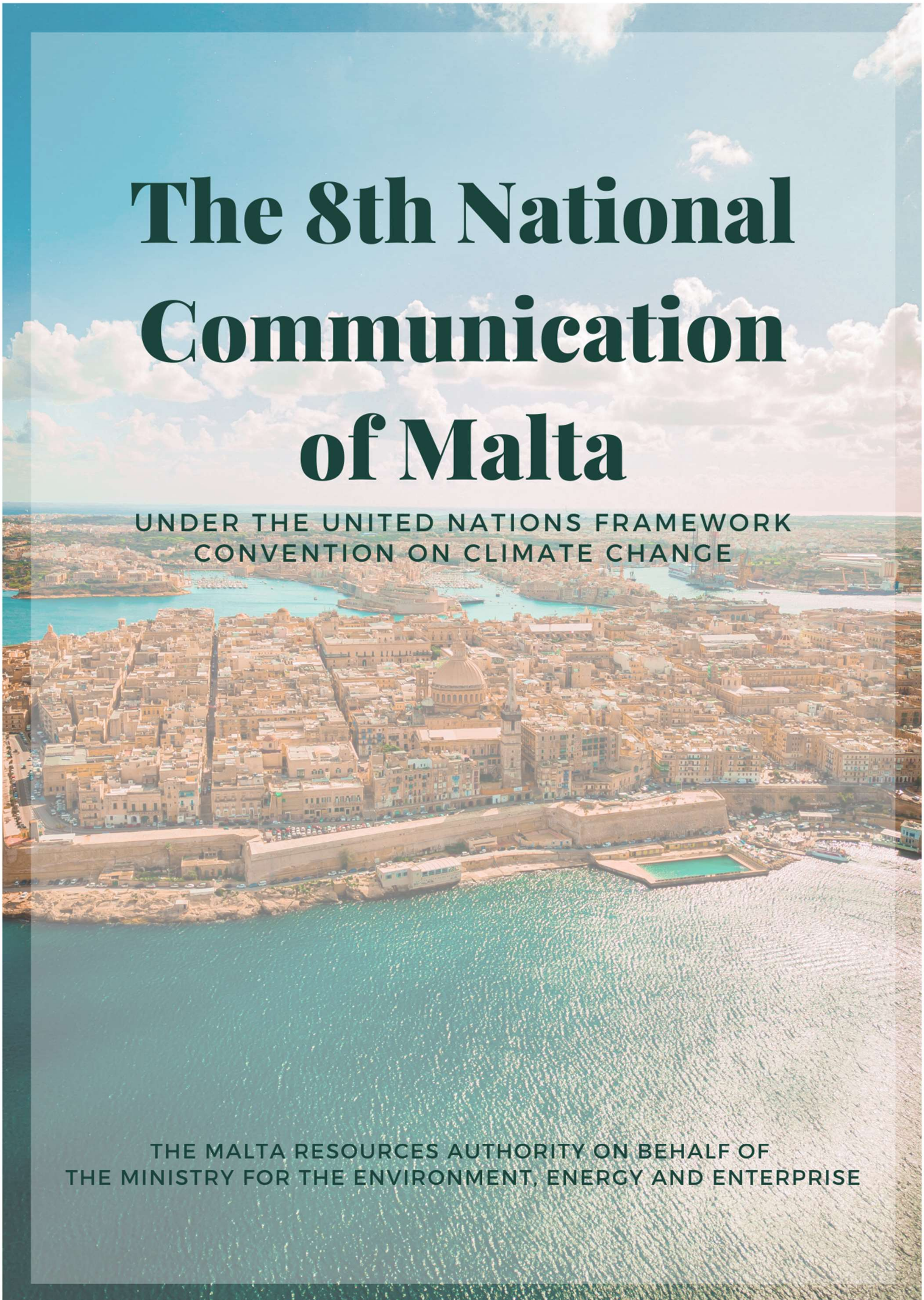


The 8th National Communication of Malta

UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

THE MALTA RESOURCES AUTHORITY ON BEHALF OF
THE MINISTRY FOR THE ENVIRONMENT, ENERGY AND ENTERPRISE

Date: June 2023

Reference Number: MRA/05/2022

Version Number: Version 6

Notes: Resubmission version

Coordinating Entity: Climate Change Unit, Malta Resources Authority

Coordinators: Marija Pia Gatt, Louise Attard Refalo

Editor: Marija Pia Gatt

Contributing institutions: Malta Resources Authority, University of Malta, Ministry for Environment, Energy and Enterprise, Malta Council for Science and Technology, National Statistics Office, Malta International Airport Meteorological Office, Malta College of Arts, Science and Technology, Energy and Water Agency and Environment and Resources Authority.

The editor would also like to thank the following for their contributions:

Dr. James Ciarlo, Dr. Maria Attard, Prof. Simone Borg, Prof. Pauline Galea, Dr. Sebastiano D'Amico, Dr. George Buhagiar, Prof. Aaron Micallef, Mr. Ray Zammit, Prof. Philip von Brockdorff, Prof. Paul Pace, Prof. Mark Mifsud, Mr. Arthur Lamoliere, Prof. David Mifsud, Prof. Charles Galdies, Dr. Stefano Moncada, Prof. Luciano Mule Stagno, Prof. Roderick Pace, Prof. Ray Ellul, Dr. Anthony Galea, Dr. Adam Gauci, Prof. Patrick J. Schembri, Dr. Julian Evans and Dr. Joseph A Borg, Saviour Vassallo, Antonella Apap, Alexander Said, Claudine Pace, Ioanna Thoma, Louise Attard Refalo, Ing. Maurizio Busuttil.

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
EWA	Energy Water Agency
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
MECP	Ministry for the Environment, Climate Change and Planning
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

[Blank Page]

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS ... III

1 EXECUTIVE SUMMARY ... 19

1.1 Introduction ... 19
1.2 The submission of a National Communication ... 19
1.3 Malta and the Paris Agreement ... 19
1.4 Malta's status and obligations under international climate treaties and EU climate policy 21
1.5 Quantified economy-wide emission reduction target ... 23
1.6 Emission reduction or limitation commitments applicable to Malta ... 23
1.7 Greenhouse gas emissions ... 24
1.8 GHG mitigation policies and measures and their aggregate effect ... 26
1.9 Vulnerability assessment, climate change impacts and adaptation measures ... 29
1.10 Financial resources and transfer of technology ... 29
1.11 Research and systematic observation ... 30
1.12 Education, training and public awareness ... 30

2 NATIONAL CIRCUMSTANCES RELEVANT TO GREENHOUSE GAS EMISSIONS AND REMOVALS .. 32

2.1 Introduction ... 32
2.2 Government structure ... 32
2.3 Population profile ... 33
2.4 Economic profile ... 35
2.5 Geographic profile ... 38
2.6 Climate profile ... 39
2.7 Energy ... 39
2.8 Transportation ... 41
2.8.1 Fuel Prices ... 41
2.8.2 Road Transportation ... 42
2.8.3 Air Transportation ... 44
2.8.4 Sea Transport ... 45
2.9 Industry ... 46
2.9.1 Mineral Products ... 46
2.9.2 Chemical Industry ... 47
2.9.3 Metal Industry ... 47
2.9.4 Non-Energy Products from Fuel and Solvent Use ... 47
2.9.5 Electronics Industry ... 48
2.9.6 Product Uses as Substitutes for Ozone Depleting Substances (ODS) ... 48
2.9.7 Other Product Manufacture and Use ... 48
2.10 Waste ... 49
2.10.1 Solid Waste Disposal ... 49
2.10.2 Biological Treatment of Solid Waste ... 49
2.10.3 Waste incineration ... 49
2.10.4 Wastewater ... 49
2.10.5 Municipal waste treatment ... 50
2.11 building stock and urban structure ... 51
2.12 Agriculture ... 52
2.13 Forest ... 53
2.14 Natural resources ... 55

