, 2014. *Agriculture and Fisheries,* s.l.: National Statistics Office - Malta.

NSO, 2014. *Malta in Figures, 2014,* s.l.: National Statistics Office - Malta.

NSO, 2016. *Agriculture and Fisheries 2014,* Valletta: s.n.

NSO, 2016. *Demographic Review - 2014,* s.l.: National Statistics Office - Malta.

NSO, 2017. *Electricity Generation: 2007-2016,* s.l.: National Statistics Office - Malta.

NSO, 2017. *Electricity Generation: 2007-2016,* s.l.: National Statistics Office - Malta.

NSO, 2017. *Regional Statistics Malta - 2017 Edition,* s.l.: National Statistics Office - Malta.

NSO, 2017. *Trends in Malta, 2016,* s.l.: National Statistics Office - Malta.

NSO, n.d. *Census 1995, Volume 6: Dwellings.* [Online]
Available at: www.nso.gov.mt

O'Donnell, D., Tsigaridis, K. & Feichter, J., 2011. Estimating the direct and indirect effects of secondary organic aerosols using ECHAM5-HAM. *Atmospheric Chemistry and Physics*, 11(16).

Perez, T., 2008. *Impact of climate change on biodiversity in the Mediterranean Sea,* s.l.: United Nations Environment Programme - MAP - RAC/SPA.

Schembri, J. & Attard, M., 2013. The Foreigner Counts: a spatio-temporal analysis of occupiers, immigrants and expatriates in Malta. *Ars & Humanitas: Journal of Arts and Humanities*, 7(2).

Stocker, T. et al., 2013. *Technical Summary. Climate Change 2013 - The Physical Science Basis: Contribution of Working Group 1 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* s.l.:Cambridge University Press.

Thomas, C. et al., 2004. Extinction risk from climate change. *Nature*, Issue 427.

TINA Vienna, 2002. *Transport Infrastructure Needs Assessment for Malta,* s.l.: TINA Vienna.

Ulman, A. et al., 2017. A massive update of non-indigenous species records in Mediterranean marinas. *PeerJ,* 5(e3954).

UNHCR, 2017. *Malta Asylum Trends.* [Online]
Available at: http://www.unhcr.org.mt/charts/

Weigle, S. M., Smith, L. D., Carlton, J. T. & Pederson, J., 2005. Assessing the risk of introducing exotic species via the live marine species trade. *Conservation Biology,* 19(1), pp. 213-223.

WHO website, n.d. *Climate Change and Human Health - Global Environmental Change.* [Online]
Available at: www.who.int/globalchange/environment/en/

World Travel and Tourism Council, 2017. *Travel and Tourism Economic Impact 2017 Malta.* [Online]
Available at: https://www.wttc.org/-/media/files/reports/economic%20impact%20research/countries%202017/malta2017.pdf

WSC, 2012. *Annual Report, 2011,* s.l.: Water Services Corporation.

# Acronyms and Abbreviations

| | |
|---|---|
| 5AR | IPCC Fifth Assessment Report |
| AESReG | MCAST Applied Environmental Sciences Research Group |
| BAU | Business-as-usual |
| BEV | Battery Electric Vehicle |
| CAB | Climate Action Board |
| CAF | Climate Action Fund |
| CCGT | Combined Cycle Gas Turbine |
| CCP | University Climate Change Platform |
| CEER | Centre for Environmental Education and Research |
| $CH_4$ | Methane |
| CHOGM | Commonwealth Heads of Government Meeting |
| CHP | Combined Heat and Power |
| CLARE | Climate Action Results Evaluation |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| CP1 | First Kyoto Protocol Commitment Period |
| CP2 | Second Kyoto Protocol Commitment Period |
| CRF | Common Reporting Format |
| CRG | Climate Research Group |
| DHIR | Directorate for Health Information and Research |
| EEA | European Environment Agency |
| EED | Energy Efficiency Directive |
| EIA | Environment Impact Assessment |
| ESD2 | Education for Sustainable Development |
| ESD1 | Effort-Sharing Decision |
| ESP | Earth System Physics |
| EU ETS | European Union Emissions Trading Scheme |
| EU | European Union |
| GDP | Gross Domestic Product |
| Gg | Giga grammes |
| GHG | Greenhouse Gas |
| GIS | Geographic Information System |
| GWP | Global Warming Potential |
| HFC | Hydrofluorocarbon |
| ICCSD | Institute for Climate Change & Sustainable Development |
| IES | Institute of Earth Systems |
| IPCC | Intergovernmental panel on Climate Change |
| IPPU | Industrial Processes and Other Product Use |
| ISE | Institute for Sustainable Energy |

| | |
|---|---|
| ISSI | Islands and Small States Institute |
| ITL | Independent Transaction Log |
| LPG | Liquid Petroleum Gas |
| LULUCF | Land Use, Land-Use Change and Forestry |
| MBB | Malta Business Bureau |
| MBT | Mechanical Biological Treatment Plants |
| MCAST | Malta College of Arts, Science and Technology |
| MCST | Malta Council for Science and Technology |
| MEPA | Malta Environment and Planning Authority |
| MERG | Marine Ecology Research Group |
| **MESDC** | Ministry for the Environment, Sustainable Development and Climate Change |
| MEUSAC | Malta-EU Steering and Action Committee |
| MRA | Malta Resources Authority |
| MRRA | Ministry for Resources and Rural Affairs |
| MSW | Municipal Solid Waste |
| MWh | Mega Watt hours |
| $N_2O$ | Nitrous oxide |
| NACE | Nomenclature des Activités Économiques dans le Communauté Européenne |
| NAP | Nitrates Action Programme |
| NCPE | National Commission for the Promotion of Equality |
| NDC | Nationally Determined Contributions |
| NEEAP | National Energy Efficiency Action Plan |
| $NF_3$ | Nitrogen trifluoride |
| NMVOC | Non-methane volatile organic compound |
| NO2 | Nitrogen dioxide |
| NOx | Nitrogen oxides |
| NREAP | National Renewable Energy Action Plan |
| NSESD | National Strategy for ESD |
| NSO | National Statistics Office - Malta |
| NTS | National Transport Strategy |
| PFC | Perfluorocarbon |
| PM | Particulate Matter |
| PO-Res.Grp | Physical Oceanography Research Group |
| PV | Photovoltaic |
| QA/QC | Quality Assurance and Quality Control |
| RCP | Representative Concentration Pathway |
| SDG | Sustainable Development Goal |
| SEA | Strategic Environment Assessment |
| $SF_6$ | Sulphur hexafluoride |
| SO2 | Sulphur dioxide |
| SOA | Secondary Organic Aerosols |
| SPED | Spatial Plan for Environment and Development |

| | |
|---|---|
| TM | Transport Malta |
| TMP | Transport Master Plan |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UWWTP | Urban Waste Water Treatment Plant |
| WAM | With Additional Measures |
| WEM | With Existing Measures |
| WHO | World Health Organization |
| WM | With Measures |
| WSC | Water Services Corporation |

# 10 Annex: CRF Tables

## 10.1 Summary Reports

**Table 10-1 Summary Report for $CO_2$ Equivalent Emissions in 1990.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ (1) | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)(1)** | 2173.69 | 154.96 | 56.34 | NO,NE,IE,NA | NO,NA | 0.01 | NA,NO | NA,NO | 2385.00 |
| **1. Energy** | 2165.07 | 52.87 | 10.01 | | | | | | 2227.95 |
| A. Fuel combustion (sectoral approach) | 2165.07 | 52.87 | 10.01 | | | | | | 2227.95 |
| 1. Energy industries | 1657.87 | 50.10 | 5.33 | | | | | | 1713.30 |
| 2. Manufacturing industries and construction | 46.09 | 0.04 | 0.10 | | | | | | 46.24 |
| 3. Transport | 312.95 | 2.29 | 4.30 | | | | | | 319.54 |
| 4. Other sectors | 145.65 | 0.43 | 0.27 | | | | | | 146.35 |
| 5. Other | 2.51 | 0.01 | 0.01 | | | | | | 2.54 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 5.28 | NO,NA | 2.64 | NO,NE,IE,NA | NO,NA | 0.01 | NA,NO | NA,NO | 7.94 |
| A. Mineral industry | 1.44 | | | | | | | | 1.44 |
| B. Chemical industry | 0.17 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.17 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.68 | NA | NA | | | | | | 3.68 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | NO,NE,IE | NO | | | | NO,NE,IE |
| G. Other product manufacture and use | | | 2.64 | | NO | 0.01 | | | 2.65 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 43.25 | 33.88 | | | | | | 77.13 |
| A. Enteric fermentation | | 38.05 | | | | | | | 38.05 |
| B. Manure management | | 5.20 | 12.99 | | | | | | 18.20 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.88 | | | | | | 20.88 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry(1)** | 2.96 | NO,NE | NO,NE,IE | | | | | | 2.96 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 2.80 | NO,NE | NO,NE,IE | | | | | | 2.80 |
| C. Grassland | -4.67 | NE,NO | NO,NE | | | | | | -4.67 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 4.27 | NO | NO | | | | | | 4.27 |
| F. Other land | 0.57 | NO | NO | | | | | | 0.57 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.37 | 58.84 | 9.81 | | | | | | 69.02 |
| A. Solid waste disposal | NO,NA | 41.50 | | | | | | | 41.50 |
| B. Biological treatment of solid waste | | NO | NO | | | | | | NO |
| C. Incineration and open burning of waste | 0.37 | 0.04 | 0.02 | | | | | | 0.43 |
| D. Waste water treatment and discharge | | 17.30 | 9.79 | | | | | | 27.09 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 952.03 | 3.14 | 2.25 | | | | | | 957.42 |
| Aviation | 215.53 | 0.75 | 0.54 | | | | | | 216.82 |
| Navigation | 736.49 | 2.39 | 1.71 | | | | | | 740.59 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ (2)** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2382.04 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2385.00 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-2 Summary Report for $CO_2$ Equivalent Emissions in 1991.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ (1) | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)(1)** | 2171.14 | 162.05 | 58.05 | NO,NE,IE,NA | NO,NA | 0.01 | NA,NO | NA,NO | 2391.24 |
| **1. Energy** | 2160.51 | 52.78 | 10.24 | | | | | | 2223.53 |
| A. Fuel combustion (sectoral approach) | 2160.51 | 52.78 | 10.24 | | | | | | 2223.53 |
| 1. Energy industries | 1630.89 | 49.85 | 5.27 | | | | | | 1686.01 |
| 2. Manufacturing industries and construction | 49.33 | 0.05 | 0.11 | | | | | | 49.49 |
| 3. Transport | 334.57 | 2.45 | 4.59 | | | | | | 341.62 |
| 4. Other sectors | 143.20 | 0.42 | 0.26 | | | | | | 143.88 |
| 5. Other | 2.51 | 0.01 | 0.01 | | | | | | 2.53 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 5.51 | NO,NA | 2.65 | NO,NE,IE,NA | NO,NA | 0.01 | NA,NO | NA,NO | 8.16 |
| A. Mineral industry | 1.50 | | | | | | | | 1.50 |
| B. Chemical industry | 0.34 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.34 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.67 | NA | NA | | | | | | 3.67 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | NO,NE,IE | NO | | | | NO,NE,IE |
| G. Other product manufacture and use | | | 2.65 | | NO | 0.01 | | | 2.66 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 44.82 | 34.62 | | | | | | 79.45 |
| A. Enteric fermentation | | 39.50 | | | | | | | 39.50 |
| B. Manure management | | 5.32 | 13.37 | | | | | | 18.69 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 21.25 | | | | | | 21.25 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[1]** | 4.75 | NO,NE | NO,NE,IE | | | | | | 4.75 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 2.75 | NO,NE | NO,NE,IE | | | | | | 2.75 |
| C. Grassland | -3.00 | NE,NO | NO,NE | | | | | | -3.00 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 4.40 | NO | NO | | | | | | 4.40 |
| F. Other land | 0.60 | NO | NO | | | | | | 0.60 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.37 | 64.44 | 10.54 | | | | | | 75.35 |
| A. Solid waste disposal | NO,NA | 46.99 | | | | | | | 46.99 |
| B. Biological treatment of solid waste | | NO | NO | | | | | | NO |
| C. Incineration and open burning of waste | 0.37 | 0.04 | 0.02 | | | | | | 0.43 |
| D. Waste water treatment and discharge | | 17.41 | 10.52 | | | | | | 27.93 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 1124.51 | 3.71 | 2.65 | | | | | | 1130.87 |
| Aviation | 246.14 | 0.86 | 0.62 | | | | | | 247.61 |
| Navigation | 878.37 | 2.85 | 2.04 | | | | | | 883.26 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [2]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2386.49 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2391.24 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-3 Summary Report for $CO_2$ Equivalent Emissions in 1992.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ [(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)[(1)]** | 2325.65 | 165.23 | 59.48 | NO,NE,IE,NA | NO,NA | 1.43 | NA,NO | NA,NO | 2551.79 |
| **1. Energy** | 2315.82 | 49.32 | 11.16 | | | | | | 2376.30 |
| A. Fuel combustion (sectoral approach) | 2315.82 | 49.32 | 11.16 | | | | | | 2376.30 |
| 1. Energy industries | 1605.72 | 45.79 | 5.08 | | | | | | 1656.59 |
| 2. Manufacturing industries and construction | 63.04 | 0.06 | 0.14 | | | | | | 63.25 |
| 3. Transport | 394.71 | 2.69 | 5.42 | | | | | | 402.82 |
| 4. Other sectors | 249.83 | 0.78 | 0.51 | | | | | | 251.12 |
| 5. Other | 2.51 | 0.01 | 0.01 | | | | | | 2.53 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 5.10 | NO,NA | 2.65 | NO,NE,IE,NA | NO,NA | 1.43 | NA,NO | NA,NO | 9.17 |
| A. Mineral industry | 1.27 | | | | | | | | 1.27 |
| B. Chemical industry | 0.17 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.17 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.66 | NA | NA | | | | | | 3.66 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | NO,NE,IE | NO | | | | NO,NE,IE |
| G. Other product manufacture and use | | | 2.65 | | NO | 1.43 | | | 4.07 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 45.55 | 35.03 | | | | | | 80.58 |
| A. Enteric fermentation | | 40.12 | | | | | | | 40.12 |
| B. Manure management | | 5.43 | 13.64 | | | | | | 19.07 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 21.39 | | | | | | 21.39 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 4.36 | NO,NE | NO,NE,IE | | | | | | 4.36 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 2.33 | NO,NE | NO,NE,IE | | | | | | 2.33 |
| C. Grassland | -3.14 | NE,NO | NO,NE | | | | | | -3.14 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 4.53 | NO | NO | | | | | | 4.53 |
| F. Other land | 0.64 | NO | NO | | | | | | 0.64 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.37 | 70.36 | 10.64 | | | | | | 81.37 |
| A. Solid waste disposal | NO,NA | 52.64 | | | | | | | 52.64 |
| B. Biological treatment of solid waste | | NO | NO | | | | | | NO |
| C. Incineration and open burning of waste | 0.37 | 0.04 | 0.02 | | | | | | 0.43 |
| D. Waste water treatment and discharge | | 17.67 | 10.63 | | | | | | 28.30 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 1399.77 | 4.60 | 3.29 | | | | | | 1407.67 |
| Aviation | 244.15 | 0.85 | 0.61 | | | | | | 245.61 |
| Navigation | 1155.62 | 3.75 | 2.68 | | | | | | 1162.06 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2547.43 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2551.79 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-4 Summary Report for $CO_2$ Equivalent Emissions in 1993.**