3 GREENHOUSE GAS INVENTORY INFORMATION ... 57

3.1 INTRODUCTION ... 57
3.1.1 *What is a national greenhouse gas inventory?* ... 57
3.2 GREENHOUSE GAS INVENTORY PREPARATION IN MALTA ... 58
3.3 GENERAL TRENDS IN GREENHOUSE GAS EMISSIONS AND REMOVALS ... 62
3.3.1 *Overview of emission trends* ... 62
3.3.2 *Emission trends and population growth* ... 65
3.3.3 *Emission trends and economic development* ... 66
3.4 TRENDS IN GREENHOUSE GAS EMISSIONS BY GAS ... 68
3.4.1 *Overview of emission trends by gas* ... 68
3.4.2 *Carbon dioxide* ... 71
3.4.3 *Methane* ... 71
3.4.4 *Nitrous oxide* ... 72
3.4.5 *Fluorinated greenhouse gases* ... 72
3.4.6 *Indirect greenhouse gases* ... 73
3.5 TRENDS IN GREENHOUSE GAS EMISSIONS BY SECTOR ... 74
3.5.1 *Energy (CRF sector 1)* ... 78
3.5.2 *Industrial Processes and Other Product Use (IPPU; CRF sector 2)* ... 82
3.5.3 *Agriculture (CRF sector 3)* ... 83
3.5.4 *Land Use, Land-use Change and Forestry (CRF sector 4)* ... 85
3.5.5 *Waste (CRF sector 5)* ... 86
3.6 KEY CATEGORY ANALYSIS AND UNCERTAINTY ... 89
3.6.1 *Key categories: level assessment* ... 91
3.6.2 *Key categories: trend assessment* ... 91
3.6.3 *Key categories: with LULUCF assessment* ... 92
3.6.4 *Key categories: without LULUCF assessment* ... 93
3.7 NATIONAL SYSTEMS IN ACCORDANCE WITH ARTICLE 5, PARAGRAPH 1, OF THE KYOTO PROTOCOL ... 93
3.8 NATIONAL REGISTRY ... 95

4 POLICIES AND MEASURES ... 97

4.1 INTRODUCTION ... 97
4.2 POLICY CONTEXT ... 97
4.3 POLICY-MAKING PROCESS ... 100
4.3.1 *Domestic and regional programmes and/or legislative arrangements and enforcement and administrative procedures* ... 102
4.4 POLICIES AND MEASURES AND THEIR EFFECT ... 105
4.4.1 *Energy Sector* ... 105
4.4.2 *Transport Sector* ... 110
4.4.3 *Industrial Processes and Product Use (IPPU)* ... 121
4.4.4 *Agriculture* ... 122
4.4.5 *Land use, land use change and forestry (LULUCF)* ... 124
4.4.6 *Waste* ... 128
4.5 USE OF MARKET-BASED MECHANISMS ... 140
4.6 ASSESSMENT OF THE ECONOMIC AND SOCIAL CONSEQUENCES OF RESPONSE MEASURES ... 140

5 PROJECTIONS AND TOTAL EFFECT OF POLICIES AND MEASURES ... 143

5.1 INTRODUCTION ... 143
5.2 PROJECTIONS ... 143
5.3 PROJECTIONS BY SECTOR ... 146
5.3.1 *Energy* ... 146
5.3.2 *Industrial Processes and Product Use (IPPU)* ... 148
5.3.3 *Agriculture* ... 148
5.3.4 *LULUCF* ... 149

5.3.5 *Waste* 150
5.4 ASSESSMENT OF AGGREGATE EFFECTS OF POLICIES AND MEASURES 155
5.5 MEETING GREENHOUSE GAS EMISSION COMMITMENTS 156
5.6 DETAILED INFORMATION ON THE METHODOLOGY AND APPROACHED USED FOR PROJECTIONS 157
5.6.1 *description of modelling framework* 157

6 VULNERABILITY ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES 175

6.1 INTRODUCTION 175
6.2 EXPECTED IMPACTS OF CLIMATE CHANGE 177
6.2.1 *The Mediterranean Basin* 177
6.2.2 *The Maltese Islands* 181
6.2.3 *Developing the local capability to study impacts of climate change* 185
6.3 VULNERABILITY ASSESSMENT AND ADAPTATION MEASURES 186
6.3.1 *Cross-sectoral vulnerability to climate change* 190
6.3.2 *Sectoral vulnerability to climate change* 192

7 FINANCIAL, TECHNOLOGICAL & CAPACITY-BUILDING SUPPORT 225

7.1 INTRODUCTION 225
7.2 SUPPORT THROUGH PUBLIC FINANCES 225

8 RESEARCH & SYSTEMATIC OBSERVATION 242

8.1 GENERAL POLICY ON RESEARCH 242
8.1.1 *Climate research policy context* 242
8.1.2 *Actions to support research* 243
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* 243
8.2 RESEARCH AND SYSTEMATIC OBSERVATION ACTIVITIES 245
8.3 THE ROLE OF THE UNIVERSITY OF MALTA IN SPEARHEADING CLIMATE RESEARCH 246
8.3.1 *Department of Geosciences - Faculty of Science* 246
8.3.2 *Department of Geography - Faculty of Arts* 247
8.3.3 *Department of Economics – Faculty of Economics, Management and Accountancy* 248
8.3.4 *Faculty of the Built Environment* 248
8.3.5 *Environmental and Resources Law Department - Faculty of Laws* 249
8.3.6 *Forum on Legal Issues for Adaptation to Climate Change* 249
8.3.7 *Centre for Environmental Education and Research* 250
8.3.8 *Institute for Climate Change and Sustainable Development* 251
8.3.9 *Institute of Earth Systems* 251
8.3.10 *Islands and Small States Institute* 252
8.3.11 *Institute for Sustainable Energy* 253
8.3.12 *Institute for European Studies* 253
8.3.13 *The Malta College of Arts, Science and Technology (MCAST)* 254
8.4 SYSTEMATIC OBSERVATION 254
8.4.1 *Systematic Observation activities at the University of Malta* 254
8.4.2 *Met Office* 258

9 EDUCATION, TRAINING & PUBLIC AWARENESS 260

9.1 EXAMPLES OF GOOD PRACTICE 261
9.1.1 *Formal education* 261
9.1.2 *Non-formal and Informal education* 264
9.2 HURDLES TO EDUCATION TARGETING CLIMATE CHANGE 266
9.3 LOOKING FORWARD 267

REFERENCES......268

10 ANNEX 1: CRF TABLES......273

10.1 SUMMARY REPORTS......273
10.2 EMISSION TRENDS BY GAS......304
10.3 EMISSION TRENDS BY SECTOR......311

11 ANNEX 2: INFORMATION PURSUANT TO ARTICLE 3, PARAGRAPH 3, AND ARTICLE 3, PARAGRAPH 4 OF THE KYOTO PROTOCOL......317

11.1 GENERAL INFORMATION......317
11.2 ELECTED ACTIVITIES UNDER ARTICLE 3, PARAGRAPH 4 OF THE KYOTO PROTOCOL......318
11.2.1 Description of how the definitions of each activity under article 3, paragraph 3 of the kyoto protocol and each mandatory and elected activity under article 3, paragraph 4 of the kyoto protocol have been implemented and applied consistently over time......318
11.2.2 Description of precedence conditions and/or hierarchy among article 3, paragraph 4 activities, and how they have been consistently applied in determining how land was classified......318
11.3 ARTICLE 3, PARAGRAPH 3 OF THE KYOTO PROTOCOL......319
11.3.1 Information that demonstrates that activities under article 3.3 began on or after 1 january 1990 and before 31 december 2012 and are direct human-induced......319
11.3.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation......319
11.3.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested......319
11.3.4 Information related to the natural disturbances provision under article 3.3......319
11.3.5 Information on harvested wood products under article 3, paragraph 3......319
11.4 ARTICLE 3, PARAGRAPH 4 OF THE KYOTO PROTOCOL......319
11.4.1 Information that demonstrates that activities under article 3.4 have occurred since 1 january 1990 and are human induced......319
11.4.2 Information relating to forest management......320
11.4.3 Other information......322

12 ANNEX 3: INFORMATION ON METHODS USED TO PROJECT THE WOM SCENARIO......323

12.1.1 Model description of the Without Measures (WOM) scenario......323

13 ANNEX 4: SUMMARY OF REPORTING OF THE SUPPLEMENTARY INFORMATION IN ACCORDANCE WITH ARTICLE 7, PARAGRAPH 2, OF THE KYOTO PROTOCOL......331