| GREENHOUSE GAS SOURCE AND | $CO_2$(1) | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| SINK CATEGORIES | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)(1)** | 2685.65 | 173.87 | 60.95 | NO,NE,IE,NA | NO,NA | 1.43 | NA,NO | NA,NO | 2921.89 |
| **1. Energy** | 2676.87 | 51.76 | 12.11 | | | | | | 2740.73 |
| A. Fuel combustion (sectoral approach) | 2676.87 | 51.76 | 12.11 | | | | | | 2740.73 |
| 1. Energy industries | 1968.57 | 48.13 | 5.98 | | | | | | 2022.69 |
| 2. Manufacturing industries and construction | 63.38 | 0.06 | 0.14 | | | | | | 63.59 |
| 3. Transport | 399.95 | 2.80 | 5.48 | | | | | | 408.24 |
| 4. Other sectors | 242.44 | 0.75 | 0.49 | | | | | | 243.69 |
| 5. Other | 2.51 | 0.01 | 0.01 | | | | | | 2.54 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 5.13 | NO,NA | 2.65 | NO,NE,IE,NA | NO,NA | 1.43 | NA,NO | NA,NO | 9.21 |
| A. Mineral industry | 1.28 | | | | | | | | 1.28 |
| B. Chemical industry | 0.21 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.21 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.65 | NA | NA | | | | | | 3.65 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | NO,NE,IE | NO | | | | NO,NE,IE |
| G. Other product manufacture and use | | | 2.65 | | NO | 1.43 | | | 4.08 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 44.76 | 34.92 | | | | | | 79.68 |
| A. Enteric fermentation | | 39.37 | | | | | | | 39.37 |
| B. Manure management | | 5.40 | 13.67 | | | | | | 19.07 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 21.25 | | | | | | 21.25 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 3.27 | NO,NE | NO,NE,IE | | | | | | 3.27 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 1.24 | NO,NE | NO,NE,IE | | | | | | 1.24 |
| C. Grassland | -3.29 | NE,NO | NO,NE | | | | | | -3.29 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 4.66 | NO | NO | | | | | | 4.66 |
| F. Other land | 0.67 | NO | NO | | | | | | 0.67 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.37 | 77.35 | 11.27 | | | | | | 88.99 |
| A. Solid waste disposal | NO,NA | 58.43 | | | | | | | 58.43 |
| B. Biological treatment of solid waste | | 0.99 | 0.70 | | | | | | 1.69 |
| C. Incineration and open burning of waste | 0.37 | 0.04 | 0.02 | | | | | | 0.43 |
| D. Waste water treatment and discharge | | 17.89 | 10.55 | | | | | | 28.44 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 1407.11 | 4.63 | 3.31 | | | | | | 1415.05 |
| Aviation | 250.28 | 0.88 | 0.63 | | | | | | 251.78 |
| Navigation | 1156.83 | 3.76 | 2.69 | | | | | | 1163.27 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2918.62 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2921.89 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-5 Summary Report for $CO_2$ Equivalent Emissions in 1994.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ (1) | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)(1)** | 2571.79 | 171.64 | 61.15 | 0.00 | NO,NA | 1.43 | NA,NO | NA,NO | 2806.01 |
| **1. Energy** | 2562.32 | 44.54 | 11.89 | | | | | | 2618.75 |
| A. Fuel combustion (sectoral approach) | 2562.32 | 44.54 | 11.89 | | | | | | 2618.75 |
| 1. Energy industries | 1811.00 | 40.73 | 5.39 | | | | | | 1857.12 |
| 2. Manufacturing industries and construction | 66.45 | 0.06 | 0.15 | | | | | | 66.66 |
| 3. Transport | 423.50 | 2.93 | 5.81 | | | | | | 432.24 |
| 4. Other sectors | 258.86 | 0.81 | 0.53 | | | | | | 260.20 |
| 5. Other | 2.51 | 0.01 | 0.01 | | | | | | 2.53 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 5.42 | NO,NA | 2.65 | 0.00 | NO,NA | 1.43 | NA,NO | NA,NO | 9.51 |
| A. Mineral industry | 1.55 | | | | | | | | 1.55 |
| B. Chemical industry | 0.23 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.23 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.63 | NA | NA | | | | | | 3.63 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 0.00 | NO | | | | 0.00 |
| G. Other product manufacture and use | | | 2.65 | | NO | 1.43 | | | 4.08 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 42.35 | 34.45 | | | | | | 76.80 |
| A. Enteric fermentation | | 37.10 | | | | | | | 37.10 |
| B. Manure management | | 5.25 | 13.47 | | | | | | 18.72 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.98 | | | | | | 20.98 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 3.68 | NO,NE | NO,NE,IE | | | | | | 3.68 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 1.24 | NO,NE | NO,NE,IE | | | | | | 1.24 |
| C. Grassland | -3.06 | NE,NO | NO,NE | | | | | | -3.06 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 4.79 | NO | NO | | | | | | 4.79 |
| F. Other land | 0.71 | NO | NO | | | | | | 0.71 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.37 | 84.75 | 12.16 | | | | | | 97.28 |
| A. Solid waste disposal | NO,NA | 64.33 | | | | | | | 64.33 |
| B. Biological treatment of solid waste | | 2.23 | 1.60 | | | | | | 3.83 |
| C. Incineration and open burning of waste | 0.37 | 0.04 | 0.02 | | | | | | 0.43 |
| D. Waste water treatment and discharge | | 18.15 | 10.54 | | | | | | 28.69 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 1672.53 | 5.51 | 3.94 | | | | | | 1681.98 |
| Aviation | 308.37 | 1.08 | 0.77 | | | | | | 310.21 |
| Navigation | 1364.16 | 4.43 | 3.17 | | | | | | 1371.76 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2802.34 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2806.01 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-6 Summary Report for $CO_2$ Equivalent Emissions in 1995.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$[(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)**[(1)] | 2363.56 | 145.49 | 59.37 | 0.00 | NO,NA | 1.44 | NA,NO | NA,NO | 2569.85 |
| **1. Energy** | 2354.73 | 15.34 | 10.62 | | | | | | 2380.68 |
| A. Fuel combustion (sectoral approach) | 2354.73 | 15.34 | 10.62 | | | | | | 2380.68 |
| 1. Energy industries | 1579.50 | 11.46 | 3.96 | | | | | | 1594.93 |
| 2. Manufacturing industries and construction | 72.47 | 0.07 | 0.16 | | | | | | 72.71 |
| 3. Transport | 433.95 | 2.96 | 5.93 | | | | | | 442.84 |
| 4. Other sectors | 266.29 | 0.83 | 0.55 | | | | | | 267.67 |
| 5. Other | 2.51 | 0.01 | 0.01 | | | | | | 2.53 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 5.38 | NO,NA | 2.65 | 0.00 | NO,NA | 1.44 | NA,NO | NA,NO | 9.47 |
| A. Mineral industry | 1.51 | | | | | | | | 1.51 |
| B. Chemical industry | 0.25 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.25 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.62 | NA | NA | | | | | | 3.62 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 0.00 | NO | | | | 0.00 |
| G. Other product manufacture and use | | | 2.65 | | NO | 1.44 | | | 4.09 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 39.12 | 33.26 | | | | | | 72.38 |
| A. Enteric fermentation | | 34.09 | | | | | | | 34.09 |
| B. Manure management | | 5.03 | 12.82 | | | | | | 17.85 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.44 | | | | | | 20.44 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 3.07 | NO,NE | NO,NE,IE | | | | | | 3.07 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 0.62 | NO,NE | NO,NE,IE | | | | | | 0.62 |
| C. Grassland | -3.20 | NE,NO | NO,NE | | | | | | -3.20 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 4.92 | NO | NO | | | | | | 4.92 |
| F. Other land | 0.72 | NO | NO | | | | | | 0.72 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.37 | 91.03 | 12.84 | | | | | | 104.24 |
| A. Solid waste disposal | NO,NA | 70.41 | | | | | | | 70.41 |
| B. Biological treatment of solid waste | | 2.28 | 1.63 | | | | | | 3.92 |
| C. Incineration and open burning of waste | 0.37 | 0.04 | 0.02 | | | | | | 0.43 |
| D. Waste water treatment and discharge | | 18.30 | 11.19 | | | | | | 29.49 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 1901.84 | 6.26 | 4.48 | | | | | | 1912.58 |
| Aviation | 329.72 | 1.15 | 0.82 | | | | | | 331.69 |
| Navigation | 1572.13 | 5.11 | 3.65 | | | | | | 1580.89 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2566.78 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2569.85 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-7 Summary Report for $CO_2$ Equivalent Emissions in 1996.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$[(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)[(1)]** | 2456.43 | 142.08 | 59.04 | 0.00 | NO,NA | 1.45 | NA,NO | NA,NO | 2659.00 |
| **1. Energy** | 2447.90 | 5.59 | 11.20 | | | | | | 2464.69 |
| A. Fuel combustion (sectoral approach) | 2447.90 | 5.59 | 11.20 | | | | | | 2464.69 |
| 1. Energy industries | 1630.84 | 1.59 | 3.78 | | | | | | 1636.20 |
| 2. Manufacturing industries and construction | 72.01 | 0.07 | 0.16 | | | | | | 72.24 |
| 3. Transport | 489.80 | 3.14 | 6.72 | | | | | | 499.66 |
| 4. Other sectors | 252.74 | 0.79 | 0.52 | | | | | | 254.05 |
| 5. Other | 2.52 | 0.01 | 0.01 | | | | | | 2.54 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 5.15 | NO,NA | 2.66 | 0.00 | NO,NA | 1.45 | NA,NO | NA,NO | 9.26 |
| A. Mineral industry | 1.40 | | | | | | | | 1.40 |
| B. Chemical industry | 0.14 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.14 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.61 | NA | NA | | | | | | 3.61 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 0.00 | NO | | | | 0.00 |
| G. Other product manufacture and use | | | 2.66 | | NO | 1.45 | | | 4.10 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 39.96 | 33.30 | | | | | | 73.26 |
| A. Enteric fermentation | | 35.13 | | | | | | | 35.13 |
| B. Manure management | | 4.83 | 12.52 | | | | | | 17.35 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.77 | | | | | | 20.77 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[1]** | 3.00 | NO,NE | NO,NE,IE | | | | | | 3.00 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 0.60 | NO,NE | NO,NE,IE | | | | | | 0.60 |
| C. Grassland | -3.28 | NE,NO | NO,NE | | | | | | -3.28 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 4.95 | NO | NO | | | | | | 4.95 |
| F. Other land | 0.73 | NO | NO | | | | | | 0.73 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.37 | 96.53 | 11.89 | | | | | | 108.78 |
| A. Solid waste disposal | NO,NA | 76.71 | | | | | | | 76.71 |
| B. Biological treatment of solid waste | | 1.38 | 0.99 | | | | | | 2.37 |
| C. Incineration and open burning of waste | 0.37 | 0.04 | 0.02 | | | | | | 0.43 |
| D. Waste water treatment and discharge | | 18.39 | 10.88 | | | | | | 29.27 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 1904.99 | 6.27 | 4.49 | | | | | | 1915.75 |
| Aviation | 326.62 | 1.14 | 0.82 | | | | | | 328.58 |
| Navigation | 1578.37 | 5.13 | 3.67 | | | | | | 1587.17 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [2]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2655.99 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2659.00 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-8 Summary Report for $CO_2$ Equivalent Emissions in 1997.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$[(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)**[(1)] | 2458.77 | 149.12 | 59.32 | 0.00 | NO,NA | 1.45 | NA,NO | NA,NO | 2668.66 |
| **1. Energy** | 2450.10 | 5.66 | 11.16 | | | | | | 2466.93 |
| A. Fuel combustion (sectoral approach) | 2450.10 | 5.66 | 11.16 | | | | | | 2466.93 |
| 1. Energy industries | 1595.50 | 1.55 | 3.69 | | | | | | 1600.74 |
| 2. Manufacturing industries and construction | 72.83 | 0.07 | 0.17 | | | | | | 73.07 |
| 3. Transport | 486.78 | 3.11 | 6.67 | | | | | | 496.56 |
| 4. Other sectors | 292.48 | 0.93 | 0.62 | | | | | | 294.03 |
| 5. Other | 2.51 | 0.01 | 0.01 | | | | | | 2.53 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 5.36 | NO,NA | 2.66 | 0.00 | NO,NA | 1.45 | NA,NO | NA,NO | 9.47 |
| A. Mineral industry | 1.54 | | | | | | | | 1.54 |
| B. Chemical industry | 0.22 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.22 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.60 | NA | NA | | | | | | 3.60 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 0.00 | NO | | | | 0.00 |
| G. Other product manufacture and use | | | 2.66 | | NO | 1.45 | | | 4.11 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 40.47 | 33.52 | | | | | | 74.00 |
| A. Enteric fermentation | | 35.60 | | | | | | | 35.60 |
| B. Manure management | | 4.87 | 12.64 | | | | | | 17.52 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.88 | | | | | | 20.88 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry(1)** | 2.93 | NO,NE | NO,NE,IE | | | | | | 2.93 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 0.57 | NO,NE | NO,NE,IE | | | | | | 0.57 |
| C. Grassland | -3.26 | NE,NO | NO,NE | | | | | | -3.26 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 4.88 | NO | NO | | | | | | 4.88 |
| F. Other land | 0.74 | NO | NO | | | | | | 0.74 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.37 | 102.99 | 11.97 | | | | | | 115.33 |
| A. Solid waste disposal | NO,NA | 83.04 | | | | | | | 83.04 |
| B. Biological treatment of solid waste | | 0.97 | 0.69 | | | | | | 1.66 |
| C. Incineration and open burning of waste | 0.37 | 0.04 | 0.02 | | | | | | 0.43 |
| D. Waste water treatment and discharge | | 18.94 | 11.26 | | | | | | 30.20 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 2212.92 | 7.31 | 5.23 | | | | | | 2225.46 |
| Aviation | 461.41 | 1.61 | 1.15 | | | | | | 464.18 |
| Navigation | 1751.51 | 5.69 | 4.07 | | | | | | 1761.27 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ (2)** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2665.73 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2668.66 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

### Table 10-9 Summary Report for $CO_2$ Equivalent Emissions in 1998.

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ (1) | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)(1)** | 2474.93 | 156.02 | 59.44 | 0.01 | NO,NA | 1.47 | NA,NO | NA,NO | 2691.85 |
| **1. Energy** | 2467.28 | 5.66 | 11.14 | | | | | | 2484.07 |
| A. Fuel combustion (sectoral approach) | 2467.28 | 5.66 | 11.14 | | | | | | 2484.07 |
| 1. Energy industries | 1619.90 | 1.57 | 3.75 | | | | | | 1625.22 |
| 2. Manufacturing industries and construction | 56.27 | 0.05 | 0.12 | | | | | | 56.45 |
| 3. Transport | 483.52 | 3.06 | 6.61 | | | | | | 493.18 |
| 4. Other sectors | 305.08 | 0.96 | 0.65 | | | | | | 306.69 |
| 5. Other | 2.51 | 0.01 | 0.01 | | | | | | 2.53 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 4.75 | NO,NA | 2.66 | 0.01 | NO,NA | 1.47 | NA,NO | NA,NO | 8.89 |
| A. Mineral industry | 0.96 | | | | | | | | 0.96 |
| B. Chemical industry | 0.20 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.20 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.59 | NA | NA | | | | | | 3.59 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 0.01 | NO | | | | 0.01 |
| G. Other product manufacture and use | | | 2.66 | | NO | 1.47 | | | 4.13 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 38.37 | 32.65 | | | | | | 71.02 |
| A. Enteric fermentation | | 33.61 | | | | | | | 33.61 |
| B. Manure management | | 4.75 | 12.20 | | | | | | 16.95 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.46 | | | | | | 20.46 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 2.55 | NO,NE | NO,NE,IE | | | | | | 2.55 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 0.52 | NO,NE | NO,NE,IE | | | | | | 0.52 |
| C. Grassland | -3.40 | NE,NO | NO,NE | | | | | | -3.40 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 4.68 | NO | NO | | | | | | 4.68 |
| F. Other land | 0.75 | NO | NO | | | | | | 0.75 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.35 | 111.99 | 12.98 | | | | | | 125.32 |
| A. Solid waste disposal | NO,NA | 90.92 | | | | | | | 90.92 |
| B. Biological treatment of solid waste | | 2.29 | 1.64 | | | | | | 3.94 |
| C. Incineration and open burning of waste | 0.35 | 0.04 | 0.02 | | | | | | 0.40 |
| D. Waste water treatment and discharge | | 18.74 | 11.32 | | | | | | 30.06 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 2190.35 | 7.20 | 5.15 | | | | | | 2202.70 |
| Aviation | 329.56 | 1.15 | 0.82 | | | | | | 331.54 |
| Navigation | 1860.79 | 6.05 | 4.33 | | | | | | 1871.16 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2689.30 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2691.85 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-10 Summary Report for $CO_2$ Equivalent Emissions in 1999.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ (1) | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)(1)** | 2583.43 | 163.19 | 59.96 | 0.01 | NO,NA | 1.47 | NA,NO | NA,NO | 2808.06 |
| **1. Energy** | 2577.17 | 5.78 | 11.90 | | | | | | 2594.85 |
| A. Fuel combustion (sectoral approach) | 2577.17 | 5.78 | 11.90 | | | | | | 2594.85 |
| 1. Energy industries | 1692.73 | 1.65 | 3.92 | | | | | | 1698.30 |
| 2. Manufacturing industries and construction | 63.55 | 0.06 | 0.14 | | | | | | 63.75 |
| 3. Transport | 524.87 | 3.13 | 7.20 | | | | | | 535.21 |
| 4. Other sectors | 293.50 | 0.93 | 0.62 | | | | | | 295.04 |
| 5. Other | 2.53 | 0.01 | 0.01 | | | | | | 2.55 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.99 | NO,NA | 2.89 | 0.01 | NO,NA | 1.47 | NA,NO | NA,NO | 8.36 |
| A. Mineral industry | 0.28 | | | | | | | | 0.28 |
| B. Chemical industry | 0.14 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.14 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.58 | NA | NA | | | | | | 3.58 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 0.01 | NO | | | | 0.01 |
| G. Other product manufacture and use | | | 2.89 | | NO | 1.47 | | | 4.35 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 39.58 | 33.07 | | | | | | 72.65 |
| A. Enteric fermentation | | 34.73 | | | | | | | 34.73 |
| B. Manure management | | 4.85 | 12.40 | | | | | | 17.25 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.67 | | | | | | 20.67 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[1]** | 1.92 | NO,NE | NO,NE,IE | | | | | | 1.92 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 0.29 | NO,NE | NO,NE,IE | | | | | | 0.29 |
| C. Grassland | -3.54 | NE,NO | NO,NE | | | | | | -3.54 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 4.42 | NO | NO | | | | | | 4.42 |
| F. Other land | 0.75 | NO | NO | | | | | | 0.75 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.35 | 117.84 | 12.10 | | | | | | 130.28 |
| A. Solid waste disposal | NO,NA | 98.53 | | | | | | | 98.53 |
| B. Biological treatment of solid waste | | 1.32 | 0.95 | | | | | | 2.27 |
| C. Incineration and open burning of waste | 0.35 | 0.04 | 0.02 | | | | | | 0.40 |
| D. Waste water treatment and discharge | | 17.94 | 11.14 | | | | | | 29.08 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 2341.11 | 7.69 | 5.50 | | | | | | 2354.30 |
| Aviation | 338.17 | 1.18 | 0.85 | | | | | | 340.20 |
| Navigation | 2002.94 | 6.51 | 4.66 | | | | | | 2014.11 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [2]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2806.14 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2808.06 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-11 Summary Report for $CO_2$ Equivalent Emissions in 2000.**

| GREENHOUSE GAS SOURCE AND | $CO_2$[(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| SINK CATEGORIES | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)[(1)]** | 2420.98 | 173.85 | 61.26 | 6.70 | NO,NA | 1.47 | NA,NO | NA,NO | 2664.26 |
| **1. Energy** | 2413.62 | 5.37 | 11.87 | | | | | | 2430.86 |
| A. Fuel combustion (sectoral approach) | 2413.62 | 5.37 | 11.87 | | | | | | 2430.86 |
| 1. Energy industries | 1587.62 | 1.55 | 3.69 | | | | | | 1592.86 |
| 2. Manufacturing industries and construction | 55.57 | 0.05 | 0.12 | | | | | | 55.75 |
| 3. Transport | 552.67 | 3.09 | 7.61 | | | | | | 563.37 |
| 4. Other sectors | 215.27 | 0.66 | 0.43 | | | | | | 216.37 |
| 5. Other | 2.49 | 0.01 | 0.01 | | | | | | 2.51 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.87 | NO,NA | 3.17 | 6.70 | NO,NA | 1.47 | NA,NO | NA,NO | 15.20 |
| A. Mineral industry | 0.21 | | | | | | | | 0.21 |
| B. Chemical industry | 0.09 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.09 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.57 | NA | NA | | | | | | 3.57 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 6.70 | NO | | | | 6.70 |
| G. Other product manufacture and use | | | 3.17 | | NO | 1.47 | | | 4.63 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 41.47 | 33.56 | | | | | | 75.03 |
| A. Enteric fermentation | | 36.15 | | | | | | | 36.15 |
| B. Manure management | | 5.32 | 12.67 | | | | | | 17.99 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.89 | | | | | | 20.89 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[1]** | 3.15 | NO,NE | NO,NE,IE | | | | | | 3.15 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 0.22 | NO,NE | NO,NE,IE | | | | | | 0.22 |
| C. Grassland | -2.08 | NE,NO | NO,NE | | | | | | -2.08 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 4.25 | NO | NO | | | | | | 4.25 |
| F. Other land | 0.76 | NO | NO | | | | | | 0.76 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.35 | 127.01 | 12.66 | | | | | | 140.02 |
| A. Solid waste disposal | NO,NA | 106.66 | | | | | | | 106.66 |
| B. Biological treatment of solid waste | | 1.55 | 1.11 | | | | | | 2.66 |
| C. Incineration and open burning of waste | 0.35 | 0.04 | 0.02 | | | | | | 0.40 |
| D. Waste water treatment and discharge | | 18.76 | 11.54 | | | | | | 30.30 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 2581.11 | 8.48 | 6.06 | | | | | | 2595.66 |
| Aviation | 366.16 | 1.28 | 0.92 | | | | | | 368.36 |
| Navigation | 2214.95 | 7.20 | 5.15 | | | | | | 2227.30 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [2]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2661.11 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2664.26 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

## Table 10-12 Summary Report for $CO_2$ Equivalent Emissions in 2001.

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$[(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)[(1)]** | 2602.03 | 178.42 | 58.17 | 11.26 | NO,NA | 1.49 | NA,NO | NA,NO | 2851.36 |
| **1. Energy** | 2595.62 | 5.21 | 10.88 | | | | | | 2611.70 |
| A. Fuel combustion (sectoral approach) | 2595.62 | 5.21 | 10.88 | | | | | | 2611.70 |
| 1. Energy industries | 1978.85 | 1.93 | 4.60 | | | | | | 1985.38 |
| 2. Manufacturing industries and construction | 48.84 | 0.05 | 0.11 | | | | | | 48.99 |
| 3. Transport | 442.98 | 2.87 | 5.94 | | | | | | 451.80 |
| 4. Other sectors | 122.43 | 0.35 | 0.21 | | | | | | 122.99 |
| 5. Other | 2.52 | 0.01 | 0.01 | | | | | | 2.54 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.96 | NO,NA | 2.51 | 11.26 | NO,NA | 1.49 | NA,NO | NA,NO | 19.22 |
| A. Mineral industry | 0.20 | | | | | | | | 0.20 |
| B. Chemical industry | 0.20 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.20 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.56 | NA | NA | | | | | | 3.56 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 11.26 | NO | | | | 11.26 |
| G. Other product manufacture and use | | | 2.51 | | NO | 1.49 | | | 4.00 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 39.47 | 32.29 | | | | | | 71.76 |
| A. Enteric fermentation | | 34.33 | | | | | | | 34.33 |
| B. Manure management | | 5.15 | 11.98 | | | | | | 17.13 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.31 | | | | | | 20.31 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 2.11 | NO,NE | NO,NE,IE | | | | | | 2.11 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | -0.51 | NO,NE | NO,NE,IE | | | | | | -0.51 |
| C. Grassland | -2.08 | NE,NO | NO,NE | | | | | | -2.08 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 3.93 | NO | NO | | | | | | 3.93 |
| F. Other land | 0.76 | NO | NO | | | | | | 0.76 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.35 | 133.74 | 12.49 | | | | | | 146.57 |
| A. Solid waste disposal | NO,NA | 113.85 | | | | | | | 113.85 |
| B. Biological treatment of solid waste | | 1.77 | 1.27 | | | | | | 3.04 |
| C. Incineration and open burning of waste | 0.35 | 0.04 | 0.02 | | | | | | 0.40 |
| D. Waste water treatment and discharge | | 18.08 | 11.21 | | | | | | 29.28 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 2564.58 | 8.40 | 6.01 | | | | | | 2579.00 |
| Aviation | 274.65 | 0.96 | 0.69 | | | | | | 276.29 |
| Navigation | 2289.94 | 7.44 | 5.32 | | | | | | 2302.71 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2849.26 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2851.36 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-13 Summary Report for $CO_2$ Equivalent Emissions in 2002.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$[(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)[(1)]** | 2615.39 | 185.04 | 59.49 | 14.99 | NO,NA | 1.50 | NA,NO | NA,NO | 2876.39 |
| **1. Energy** | 2609.90 | 5.19 | 11.34 | | | | | | 2626.43 |
| A. Fuel combustion (sectoral approach) | 2609.90 | 5.19 | 11.34 | | | | | | 2626.43 |
| 1. Energy industries | 1938.98 | 1.89 | 4.51 | | | | | | 1945.38 |
| 2. Manufacturing industries and construction | 54.52 | 0.05 | 0.12 | | | | | | 54.69 |
| 3. Transport | 481.30 | 2.85 | 6.47 | | | | | | 490.62 |
| 4. Other sectors | 132.54 | 0.38 | 0.23 | | | | | | 133.15 |
| 5. Other | 2.56 | 0.01 | 0.01 | | | | | | 2.59 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.92 | NO,NA | 2.74 | 14.99 | NO,NA | 1.50 | NA,NO | NA,NO | 23.13 |
| A. Mineral industry | 0.20 | | | | | | | | 0.20 |
| B. Chemical industry | 0.17 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.17 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.55 | NA | NA | | | | | | 3.55 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 14.99 | NO | | | | 14.99 |
| G. Other product manufacture and use | | | 2.74 | | NO | 1.50 | | | 4.23 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 39.09 | 33.31 | | | | | | 72.40 |
| A. Enteric fermentation | | 34.03 | | | | | | | 34.03 |
| B. Manure management | | 5.06 | 12.33 | | | | | | 17.39 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.98 | | | | | | 20.98 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry(1)** | 1.23 | NO,NE | NO,NE,IE | | | | | | 1.23 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | -1.07 | NO,NE | NO,NE,IE | | | | | | -1.07 |
| C. Grassland | -2.08 | NE,NO | NO,NE | | | | | | -2.08 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 3.62 | NO | NO | | | | | | 3.62 |
| F. Other land | 0.76 | NO | NO | | | | | | 0.76 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.35 | 140.76 | 12.10 | | | | | | 153.20 |
| A. Solid waste disposal | NO,NA | 121.55 | | | | | | | 121.55 |
| B. Biological treatment of solid waste | | 0.96 | 0.69 | | | | | | 1.66 |
| C. Incineration and open burning of waste | 0.35 | 0.04 | 0.02 | | | | | | 0.40 |
| D. Waste water treatment and discharge | | 18.20 | 11.39 | | | | | | 29.59 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 2899.19 | 9.49 | 6.79 | | | | | | 2915.47 |
| Aviation | 267.75 | 0.94 | 0.67 | | | | | | 269.36 |
| Navigation | 2631.44 | 8.56 | 6.12 | | | | | | 2646.11 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | IE,NO | | | | | | | | IE,NO |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ (2)** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2875.17 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2876.39 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-14 Summary Report for $CO_2$ Equivalent Emissions in 2003.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ (1) | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)(1)** | 2887.45 | 192.12 | 61.04 | 16.45 | NO,NA | 2.06 | NA,NO | NA,NO | 3159.13 |
| **1. Energy** | 2882.03 | 5.47 | 12.78 | | | | | | 2900.28 |
| A. Fuel combustion (sectoral approach) | 2882.03 | 5.47 | 12.78 | | | | | | 2900.28 |
| 1. Energy industries | 2140.72 | 2.09 | 4.99 | | | | | | 2147.81 |
| 2. Manufacturing industries and construction | 59.06 | 0.06 | 0.13 | | | | | | 59.25 |
| 3. Transport | 542.34 | 2.91 | 7.40 | | | | | | 552.66 |
| 4. Other sectors | 137.49 | 0.40 | 0.24 | | | | | | 138.13 |
| 5. Other | 2.41 | 0.01 | 0.01 | | | | | | 2.43 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.76 | NO,NA | 2.57 | 16.45 | NO,NA | 2.06 | NA,NO | NA,NO | 24.85 |
| A. Mineral industry | 0.13 | | | | | | | | 0.13 |
| B. Chemical industry | 0.09 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.09 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.54 | NA | NA | | | | | | 3.54 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 16.45 | NO | | | | 16.45 |
| G. Other product manufacture and use | | | 2.57 | | NO | 2.06 | | | 4.63 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 37.64 | 33.14 | | | | | | 70.78 |
| A. Enteric fermentation | | 32.90 | | | | | | | 32.90 |
| B. Manure management | | 4.73 | 11.97 | | | | | | 16.71 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 21.16 | | | | | | 21.16 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 1.31 | NO,NE | NO,NE,IE | | | | | | 1.31 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | -0.86 | NO,NE | NO,NE,IE | | | | | | -0.86 |
| C. Grassland | -2.00 | NE,NO | NO,NE | | | | | | -2.00 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 3.41 | NO | NO | | | | | | 3.41 |
| F. Other land | 0.76 | NO | NO | | | | | | 0.76 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.35 | 149.01 | 12.55 | | | | | | 161.91 |
| A. Solid waste disposal | NO,NA | 129.20 | | | | | | | 129.20 |
| B. Biological treatment of solid waste | | 1.45 | 1.04 | | | | | | 2.49 |
| C. Incineration and open burning of waste | 0.35 | 0.04 | 0.02 | | | | | | 0.40 |
| D. Waste water treatment and discharge | | 18.32 | 11.50 | | | | | | 29.82 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 3130.14 | 10.24 | 7.32 | | | | | | 3147.70 |
| Aviation | 255.45 | 0.89 | 0.64 | | | | | | 256.98 |
| Navigation | 2874.69 | 9.35 | 6.68 | | | | | | 2890.72 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 0.07 | | | | | | | | 0.07 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 3157.82 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 3159.13 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-15 Summary Report for $CO_2$ Equivalent Emissions in 2004.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ (1) | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)(1)** | 2760.39 | 201.80 | 60.20 | 29.48 | NO,NA | 1.54 | NA,NO | NA,NO | 3053.41 |
| **1. Energy** | 2755.08 | 5.33 | 11.92 | | | | | | 2772.34 |
| A. Fuel combustion (sectoral approach) | 2755.08 | 5.33 | 11.92 | | | | | | 2772.34 |
| 1. Energy industries | 2046.19 | 1.99 | 4.76 | | | | | | 2052.94 |
| 2. Manufacturing industries and construction | 58.02 | 0.06 | 0.13 | | | | | | 58.21 |
| 3. Transport | 509.11 | 2.87 | 6.78 | | | | | | 518.76 |
| 4. Other sectors | 139.36 | 0.40 | 0.25 | | | | | | 140.01 |
| 5. Other | 2.40 | 0.01 | 0.01 | | | | | | 2.42 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.53 | NO,NA | 2.56 | 29.48 | NO,NA | 1.54 | NA,NO | NA,NO | 37.11 |
| A. Mineral industry | 0.18 | | | | | | | | 0.18 |
| B. Chemical industry | 0.16 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.16 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.19 | NA | NA | | | | | | 3.19 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 29.48 | NO | | | | 29.48 |
| G. Other product manufacture and use | | | 2.56 | | NO | 1.54 | | | 4.11 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 39.31 | 32.93 | | | | | | 72.24 |
| A. Enteric fermentation | | 34.57 | | | | | | | 34.57 |
| B. Manure management | | 4.74 | 12.21 | | | | | | 16.95 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.73 | | | | | | 20.73 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 1.46 | NO,NE | NO,NE,IE | | | | | | 1.46 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | -0.61 | NO,NE | NO,NE,IE | | | | | | -0.61 |
| C. Grassland | -1.91 | NE,NO | NO,NE | | | | | | -1.91 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 3.22 | NO | NO | | | | | | 3.22 |
| F. Other land | 0.76 | NO | NO | | | | | | 0.76 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.32 | 157.16 | 12.78 | | | | | | 170.26 |
| A. Solid waste disposal | NO,NA | 137.14 | | | | | | | 137.14 |
| B. Biological treatment of solid waste | | 1.57 | 1.12 | | | | | | 2.69 |
| C. Incineration and open burning of waste | 0.32 | 0.00 | 0.00 | | | | | | 0.32 |
| D. Waste water treatment and discharge | | 18.44 | 11.66 | | | | | | 30.11 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 3370.43 | 11.04 | 7.90 | | | | | | 3389.37 |
| Aviation | 301.54 | 1.05 | 0.75 | | | | | | 303.35 |
| Navigation | 3068.89 | 9.99 | 7.14 | | | | | | 3086.02 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 0.43 | | | | | | | | 0.43 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 3051.95 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 3053.41 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-16 Summary Report for $CO_2$ Equivalent Emissions in 2005.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ [(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)[(1)]** | 2706.17 | 212.91 | 58.02 | 41.78 | NO,NA | 1.56 | NA,NO | NA,NO | 3020.44 |
| **1. Energy** | 2700.54 | 4.94 | 10.12 | | | | | | 2715.60 |
| A. Fuel combustion (sectoral approach) | 2700.54 | 4.94 | 10.12 | | | | | | 2715.60 |
| 1. Energy industries | 1981.16 | 1.93 | 4.59 | | | | | | 1987.69 |
| 2. Manufacturing industries and construction | 41.75 | 0.04 | 0.09 | | | | | | 41.88 |
| 3. Transport | 539.81 | 2.58 | 5.20 | | | | | | 547.59 |
| 4. Other sectors | 135.38 | 0.38 | 0.22 | | | | | | 135.99 |
| 5. Other | 2.44 | 0.01 | 0.01 | | | | | | 2.46 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.68 | NO,NA | 2.46 | 41.78 | NO,NA | 1.56 | NA,NO | NA,NO | 49.48 |
| A. Mineral industry | 0.06 | | | | | | | | 0.06 |
| B. Chemical industry | 0.26 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.26 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.36 | NA | NA | | | | | | 3.36 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 41.78 | NO | | | | 41.78 |
| G. Other product manufacture and use | | | 2.46 | | NO | 1.56 | | | 4.02 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 41.62 | 32.89 | | | | | | 74.51 |
| A. Enteric fermentation | | 36.70 | | | | | | | 36.70 |
| B. Manure management | | 4.92 | 12.42 | | | | | | 17.34 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.46 | | | | | | 20.46 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry(1)** | 1.63 | NO,NE | NO,NE,IE | | | | | | 1.63 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | -0.36 | NO,NE | NO,NE,IE | | | | | | -0.36 |
| C. Grassland | -1.81 | NE,NO | NO,NE | | | | | | -1.81 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 3.04 | NO | NO | | | | | | 3.04 |
| F. Other land | 0.76 | NO | NO | | | | | | 0.76 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.32 | 166.35 | 12.56 | | | | | | 179.22 |
| A. Solid waste disposal | NO,NA | 146.19 | | | | | | | 146.19 |
| B. Biological treatment of solid waste | | 1.60 | 1.15 | | | | | | 2.75 |
| C. Incineration and open burning of waste | 0.32 | 0.00 | 0.00 | | | | | | 0.32 |
| D. Waste water treatment and discharge | | 18.55 | 11.41 | | | | | | 29.96 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 2330.85 | 7.66 | 5.48 | | | | | | 2343.99 |
| Aviation | 266.56 | 0.93 | 0.67 | | | | | | 268.16 |
| Navigation | 2064.28 | 6.73 | 4.81 | | | | | | 2075.83 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 3.59 | | | | | | | | 3.59 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ (2)** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 3018.81 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 3020.44 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-17 Summary Report for $CO_2$ Equivalent Emissions in 2006.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$(1) | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)(1)** | 2709.70 | 220.58 | 58.29 | 78.86 | NO,NA | 1.57 | NA,NO | NA,NO | 3069.01 |
| **1. Energy** | 2703.35 | 4.81 | 9.99 | | | | | | 2718.15 |
| A. Fuel combustion (sectoral approach) | 2703.35 | 4.81 | 9.99 | | | | | | 2718.15 |
| 1. Energy industries | 1995.74 | 1.94 | 4.63 | | | | | | 2002.31 |
| 2. Manufacturing industries and construction | 36.63 | 0.03 | 0.08 | | | | | | 36.74 |
| 3. Transport | 546.80 | 2.49 | 5.09 | | | | | | 554.38 |
| 4. Other sectors | 121.74 | 0.33 | 0.19 | | | | | | 122.27 |
| 5. Other | 2.43 | 0.01 | 0.01 | | | | | | 2.45 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 4.23 | NO,NA | 2.24 | 78.86 | NO,NA | 1.57 | NA,NO | NA,NO | 86.90 |
| A. Mineral industry | 0.18 | | | | | | | | 0.18 |
| B. Chemical industry | 0.09 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.09 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.95 | NA | NA | | | | | | 3.95 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 78.86 | NO | | | | 78.86 |
| G. Other product manufacture and use | | | 2.24 | | NO | 1.57 | | | 3.81 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 40.90 | 32.90 | | | | | | 73.80 |
| A. Enteric fermentation | | 35.92 | | | | | | | 35.92 |
| B. Manure management | | 4.98 | 12.41 | | | | | | 17.39 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.49 | | | | | | 20.49 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 1.80 | NO,NE | NO,NE,IE | | | | | | 1.80 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | -0.11 | NO,NE | NO,NE,IE | | | | | | -0.11 |
| C. Grassland | -1.71 | NE,NO | NO,NE | | | | | | -1.71 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 2.86 | NO | NO | | | | | | 2.86 |
| F. Other land | 0.76 | NO | NO | | | | | | 0.76 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.32 | 174.88 | 13.17 | | | | | | 188.36 |
| A. Solid waste disposal | NO,NA | 154.11 | | | | | | | 154.11 |
| B. Biological treatment of solid waste | | 2.08 | 1.49 | | | | | | 3.58 |
| C. Incineration and open burning of waste | 0.32 | 0.00 | 0.00 | | | | | | 0.32 |
| D. Waste water treatment and discharge | | 18.68 | 11.68 | | | | | | 30.36 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 2619.17 | 8.61 | 6.16 | | | | | | 2633.93 |
| Aviation | 269.49 | 0.94 | 0.67 | | | | | | 271.11 |
| Navigation | 2349.68 | 7.66 | 5.48 | | | | | | 2362.83 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 4.05 | | | | | | | | 4.05 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 3067.21 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 3069.01 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