TABLE OF FIGURES

FIGURE 1-1 DETERMINATION OF LINEAR TRAJECTORY AND ANNUAL EMISSION ALLOCATIONS FOR MALTA, UNDER THE EFFORT SHARING DECISION, INCLUDING ADJUSTMENTS FOR YEARS 2017-2020 PURSUANT TO DECISION (EU) 2017/1471 23
FIGURE 1-2 PERCENTAGE SHARE OF EMISSIONS BY GAS FOR 2020 24
FIGURE 1-3 TRENDS IN EMISSIONS OF GREENHOUSE GASES, BY GAS. 25
FIGURE 1-4 TRENDS IN EMISSIONS BY SOURCES OF GREENHOUSE GASES, BY SECTOR. 26
FIGURE 1-5 PROJECTIONS (WEM) OF TOTAL EMISSIONS DIFFERENTIATED BY SECTOR. 27
FIGURE 1-6 PROJECTIONS (WEM) OF TOTAL EMISSIONS DIFFERENTIATED BY GAS. 28
FIGURE 2-1 POPULATION GROWTH SINCE 1901 (NSO, 2012; NSO, 2021; EUROSTAT, 2021) 33
FIGURE 2-2 POPULATION BY DISTRICT AND SELECTED YEARS (NSO, 2021). 34
FIGURE 2-3 PERCENTAGE CONTRIBUTION OF ECONOMIC SECTORS (BY NACE CODE) TO GROSS ADDED VALUE FOR 2015 (NSO, 2021). 36
FIGURE 2-4 MAP OF THE MEDITERRANEAN SEA AND THE MALTESE ISLANDS SHOWING THE GEOGRAPHICAL LOCATION OF MALTA (ADAPTED FROM GOOGLE MAPS AND NASA EARTH OBSERVATORY). 38
FIGURE 2-5 FUEL CONSUMPTION BY TYPE (PERCENT OF TOTAL) IN 2013 (NSO, 2014). 41
FIGURE 2-6 AVERAGE TRANSPORT FUEL PRICES (2017-2021) 42
FIGURE 2-7 STOCK OF LICENSED MOTOR VEHICLES BY PERIOD (2000-2020) 42
FIGURE 2-8 PERCENTAGE SHARE OF LICENSED MOTOR VEHICLES BY ENGINE TYPE IN 2020 43
FIGURE 2-9 PASSENGER TRAFFIC AT THE MALTA INTERNATIONAL AIRPORT (2015-2020) 44
FIGURE 2-10: TOTAL WEIGHT OF CARGO AND MAIL (2015-2020) 45
FIGURE 2-11: SEA TRANSPORT STATISTICS (2015-2016) 45
FIGURE 2-12: GROSS TONNAGE OF UNITISED CARGO (2020). 46
FIGURE 2-13 MUNICIPAL WASTE TREATMENT (NSO, 2021). 50
FIGURE 2-14. TREND OF AGRICULTURE EMISSIONS SHOWING A DECREASE OVER TIME. 53
FIGURE 2-15 PRODUCTION OF POTABLE WATER IN MALTA (% OF TOTAL) FOR 2011 (NSO, 2021). 56
FIGURE 3-1 SCHEMATIC REPRESENTATION OF THE INSTITUTIONAL AND PROCEDURAL ARRANGEMENTS FOR THE PREPARATION AND SUBMISSION OF NATIONAL GREENHOUSE GAS INVENTORIES OF MALTA. 61
FIGURE 3-2 GHG INVENTORY ANNUAL SUBMISSION CYCLE. 61
FIGURE 3-3 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. 64
FIGURE 3-4 ANNUAL PERCENTAGE INCREASE OR DECREASE IN TOTAL GREENHOUSE GAS EMISSIONS (BASED ON TOTAL EMISSIONS INCLUDING LULUCF). 65
FIGURE 3-5 GHG EMISSIONS PER CAPITA [SOURCE OF POPULATION DATA: EUROSTAT]. 66
FIGURE 3-6 TREND IN EMISSIONS PER GDP COMPARED TO GDP TREND 67
FIGURE 3-7 GDP VS NATIONAL EMISSIONS INCLUDING INTERNATIONAL BUNKERS (STANDARDISED) FROM 1990-2019 [SOURCE OF GDP DATA: EUROSTAT]. 68
FIGURE 3-8 EMISSIONS OF GREENHOUSE GASES BY TYPE OF GAS, INCLUDING LULUCF, FOR 1990 – 2020. 70
FIGURE 3-9 PERCENTAGE CONTRIBUTION OF EACH GREENHOUSE GAS TO TOTAL NATIONAL GREENHOUSE GAS EMISSIONS (WITH-LULUCF). 70
FIGURE 3-10 TRENDS IN EMISSIONS BY SOURCES AND REMOVALS BY SINKS FOR CARBON DIOXIDE. 71
FIGURE 3-11 TREND IN TOTAL AND SECTORAL EMISSIONS OF METHANE. 72
FIGURE 3-12 TRENDS IN TOTAL AND SECTORAL EMISSIONS OF NITROUS OXIDE. 73
FIGURE 3-13 TRENDS IN EMISSIONS OF FLUORINATED GREENHOUSE GASES. 73
FIGURE 3-14 EMISSION TRENDS FOR INDIRECT GREENHOUSE GASES. 74
FIGURE 3-15 ANNUAL PERCENTAGE CHANGE COMPARED TO 1990, BY SECTOR. 75
FIGURE 3-16 NATIONAL TOTAL GREENHOUSE GAS EMISSION TRENDS (TOTAL; BY SECTOR) 76
FIGURE 3-17 ANNUAL PERCENTAGE SHARE OF NATIONAL EMISSIONS FOR EACH SECTOR. 77
FIGURE 3-18 EMISSION TRENDS FOR SECTOR ENERGY 78
FIGURE 3-19: TOTAL GREENHOUSE GAS EMISSIONS (TRANSPORT 1.A.3) 79
FIGURE 3-20: GREENHOUSE GAS EMISSIONS BY GAS (ROAD TRANSPORT) 81

Figure 3-21: Greenhouse gas emissions by Gas (Domestic Navigation) 81
Figure 3-22: Greenhouse gas emissions by Gas (Domestic Aviation) 82
Figure 3-23 Emission trends for the sector IPPU 83
Figure 3-24 Emissions from Agriculture. 84
Figure 3-25 Percentage share of agriculture emissions by gas and category. 84
Figure 3-26. Comparison between 2020 and 2022 agriculture inventory. 85
Figure 3-27 Emission Trends for sector LULUCF. 86
Figure 3-28 Emission trends for the Waste sector 87
Figure 3-29 Total GHG emissions from waste management overview by activity for sector Waste.... 87
Figure 3-30 Share of emissions, by gas, for sector Waste (% share by gas, based on CO2 equivalents). 88
Figure 5-1 Projections (WEM) of total emissions differentiated by sector. 145
Figure 5-2 Projections (WEM) of total emissions differentiated by gas. 145
Figure 5-3 Projected emissions scenarios for the energy sector (excl. transport) 147
Figure 5-4 Projected emissions scenarios for the transport sector 147
Figure 5-5 Projected HFC scenario for sector IPPU 148
Figure 5-6 Projection of emissions by scenario for the agriculture sector 149
Figure 5-7 Projections of greenhouse gas emissions for LULUCF 150
Figure 5-8 Projection of emissions by scenario for the Waste Sector 152
Figure 5-9 Comparison of Malta's emissions covered by the Effort -sharing Decision with annual emission limits 157
Figure 6-1 Global annual mean changes for temperature (left) and land precipitation (right), according to CMIP6 simulations presented in the AR6 (Lee, et al. 2021). The SSP scenarios are described in the top left with different colours, together with the number of models making up each ensemble. The solid line describes the ensemble mean while the accompanying shaded section describes the 5-95% range of the models. Periods defined as Near-, Mid-, and Long-term are also highlighted with shaded vertical columns. 176
Figure 6-2 Global annual mean changes for temperature (left) and land precipitation (right), according to CMIP6 simulations presented in the AR6 (Lee, et al. 2021). The SSP scenarios are described in the top left with different colours, together with the number of models making up each ensemble. The solid line describes the ensemble mean while the accompanying shaded section describes the 5-95% range of the models. Periods defined as Near-, Mid-, and Long-term are also highlighted with shaded vertical columns. 177
Figure 6-3. Mean temperature annual cycle of the Mediterranean Basin for the 1.5°C GWS (top) and 4°C GWS (bottom), as presented on the AR6 Interactive Atlas. The ensemble consists of 47 and 39 models (top and bottom respectively) from the CORDEX Europe dataset. 178
Figure 6-4 Annual cycle of Change in Days with Maximum Temperature above 40°C in the Mediterranean Basin for the 1.5°C GWS (top) and 4°C GWS (bottom), as presented on the AR6 Interactive Atlas. The ensemble consists of 46 and 38 models (top and bottom respectively) from the CORDEX Europe dataset. 180
Figure 6-5 Annual cycle of Change (%) in Total Precipitation in the Mediterranean Basin for the 1.5°C GWS (top) and 4°C GWS (bottom), as presented on the AR6 Interactive Atlas. The ensemble consists of 48 and 40 models (top and bottom respectively) from the CORDEX Europe dataset. 181
Figure 6-6 Time Series of Mean Annual Temperature (°C) of the Maltese Islands from the 12km CORDEX Europe dataset. The ensemble consists of 70, 30, and 65 models for the Historical, RCP2.6, and RCP8.5 scenarios respectively 182
Figure 6-7 Time Series (5-year running mean) of Maximum Annual Temperature (°C) of the Maltese Islands from the 12km CORDEX Europe dataset. The ensemble consists of 65, 29, and 66 models for the Historical, RCP2.6, and RCP8.5 scenarios respectively. 183