### Table 10-18 Summary Report for $CO_2$ Equivalent Emissions in 2007.

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$[(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)[(1)]** | 2778.84 | 226.85 | 59.04 | 96.74 | 0.00 | 1.58 | NA,NO | NA,NO | 3163.05 |
| **1. Energy** | 2773.21 | 4.89 | 10.29 | | | | | | 2788.39 |
| A. Fuel combustion (sectoral approach) | 2773.21 | 4.89 | 10.29 | | | | | | 2788.39 |
| 1. Energy industries | 2037.55 | 1.98 | 4.72 | | | | | | 2044.26 |
| 2. Manufacturing industries and construction | 38.91 | 0.04 | 0.08 | | | | | | 39.02 |
| 3. Transport | 571.25 | 2.52 | 5.28 | | | | | | 579.05 |
| 4. Other sectors | 123.01 | 0.34 | 0.19 | | | | | | 123.55 |
| 5. Other | 2.49 | 0.01 | 0.01 | | | | | | 2.51 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.38 | NO,NA | 2.90 | 96.74 | 0.00 | 1.58 | NA,NO | NA,NO | 104.59 |
| A. Mineral industry | 0.07 | | | | | | | | 0.07 |
| B. Chemical industry | 0.10 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.10 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.21 | NA | NA | | | | | | 3.21 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 96.74 | NO | | | | 96.74 |
| G. Other product manufacture and use | | | 2.90 | | 0.00 | 1.58 | | | 4.48 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 41.46 | 33.70 | | | | | | 75.16 |
| A. Enteric fermentation | | 36.33 | | | | | | | 36.33 |
| B. Manure management | | 5.13 | 12.83 | | | | | | 17.95 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.88 | | | | | | 20.88 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry(1)** | 1.94 | NO,NE | NO,NE,IE | | | | | | 1.94 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 0.15 | NO,NE | NO,NE,IE | | | | | | 0.15 |
| C. Grassland | -1.61 | NE,NO | NO,NE | | | | | | -1.61 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 2.63 | NO | NO | | | | | | 2.63 |
| F. Other land | 0.77 | NO | NO | | | | | | 0.77 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.32 | 180.50 | 12.15 | | | | | | 192.97 |
| A. Solid waste disposal | NO,NA | 161.71 | | | | | | | 161.71 |
| B. Biological treatment of solid waste | | NO | NO | | | | | | NO |
| C. Incineration and open burning of waste | 0.32 | 0.00 | 0.00 | | | | | | 0.32 |
| D. Waste water treatment and discharge | | 18.79 | 12.15 | | | | | | 30.94 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 2947.12 | 9.67 | 6.91 | | | | | | 2963.70 |
| Aviation | 282.81 | 0.99 | 0.71 | | | | | | 284.51 |
| Navigation | 2664.31 | 8.68 | 6.21 | | | | | | 2679.19 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 5.44 | | | | | | | | 5.44 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ (2)** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 3161.11 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 3163.05 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-19 Summary Report for $CO_2$ Equivalent Emissions in 2008.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$[(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)[(1)]** | 2786.50 | 146.16 | 56.91 | 112.37 | 0.00 | 1.75 | NA,NO | NA,NO | 3103.69 |
| **1. Energy** | 2780.47 | 4.90 | 10.27 | | | | | | 2795.65 |
| A. Fuel combustion (sectoral approach) | 2780.47 | 4.90 | 10.27 | | | | | | 2795.65 |
| 1. Energy industries | 2018.59 | 1.97 | 4.69 | | | | | | 2025.25 |
| 2. Manufacturing industries and construction | 38.87 | 0.03 | 0.08 | | | | | | 38.98 |
| 3. Transport | 578.98 | 2.49 | 5.25 | | | | | | 586.73 |
| 4. Other sectors | 141.32 | 0.40 | 0.23 | | | | | | 141.95 |
| 5. Other | 2.72 | 0.01 | 0.01 | | | | | | 2.74 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.61 | NO,NA | 2.31 | 112.37 | 0.00 | 1.75 | NA,NO | NA,NO | 120.03 |
| A. Mineral industry | 0.05 | | | | | | | | 0.05 |
| B. Chemical industry | 0.06 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.06 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.50 | NA | NA | | | | | | 3.50 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 112.37 | NO | | | | 112.37 |
| G. Other product manufacture and use | | | 2.31 | | 0.00 | 1.75 | | | 4.06 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 39.62 | 33.06 | | | | | | 72.68 |
| A. Enteric fermentation | | 34.80 | | | | | | | 34.80 |
| B. Manure management | | 4.82 | 12.17 | | | | | | 16.99 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.89 | | | | | | 20.89 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry(1)** | 2.07 | NO,NE | NO,NE,IE | | | | | | 2.07 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 0.37 | NO,NE | NO,NE,IE | | | | | | 0.37 |
| C. Grassland | -1.50 | NE,NO | NO,NE | | | | | | -1.50 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 2.42 | NO | NO | | | | | | 2.42 |
| F. Other land | 0.77 | NO | NO | | | | | | 0.77 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.35 | 101.64 | 11.27 | | | | | | 113.26 |
| A. Solid waste disposal | NO,NA | 83.96 | | | | | | | 83.96 |
| B. Biological treatment of solid waste | | NO | NO | | | | | | NO |
| C. Incineration and open burning of waste | 0.35 | 0.00 | 0.16 | | | | | | 0.51 |
| D. Waste water treatment and discharge | | 17.68 | 11.11 | | | | | | 28.79 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 3231.86 | 10.63 | 7.61 | | | | | | 3250.10 |
| Aviation | 384.41 | 1.34 | 0.96 | | | | | | 386.71 |
| Navigation | 2847.45 | 9.29 | 6.64 | | | | | | 2863.39 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 2.89 | | | | | | | | 2.89 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ (2)** | NO,NE | | | | | | | | |
| | | | | | | | | **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | 3101.62 |
| | | | | | | | | **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | 3103.69 |
| | | | | | | | | **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | NA |
| | | | | | | | | **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | NA |

**Table 10-20 Summary Report for $CO_2$ Equivalent Emissions in 2009.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$[(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)[(1)]** | 2633.74 | 161.44 | 54.51 | 133.13 | 0.00 | 1.50 | NA,NO | NA,NO | 2984.32 |
| **1. Energy** | 2627.12 | 4.60 | 9.79 | | | | | | 2641.50 |
| A. Fuel combustion (sectoral approach) | 2627.12 | 4.60 | 9.79 | | | | | | 2641.50 |
| 1. Energy industries | 1897.11 | 1.85 | 4.41 | | | | | | 1903.37 |
| 2. Manufacturing industries and construction | 36.27 | 0.03 | 0.07 | | | | | | 36.37 |
| 3. Transport | 549.66 | 2.32 | 5.07 | | | | | | 557.05 |
| 4. Other sectors | 141.53 | 0.39 | 0.22 | | | | | | 142.14 |
| 5. Other | 2.55 | 0.01 | 0.01 | | | | | | 2.57 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.89 | NO,NA | 1.83 | 133.13 | 0.00 | 1.50 | NA,NO | NA,NO | 140.35 |
| A. Mineral industry | 0.06 | | | | | | | | 0.06 |
| B. Chemical industry | 0.10 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.10 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.74 | NA | NA | | | | | | 3.74 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 133.13 | NO | | | | 133.13 |
| G. Other product manufacture and use | | | 1.83 | | 0.00 | 1.50 | | | 3.32 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 37.89 | 32.50 | | | | | | 70.38 |
| A. Enteric fermentation | | 33.27 | | | | | | | 33.27 |
| B. Manure management | | 4.62 | 11.64 | | | | | | 16.26 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.86 | | | | | | 20.86 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 2.20 | NO,NE | NO,NE,IE | | | | | | 2.20 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 0.60 | NO,NE | NO,NE,IE | | | | | | 0.60 |
| C. Grassland | -1.39 | NE,NO | NO,NE | | | | | | -1.39 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 2.22 | NO | NO | | | | | | 2.22 |
| F. Other land | 0.78 | NO | NO | | | | | | 0.78 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.53 | 118.96 | 10.40 | | | | | | 129.89 |
| A. Solid waste disposal | NO,NA | 103.40 | | | | | | | 103.40 |
| B. Biological treatment of solid waste | | NO | NO | | | | | | NO |
| C. Incineration and open burning of waste | 0.53 | 0.00 | 0.20 | | | | | | 0.73 |
| D. Waste water treatment and discharge | | 15.55 | 10.19 | | | | | | 25.75 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 3814.44 | 12.47 | 8.92 | | | | | | 3835.83 |
| Aviation | 273.79 | 0.96 | 0.68 | | | | | | 275.43 |
| Navigation | 3540.65 | 11.52 | 8.24 | | | | | | 3560.40 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 2.00 | | | | | | | | 2.00 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2982.12 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2984.32 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-21 Summary Report for $CO_2$ Equivalent Emissions in 2010.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ (1) | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)(1)** | 2640.43 | 179.58 | 53.97 | 145.49 | 0.00 | 1.69 | NA,NO | NA,NO | 3021.16 |
| **1. Energy** | 2634.37 | 4.42 | 9.68 | | | | | | 2648.46 |
| A. Fuel combustion (sectoral approach) | 2634.37 | 4.42 | 9.68 | | | | | | 2648.46 |
| 1. Energy industries | 1878.31 | 1.83 | 4.37 | | | | | | 1884.51 |
| 2. Manufacturing industries and construction | 25.72 | 0.02 | 0.05 | | | | | | 25.79 |
| 3. Transport | 593.44 | 2.09 | 5.02 | | | | | | 600.55 |
| 4. Other sectors | 134.61 | 0.47 | 0.23 | | | | | | 135.31 |
| 5. Other | 2.30 | 0.01 | 0.01 | | | | | | 2.32 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.45 | NO,NA | 1.53 | 145.49 | 0.00 | 1.69 | NA,NO | NA,NO | 152.17 |
| A. Mineral industry | 0.05 | | | | | | | | 0.05 |
| B. Chemical industry | 0.10 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.10 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.31 | NA | NA | | | | | | 3.31 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 145.49 | NO | | | | 145.49 |
| G. Other product manufacture and use | | | 1.53 | | 0.00 | 1.69 | | | 3.23 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 36.87 | 32.04 | | | | | | 68.91 |
| A. Enteric fermentation | | 32.35 | | | | | | | 32.35 |
| B. Manure management | | 4.52 | 11.19 | | | | | | 15.71 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.85 | | | | | | 20.85 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 1.95 | NO,NE | NO,NE,IE | | | | | | 1.95 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 0.82 | NO,NE | NO,NE,IE | | | | | | 0.82 |
| C. Grassland | -1.40 | NE,NO | NO,NE | | | | | | -1.40 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 1.74 | NO | NO | | | | | | 1.74 |
| F. Other land | 0.79 | NO | NO | | | | | | 0.79 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.65 | 138.29 | 10.72 | | | | | | 149.66 |
| A. Solid waste disposal | NO,NA | 121.50 | | | | | | | 121.50 |
| B. Biological treatment of solid waste | | 0.15 | NO,NA | | | | | | 0.15 |
| C. Incineration and open burning of waste | 0.65 | 0.00 | 0.21 | | | | | | 0.86 |
| D. Waste water treatment and discharge | | 16.64 | 10.51 | | | | | | 27.15 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 4842.01 | 15.83 | 11.32 | | | | | | 4869.16 |
| Aviation | 304.54 | 1.06 | 0.76 | | | | | | 306.37 |
| Navigation | 4537.46 | 14.77 | 10.56 | | | | | | 4562.79 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 3.58 | | | | | | | | 3.58 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 3019.21 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 3021.16 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-22 Summary Report for $CO_2$ Equivalent Emissions in 2011.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$[(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)[(1)]** | 2727.94 | 167.53 | 48.10 | 169.02 | 0.00 | 4.59 | NA,NO | NA,NO | 3117.20 |
| **1. Energy** | 2721.07 | 4.46 | 9.70 | | | | | | 2735.23 |
| A. Fuel combustion (sectoral approach) | 2721.07 | 4.46 | 9.70 | | | | | | 2735.23 |
| 1. Energy industries | 1931.57 | 1.88 | 4.49 | | | | | | 1937.94 |
| 2. Manufacturing industries and construction | 38.45 | 0.03 | 0.08 | | | | | | 38.56 |
| 3. Transport | 609.36 | 2.05 | 4.88 | | | | | | 616.28 |
| 4. Other sectors | 138.69 | 0.49 | 0.24 | | | | | | 139.42 |
| 5. Other | 3.01 | 0.01 | 0.01 | | | | | | 3.04 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.85 | NO,NA | 1.55 | 169.02 | 0.00 | 4.59 | NA,NO | NA,NO | 179.02 |
| A. Mineral industry | 0.03 | | | | | | | | 0.03 |
| B. Chemical industry | 0.13 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.13 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.69 | NA | NA | | | | | | 3.69 |
| E. Electronic Industry | | | | NO | NO | NO | NO | NO | NO |
| F. Product uses as ODS substitutes | | | | 169.02 | NO | | | | 169.02 |
| G. Other product manufacture and use | | | 1.55 | | 0.00 | 4.59 | | | 6.14 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 35.45 | 31.05 | | | | | | 66.50 |
| A. Enteric fermentation | | 31.26 | | | | | | | 31.26 |
| B. Manure management | | 4.19 | 10.59 | | | | | | 14.78 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.47 | | | | | | 20.47 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 2.19 | NO,NE | NO,NE,IE | | | | | | 2.19 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 1.04 | NO,NE | NO,NE,IE | | | | | | 1.04 |
| C. Grassland | -1.26 | NE,NO | NO,NE | | | | | | -1.26 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 1.61 | NO | NO | | | | | | 1.61 |
| F. Other land | 0.79 | NO | NO | | | | | | 0.79 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.83 | 127.62 | 5.80 | | | | | | 134.26 |
| A. Solid waste disposal | NO,NA | 122.36 | | | | | | | 122.36 |
| B. Biological treatment of solid waste | | 0.88 | NO,NA | | | | | | 0.88 |
| C. Incineration and open burning of waste | 0.83 | 0.00 | 0.18 | | | | | | 1.02 |
| D. Waste water treatment and discharge | | 4.39 | 5.62 | | | | | | 10.00 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 4454.87 | 14.56 | 10.42 | | | | | | 4479.86 |
| Aviation | 316.77 | 1.11 | 0.79 | | | | | | 318.67 |
| Navigation | 4138.10 | 13.46 | 9.62 | | | | | | 4161.18 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 11.76 | | | | | | | | 11.76 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 3115.01 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 3117.20 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-23 Summary Report for $CO_2$ Equivalent Emissions in 2012.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ (1) | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)(1)** | 2821.85 | 165.34 | 47.30 | 201.03 | 0.00 | 0.45 | NA,NO | NA,NO | 3235.97 |
| **1. Energy** | 2815.43 | 4.40 | 9.89 | | | | | | 2829.73 |
| A. Fuel combustion (sectoral approach) | 2815.43 | 4.40 | 9.89 | | | | | | 2829.73 |
| 1. Energy industries | 2051.83 | 2.00 | 4.76 | | | | | | 2058.59 |
| 2. Manufacturing industries and construction | 40.55 | 0.04 | 0.08 | | | | | | 40.67 |
| 3. Transport | 571.01 | 1.80 | 4.77 | | | | | | 577.57 |
| 4. Other sectors | 149.30 | 0.56 | 0.27 | | | | | | 150.13 |
| 5. Other | 2.74 | 0.01 | 0.01 | | | | | | 2.76 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.16 | NO,NA | 2.13 | 201.03 | 0.00 | 0.45 | NA,NO | NA,NO | 206.76 |
| A. Mineral industry | 0.08 | | | | | | | | 0.08 |
| B. Chemical industry | 0.03 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.03 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.04 | NA | NA | | | | | | 3.04 |
| E. Electronic Industry | | | | 0.56 | NO | NO | NO | NO | 0.56 |
| F. Product uses as ODS substitutes | | | | 200.47 | NO | | | | 200.47 |
| G. Other product manufacture and use | | | 2.13 | | 0.00 | 0.45 | | | 2.58 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 36.09 | 31.15 | | | | | | 67.24 |
| A. Enteric fermentation | | 31.87 | | | | | | | 31.87 |
| B. Manure management | | 4.22 | 10.66 | | | | | | 14.88 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.49 | | | | | | 20.49 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[1]** | 2.42 | NO,NE | NO,NE,IE | | | | | | 2.42 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 1.26 | NO,NE | NO,NE,IE | | | | | | 1.26 |
| C. Grassland | -1.12 | NE,NO | NO,NE | | | | | | -1.12 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 1.49 | NO | NO | | | | | | 1.49 |
| F. Other land | 0.79 | NO | NO | | | | | | 0.79 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.84 | 124.85 | 4.13 | | | | | | 129.82 |
| A. Solid waste disposal | NO,NA | 123.81 | | | | | | | 123.81 |
| B. Biological treatment of solid waste | | 1.04 | NO,NA | | | | | | 1.04 |
| C. Incineration and open burning of waste | 0.84 | 0.00 | 0.17 | | | | | | 1.01 |
| D. Waste water treatment and discharge | | NA,IE | 3.96 | | | | | | 3.96 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 4056.54 | 13.27 | 9.49 | | | | | | 4079.29 |
| Aviation | 304.48 | 1.06 | 0.76 | | | | | | 306.31 |
| Navigation | 3752.05 | 12.20 | 8.73 | | | | | | 3772.98 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 18.25 | | | | | | | | 18.25 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [2]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 3233.55 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 3235.97 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-24 Summary Report for $CO_2$ Equivalent Emissions in 2013.**

| GREENHOUSE GAS SOURCE AND | $CO_2$[(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| SINK CATEGORIES | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)[(1)]** | 2484.66 | 155.34 | 45.58 | 216.32 | 0.00 | 2.68 | NA,NO | NA,NO | 2904.58 |
| **1. Energy** | 2478.02 | 4.00 | 8.92 | | | | | | 2490.94 |
| A. Fuel combustion (sectoral approach) | 2478.02 | 4.00 | 8.92 | | | | | | 2490.94 |
| 1. Energy industries | 1694.77 | 1.62 | 3.86 | | | | | | 1700.25 |
| 2. Manufacturing industries and construction | 39.15 | 0.03 | 0.08 | | | | | | 39.26 |
| 3. Transport | 573.93 | 1.73 | 4.65 | | | | | | 580.32 |
| 4. Other sectors | 166.92 | 0.61 | 0.31 | | | | | | 167.83 |
| 5. Other | 3.25 | 0.01 | 0.01 | | | | | | 3.28 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.42 | NO,NA | 1.44 | 216.32 | 0.00 | 2.68 | NA,NO | NA,NO | 223.85 |
| A. Mineral industry | 0.06 | | | | | | | | 0.06 |
| B. Chemical industry | 0.03 | NO,NA | NO,NA | NO,NA | NA | NA | NA | NA | 0.03 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.32 | NA | NA | | | | | | 3.32 |
| E. Electronic Industry | | | | 1.33 | NO | NO | NO | NO | 1.33 |
| F. Product uses as ODS substitutes | | | | 214.99 | NO | | | | 214.99 |
| G. Other product manufacture and use | | | 1.44 | | 0.00 | 2.68 | | | 4.12 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 35.97 | 31.02 | | | | | | 66.99 |
| A. Enteric fermentation | | 31.72 | | | | | | | 31.72 |
| B. Manure management | | 4.25 | 10.67 | | | | | | 14.92 |
| C. Rice cultivation | | NO,NA | | | | | | | NO,NA |
| D. Agricultural soils | | NA,NE | 20.35 | | | | | | 20.35 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NA,NO | NA,NO | | | | | | NA,NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | NA | NA | | | | | | NA |
| **4. Land use, land-use change and forestry[(1)]** | 2.66 | NO,NE | NO,NE,IE | | | | | | 2.66 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 1.49 | NO,NE | NO,NE,IE | | | | | | 1.49 |
| C. Grassland | -0.98 | NE,NO | NO,NE | | | | | | -0.98 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 1.36 | NO | NO | | | | | | 1.36 |
| F. Other land | 0.79 | NO | NO | | | | | | 0.79 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.56 | 115.37 | 4.20 | | | | | | 120.13 |
| A. Solid waste disposal | NO,NA | 114.36 | | | | | | | 114.36 |
| B. Biological treatment of solid waste | | 1.01 | NO,NA | | | | | | 1.01 |
| C. Incineration and open burning of waste | 0.56 | 0.00 | 0.18 | | | | | | 0.74 |
| D. Waste water treatment and discharge | | NA,IE | 4.02 | | | | | | 4.02 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 4067.93 | 13.30 | 9.51 | | | | | | 4090.75 |
| Aviation | 316.78 | 1.11 | 0.79 | | | | | | 318.68 |
| Navigation | 3751.15 | 12.19 | 8.72 | | | | | | 3772.07 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 16.38 | | | | | | | | 16.38 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2901.92 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2904.58 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