Figure 6-8 Time Series (5-year running mean) of Minimum Annual Temperature (°C) of the Maltese Islands from the 12km CORDEX Europe dataset. The ensemble consists of 66, 29, and 66 models for the Historical, RCP2.6, and RCP8.5 scenarios respectively. 183
Figure 6-9 Time Series (5-year running mean) of Total Annual Precipitation (mm) of the Maltese Islands from the 12km CORDEX Europe dataset. The ensemble consists of 57, 31, and 67 models for the Historical, RCP2.6, and RCP8.5 scenarios respectively. 184
Figure 6-10 Time Series (5-year running mean) of Maximum Annual 1-day Precipitation (mm) of the Maltese Islands from the 12km CORDEX Europe dataset. The ensemble consists of 57, 31, and 67 models for the Historical, RCP2.6, and RCP8.5 scenarios respectively. 185
Figure 6-11. Sea level rise scenarios along the main island's coastline (Attard, 2015). 199
Figure 6-12. Malta TEN-T Core and Comprehensive Network as identified by the TEN-T Regulations 1315/2013 (European Commission, 2014) 200
Figure 6-13. Built-up areas within 0 to 1 km of the coast (2004) (MEPA 2006). 205
Figure 6-14. Terrestrial Natura 2000 Sites in the Maltese Islands. 209
Figure 6-15. Marine Natura 2000 Sites in the Maltese Islands. 209
Figure 6-16. Number of agricultural holdings by size for 2003 to 2013 (NSO 2016, NSO 2020). 212
Figure 6-17. Size of utilizable agricultural area by type of crop for 2003 to 2013 (NSO 2016, NSO 2020). 212
Figure 6-18. Maltese perceptions of likelihood of health risks resulting from climate change (Akerlof, et al. 2010). 220
Figure 6-19. Most common causes of death using broad categories (DHIR 2018). 220
Figure 6-20. Population projections for Malta 2010-2060. (NSO 2012) 221

TABLE OF TABLES

Table 1.1 Overview of Greenhouse gas emission trends (Gg CO_2 equivalent), by gas........................25
Table 1.2 Overview of Greenhouse gas emissions (Gg CO_2 equivalent), by sector............................25
Table 1.3 Summary of policy approach in respect of greenhouse gases..26
Table 1.4 Emission projections by sector and by gas for the 'with existing measures' scenario. 28
Table 1.5 A summary of the projects funded though Malta's contributions from 2013 till 2020......30
Table 2.1 Age Profile for Malta at 5-year intervals (NSO, 2021)..34
Table 2.2 Education Profile for Malta at 5-year intervals (NSO, 2021) 34
Table 2.3 Employment Status in Malta at 5-year intervals (NSO, 2021) 35
Table 2.4 Employment by Sector in Malta at 5-year intervals (NSO, 2021) 35
Table 2.5 Tourist arrivals in Malta at regular intervals (NSO, 2021) 35
Table 2.6 Energy intensity (Energy Supply in kWh / GDP at PPP in $) of Maltese and EU economies at 5-year intervals (World Bank, Energy intensity level of primary energy (MJ/$2011 PPP GDP), 2021) 36
Table 2.7 Emissions intensity (CO2 emissions in kg / GDP at PPP in $) of Maltese and EU economies at 5-year intervals (World Bank, 2022)..37
Table 2.8 Government spending as percentage of GDP at regular intervals (EUROSTAT, 2021).......37
Table 2.9 Trade Balance of goods in millions of euros (EUROSTAT, 2021)..37
Table 2.10 Geographical data for the Maltese Islands (NSO, 2021)..38
Table 2.11 Mean air temperature, sunshine, wind velocity and total rainfall for the years 2005 to 2020 (NSO, 2021; NSO, 2014). 39
Table 3.1 Total emissions with/without LULUCF for the period 1990 to 2015 (Gg CO2 equivalent)...62
Table 3.2 GHG emissions per unit of GDP (tCO2 eq./GDP) at 5-year intervals (with/without LULUCF). 67
Table 3.3 Greenhouse gas emission trends by gas for 1990-2020 (Gg CO_2 equivalent). 69
Table 3.4 Emissions of greenhouse gases by gas for the years 1990 and 2020 (Gg CO_2 equivalent)..69
Table 3.5 Emissions of greenhouse gases by sector for the years 1990 to 2020 (Gg CO_2 equivalent). 74
Table 3.6 Emissions of greenhouse gases by sector for the years 1990 and 2015 and the corresponding change between the two years (Gg CO2 equivalent). 77
Table 3.7 Total GHG emissions in kt CO_2 eq from category 1.A.3-Tranport 80
Table 3.8 GHG emissions from the Waste sector. 88
Table 3.9 KCA including Approach 1 for base year (1990) and latest year (2020) with LULUCF both Level and Trend Assessment...92
Table 3.10 KCA including Approach 1 for base year (1990) and latest year (2020) without LULUCF both Level and Trend Assessment 93
Table 4.1. Energy LCDS Measures Abatement Potentials (LCDS, 2021)..108
Table 4.2. A comparison of measures reported in previous reporting and the NC8. 108
Table 4.3 Mitigation co-benefits (Energy)..109
Table 4.4 Mitigation co-benefits (Industry) 109
Table 4.5 Mitigation co-benefits (Buildings)...110
Table 4.6: Abatement potentials (transport)...118
Table 4.7 Mitigation measures in Road Transportation as described in reports NC7 ad NC8. 118
Table 4.8: Mitigation co-benefits (Transport) 119
Table 4.9. A comparison of measures reported in previous reporting and the NC8. 122
Table 4.10. Agriculture LCDS Measures Abatement Potentials (LCDS, 2021)...................................123
Table 4.11. A comparison of measures reported in previous reporting and the NC8. 123
Table 4.12. Information on non-GHG mitigation benefits of agriculture measures..........................124
Table 4.13 Mitigation impact of LULUCF policies and measures. 127

Table 4.14. A comparison of LULUCF measures reported in previous reporting and the NC8 127
Table 4.15. Type of instrument definitions. 132
Table 4.16 Summary of Policies and measures by sector (WOM) 134
Table 4.17 Summary of Policies and measures by sector (WEM) 136
Table 5.1 Emissions projections by sector and by gas for the 'with existing measures' scenario 144
Table 5.2 Projected emissions in GgCO2eq. for sector energy, by gas (WEM) 146
Table 5.3 Projected emissions in Kt CO_2eq. for sector IPPU, by gas (WEM) 148
Table 5.4 Projected emissions in Kt CO2eq. for sector Agriculture, by gas (WEM) 149
Table 5.5 Projected emissions and removals in Kt CO2eq. for sector LULUCF, by gas (BAU) 150
Table 5.6 Projected emissions in Kt CO2eq. for sector Waste, by gas (WEM) 151
5.4 Table 5.7 Information on updated greenhouse gas projections under a 'without measures scenario' 153
Table 5.8 Information on updated greenhouse gas projections under a 'with measures scenario' .. 154
Table 5.9 Estimated aggregate effect of Policies and measures 155
Table 6.1 Mean temperature (°C) of the Mediterranean Basin at different GWS, as shown on the AR6 Interactive Atlas. The table shows the values for annual, winter (DJF), and summer (JJA) means. The statistics included are the median, 5th and 95th percentiles (P5, P95). The ensemble consists of 39 models from the CORDEX Europe dataset. 178
Table 6.2 Maximum annual temperatures (°C) of the Mediterranean Basin at different GWS, as shown on the AR6 Interactive Atlas. The table shows the mean of maximum temperatures as well as the maximum of maximum temperatures. The statistics included are the median, 5th and 95th percentiles (P5, P95). The ensemble consists of 38 models from the CORDEX Europe dataset. 179
Table 6.3 Change (relative to 1995-2014) in precipitation extremes of the Mediterranean Basin at different GWS, as shown on the AR6 Interactive Atlas. The table shows the values for Maximum 1-day precipitation (RX1d in %), Maximum 5-day precipitation (RX5d in %), and Consecutive Dry Days (CDD in days). The statistics included are the median, 5th and 95th percentiles (P5, P95). The ensemble consists of 38 models from the CORDEX Europe dataset. 181
Table 6.4. A qualitative assessment of climate change vulnerability of production activities (MRRA 2010). 188
Table 6.5. A qualitative assessment of climate change vulnerability of expenditure activities (MRRA, 2010). 188
Table 6.6. High priority risks and vulnerabilities Invalid source specified.. 189
Table 6.7. External Costs of Transport by Category (2012) (Attard, Von Brockdorff and Bezzina, The External Costs of Passenger and Commercial Vehicle Use in Malta 2015) 197
Table 6.8. Land Cover Distribution for Malta 2000-2018. Compiled from the Copernicus Land Monitoring Service Corine Land Cover data. 201
Table 6.9. Land use in Malta (2006) (NSO 2011) 202
Table 6.10. Summary of land use vulnerability from climate change (adapted from (MRRA 2010)).204
Table 6.11. Terrestrial Natura 2000 Sites in Malta. 209
Table 6.12. Top 75% of species landed by the Maltese fishing fleet in 2015-2017. 211
Table 6.13 Aquaculture Annual Production (in kg) 2009-2014 (NSO 2016) 211
Table 6.14. Climate change impacts and vulnerability for terrestrial and marine ecosystems. (adapted from (MRRA 2010)). 213
Table 6.15. The impacts expected on important components within agriculture in Malta; adapted from MRRA (2010) 215
Table 6.16. General and specific objectives of the CAP Strategic Plan 2023-2027 (Government of Malta 2021). 217
Table 7.1 Provision of public financial support: summary information in 2017 227
Table 7.2 Provision of public financial support: summary information in 2018 228
Table 7.3 Provision of public financial support: summary information in 2019 229
Table 7.4 Provision of public financial support: summary information in 2020 230