**Table 10-25 Summary Report for $CO_2$ Equivalent Emissions in 2014.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$[(1)] | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)[(1)]** | 2484.16 | 171.53 | 46.12 | 230.77 | 0.00 | 0.58 | NA,NO | NA,NO | 2933.16 |
| **1. Energy** | 2477.25 | 4.21 | 9.50 | | | | | | 2490.95 |
| A. Fuel combustion (sectoral approach) | 2477.25 | 4.21 | 9.50 | | | | | | 2490.95 |
| 1. Energy industries | 1657.44 | 1.59 | 3.78 | | | | | | 1662.81 |
| 2. Manufacturing industries and construction | 39.94 | 0.04 | 0.08 | | | | | | 40.06 |
| 3. Transport | 589.14 | 1.87 | 5.25 | | | | | | 596.27 |
| 4. Other sectors | 187.07 | 0.70 | 0.36 | | | | | | 188.14 |
| 5. Other | 3.65 | 0.01 | 0.01 | | | | | | 3.68 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 3.23 | NA,NO | 0.87 | 230.77 | 0.00 | 0.58 | NA,NO | NA,NO | 235.45 |
| A. Mineral industry | 0.04 | | | | | | | | 0.04 |
| B. Chemical industry | 0.07 | NO,NA | NO,NA | NA,NO | NA | NA | NA | NA | 0.07 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 3.12 | NA | NA | | | | | | 3.12 |
| E. Electronic Industry | | | | 0.34 | NO | NO | NO | NO | 0.34 |
| F. Product uses as ODS substitutes | | | | 230.43 | NO | | | | 230.43 |
| G. Other product manufacture and use | | | 0.87 | | 0.00 | 0.58 | | | 1.46 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 35.46 | 30.85 | | | | | | 66.31 |
| A. Enteric fermentation | | 31.27 | | | | | | | 31.27 |
| B. Manure management | | 4.19 | 10.56 | | | | | | 14.75 |
| C. Rice cultivation | | NA,NO | | | | | | | NA,NO |
| D. Agricultural soils | | | 20.29 | | | | | | 20.29 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NO | NO | | | | | | NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | | | | | | | | |
| **4. Land use, land-use change and forestry[(1)]** | 2.89 | NE,NO | NO,NE,IE | | | | | | 2.89 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 1.70 | NE,NO | NO,NE,IE | | | | | | 1.70 |
| C. Grassland | -0.84 | NE,NO | NO,NE | | | | | | -0.84 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 1.23 | NO | NO | | | | | | 1.23 |
| F. Other land | 0.79 | NO | NO | | | | | | 0.79 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.79 | 131.86 | 4.90 | | | | | | 137.55 |
| A. Solid waste disposal | NA,NO | 129.67 | | | | | | | 129.67 |
| B. Biological treatment of solid waste | | 0.88 | NA,NO | | | | | | 0.88 |
| C. Incineration and open burning of waste | 0.79 | 0.00 | 0.17 | | | | | | 0.96 |
| D. Waste water treatment and discharge | | 1.31 | 4.73 | | | | | | 6.04 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 4340.65 | 14.20 | 10.15 | | | | | | 4365.00 |
| Aviation | 335.22 | 1.17 | 0.84 | | | | | | 337.23 |
| Navigation | 4005.43 | 13.03 | 9.32 | | | | | | 4027.77 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 22.17 | | | | | | | | 22.17 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [(2)]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2930.27 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2933.16 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

### Table 10-26 Summary Report for $CO_2$ Equivalent Emissions in 2015.

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$(1) | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Unspecified mix of HFCs and PFCs | $NF_3$ | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (kt ) | | | | | | | | |
| **Total (net emissions)(1)** | 1760.04 | 178.02 | 44.74 | 247.00 | 0.00 | 0.19 | NA,NO | NA,NO | 2229.99 |
| **1. Energy** | 1755.67 | 3.34 | 7.43 | | | | | | 1766.44 |
| A. Fuel combustion (sectoral approach) | 1755.67 | 3.34 | 7.43 | | | | | | 1766.44 |
| 1. Energy industries | 887.70 | 0.84 | 2.01 | | | | | | 890.55 |
| 2. Manufacturing industries and construction | 42.48 | 0.04 | 0.09 | | | | | | 42.61 |
| 3. Transport | 624.87 | 1.75 | 4.95 | | | | | | 631.56 |
| 4. Other sectors | 196.44 | 0.70 | 0.37 | | | | | | 197.51 |
| 5. Other | 4.18 | 0.01 | 0.02 | | | | | | 4.21 |
| B. Fugitive emissions from fuels | NO | NO | NO | | | | | | NO |
| 1. Solid fuels | NO | NO | NO | | | | | | NO |
| 2. Oil and natural gas | NO | NO | NO | | | | | | NO |
| C. $CO_2$ transport and storage | NO | | | | | | | | NO |
| **2. Industrial processes and product use** | 0.56 | NA,NO | 0.64 | 247.00 | 0.00 | 0.19 | NA,NO | NA,NO | 248.39 |
| A. Mineral industry | 0.02 | | | | | | | | 0.02 |
| B. Chemical industry | 0.07 | NO,NA | NO,NA | NA,NO | NA | NA | NA | NA | 0.07 |
| C. Metal industry | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| D. Non-energy products from fuels and solvent use | 0.47 | NA | NA | | | | | | 0.47 |
| E. Electronic Industry | | | | 0.40 | NO | NO | NO | NO | 0.40 |
| F. Product uses as ODS substitutes | | | | 246.60 | NO | | | | 246.60 |
| G. Other product manufacture and use | | | 0.64 | | 0.00 | 0.19 | | | 0.83 |
| H. Other | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **3. Agriculture** | NE,NO | 34.98 | 30.91 | | | | | | 65.90 |
| A. Enteric fermentation | | 30.92 | | | | | | | 30.92 |
| B. Manure management | | 4.06 | 10.62 | | | | | | 14.68 |
| C. Rice cultivation | | NA,NO | | | | | | | NA,NO |
| D. Agricultural soils | | | 20.30 | | | | | | 20.30 |
| E. Prescribed burning of savannas | | NO | NO | | | | | | NO |
| F. Field burning of agricultural residues | | NO | NO | | | | | | NO |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| G. Liming | NO | | | | | | | | NO |
| H. Urea application | NE | | | | | | | | NE |
| I. Other carbon-containing fertilizers | NO | | | | | | | | NO |
| J. Other | | | | | | | | | |
| **4. Land use, land-use change and forestry[1]** | 3.13 | NE,NO | NO,NE,IE | | | | | | 3.13 |
| A. Forest land | 0.00 | NO | NO | | | | | | 0.00 |
| B. Cropland | 1.93 | NE,NO | NO,NE,IE | | | | | | 1.93 |
| C. Grassland | -0.70 | NE,NO | NO,NE | | | | | | -0.70 |
| D. Wetlands | NO | NO | NO | | | | | | NO |
| E. Settlements | 1.11 | NO | NO | | | | | | 1.11 |
| F. Other land | 0.79 | NO | NO | | | | | | 0.79 |
| G. Harvested wood products | NO | | | | | | | | NO |
| H. Other | NO | NO | NO | | | | | | NO |
| **5. Waste** | 0.68 | 139.70 | 5.76 | | | | | | 146.14 |
| A. Solid waste disposal | NA,NO | 136.47 | | | | | | | 136.47 |
| B. Biological treatment of solid waste | | 0.83 | NA,NO | | | | | | 0.83 |
| C. Incineration and open burning of waste | 0.68 | 0.00 | 0.16 | | | | | | 0.84 |
| D. Waste water treatment and discharge | | 2.40 | 5.60 | | | | | | 8.00 |
| E. Other | NO | NO | NO | | | | | | NO |
| **6. Other *(as specified in summary 1.A)*** | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Memo items:** | | | | | | | | | |
| **International bunkers** | 5447.17 | 17.81 | 12.74 | | | | | | 5477.72 |
| Aviation | 349.91 | 1.22 | 0.88 | | | | | | 352.01 |
| Navigation | 5097.26 | 16.59 | 11.86 | | | | | | 5125.71 |
| **Multilateral operations** | NO | NO | NO | | | | | | NO |
| **$CO_2$ emissions from biomass** | 19.36 | | | | | | | | 19.36 |
| **$CO_2$ captured** | NO,IE | | | | | | | | NO,IE |
| **Long-term storage of C in waste disposal sites** | NE | | | | | | | | NE |
| **Indirect $N_2O$** | | | NO,NE | | | | | | |
| **Indirect $CO_2$ [2]** | NO,NE | | | | | | | | |
| **Total $CO_2$ equivalent emissions without land use, land-use change and forestry** | | | | | | | | | 2226.87 |
| **Total $CO_2$ equivalent emissions with land use, land-use change and forestry** | | | | | | | | | 2229.99 |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, without land use, land-use change and forestry** | | | | | | | | | NA |
| **Total $CO_2$ equivalent emissions, including indirect $CO_2$, with land use, land-use change and forestry** | | | | | | | | | NA |

## 10.2 Emission Trends by Gas

**Note**:

(1) The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the COP. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.

**Table 10-27 Emission Trends by Gas (in kt equivalent to $CO_2$) for 1990.**

| GREENHOUSE GAS EMISSIONS | Base year(3) | 1990 | Change from base to latest reported year |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2170.72 | 0.00 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2173.69 | 0.00 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 154.96 | 0.00 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 154.96 | 0.00 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 56.34 | 0.00 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 56.34 | 0.00 |
| HFCs | NO,NE,IE,NA | NO,NE,IE,NA | 0.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 0.01 | 0.00 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2382.04 | 0.00 |
| **Total (with LULUCF)** | 2385.00 | 2385.00 | 0.00 |

## Table 10-28 Emission Trends by Gas (in kt equivalent to $CO_2$) for 1991.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 1991 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2166.39 | -0.20 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2171.14 | -0.12 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 162.05 | 4.57 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 162.05 | 4.57 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 58.05 | 3.03 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 58.05 | 3.03 |
| HFCs | NO,NE,IE,NA | NO,NE,IE,NA | 0.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 0.01 | 0.00 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2386.49 | 0.19 |
| **Total (with LULUCF)** | 2385.00 | 2391.24 | 0.26 |

## Table 10-29 Emission Trends by Gas (in kt equivalent to $CO_2$) for 1992.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 1992 | Change from base to previous year |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2321.29 | 6.94 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2325.65 | 6.99 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 165.23 | 6.63 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 165.23 | 6.63 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 59.48 | 5.58 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 59.48 | 5.58 |
| HFCs | NO,NE,IE,NA | NO,NE,IE,NA | 0.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.43 | 13330.47 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2547.43 | 6.94 |
| **Total (with LULUCF)** | 2385.00 | 2551.79 | 6.99 |

### Table 10-30 Emission Trends by Gas (in kt equivalent to $CO_2$) for 1993.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 1993 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2682.37 | 23.57 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2685.65 | 23.55 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 173.87 | 12.20 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 173.87 | 12.20 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 60.95 | 8.18 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 60.95 | 8.18 |
| HFCs | NO,NE,IE,NA | NO,NE,IE,NA | 0.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.43 | 13330.47 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2918.62 | 22.53 |
| **Total (with LULUCF)** | 2385.00 | 2921.89 | 22.51 |

### Table 10-31 Emission Trends by Gas (in kt equivalent to $CO_2$) for 1994.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 1994 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2568.11 | 18.31 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2571.79 | 18.31 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 171.64 | 10.77 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 171.64 | 10.77 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 61.15 | 8.53 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 61.15 | 8.53 |
| HFCs | NO,NE,IE,NA | 0.00 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.43 | 13372.32 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2802.34 | 17.64 |
| **Total (with LULUCF)** | 2385.00 | 2806.01 | 17.65 |

### Table 10-32 Emission Trends by Gas (in kt equivalent to $CO_2$) for 1995.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 1995 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2360.48 | 8.74 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2363.56 | 8.73 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 145.49 | -6.11 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 145.49 | -6.11 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 59.37 | 5.37 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 59.37 | 5.37 |
| HFCs | NO,NE,IE,NA | 0.00 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.44 | 13418.45 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2566.78 | 7.76 |
| **Total (with LULUCF)** | 2385.00 | 2569.85 | 7.75 |

### Table 10-33 Emission Trends by Gas (in kt equivalent to $CO_2$) for 1996.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 1996 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2453.42 | 13.02 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2456.43 | 13.01 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 142.08 | -8.31 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 142.08 | -8.31 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 59.04 | 4.79 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 59.04 | 4.79 |
| HFCs | NO,NE,IE,NA | 0.00 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.45 | 13521.46 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2655.99 | 11.50 |
| **Total (with LULUCF)** | 2385.00 | 2659.00 | 11.49 |

### Table 10-34 Emission Trends by Gas (in kt equivalent to $CO_2$) for 1997.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 1997 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2455.84 | 13.13 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2458.77 | 13.12 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 149.12 | -3.77 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 149.12 | -3.77 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 59.32 | 5.28 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 59.32 | 5.28 |
| HFCs | NO,NE,IE,NA | 0.00 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.45 | 13521.46 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2665.73 | 11.91 |
| **Total (with LULUCF)** | 2385.00 | 2668.66 | 11.89 |

### Table 10-35 Emission Trends by Gas (in kt equivalent to $CO_2$) for 1998.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 1998 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2472.38 | 13.90 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2474.93 | 13.86 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 156.02 | 0.68 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 156.02 | 0.68 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 59.44 | 5.49 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 59.44 | 5.49 |
| HFCs | NO,NE,IE,NA | 0.01 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.47 | 13690.99 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2689.30 | 12.90 |
| **Total (with LULUCF)** | 2385.00 | 2691.85 | 12.87 |

**Table 10-36 Emission Trends by Gas (in kt equivalent to $CO_2$) for 1999.**

| GREENHOUSE GAS EMISSIONS | Base year(3) | 1999 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2581.51 | 18.92 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2583.43 | 18.85 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 163.19 | 5.31 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 163.19 | 5.31 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 59.96 | 6.42 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 59.96 | 6.42 |
| HFCs | NO,NE,IE,NA | 0.01 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.47 | 13690.99 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2806.14 | 17.80 |
| **Total (with LULUCF)** | 2385.00 | 2808.06 | 17.74 |

**Table 10-37 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2000.**

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2000 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2417.83 | 11.38 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2420.98 | 11.38 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 173.85 | 12.19 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 173.85 | 12.19 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 61.26 | 8.72 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 61.26 | 8.72 |
| HFCs | NO,NE,IE,NA | 6.70 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.47 | 13727.47 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2661.11 | 11.72 |
| **Total (with LULUCF)** | 2385.00 | 2664.26 | 11.71 |

Table 10-38 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2001.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2001 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2599.92 | 19.77 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2602.03 | 19.71 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 178.42 | 15.14 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 178.42 | 15.14 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 58.17 | 3.24 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 58.17 | 3.24 |
| HFCs | NO,NE,IE,NA | 11.26 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.49 | 13920.64 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2849.26 | 19.61 |
| **Total (with LULUCF)** | 2385.00 | 2851.36 | 19.55 |

Table 10-39 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2002.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2002 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2614.16 | 20.43 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2615.39 | 20.32 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 185.04 | 19.41 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 185.04 | 19.41 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 59.49 | 5.59 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 59.49 | 5.59 |
| HFCs | NO,NE,IE,NA | 14.99 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.50 | 13976.54 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2875.17 | 20.70 |
| **Total (with LULUCF)** | 2385.00 | 2876.39 | 20.60 |

### Table 10-40 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2003.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2003 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2886.14 | 32.96 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2887.45 | 32.84 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 192.12 | 23.98 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 192.12 | 23.98 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 61.04 | 8.34 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 61.04 | 8.34 |
| HFCs | NO,NE,IE,NA | 16.45 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 2.06 | 19303.28 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 3157.82 | 32.57 |
| **Total (with LULUCF)** | 2385.00 | 3159.13 | 32.46 |

### Table 10-41 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2004.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2004 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2758.93 | 27.10 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2760.39 | 26.99 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 201.80 | 30.23 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 201.80 | 30.23 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 60.20 | 6.85 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 60.20 | 6.85 |
| HFCs | NO,NE,IE,NA | 29.48 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.54 | 14430.21 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 3051.95 | 28.12 |
| **Total (with LULUCF)** | 2385.00 | 3053.41 | 28.03 |

## Table 10-42 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2005.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2005 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2704.54 | 24.59 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2706.17 | 24.50 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 212.91 | 37.39 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 212.91 | 37.39 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 58.02 | 2.98 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 58.02 | 2.98 |
| HFCs | NO,NE,IE,NA | 41.78 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.56 | 14625.60 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 3018.81 | 26.73 |
| **Total (with LULUCF)** | 2385.00 | 3020.44 | 26.64 |

## Table 10-43 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2006.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2006 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2707.90 | 24.75 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2709.70 | 24.66 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 220.58 | 42.35 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 220.58 | 42.35 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 58.29 | 3.47 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 58.29 | 3.47 |
| HFCs | NO,NE,IE,NA | 78.86 | 100.00 |
| PFCs | NO,NA | NO,NA | 0.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.57 | 14720.60 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 3067.21 | 28.76 |
| **Total (with LULUCF)** | 2385.00 | 3069.01 | 28.68 |

### Table 10-44 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2007.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2007 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2776.90 | 27.93 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2778.84 | 27.84 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 226.85 | 46.39 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 226.85 | 46.39 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 59.04 | 4.79 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 59.04 | 4.79 |
| HFCs | NO,NE,IE,NA | 96.74 | 100.00 |
| PFCs | NO,NA | 0.00 | 100.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.58 | 14797.13 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 3161.11 | 32.71 |
| **Total (with LULUCF)** | 2385.00 | 3163.05 | 32.62 |

### Table 10-45 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2008.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2008 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2784.43 | 28.27 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2786.50 | 28.19 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 146.16 | -5.68 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 146.16 | -5.68 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 56.91 | 1.02 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 56.91 | 1.02 |
| HFCs | NO,NE,IE,NA | 112.37 | 100.00 |
| PFCs | NO,NA | 0.00 | 100.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.75 | 16362.03 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 3101.62 | 30.21 |
| **Total (with LULUCF)** | 2385.00 | 3103.69 | 30.13 |

**Table 10-46 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2009.**

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2009 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2631.54 | 21.23 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2633.74 | 21.16 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 161.44 | 4.18 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 161.44 | 4.18 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 54.51 | -3.24 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 54.51 | -3.24 |
| HFCs | NO,NE,IE,NA | 133.13 | 100.00 |
| PFCs | NO,NA | 0.00 | 100.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.50 | 13988.64 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2982.12 | 25.19 |
| **Total (with LULUCF)** | 2385.00 | 2984.32 | 25.13 |

**Table 10-47 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2010.**

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2010 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2638.47 | 21.55 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2640.43 | 21.47 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 179.58 | 15.89 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 179.58 | 15.89 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 53.97 | -4.21 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 53.97 | -4.21 |
| HFCs | NO,NE,IE,NA | 145.49 | 100.00 |
| PFCs | NO,NA | 0.00 | 100.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 1.69 | 15851.30 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 3019.21 | 26.75 |
| **Total (with LULUCF)** | 2385.00 | 3021.16 | 26.67 |

## Table 10-48 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2011.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2011 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2725.75 | 25.57 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2727.94 | 25.50 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 167.53 | 8.11 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 167.53 | 8.11 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 48.10 | -14.62 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 48.10 | -14.62 |
| HFCs | NO,NE,IE,NA | 169.02 | 100.00 |
| PFCs | NO,NA | 0.00 | 100.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 4.59 | 43141.00 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 3115.01 | 30.77 |
| **Total (with LULUCF)** | 2385.00 | 3117.20 | 30.70 |

## Table 10-49 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2012.

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2012 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2819.43 | 29.88 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2821.85 | 29.82 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 165.34 | 6.70 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 165.34 | 6.70 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 47.30 | -16.05 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 47.30 | -16.05 |
| HFCs | NO,NE,IE,NA | 201.03 | 100.00 |
| PFCs | NO,NA | 0.00 | 100.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 0.45 | 4149.59 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 3233.55 | 35.75 |
| **Total (with LULUCF)** | 2385.00 | 3235.97 | 35.68 |

**Table 10-50 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2013.**

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2013 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2482.00 | 14.34 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2484.66 | 14.31 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 155.34 | 0.25 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 155.34 | 0.25 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 45.58 | -19.10 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 45.58 | -19.10 |
| HFCs | NO,NE,IE,NA | 216.32 | 100.00 |
| PFCs | NO,NA | 0.00 | 100.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 2.68 | 25093.79 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2901.92 | 21.83 |
| **Total (with LULUCF)** | 2385.00 | 2904.58 | 21.79 |

**Table 10-51 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2014.**

| GREENHOUSE GAS EMISSIONS | Base year(3) | 2014 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 2481.26 | 14.31 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 2484.16 | 14.28 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 171.53 | 10.69 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 171.53 | 10.69 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 46.12 | -18.14 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 46.12 | -18.14 |
| HFCs | NO,NE,IE,NA | 230.77 | 100.00 |
| PFCs | NO,NA | 0.00 | 100.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 0.58 | 5402.81 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2930.27 | 23.02 |
| **Total (with LULUCF)** | 2385.00 | 2933.16 | 22.98 |

### Table 10-52 Emission Trends by Gas (in kt equivalent to $CO_2$) for 2015.

| GREENHOUSE GAS EMISSIONS | Base year[3] | 2015 | Change from base to previous year (%) |
|---|---|---|---|
| $CO_2$ emissions without net $CO_2$ from LULUCF | 2170.72 | 1756.91 | -19.06 |
| $CO_2$ emissions with net $CO_2$ from LULUCF | 2173.69 | 1760.04 | -19.03 |
| $CH_4$ emissions without $CH_4$ from LULUCF | 154.96 | 178.02 | 14.88 |
| $CH_4$ emissions with $CH_4$ from LULUCF | 154.96 | 178.02 | 14.88 |
| $N_2O$ emissions without $N_2O$ from LULUCF | 56.34 | 44.74 | -20.58 |
| $N_2O$ emissions with $N_2O$ from LULUCF | 56.34 | 44.74 | -20.58 |
| HFCs | NO,NE,IE,NA | 247.00 | 100.00 |
| PFCs | NO,NA | 0.00 | 100.00 |
| Unspecified mix of HFCs and PFCs | NA,NO | NA,NO | 0.00 |
| $SF_6$ | 0.01 | 0.19 | 1679.63 |
| $NF_3$ | NA,NO | NA,NO | 0.00 |
| **Total (without LULUCF)** | 2382.04 | 2226.87 | -6.51 |
| **Total (with LULUCF)** | 2385.00 | 2229.99 | -6.50 |

## 10.3 Emission Trends by Sector

**Note**:

(2) The column "Base year" should be filled in only by those Parties with economies in transition that use a base year different from 1990 in accordance with the relevant decisions of the COP. For these Parties, this different base year is used to calculate the percentage change in the final column of this table.
(3) Includes net $CO_2$, $CH_4$ and $N_2O$ from LULUCF.

**Table 10-53 Emission Trends by Sector (in kt equivalent to $CO_2$) for 1990.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 1990 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2227.95 | 0.00 |
| 2. Industrial processes and product use | 7.94 | 7.94 | 0.00 |
| 3. Agriculture | 77.13 | 77.13 | 0.00 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 2.96 | 0.00 |
| 5. Waste | 69.02 | 69.02 | 0.00 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 2385.00 | 0.00 |

**Table 10-54 Emission Trends by Sector (in kt equivalent to $CO_2$) for 1991.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 1991 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2223.53 | -0.20 |
| 2. Industrial processes and product use | 7.94 | 8.16 | 2.85 |
| 3. Agriculture | 77.13 | 79.45 | 3.01 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 4.75 | 60.35 |
| 5. Waste | 69.02 | 75.35 | 9.17 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 2391.24 | 0.26 |

**Table 10-55 Emission Trends by Sector (in kt equivalent to $CO_2$) for 1992.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year[(4)] | 1992 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2376.30 | 6.66 |
| 2. Industrial processes and product use | 7.94 | 9.17 | 15.58 |
| 3. Agriculture | 77.13 | 80.58 | 4.48 |
| 4. Land use, land-use change and forestry[(5)] | 2.96 | 4.36 | 47.03 |
| 5. Waste | 69.02 | 81.37 | 17.90 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)[(5)]** | 2385.00 | 2551.79 | 6.99 |

**Table 10-56 Emission Trends by Sector (in kt equivalent to $CO_2$) for 1993.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year[(4)] | 1993 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2740.73 | 23.02 |
| 2. Industrial processes and product use | 7.94 | 9.21 | 16.07 |
| 3. Agriculture | 77.13 | 79.68 | 3.31 |
| 4. Land use, land-use change and forestry[(5)] | 2.96 | 3.27 | 10.49 |
| 5. Waste | 69.02 | 88.99 | 28.94 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)[(5)]** | 2385.00 | 2921.89 | 22.51 |

**Table 10-57 Emission Trends by Sector (in kt equivalent to $CO_2$) for 1994.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year[(4)] | 1994 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2618.75 | 17.54 |
| 2. Industrial processes and product use | 7.94 | 9.51 | 19.79 |
| 3. Agriculture | 77.13 | 76.80 | -0.43 |
| 4. Land use, land-use change and forestry[(5)] | 2.96 | 3.68 | 24.19 |
| 5. Waste | 69.02 | 97.28 | 40.95 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)[(5)]** | 2385.00 | 2806.01 | 17.65 |

### Table 10-58 Emission Trends by Sector (in kt equivalent to $CO_2$) for 1995.

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year[4] | 1995 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2380.68 | 6.86 |
| 2. Industrial processes and product use | 7.94 | 9.47 | 19.38 |
| 3. Agriculture | 77.13 | 72.38 | -6.16 |
| 4. Land use, land-use change and forestry[5] | 2.96 | 3.07 | 3.67 |
| 5. Waste | 69.02 | 104.24 | 51.04 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)[5]** | 2385.00 | 2569.85 | 7.75 |

### Table 10-59 Emission Trends by Sector (in kt equivalent to $CO_2$) for 1996.

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year[4] | 1996 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2464.69 | 10.63 |
| 2. Industrial processes and product use | 7.94 | 9.26 | 16.64 |
| 3. Agriculture | 77.13 | 73.26 | -5.02 |
| 4. Land use, land-use change and forestry[5] | 2.96 | 3.00 | 1.39 |
| 5. Waste | 69.02 | 108.78 | 57.62 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)[5]** | 2385.00 | 2659.00 | 11.49 |

### Table 10-60 Emission Trends by Sector (in kt equivalent to $CO_2$) for 1997.

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year[4] | 1997 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2466.93 | 10.73 |
| 2. Industrial processes and product use | 7.94 | 9.47 | 19.33 |
| 3. Agriculture | 77.13 | 74.00 | -4.06 |
| 4. Land use, land-use change and forestry[5] | 2.96 | 2.93 | -1.08 |
| 5. Waste | 69.02 | 115.33 | 67.10 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)[5]** | 2385.00 | 2668.66 | 11.89 |

**Table 10-61 Emission Trends by Sector (in kt equivalent to $CO_2$) for 1998.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 1998 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2484.07 | 11.50 |
| 2. Industrial processes and product use | 7.94 | 8.89 | 11.98 |
| 3. Agriculture | 77.13 | 71.02 | -7.92 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 2.55 | -14.03 |
| 5. Waste | 69.02 | 125.32 | 81.58 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 2691.85 | 12.87 |

**Table 10-62 Emission Trends by Sector (in kt equivalent to $CO_2$) for 1999.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 1999 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2594.85 | 16.47 |
| 2. Industrial processes and product use | 7.94 | 8.36 | 5.32 |
| 3. Agriculture | 77.13 | 72.65 | -5.81 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 1.92 | -35.20 |
| 5. Waste | 69.02 | 130.28 | 88.77 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 2808.06 | 17.74 |

**Table 10-63 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2000.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2000 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2430.86 | 9.11 |
| 2. Industrial processes and product use | 7.94 | 15.20 | 91.56 |
| 3. Agriculture | 77.13 | 75.03 | -2.72 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 3.15 | 6.36 |
| 5. Waste | 69.02 | 140.02 | 102.87 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 2664.26 | 11.71 |

### Table 10-64 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2001.

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2001 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2611.70 | 17.22 |
| 2. Industrial processes and product use | 7.94 | 19.22 | 142.20 |
| 3. Agriculture | 77.13 | 71.76 | -6.96 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 2.11 | -28.94 |
| 5. Waste | 69.02 | 146.57 | 112.37 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 2851.36 | 19.55 |

### Table 10-65 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2002.

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2002 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2626.43 | 17.89 |
| 2. Industrial processes and product use | 7.94 | 23.13 | 191.48 |
| 3. Agriculture | 77.13 | 72.40 | -6.14 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 1.23 | -58.56 |
| 5. Waste | 69.02 | 153.20 | 121.98 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 2876.39 | 20.60 |

### Table 10-66 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2003.

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2003 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2900.28 | 30.18 |
| 2. Industrial processes and product use | 7.94 | 24.85 | 213.05 |
| 3. Agriculture | 77.13 | 70.78 | -8.24 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 1.31 | -55.65 |
| 5. Waste | 69.02 | 161.91 | 134.59 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 3159.13 | 32.46 |

**Table 10-67 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2004.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2004 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2772.34 | 24.43 |
| 2. Industrial processes and product use | 7.94 | 37.11 | 367.58 |
| 3. Agriculture | 77.13 | 72.24 | -6.34 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 1.46 | -50.78 |
| 5. Waste | 69.02 | 170.26 | 146.69 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 3053.41 | 28.03 |

**Table 10-68 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2005.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2005 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2715.60 | 21.89 |
| 2. Industrial processes and product use | 7.94 | 49.48 | 523.42 |
| 3. Agriculture | 77.13 | 74.51 | -3.40 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 1.63 | -44.82 |
| 5. Waste | 69.02 | 179.22 | 159.67 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 3020.44 | 26.64 |

**Table 10-69 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2006.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2006 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2718.15 | 22.00 |
| 2. Industrial processes and product use | 7.94 | 86.90 | 994.88 |
| 3. Agriculture | 77.13 | 73.80 | -4.32 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 1.80 | -39.18 |
| 5. Waste | 69.02 | 188.36 | 172.92 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 3069.01 | 28.68 |

**Table 10-70 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2007.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2007 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2788.39 | 25.15 |
| 2. Industrial processes and product use | 7.94 | 104.59 | 1217.85 |
| 3. Agriculture | 77.13 | 75.16 | -2.56 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 1.94 | -34.50 |
| 5. Waste | 69.02 | 192.97 | 179.60 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 3163.05 | 32.62 |

**Table 10-71 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2008.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2008 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2795.65 | 25.48 |
| 2. Industrial processes and product use | 7.94 | 120.03 | 1412.40 |
| 3. Agriculture | 77.13 | 72.68 | -5.77 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 2.07 | -30.26 |
| 5. Waste | 69.02 | 113.26 | 64.10 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 3103.69 | 30.13 |

**Table 10-72 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2009.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2009 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2641.50 | 18.56 |
| 2. Industrial processes and product use | 7.94 | 140.35 | 1668.36 |
| 3. Agriculture | 77.13 | 70.38 | -8.75 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 2.20 | -25.67 |
| 5. Waste | 69.02 | 129.89 | 88.19 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 2984.32 | 25.13 |

**Table 10-73 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2010.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2010 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2648.46 | 18.87 |
| 2. Industrial processes and product use | 7.94 | 152.17 | 1817.36 |
| 3. Agriculture | 77.13 | 68.91 | -10.66 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 1.95 | -34.04 |
| 5. Waste | 69.02 | 149.66 | 116.84 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 3021.16 | 26.67 |

**Table 10-74 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2011.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2011 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2735.23 | 22.77 |
| 2. Industrial processes and product use | 7.94 | 179.02 | 2155.58 |
| 3. Agriculture | 77.13 | 66.50 | -13.78 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 2.19 | -26.23 |
| 5. Waste | 69.02 | 134.26 | 94.53 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 3117.20 | 30.70 |

**Table 10-75 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2012.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2012 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2829.73 | 27.01 |
| 2. Industrial processes and product use | 7.94 | 206.76 | 2505.14 |
| 3. Agriculture | 77.13 | 67.24 | -12.82 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 2.42 | -18.29 |
| 5. Waste | 69.02 | 129.82 | 88.10 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 3235.97 | 35.68 |

**Table 10-76 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2013.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2013 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2490.94 | 11.80 |
| 2. Industrial processes and product use | 7.94 | 223.85 | 2720.47 |
| 3. Agriculture | 77.13 | 66.99 | -13.15 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 2.66 | -10.17 |
| 5. Waste | 69.02 | 120.13 | 74.06 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 2904.58 | 21.79 |

**Table 10-77 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2014.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2014 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 2490.95 | 11.80 |
| 2. Industrial processes and product use | 7.94 | 235.45 | 2866.63 |
| 3. Agriculture | 77.13 | 66.31 | -14.02 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 2.89 | -2.35 |
| 5. Waste | 69.02 | 137.55 | 99.29 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 2933.16 | 22.98 |

**Table 10-78 Emission Trends by Sector (in kt equivalent to $CO_2$) for 2015.**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | Base year(4) | 2015 | Change from base to previous year (%) |
|---|---|---|---|
| 1. Energy | 2227.95 | 1766.44 | -20.71 |
| 2. Industrial processes and product use | 7.94 | 248.39 | 3029.70 |
| 3. Agriculture | 77.13 | 65.90 | -14.56 |
| 4. Land use, land-use change and forestry(5) | 2.96 | 3.13 | 5.59 |
| 5. Waste | 69.02 | 146.14 | 111.74 |
| 6. Other | NA | NA | 0.00 |
| **Total (including LULUCF)(5)** | 2385.00 | 2229.99 | -6.50 |

# 11 Annex: Detailed information on the methodology and approaches used for projections

The Climate Action Results Evaluation (CLARE) Model is used to project emissions associated with the sectors and subcategories of Malta's GHG inventory under different scenarios for individual years running until 2050. These modelled scenarios are based on specific assumptions regarding framework conditions, including demographic and economic activity, technological trends, energy costs/prices and similarly relevant variables. The policies and measures, and combinations thereof, that have been implemented, or will be implemented, at different points in time are modelled as exogeneous variables. The model also distinguishes between greenhouse gas emissions covered by Directive 2003/87/EC and those covered by Decision No 406/2009/EC. The CLARE model is sub-divided into a number of sector-specific sub-models having different levels of complexity. The electricity generation model is a partial equilibrium model wherein demand for electricity is equated with supply sources according to the least cost of various supply sources and on exogenous policy decisions (e.g. the use of renewable energy sources (RES) in the electricity mix). The other sub-models adopt a more simplistic approach and are based on the economic estimation of their main demographic, economic and key drivers.

The historic data feeding into the sectoral models to estimate GHG emissions projections is the same as the reported for submission in 2017, i.e. latest historic year of 2015, with the exception of Waste and IPPU sectors, where the latest historic year is 2013. Two main policy scenarios have been projected, namely **(1)** the Business-as-Usual (BAU) scenario, which assumes that no further measures are implemented after the reference or base year (taken as 2015 for most sectors) and **(2)** the 'with existing measures' (WEM) scenario, which takes into account currently implemented and adopted policies and measures as at end 2015.

The 'with additional measures' (WAM) scenario, i.e. the projected effect of *planned* policies and measures, has been excluded from this report given that the data submitted by the relevant stakeholders indicate all the measures are either existing or implemented. Notwithstanding, efforts are being made to address the lack of information, particularly to translate current and planned strategies being drawn up in various sectors, into quantifiable emission reduction policies and measures.