TABLE 7.5 PROVISION OF PUBLIC FINANCIAL SUPPORT: CONTRIBUTION THROUGH MULTILATERAL CHANNELS IN 2017 231
TABLE 7.6 PROVISION OF PUBLIC FINANCIAL SUPPORT: CONTRIBUTION THROUGH MULTILATERAL CHANNELS IN 2018 233
TABLE 7.7 PROVISION OF PUBLIC FINANCIAL SUPPORT: CONTRIBUTION THROUGH MULTILATERAL CHANNELS IN 2019 235
TABLE 7.8 PROVISION OF PUBLIC FINANCIAL SUPPORT: CONTRIBUTION THROUGH MULTILATERAL CHANNELS IN 2020 237
TABLE 7.9 PROVISION OF PUBLIC FINANCIAL SUPPORT: CONTRIBUTION THROUGH BILATERAL, REGIONAL AND OTHER CHANNELS IN 2017. 239
TABLE 7.10 PROVISION OF PUBLIC FINANCIAL SUPPORT: CONTRIBUTION THROUGH BILATERAL, REGIONAL AND OTHER CHANNELS IN 2018 240
TABLE 7.11 PROVISION OF PUBLIC FINANCIAL SUPPORT: CONTRIBUTION THROUGH BILATERAL, REGIONAL AND OTHER CHANNELS IN 2019 240
TABLE 7.12 PROVISION OF PUBLIC FINANCIAL SUPPORT: CONTRIBUTION THROUGH BILATERAL, REGIONAL AND OTHER CHANNELS IN 2020 241
TABLE 8.1 OVERVIEW OF MALTESE INSTITUTIONS THAT CONTRIBUTE TO RESEARCH EFFORTS IN (A) CLIMATE PROCESS AND CLIMATE SYSTEM STUDIES, INCLUDING PALEOCLIMATE STUDIES; (B) MODELLING AND PREDICTION, INCLUDING GENERAL CIRCULATION MODELS; (C) RESEARCH ON THE IMPACTS OF CLIMATE CHANGE; (D) SOCIO-ECONOMIC ANALYSIS, INCLUDING ANALYSIS OF BOTH THE IMPACTS OF CLIMATE CHANGE AND RESPONSE OPTIONS; AND (E) RESEARCH AND DEVELOPMENT ON MITIGATION AND ADAPTATION TECHNOLOGIES. 245
TABLE 8.2 OVERVIEW OF MALTESE INSTITUTIONS THAT CONTRIBUTE TO SYSTEMATIC OBSERVATION ACTIVITIES IN (A) ATMOSPHERIC CLIMATE OBSERVING SYSTEMS, INCLUDING THOSE MEASURING ATMOSPHERIC CONSTITUENTS; (B) OCEAN CLIMATE OBSERVING SYSTEMS; (C) TERRESTRIAL CLIMATE OBSERVING SYSTEMS; AND (D) SUPPORT FOR DEVELOPING COUNTRIES TO ESTABLISH AND MAINTAIN OBSERVING SYSTEMS, AND RELATED DATA AND MONITORING SYSTEMS. NOTE THAT NO LOCAL INSTITUTION CURRENTLY CONTRIBUTES TO ACTIVITY (D) 246
TABLE 10.1 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 1990. 273
TABLE 10.2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 1991 274
TABLE 10.3 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 1992 275
TABLE 10.4 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 1993 276
TABLE 10.5 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 1994 277
TABLE 10.6 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 1995 278
TABLE 10.7 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 1996 279
TABLE 10.8 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 1997 280
TABLE 10.9 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 1998 281
TABLE 10.10 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 1999 282
TABLE 10.11 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2000 283
TABLE 10.12 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2001 284
TABLE 10.13 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2002 285
TABLE 10.14 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2003 286
TABLE 10.15 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2004 287
TABLE 10.16 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2005 288
TABLE 10.17 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2006 289
TABLE 10.18 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2007 290
TABLE 10.19 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2008 291
TABLE 10.20 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2009 292
TABLE 10.21 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2010 293
TABLE 10.22 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2011 294
TABLE 10.23 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2012 295
TABLE 10.24 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2013 296
TABLE 10.25 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS IN 2014 297

Table 10.26 Summary Report for CO_2 Equivalent Emissions in 2015 298
Table 10.27 Summary Report for CO_2 Equivalent Emissions in 2016 299
Table 10.28 Summary Report for CO_2 Equivalent Emissions in 2017 300
Table 10.29 Summary Report for CO_2 Equivalent Emissions in 2018 301
Table 10.30 Summary Report for CO_2 Equivalent Emissions in 2019 302
Table 10.31 Summary Report for CO_2 Equivalent Emissions in 2020 303
Table 10.32 Emission Trends by Gas (in kt equivalent to CO_2) for 1990. 304
Table 10.33 Emission Trends by Gas (in kt equivalent to CO2) for 1991. 304
Table 10.34 Emission Trends by Gas (in kt equivalent to CO_2) for 1992. 304
Table 10.35 Emission Trends by Gas (in kt equivalent to CO2) for 1993. 304
Table 10.36 Emission Trends by Gas (in kt equivalent to CO2) for 1994. 305
Table 10.37 Emission Trends by Gas (in kt equivalent to CO2) for 1995. 305
Table 10.38 Emission Trends by Gas (in kt equivalent to CO2) for 1996. 305
Table 10.39 Emission Trends by Gas (in kt equivalent to CO2) for 1997. 305
Table 10.40 Emission Trends by Gas (in kt equivalent to CO_2) for 1998. 306
Table 10.41 Emission Trends by Gas (in kt equivalent to CO2) for 1999. 306
Table 10.42 Emission Trends by Gas (in kt equivalent to CO_2) for 2000. 306
Table 10.43 Emission Trends by Gas (in kt equivalent to CO2) for 2001. 306
Table 10.44 Emission Trends by Gas (in kt equivalent to CO2) for 2002. 307
Table 10.45 Emission Trends by Gas (in kt equivalent to CO2) for 2003. 307
Table 10.46 Emission Trends by Gas (in kt equivalent to CO2) for 2004. 307
Table 10.47 Emission Trends by Gas (in kt equivalent to CO2) for 2005. 307
Table 10.48 Emission Trends by Gas (in kt equivalent to CO2) for 2006. 308
Table 10.49 Emission Trends by Gas (in kt equivalent to CO2) for 2007. 308
Table 10.50 Emission Trends by Gas (in kt equivalent to CO2) for 2008. 308
Table 10.51 Emission Trends by Gas (in kt equivalent to CO2) for 2009. 308
Table 10.52 Emission Trends by Gas (in kt equivalent to CO2) for 2010. 309
Table 10.53 Emission Trends by Gas (in kt equivalent to CO2) for 2011. 309
Table 10.54 Emission Trends by Gas (in kt equivalent to CO2) for 2012. 309
Table 10.55 Emission Trends by Gas (in kt equivalent to CO2) for 2013. 309
Table 10.56 Emission Trends by Gas (in kt equivalent to CO2) for 2014. 310
Table 10.57 Emission Trends by Gas (in kt equivalent to CO2) for 2015. 310
Table 10.58 Emission Trends by Gas (in kt equivalent to CO2) for 2016 310
Table 10.59 Emission Trends by Gas (in kt equivalent to CO2) for 2017 310
Table 10.60 Emission Trends by Gas (in kt equivalent to CO2) for 2018 311
Table 10.61 Emission Trends by Gas (in kt equivalent to CO2) for 2019 311
Table 10.62 Emission Trends by Gas (in kt equivalent to CO2) for 2020 311
Table 10.63 Emission Trends by Sector (in kt equivalent to CO_2) for 1990. 311
Table 10.64 Emission Trends by Sector (in kt equivalent to CO_2) for 1991. 312
Table 10.65 Emission Trends by Sector (in kt equivalent to CO_2) for 1992. 312
Table 10.66 Emission Trends by Sector (in kt equivalent to CO_2) for 1993. 312
Table 10.67 Emission Trends by Sector (in kt equivalent to CO_2) for 1994. 312
Table 10.68 Emission Trends by Sector (in kt equivalent to CO_2) for 1995. 312
Table 10.69 Emission Trends by Sector (in kt equivalent to CO_2) for 1996. 312
Table 10.70 Emission Trends by Sector (in kt equivalent to CO_2) for 1997. 312
Table 10.71 Emission Trends by Sector (in kt equivalent to CO_2) for 1998. 313
Table 10.72 Emission Trends by Sector (in kt equivalent to CO_2) for 1999. 313
Table 10.73 Emission Trends by Sector (in kt equivalent to CO_2) for 2000. 313
Table 10.74 Emission Trends by Sector (in kt equivalent to CO_2) for 2001. 313
Table 10.75 Emission Trends by Sector (in kt equivalent to CO_2) for 2002. 313
Table 10.76 Emission Trends by Sector (in kt equivalent to CO_2) for 2003. 313

TABLE 10.77 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2004. 313
TABLE 10.78 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2005. 314
TABLE 10.79 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2006. 314
TABLE 10.80 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2007. 314
TABLE 10.81 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2008. 314
TABLE 10.82 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2009. 314
TABLE 10.83 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2010. 314
TABLE 10.84 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2011. 315
TABLE 10.85 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2012. 315
TABLE 10.86 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2013. 315
TABLE 10.87 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2014. 315
TABLE 10.88 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2015. 315
TABLE 10.89 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2016 315
TABLE 10.90 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2017 315
TABLE 10.91 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2018 316
TABLE 10.92 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2019 316
TABLE 10.93 EMISSION TRENDS BY SECTOR (IN KT EQUIVALENT TO CO_2) FOR 2020 316
TABLE 12.1 TRANSPORT MODELS (WOM SCENARIO) 324
TABLE 12.2 EWC-STAT DRIVER ASSOCIATION EWC-STAT CODE 329

1 EXECUTIVE SUMMARY

1.1 INTRODUCTION

This is the seventh time that Malta is submitting a National Communication under the United Nations Framework Convention on Climate Change (UNFCCC). This is also the third 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.

1.2 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].

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*"[3] 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*"[4] 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*"[5].

This National Communication is the eighth communication to be submitted by Malta. Malta had previously submitted a First[6] and a Second[7] Communication in 2004 and 2010 respectively, always as a non-Annex I Party to the Convention. The third Communication, submitted in 2014 as an Annex I Party, served as Malta's 3rd, 4th, 5th and 6th National Communication to the UNFCCC. The 7th Communication was submitted in 2019.

Although this National Communication was not subjected to a formal process of public review prior to submission, its preparation involved contributions from a number of organizations representing a wide range of expertise. This provides a comprehensive overview of the status of climate action in Malta at different levels and across various relevant sectors.

It is also to note that Malta's Low Carbon Development Strategy, which is extensively referred to with regards to national policy for the mitigation of national greenhouse gas emissions, underwent an extensive process of public consultation and stakeholder engagement, as discussed in detail in the Strategy document published in 2021.

1.3 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

[1] United Nations Framework Convention on Climate Change, United Nations, 1992.
[2] UNFCCC: Article 12 'Communication of Information Related to Implementation'.
[3] UNFCCC: Article 4 'Commitments', paragraph 3.
[4] UNFCCC: Article 4 'Commitments', paragraph 4.
[5] UNFCCC: Article 4 'Commitments': paragraph 5.
[6] *The First Communication of Malta to the United Nations Framework Convention on Climate Change*, Ministry for Rural Affairs and the Environment, 2004.
[7] *The Second Communication of Malta to the United Nations Framework Convention on Climate Change*, Ministry for Resources and Rural Affairs, 2010.

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 of the instruments of ratification 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 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 came into force in 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 a 40% cut in greenhouse gas emissions from 1990 levels, at least a 27% share of energy would come from renewable energy resources and at least a 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 binds the EU to meet its climate and energy targets for the year 2020, implementing and 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 took 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 Secretary General 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 also working 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 the need for more focus on both adaptation to climate change and the relationship 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.

In November of 2021 Nations adopted the Glasgow Climate Pact at COP26. The package of decisions consisted of several agreed items, including efforts to build resilience to climate change, to curb GHG emissions and to provide finance for both. Moreover, developed nations reaffirmed their duty to pledge 100 billion dollars annually to developing countries, while both developed and developing countries collectively agreed to work to reduce the gap between existing emission reduction plans and what is required to reduce emissions, to ensure limiting the rise in global average temperature to 1.5 degrees Celsius. Nations also called for the phasing down of unabated coal power and inefficient subsidies for fossil fuels and completed the Paris Agreement's rulebook relating to market mechanisms and non-market approached and the transparent reporting of climate actions and support provided or received, including for loss and damage. Malta, as part of the EU, is amongst the nations who have committed to a reduction target of 55% by 2030 and carbon neutrality by 2050, compared to 2010. Being the smallest emitter in the EU, and having the highest disproportionate costs burden to reduce emissions, Malta was assigned a national emission reduction target of -19%

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

Malta ratified the UNFCCC in 1994 and the Kyoto Protocol[8] 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[9], this has now been replaced by Regulation (EU) No 525/2013[10]. 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 to a certain extent on work undertaken in fulfilling reporting obligations under the Monitoring Mechanism;

[8] Kyoto Protocol to the United National Framework Convention on Climate Change, United Nations, 1997.

[9] 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.

[10] 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.

The ***EU Emissions Trading Scheme*** (EU ETS): established through Directive 2003/87/EC[11], 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[12] 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[13], 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.

[11] 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.

[12] 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.

1.5 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[14] 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[15]. 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.

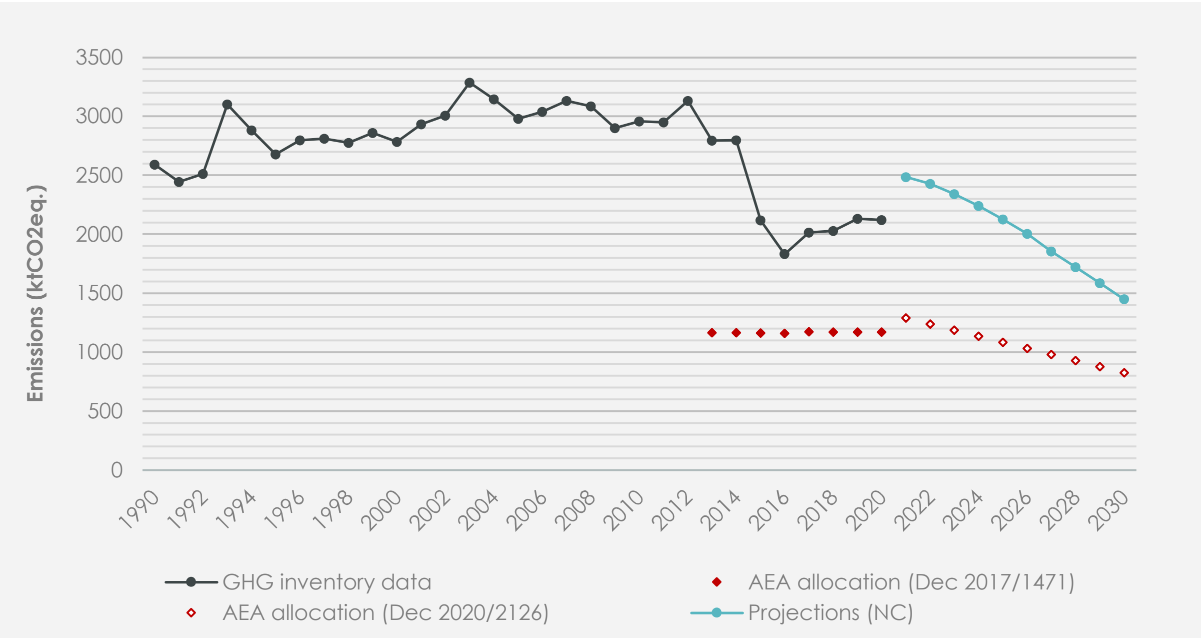


Figure 1-1 Determination of linear trajectory and annual emission allocations for Malta, under the Effort Sharing Decision, including adjustments for years 2017-2020 pursuant to Decision (EU) 2017/1471

1.6 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

[14] 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.