## 11.1 Description of the Modelling Framework

This section provides a detailed description of the modelling framework used to project emissions up to 2035 by sector and by type of greenhouse gas. A secondary function is to estimate the impact of measures aimed at reducing the emissions relative to a BAU scenario.

### *11.1.1 Energy Industries Model*

Underpinning the projections of emission trends for the energy sector is a modelling exercise developed over 2015. This model serves to extrapolate a BAU scenario covering a period from 1990 to 2050. It measures the GHG emissions from fuels used for electricity generation given present conditions and expected future developments. It therefore enables the analysis of the incremental effect between the BAU scenario and the introduction of new measures to reduce GHG emissions when generating electricity.

The developments being foreseen in this sector required that fuel substitution in favour of cleaner alternatives is based on a cost-optimisation modelling approach whereby the cheapest fuel types or more efficient generation alternatives are given priority. This assumption is superseded by policy decision e.g. mandatory use of RES, irrespective of their cost.

The fuel switching depends on four factors, namely the potential for renewables capacity, which consists of solar, wind and Waste to Energy (W2E), as well as the supply mix between natural gas (NG) and the interconnector between Malta and Sicily. Moreover, other influencing factors are the NG generation efficiency and final electricity demand.

The final electricity demand is based on a number of exogenous factors, which include GDP, end users' energy efficiency, which is increased by products such as solar water heaters and energy saving light bulbs and energy substitution (the extent to which NG is substituted for electricity), distribution losses and electricity prices.

Electricity prices depend on the cost of electricity generation from both renewable and non-renewable sources - solar, wind, W2E, gasoil, fuel oil, NG and the interconnector - and on the price of carbon emissions.

The relationships described above are presented in graphical form in Figure 11-1 and are summarized as follows:

(1) An increase in GDP impacts emissions through the following channels:

   a) Increase in final electricity demand;

   b) Increase in use of NG for electricity generation;

   c) Increase in emissions from NG for electricity generation.

(2) The impact of a decrease in the price of solar energy would:

   a) Decrease in the cost of electricity generation;

   b) Decrease in electricity pricing;

   c) Increase in final electricity demand;

   d) Increase in use of NG for electricity generation;

   e) Increase in emissions from NG for electricity generation.

However, the increase in emissions from NG is offset by the increase in solar energy capacity caused by the decrease in the price of solar energy. The effects of an increase in solar capacity would:

   a) Decrease in use of NG for electricity generation;

   b) Decrease in emissions from NG for electricity generation.

(3) An increase in end user energy efficiency impacts on emissions through the following channels:

   a) Decrease in final electricity demand;

   b) Decrease in use of fossils fuels used for electricity generation;

   c) Decrease in emissions from fossil fuels used for electricity generation.

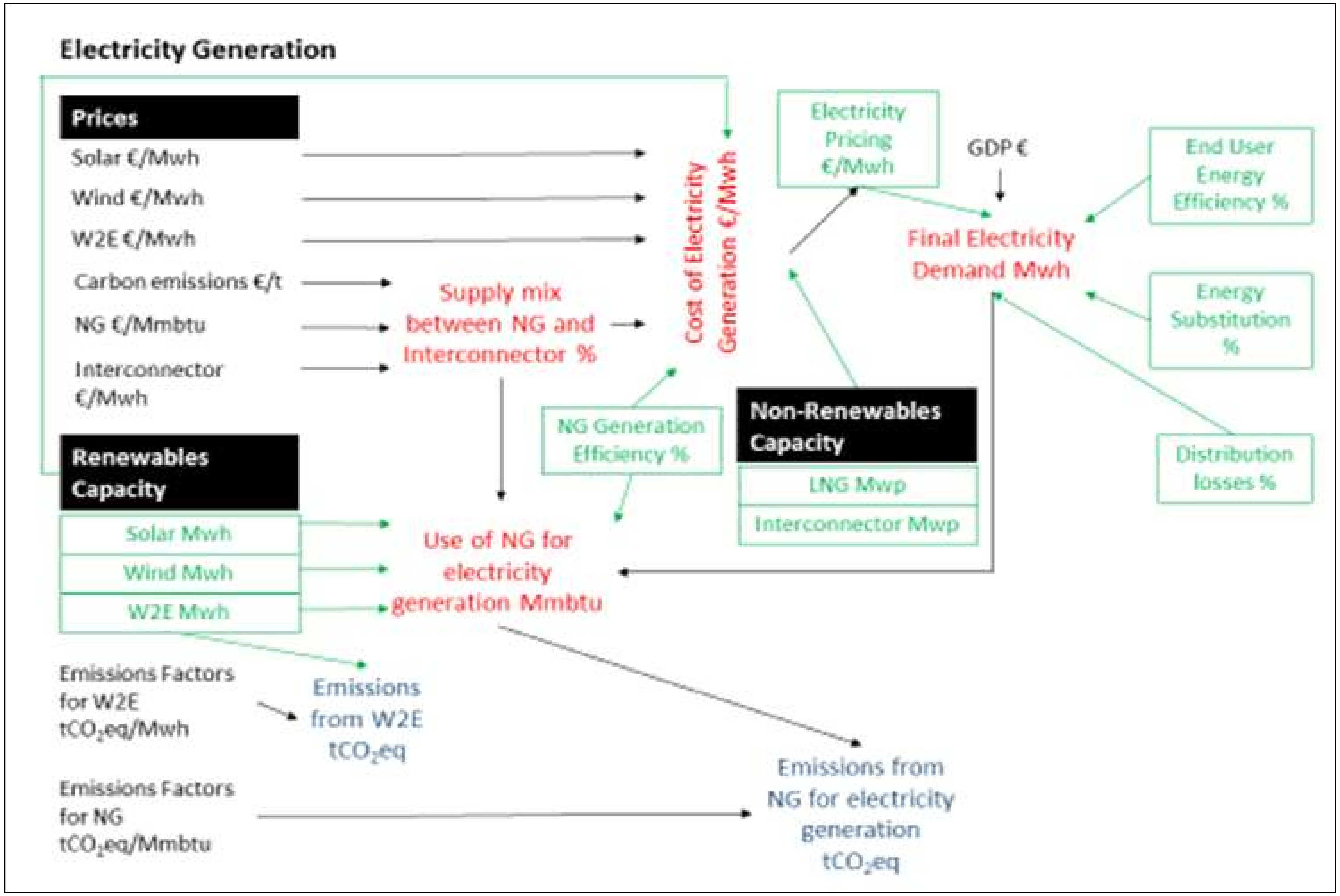



**Figure 11-1 Energy Industries Modelling Framework**

A brief description of the equations underpinning the key factors making up the electricity generation model is presented below.

#### 11.1.1.1 Fossil Fuel

$$\frac{\text{Cost of CO}_2{}^{\text{Elasticity of fossil fuel in Te}} \times \text{Fossil fuel mix}^{\text{Elasicity of fossil fuel in Te}} \times \text{Interconnector}^{\text{Elasticity of fossil fuel in Te}}}{8}$$

The percentage use of fossil fuel used for electricity generation depends on the cost of Carbon Dioxide (CO□), the cost of the fossil fuel mix, cost of interconnector and the elasticity of fossil fuel with respect to the above-mentioned variables. In other words, the percentage use of fossil fuel depends on the responsiveness of fossil fuel to the cost of CO□, fossil fuel mix and the interconnector. The numerator is divided by a constant figure, which represents a standardised baseline value to obtain the percentage value use of fossil fuel.

#### 11.1.1.2 Cost of electricity generation

$$\frac{\begin{gathered}[(Cost\ of\ solar\ energy \times Supply\ of\ solar\ energy) + \\ (Cost\ of\ wind\ energy\ \times Supply\ of\ wind\ energy) + \\ (Cost\ of\ W2E \times Supply\ of\ W2E) \times 8760\ hours] \times \\ [Fossil\ fuel\ mix\ in\ Te \times Cost\ of\ fossil\ fuel\ mix \times\ Fossil\ fuel\ efficiency + 30] \\ + [IC\ in\ TE \times Cost\ of\ IC]\end{gathered}}{(Supply\ of\ fossil\ fuel\ mix + IC) \times 8760\ hours + Supply\ of\ solar, wind\ and\ W2E}$$

The cost of electricity generation depends on the amount supplied from each energy source and its cost per unit supplied. The total cost of renewables is multiplied by 8760 hours to obtain the total cost of energy generated per annum. The cost of electricity generated from fossil fuel also depends on its efficiency and other operating costs, denoted by 30. The numerator representing the total cost of energy supplied from different source of energy is divided by the total supply of energy mix to obtain the cost of electricity generated per unit of Megawatt hour (MWh).

#### 11.1.1.3 Electricity price

$$Cost\ of\ electricity\ generation \times Electricity\ price\ to\ generation\ cost\ ratio$$

The electricity price depends on the cost of generating electricity (equation in section 11.1.1.2) and the electricity price to generation cost ratio. This ratio relates the price charged for electricity to consumers to the cost incurred for generating electricity to meet the final electricity demand.

#### 11.1.1.4 Final electricity demand

$$\begin{gathered}[GDP^{Final\ demand\ to\ GDP\ elasticity} \times Electricity\ price \times 20 \times \\ (1 - \frac{End\ use\ Efficiency}{100}) \times \left(1 + \frac{Efficiency\ distribution\ loss}{100}\right)\end{gathered}$$

Final electricity demand depends on GDP and its responsiveness to GDP, the electricity pricing and other variable costs. It also depends on the end users' energy efficiency, which increases as consumption efficiency of electricity increases reducing electricity demand overtime and distribution losses which increase demand for electricity to make up for energy lost along the distribution channel.

#### 11.1.1.5 Use of fossil fuel mix:

$$(Final\ electricity\ demand - Supply\ of\ wind, solar\ and\ W2E) \times$$
$$Fossil\ Fuel\ mix\ \times Efficiency\ in\ Million\ mbtu\ Fossil\ Fuel\ primary\ /Mwhe\ final$$

The amount of fossil fuel mix used is dependent on the demand for electricity (equation in section 11.1.1.4) net energy generation from renewable energy (wind, solar and W2E) since the interconnector is given first priority before fossil fuel for demand exceeding renewable capacity. The use of fossil fuel mix also depends on the percentage use of fossil fuel mix (equation in section 11.1.1.5) and its efficiency.

#### 11.1.1.6 Emissions from fossil fuels

$$Supply\ of\ fossil\ fuels \times Emissions\ of\ fossil\ fuel\ mix\ in\ tC0_2eq/Mmbtu\ primary$$

The emissions from fossil fuels depends on the amount of fossil fuels used in generation of electricity and its emissions in tonnes of CO□ equivalent generated per Mmbtu (Million British Thermal Unit) of fossil fuel mix.

#### 11.1.1.7 Emissions from W2E

$$Supply\ of\ W2E \times Emissions\ of\ W2E\ in\ tCO_2eq/Mwhe$$

The emissions from fossil fuels depends on the amount of W2E used in generation of electricity and its emissions in tonnes of CO□ equivalent generated per MWhe (Megawatt hour of electricity) of W2E.

#### 11.1.1.8 Emissions of CO2 (HFO)

$$[Final\ electricity\ demand - (Supply\ of\ solar,\ wind,\ W2E)] \times\ Fossil\ fuel\ mix\ in\ Te \times$$
$$Weight\ of\ HFO\ in\ mix \times Efficiency\ of\ HFO\ in\ Mmbtu\ HFO\ primary\ per\ Mwhe\ final \times$$
$$Emissions\ factor\ of\ CO_2\ from\ HFO \times GHG\ potential\ of\ CO_2$$

The amount of CO□ emitted from fossil fuel depends on the amount of electricity demand excluding electricity generated from renewable energy (wind, solar and W2E), the amount of fossil fuel used for electricity generation to meet the demand as well as the weight of heavy fuel oil (HFO) in mix, which represents the percentage of HFO used in the total mix of energy used to generate electricity. It also depends on the efficiency of HFO to generate electricity (in Mmbtu/primary MWhe), the amount of CO□ emitted from the combustion of HFO and its contribution to global warming.

#### 11.1.1.9 Emissions of $CH_4$ (HFO)

$$[Final\ electricity\ demand - (Supply\ of\ solar,\ wind,\ W2E)] \times\ Fossil\ fuel\ mix\ in\ Te \times$$
$$Weight\ of\ HFO\ in\ mix \times Efficiency\ of\ HFO\ in\ Mmbtu\ HFO\ primary\ per\ Mwhe\ final \times Emissions$$
$$factor\ of\ CH_4\ from\ HFO \times GHG\ potential\ of\ CH_4$$

The amount of CH□ emitted from fossil fuel depends on the amount of electricity demand, net renewable energy (wind, solar and W2E), the amount of fossil fuel used as well as the weight of heavy fuel oil (HFO) in mix of energy used to generate electricity. Moreover, it depends on the efficiency of HFO, the amount of Methane (CH□) generated from HFO and its global warming potential.

### 11.1.1.10 Emissions of $N_2O$ (HFO)

$$[\text{Final electricity demand - (Supply of solar, wind, W2E)}] \times \text{Fossil fuel mix in Te} \times \text{Weight of HFO in mix} \times \text{Efficiency of HFO in Mmbtu HFO primary per Mwhe final} \times \text{Emissions factor of } N_2O \text{ from HFO} \times \text{GHG potential of } N_2O$$

The amount of $N_2O$ emitted from fossil fuel depends on the amount of electricity demand, net renewable energy (wind, solar and W2E), multiplied by the amount of fossil fuel used as well as the percentage of HFO used in the total mix of energy to generate electricity. It also depends on the efficiency of HFO, the amount of Nitrous Oxide ($N_2O$) generated from HFO and its global warming potential.

### 11.1.1.11 Emissions of $CO_2$ (Gasoil)

$$[\text{Final electricity demand - (Supply of solar, wind, W2E)}] \times \text{Fossil fuel mix in Te} \times \text{Weight of gasoil in mix} \times \text{Efficiency of gasoil in Mmbtu gasoil primary per Mwhe final} \times \text{Emissions factor of } CO_2 \text{ from gasoil} \times \text{GHG potential of } CO_2$$

The amount of $CO_2$ emitted from fossil fuel depends on the amount of electricity demand, net electricity generated from renewable energy (wind, solar and W2E), the amount of fossil fuel used as well as the weight of gasoil in mix, which represents the percentage of gasoil used in the total mix of energy to generate electricity. It also depends on the efficiency of gasoil, the amount of $CO_2$ generated from gasoil and its global warming potential.

### 11.1.1.12 Emissions of $CH_4$ (Gasoil)

$$[\text{Final electricity demand - (Supply of solar, wind, W2E)}] \times \text{Fossil fuel mix in Te} \times \text{Weight of gasoil in mix} \times \text{Efficiency of gasoil in Mmbtu gasoil primary per Mwhe final} \times \text{Emissions factor of } CH_4 \text{ from gasoil} \times \text{GHG potential of } CH_4$$

The amount of $CH_4$ emitted from fossil fuel depends on the amount of electricity demand, net renewable energy (wind, solar and W2E), multiplied by the amount of fossil fuel used as well as the weight of gasoil in mix of energy to generate electricity. It also depends on the efficiency of gasoil, the amount of $CH_4$ generated from gasoil and its global warming potential.

### 11.1.1.13 Emissions of $N_2O$ (Gasoil)

$$[\text{Final electricity demand - (Supply of solar, wind, W2E)}] \times \text{Fossil fuel mix in Te} \times \text{Weight of gasoil in mix} \times \text{Efficiency of gasoil in Mmbtu gasoil primary per Mwhe final} \times \text{Emissions factor of } N_2O \text{ from gasoil} \times \text{GHG potential of } N_2O$$

The amount of $N_2O$ emitted from fossil fuel depends on the amount of electricity demand, net renewable energy (wind, solar and W2E), the amount of fossil fuel used, the weight of gasoil in mix of energy to generate electricity, its efficiency, the amount of $N_2O$ generated from gasoil and its global warming potential.

### 11.1.1.14 Emissions of $CO_2$ (NG)

$$[\text{Final electricity demand - (Supply of solar, wind, W2E)}] \times \text{Fossil fuel mix in Te} \times \text{Weight of NG in mix} \times \text{Efficiency of NG in Mmbtu fossil fuel primary per Mwhe final} \times \text{Emissions factor of } CO_2 \text{ from NG} \times \text{GHG potential of } CO_2$$

The amount of $CO_2$ emitted from fossil fuel depends on the amount of electricity demand, net renewable energy (wind, solar and W2E), multiplied by the amount of fossil fuel used as well as the weight of NG in mix of energy to generate electricity. It also depends on the efficiency of NG, the amount of CO□ generated from NG and its global warming potential.

### 11.1.1.15 Emissions of $CH_4$ (NG)

$$[\textit{Final electricity demand - (Supply of solar, wind, W2E)}] \times Fossil\ fuel\ mix\ in\ Te \times Weight\ of\ NG\ in\ mix \times \textit{Efficiency of NG in Mmbtu fossil fuel primary per Mwhe final} \times \textit{Emissions factor of } CH_4 \textit{ from NG} \times GHG\ potential\ of\ CH_4$$

The amount of CH□ emitted from fossil fuel depends on the amount of electricity demand, net renewable energy (wind, solar and W2E), multiplied by the amount of fossil fuel used as well as the weight of natural gas (NG) in mix of energy to generate electricity. It also depends on the efficiency of NG, the amount of CH□ generated from NG and its global warming potential.

### 11.1.1.16 Emissions of N2O (NG)

$$[\textit{Final electricity demand - (Supply of solar, wind, W2E)}] \times Fossil\ fuel\ mix\ in\ Te \times Weight\ of\ NG\ in\ mix \times \textit{Efficiency of NG in Mmbtu fossil fuel primary per Mwhe final} \times \textit{Emissions factor of } N_2O \textit{ from NG} \times GHG\ potential\ of\ N_2O$$

The amount of N□O emitted from fossil fuel depends on the amount of electricity demand, net renewable energy (wind, solar and W2E), multiplied by the amount of fossil fuel used as well as the weight of natural gas (NG) in mix of energy to generate electricity. It also depends on the efficiency of NG, the amount of N□O generated from NG and its global warming potential.

### 11.1.1.17 Fuel combustion in Energy Industries

Emission projections relating to energy industries take into account additional savings from demand-side measures and renewable energy projects and schemes (over and above efficiency savings occurring directly at the generation source e.g. by switching to a more efficient turbine). These demand-side emission savings include energy usage by waste facilities and waste water treatment plants, emissions due to a waste-to-energy facility, emissions from charging electrical vehicles and savings from energy efficiency measures, which in general will meet or reduce part of the demand that would otherwise have to be met by electricity generated at the power plants or imported from the European grid.