[15] 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.*"

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.

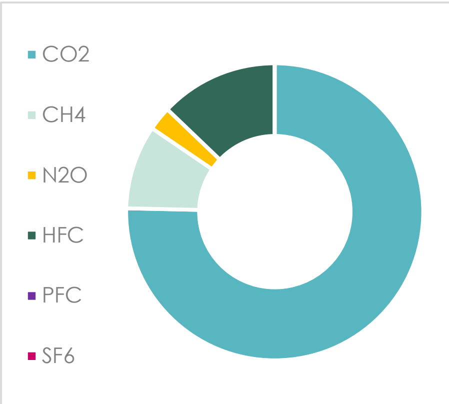
1.7 GREENHOUSE GAS EMISSIONS

(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 2020 (the latter being the most recent year for which inventory data submission to the UNFCCC is available) are presented in Table 1.1 and Figure 1-3 (by gas) and Table 1.2 and Figure 1-4 (by sector). Total emissions in 2020 decreased to 2,119.41 Gg CO_2 equivalent, 18% fewer emissions than 1990 levels, when total emissions are estimated to have been 2,591.13 Gg CO_2 equivalent.

Figure 1-2 Percentage share of emissions by gas for 2020



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 75% of total national emissions (for 2020). Hydrofluorocarbons (13%) and methane (9%) 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 76% of total national greenhouse gas emissions (for 2020). 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	2015	2020
CO2	2385.86	2435.10	2502.02	2643.89	2600.14	1661.32	1597.28
CH4	125.21	157.25	190.46	219.56	147.76	171.09	193.81
N2O	80.04	84.52	84.01	76.60	65.36	55.64	55.58
HFC	0.00	0.00	6.70	38.36	141.07	230.25	272.34
PFC	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.01	1.44	1.47	1.56	1.79	0.28	0.40
National (without LULUCF)	2599.28	2682.41	2789.72	2980.54	2944.94	2122.41	2121.59
National (with LULUCF)	2591.13	2678.31	2784.67	2979.97	2956.11	2118.58	2119.41

Table 1.2 Overview of Greenhouse gas emissions (Gg CO_2 equivalent), by sector.

	1990	1995	2000	2005	2010	2015	2020
Energy	2403.14	2449.55	2519.12	2657.05	2598.51	1664.68	1602.33
Industrial Processes & Product Use	7.78	9.29	14.99	46.03	147.96	240.72	279.62
Agriculture	119.07	119.04	115.41	99.11	86.21	81.95	80.24
LULUCF	-8.15	-4.10	-5.05	-0.56	11.17	-3.84	-2.18
Waste	69.30	104.53	140.20	178.34	112.26	135.05	159.41
Total (with LULUCF)	2591.13	2678.31	2784.67	2979.97	2956.11	2118.58	2119.41
Total (without LULUCF)	2599.28	2682.41	2789.72	2980.54	2944.94	2122.41	2121.59

Figure 1-3 Trends in emissions of greenhouse gases, by gas.

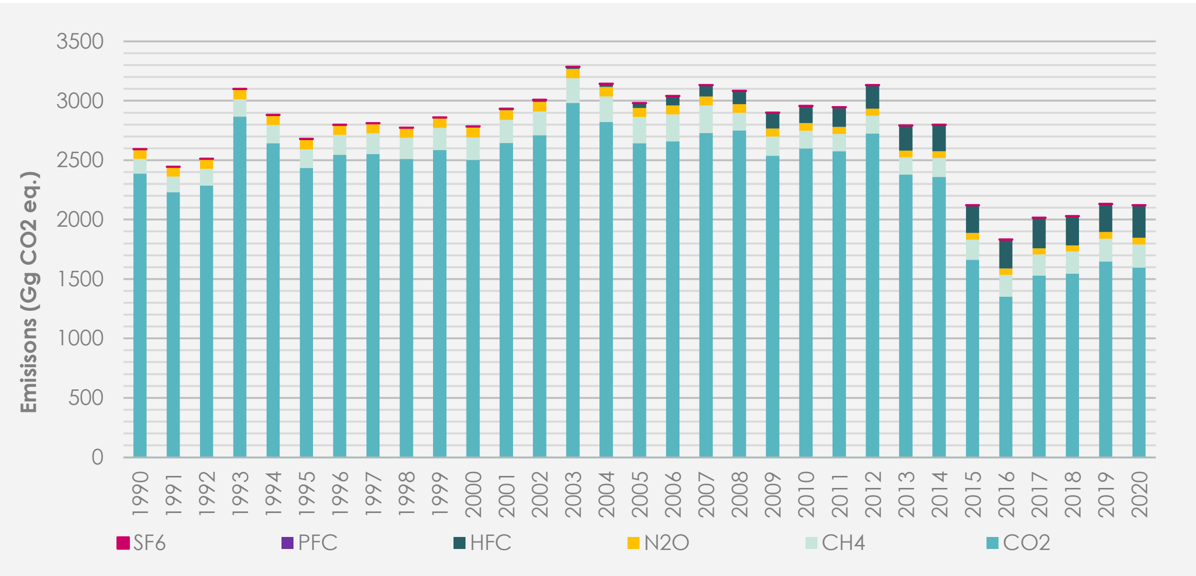
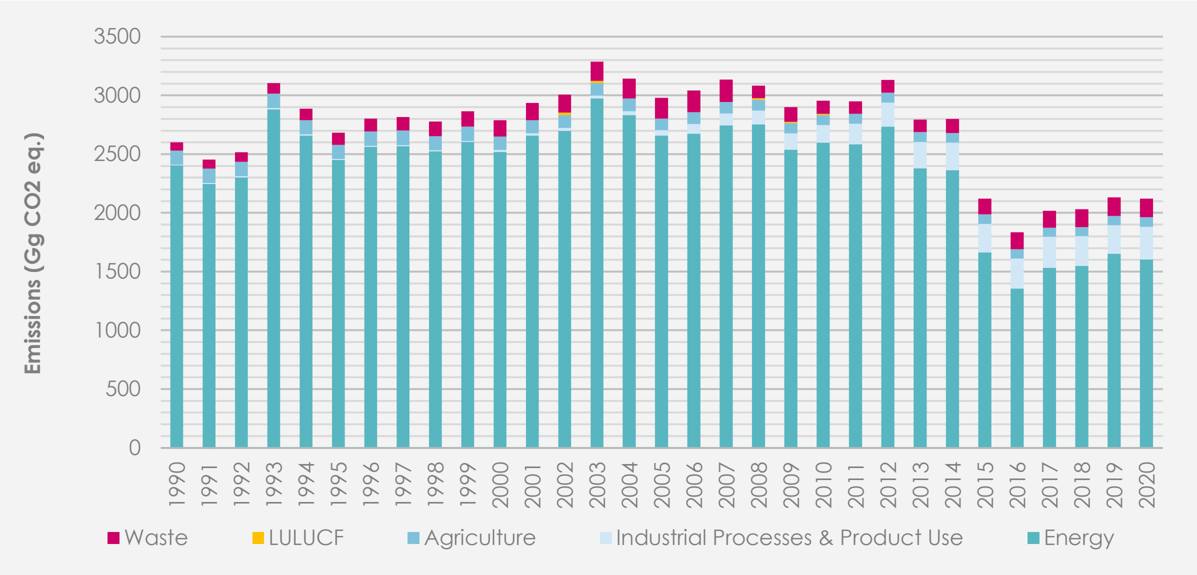


Figure 1-4 Trends in emissions by sources of greenhouse gases, by sector.



1.8 GHG MITIGATION POLICIES AND MEASURES AND THEIR AGGREGATE EFFECT

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

In Malta, policy-making for greenhouse gas mitigation is a combination of bottom-up sectoral adoption and implementation of measures by stakeholders within the respective sectors, and top-down policy processes looking at mitigation from a more holistic, coordinated perspective. Moreover, 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 taken by the newest Low Carbon Development Strategy is summarized as follows:

Table 1.3 Summary of policy approach in respect of greenhouse gases.