The estimation of emission savings from demand-side measures and measures related to renewable energy sources are calculated on the basis of emissions per unit MWh as estimated for each year, taking into account the contribution of both the local electricity generating plants and electricity imported via the interconnection with mainland Europe.

## 11.1.2 Road Transport Model

GHG emissions and projections from road transportation are based on a model developed over 2015. This model serves to extrapolate a BAU scenario covering a period from 1990 to 2050. It also identifies the impact of existing or new measures on road transport, when it comes to the generation of GHG emissions. It enables the analysis of the incremental effect between the BAU scenario and the introduction of new measures to reduce GHG emissions from road transport.

This model is divided into two categories, these being passenger vehicles and cargo transport. Each category is further analysed by subdividing into type of transport mode and fuel type. The source data was extracted from the COPERT 5 model, which in turn, is populated by data on the vehicle fleet and other key parameters in Malta.

The estimation of GHG emissions in road transportation is therefore a direct result of the characteristics of the vehicle fleet, their estimated usage and other key parameters. The main variables that were identified as being key factors are the following:

- Fuel/km;
- Average Number of Passengers or Average Tonnes in the case of cargo vehicles;
- Passenger km/yr or Tonne km/yr;
- Fuel/yr.

Data was collected for the year 2015 representing the base year for the road transport model. This was back-casted to 1990 by calibrating the total fuel sold in the inland market for road transportation with estimated fuel used by each type of vehicle. This calibration exercise assumed that the share of fuel by type of vehicle remained constant over the period 1990-2014. This implies that vehicle fuel efficiency remained constant throughout this time series. Notwithstanding, further studies are being carried out with the relevant stakeholders to further refine this assumption. Data on fuel/km, average passengers (or average tonnes in the case of cargo) and km/year was extracted from the COPERT model whilst figures for passengers (tonnes) km/yr and fuel/yr are calculated as follows:

*Passenger (tonnes) km/yr = km/yr / Average Passengers (average tonnes)*

*Fuel/yr = Passenger (tonnes) km/yr x Passenger (tonnes) Fuel/km*

A brief description of the equations underpinning the key factors making up the transport model is presented below.

#### 11.1.2.1 $CO_2$/yr (000t)

$$\frac{Fuel/yr\ (Tj) \times CO_2/TJ}{1{,}000}$$

The amount of $CO_2$ emitted per annum depends on the amount of fuel used per annum and the amount of $CO_2$ it emits per terajoule (TJ). This is then converted into thousand tonnes (000t).

#### 11.1.2.2 $CH_4$/yr (000t)

$$\frac{Fuel/yr\ (Tj) \times\ CH_4/TJ}{1{,}000}$$

The amount of $CH_4$ emitted per annum is found by multiplying the amount of fuel used per year and the emission of $CH_4$ from fuel per TJ. This is then converted into thousand tonnes (000t).

#### 11.1.2.3 $N_2O$/yr (000t)

$$\frac{Fuel/yr\ (Tj)\ \times\ N_2O/TJ}{1{,}000}$$

The amount of $N_2O$ emitted per annum depends on the amount of fuel used per year and its $N_2O$ emissions per TJ which is then converted into thousand tonnes (000t).

#### 11.1.2.4 $CO_2$eq (000t)

$$CO_2/yr\ (000t) + (CH_4/yr\ (000t) \times GHG\ potential\ of\ CH_4) + (N_2O/yr\ (000t) \times GHG\ potential\ of\ N_2O)$$

The projected future emissions from road transport take into account existing measures (WEM scenario) against a BAU scenario. For the purposes of these projections, no differentiation is made in respect of emission efficiency of different types of vehicles. It is assumed that autogas will partially substitute petrol, while biogenic emissions from biodiesel and the biogenic part of bio-ETBE are not included.

### 11.1.3 National Navigation

Activity data categorised between national navigation and international marine bunkers was provided by the Malta Resources Authority for the years 2010-2014. An extensive exercise was carried out by the Malta Resources Authority and Transport Malta to improve the methodology to identify those fuels that are used within Maltese territorial waters and those used outside Malta's territory. Furthermore, this improved methodological approach was applied to past years (1990-2009) in order to streamline the whole time series.

Emissions estimated for International Bunker activities are considered as 'Memo Items' and are not taken into account when speaking in terms of 'national' emissions of greenhouse gases. These memo items refer to fuels used for marine bunkering, namely fuel oil and gasoil, with the former making up the greater share of the total fuels used for this purpose (84% in 2014) within this sector.

To date, there is no econometric model that projects the fuels used, or emissions generated, from fuel combustion in marine vessels operating within Malta's territorial waters. Hence, for the purposes of this report, the projected emissions have been kept constant as at the latest available year (2015) until 2050.

### 11.1.4 Economic Sectors Model

The Economic Sectors model aggregates the emissions generated from the combustion of fuels in those sectors that do not fall under energy industries or transportation. These sectors comprise of economic operators within the agriculture, forestry & fisheries, manufacturing and construction, and commercial & institutional sectors.

Data on the quantity of fuels used by these sectors was, up until 2009, provided by the Petroleum Division of Enemalta Corporation, which for many years was the sole importer of fuels used in the economic sectors. Following the liberalisation of the inland fuel market and the entry of new operators into the market, the Malta Resources Authority implemented a reporting system to collect, collate, audit and report fuel-related data to the National Statistics Office. In 2015, this role has been taken over by the Regulator for Energy and Water Services (REWS).

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), by the economic sectors over 2010 - 2013. The results of the survey distinguished the fuel usage in 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 using an index based on the gainfully occupied population for each NACE category.

GHG emissions and projections from economic sectors were estimated using a model developed over 2015. This model serves to extrapolate a baseline scenario covering a period from 1990 to 2035. This model groups the fuel use by NACE section in the following categories: NACE A, NACE B-F, NACE G-I, NACE J-L and NACE M-T.

The main drivers of fuel use, and GHG emissions, in each of these NACE groups are assumed to be the projected growth in output, the effective elasticity between fuel use and output levels and the projected energy intensity of each NACE group. Therefore, an increase in the annual projected growth in output in a particular NACE group would result in an increase in the fuel use and consequently, in GHG emissions. On the other hand, an improvement in energy intensity i.e. the tons of fuels used to generate a unit of output, in a particular NACE group, would result in a decrease in the use of fuels and thus, GHG emissions.

### 11.1.5 Industrial Process and Product Use (IPPU) Model

Industrial Processes and Product Use (IPPU) covers GHG emissions occurring from industrial processes, from the use of GHG in products, and from non-energy uses of fossil fuel carbon. Industrial processes are the major sources of GHG emissions including $CO_2$, $CH_4$, $N_2O$ and HFCs by chemically or physically transforming materials like iron and steel, ammonia and other chemical products manufactured from fossil fuels used as chemical feedstock and the cement industry. The abovementioned GHG are also used in products such as refrigerators, foams or aerosol cans. Product use is often combined with the industrial process because production and import/export data is required to estimate emissions in a product and product use may also occur as part of industrial activities.

Over 2015, a model was developed to project GHG emissions from industrial processes over a time-period covering 1990-2035. The IPPU model includes two scenarios, these being the BAU and WEM scenarios. The base year for this model is taken to be 2013 while projections are estimated thereon. This model allows for the introduction of new measures affecting the generation of GHG emissions in IPPU. The results obtained for the WEM scenario are identical to those obtained from the BAU with the only difference being the impact of the new measures, and thus allows for the identification of the incremental impact relative to the BAU scenario.

The model takes into consideration five different groups, namely; residential (domestic), commercial, ships, transport and stationary (includes large exhaust stacks like boilers and furnaces burning fossil fuel typically found in power and industry sectors). It estimates the stock and imports of a list of gases generated from the abovementioned groups contributing to global warming from 2014 onwards based on historical data including demand, imports, stock and historic emissions. A brief description of the equations underpinning the key factors making up the IPPU model is presented below.

#### 11.1.5.1 To forecast stock from 2014 onwards

$$\textit{Stock in 2014} \times (1 - \textit{emission factor} + \textit{reuse}) + \textit{imports}$$

The stock forecast depends on the stock in existence from previous year, the amount escaped through emissions and the amount reused. This is then added to the amount imported.

#### 11.1.5.2 To forecast imports from 2014 onwards

$$\textit{Stock in 2014} \times (1 + \textit{activity growth}) \times \exp(\textit{efficiency improvement}) - (1 - \textit{emission factor} + \textit{reuse})$$

The forecast of imports depends on the stock level from the previous year, the sector or activity growth rate and the improvement in efficiency which increases exponentially. It also depends on its emission factor or fugitives which have to be replaced and the amount of gases that will be reused and thus deducted from the amount to be imported.

#### 11.1.5.3 To forecast activity growth from 2014 onwards

The forecast of activity growth depends on the activity indicators and its stock elasticity to the activity indicator.

$$[\textit{Domestic: Private consumption} \times \textit{Elasticity of activity growth to household consumption}$$
$$\textit{Commercial: GDP} \times \textit{Elasticity of activity growth to GDP}$$

In case of the domestic sector, the activity indicator used is private consumption, whilst GDP is used for the commercial sector.

In view of the limited nature of activities under the sectors Industrial Processes and Product Use, the main potential for emission savings is the implementation of the F-gases Regulation. A reliable estimation of the effect of this measure is not yet possible; however, the regulation is expected to influence greatly the manner and extent to which fluorinated gases are used in future, and thus, for the purposes of this discussion, it is assumed that emissions will eventually almost stabilise.

### 11.1.6 Agriculture Model

In agriculture, future GHG emission trends may be influenced both by measures taken to address emissions directly or measures that indirectly contribute towards decreasing emissions, and by inherent trends in activity in the sector. In animal husbandry for example, the restructuring of the sector to conform to animal welfare, food safety, veterinary and waste management requirements, particularly those arising from EU legislation, has led directly to a decrease in emissions due to reduced activity or reduction in emissions from the realization of the requirements already mentioned.

Projected animal numbers for cattle, swine and sheep are taken from a draft report on the Management of Agricultural Waste.[125] Figures for the years 2020, 2025 and 2030 are presented. The intervening years are interpolated and figures for sub-categories of animal classes were estimated, in order to be able to make emission estimates in the same manner as the methodology applied for historic emissions. For other animal species and activity data such as fertiliser application, projections were based on a five-year moving average taking actual data for 2015 as the base year.

### 11.1.7 Land Use, Land-use Change and Forestry

The growth in the level of sequestration of carbon by trees is not expected to be major. For the purposes of projecting emissions, a moving 5-year average is applied.

### 11.1.8 Waste Model

The approach to projecting future trends for emissions from the waste sector is based on the same methodology used for the estimation of historic sector emissions for the national greenhouse gas inventory, whilst incorporating a number of assumptions, including that current trends in generation of municipal solid waste per capita and industrial waste per unit GDP remain applicable for the projection time series, that future landfilling facilities are managed to current standards and that methane generated from biological treatment of waste is flared with all emissions resulting from this being considered as biogenic.

To aggregate the impact of these assumptions, a model was developed over 2015 with the explicit purpose to measure GHG emissions from domestic, commercial and industrial waste. GHG emissions from waste are forecasted up to 2035 using the following regressions.

#### 11.1.8.1 Estimation of MSW (Municipal Solid Waste) generated

$$Ln(MSW/capita) = -\alpha + \beta_1 ln(GDP/capita) - \beta_2 (time)$$
$$ln(MSW/capita) = -6.54 + 1.399\, ln(GDP/capita) - 0.040\, (Time)$$

This means that the municipal solid waste generated per capita depends on the GDP per capita and time. No activity will result into negative generation of waste represented by the negative relationship between MSW and the intercept. However, a percentage change in GDP per capita

125 Agricultural Waste Management in the Maltese Islands (2015-2030). Draft Report prepared for the Ministry for Sustainable Development, Environment and Climate Change. 2015. https://msdeccms.gov.mt/en/government/Press%20Releases/Documents/2016/Agricultural%20Waste%20Management%20Clean%20Version%2015%2012%202015.pdf

will cause a rise of 1.4% in MSW per capita but it is expected to decline overtime. Overtime, MSW per capita falls by 0.04%. The MSW generated (000t) annually is forecasted as follows:

$$\textbf{000tIndW generated forecast} = EXP\ (-6.54+ 1.399 \ln\ (Waste/GDP)-0.040(Time))*GDP$$

### 11.1.8.2 Estimation of IndW (Industrial waste) generated:

$$Ln(IndW/GDP)= -\alpha + \beta_1(Time)- \beta_2(Dummy)$$

$$Ln(IndW/GDP)= -17.728 -0.116\ (Time)+0.959\ (Dummy)$$

The ratio of industrial waste generation to GDP depends on time and a dummy variable to account for variability in the data provided. At time zero and dummy variable zero the activity waste generation is negative. Overtime, as time changes, industrial waste per unit of GDP is expected to decrease by 0.116 tonnes represented by the negative relationship between IndW/GDP and time.

The IndW generated (000t) annually is forecasted as follows:

$$\textbf{000tIndW generated forecast}= EXP\ (-17.728 -0.116\ (Time)+0.959(Dummy))*GDP$$

# 12 Annex: Information pursuant to Article 3, paragraph 3, and Article 3, paragraph 4 of the Kyoto Protocol

## *12.1* Definition of forest and any other criteria

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 definition of Planted Forest and Natural forest are defined here aiding to distinguish better 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'.

The two dominant forests which are present in the Maltese landscape are the Buskett and Mizieb woodland areas, which are highly considered as woodlands rather than forests. None of these woodland areas are utilized for logging or harvesting, thus harvested wood production does not occur (MRRA, 2009). Both areas are under a management plan under the responsibility of the Environment and Resource Authority (former Malta Environment Planning Authority).

Buskett Woodland is the only occurring significant extent of mature woodland in the Maltese Islands, which is a result of afforestation that started during the Knights of St. John's period. Today a large part of Buskett Woodland is semi-natural woodland. There are still some areas that are managed particularly the citrus groves from the alcove to the picnic area. The land management at Il-Buskett is particularly unique for a Special Area of Conservation 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 Directorate for Parks, Afforestation and Countryside Restoration (PARKS) within the Ministry for Sustainable Development, the Environment and Climate Change is responsible for the woodland. There are a number of plans to rehabilitate the area. Specific interest is ensuring that forested areas are safeguarded, enhanced and positively promoted.

Mizieb area is also part of the Natura 2000 network but is largely privately owned. The site is mainly managed by the area's landowners who use the area for its agricultural value. A number of landowners have received funding in order to conserve the area. Some invasive alien species have been removed and replaced by the Sandarac Gum tree (MEPA 2015). The Miżieb Special Area of Conservation incorporates a plateau that has been weathered to give a karstic landscape bounded by a steep scarp that indents to form the headwaters of two small valleys which flow into Wied il-Miżieb. The southern half of the site is located below the coralline plateau and consists of a mixture of used and abandoned agricultural land.

Woodland is protected under Maltese legislation, namely Legal Notice 12 of 2001[126] '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.

The area contributing to the Buskett and Mizieb woodland locations is equivalent to 0.072 Kha. The areas reported for Forest Management are equivalent to the areas reported under category 4A Forest Land.

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

## 12.2 Elected activities under Article 3, paragraph 4 of the Kyoto Protocol

Malta confirms 'Forest Management' as the only activity elected under Article 3(4) of the Kyoto Protocol for inclusion in the accounting for the 2nd Commitment Period of the Kyoto Protocol (period 2013-2020).

## 12.3 Land-related information

### *12.3.1 Spatial assessment used for determining the area of the units of land under Article 3, paragraph 3 of the Kyoto Protocol*

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 in the profile of the forested lands. Furthermore, as aforementioned, these woodlands are protected under legislation. In view of this, no activity from Afforestation and Deforestation is occurring in these areas.

## 12.4 Activity-specific information

No emissions and removals estimations occurred from management of forests.

## 12.5 Article 3, paragraph 3 of the Kyoto Protocol

### *12.5.1 Information relating to Afforestation and Deforestation*

No activity is occurring in Afforestation and Deforestation.

### *12.5.2 Information on harvested wood products under Article 3, paragraph 3*

Malta does not produce any harvested wood products.

## 12.6 Article 3, paragraph 4 of the Kyoto Protocol

### *12.6.1 Information relating to forest management*

Malta is limited to two forest reserves, where the forest cover is almost at maturity and where therefore carbon stock losses are offset by carbon stock gains, so that, without considering the indirect impacts as the fertilization effect due to nitrogen deposition and the increasing $CO_2$ concentration in the atmosphere, their long-term carbon stock balance can be assumed at equilibrium. Thus, since this is in equilibrium the estimates of emissions and removals from this category is considered to be zero.

### *12.6.2 Forest management reference level*

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 the Forest Management Reference Level

(FRL) value for Malta at -0.049 Mt $CO_2$ equivalent/year, indicating that this was derived through extrapolation of historic data on greenhouse removals related to forest management.

### *12.6.3 Technical correction of the FMRL*

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', and is now classified as part of the category 'Grassland'. In view of this, a correction of the FMRL currently inscribed under the Kyoto Protocol becomes relevant. 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. The methodological change leads to the sink value of -49Gg $CO_2$ equivalent as reported when using the previous methodology being reduced to a net removal for the category '*Forestland remaining forestland*' of 0Gg $CO_2$ equivalent. This means that if a FMRL value of -49 Gg $CO_2$ equivalent had to continue being applied, Malta would always start which a deficit of -49 Gg $CO_2$ equivalent when accounting for national emissions under the Kyoto Protocol. The reasoning behind this is that forests in Malta are almost at maturity and where therefore C stock losses are offset by C stock gains, the long-term C stock balance in Maltese forests is 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 is set at 49 Gg $CO_2$ equivalent.

**Table 12-1 Technical Correction for the Forest Management Reference Level.**

| | Emissions and removals |
|---|---|
| **FMRL**<br><br>(Forest Management Reference Level inscribed in the appendix to Decision 2/CMP.7)) | -49 [Gg $yr^{-1}$] |
| **$FMRL_{corr}$**<br><br>(recalculated FMRL) | 0 [Gg $yr^{-1}$] |
| **Difference in per cent = 100 * [($FMRL_{corr}$ – FMRL)/FMRL] %** | 100% |
| **Technical correction = $FMRL_{corr}$ – FMRL**<br><br>(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 $yr^{-1}$] |

### *12.6.4 Information related to natural disturbances*

Malta is not applying the provisions related to Natural Disturbances.

### *12.6.5 Information on harvested wood products under Article 3, paragraph 4*

Malta does not produce any harvested wood products.