Sector	Mitigation action focus
Energy	Domestic LEDs
	Domestic Non-solar AWHPs
	Energy-efficient Domestic Refrigeration
	Energy-efficient Domestic Dishwashing
	Single-family building Roof Insulation
	Multi-family building Roof Insulation
	Office-building Roof Insulation
	Non-residential LEDs
	Non-residential Light Sensors
	Energy-efficient office appliances
	Solar PV
	Additional interconnector

Sector	Mitigation action focus
	Floating offshore wind
	Solar Water Heaters
	Industrial Energy Efficiency
	SME Energy efficiency
	Blended Zero Carbon Generation
Transport	Active transport, teleworking and remote working
	Electrification of heavy vehicles - Battery EVs
	Electrification of light vehicles - 65k BEVs & PHEVs by 2030
	Public Transport (with additional EV buses)
	Electrification of 370 Buses by 2030
	Electrification of the Government fleet of vehicles
Agriculture	Aquaponics
	Vaccination
Waste	High Biowaste Capture and Biogas Upgrade
	Incineration pre-sorting
	Waste prevention

The combined effect of these measures discussed and presented in this Communication is represented in the projected emission profiles by sector (Figure 1-5) and by gas (Figure 1-6). 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.

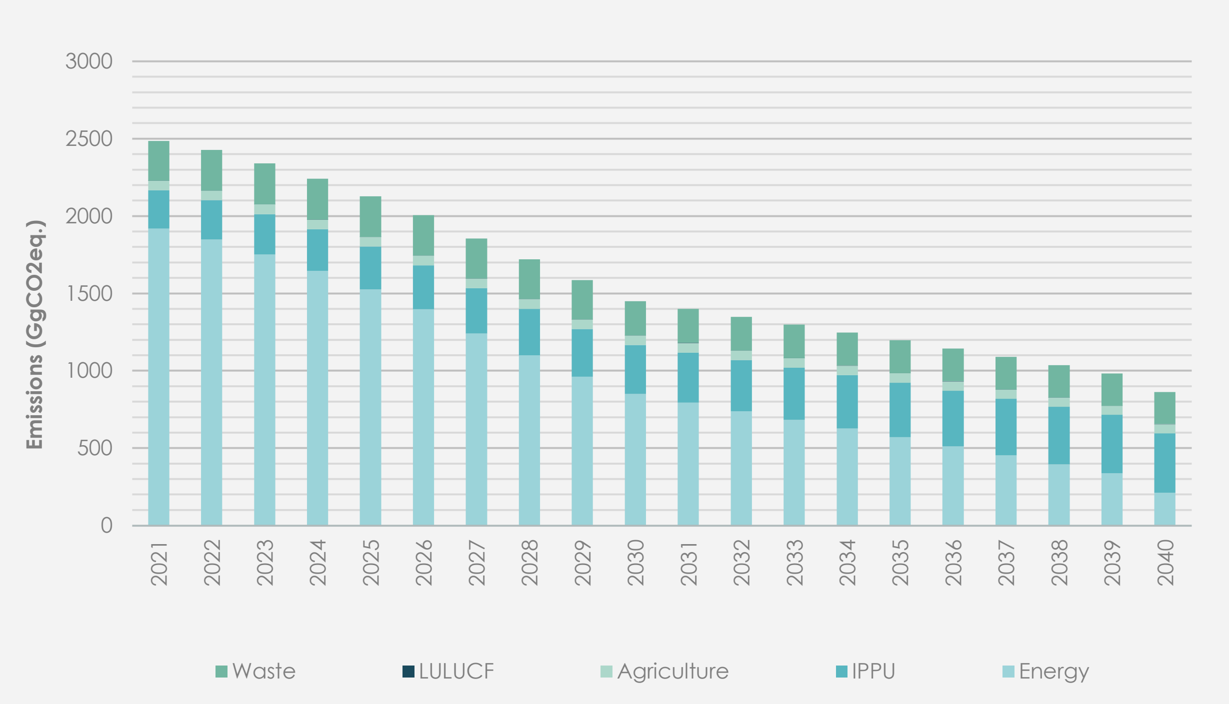


Figure 1-5 Projections (WEM) of total emissions differentiated by sector.

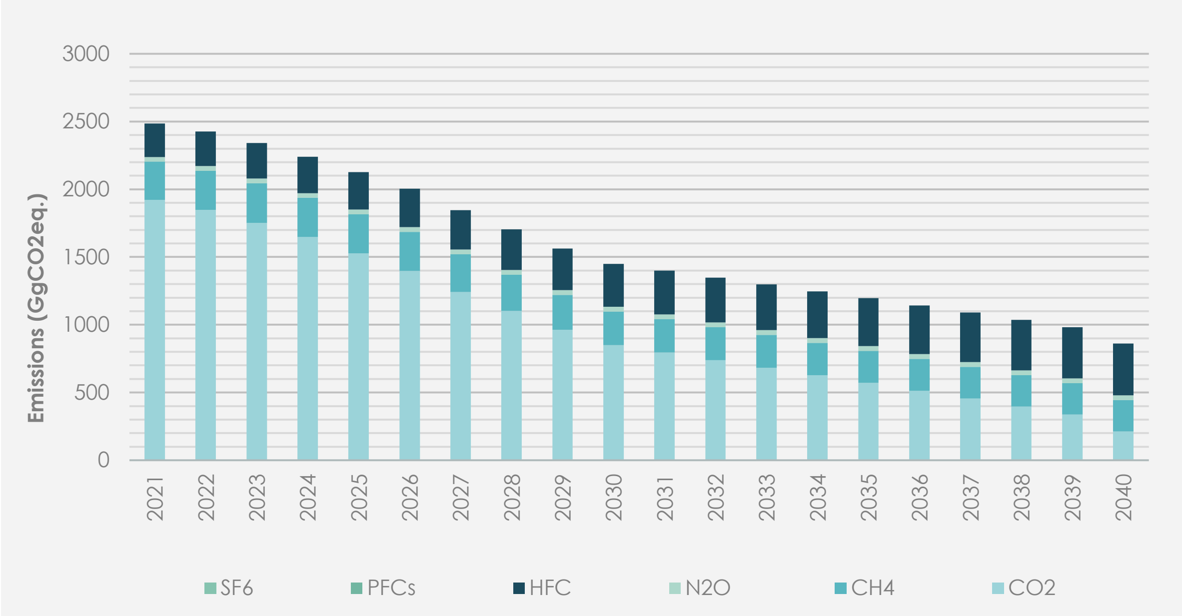


Figure 1-6 Projections (WEM) of total emissions differentiated by gas.

Emissions are seen to drop substantially from 2030 onwards, particularly due to significant work on the energy sector. This downwards shift in emissions is largely due to various electrification measures in the transport sector, the installation of additional interconnectors, and increased use of renewables and energy efficient appliances in both the residential and non-residential buildings.

Carbon dioxide is expected to experience the biggest change, also given that the majority of the emissions reduced from the energy sector are carbon dioxide emissions. HFCs are here seen to increase over time, however the implementation of the F-gas regulation is expected to curb emissions from this sector.

Table 1.4 Emission projections by sector and by gas for the 'with existing measures' scenario.

Sector	Gas	1990	1995	2005	2020	2025	2030	2035	2040
Energy	*CO2*	2388.70	2433.86	2640.70	1594.47	1515.41	839.79	559.92	201.61
	CH4	5.24	5.92	4.85	2.37	4.48	4.48	4.47	4.42
	N2O	9.20	9.78	11.49	5.49	5.57	5.70	5.80	5.86
	Total	2403.14	2449.55	2657.05	1602.33	1525.47	849.97	570.18	211.89
IPPU	*CO2*	5.13	5.19	3.65	4.46	NE	NE	NE	NE
	CH4	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
	N2O	2.64	2.65	2.46	2.42	~~0.00~~NE	~~0.00~~NE	~~0.00~~NE	~~0.00~~NE
	HFC	NO	0.002	38.36	272.34	276.85	315.55	353.10	384.48
	PFCs	NO	NO	NO	NO	NE	NE	NE	NE
	SF6	0.01	1.44	1.56	0.40	NE	NE	NE	NE
	Total	7.78	9.29	46.03	279.62	276.85	315.55	353.10	384.48
Agriculture	*CO2*	NO	NO	NO	NO	NO	NO	NO	NO
	CH4	61.21	60.39	49.52	39.53	33.32	33.53	31.06	28.60
	N2O	57.86	58.65	49.59	40.71	29.20	29.48	29.49	29.49
	Total	119.07	119.04	99.11	80.24	62.52	63.01	60.55	58.08
LULUCF	*CO2*	-8.33	-4.32	-0.78	-2.29	0.71	0.56	0.49	0.43
	CH4	0.02	0.02	0.02	0.00	NO	NO	NO	NO
	N2O	0.15	0.19	0.19	0.11	NO	NO	NO	NO
	Total	-8.15	-4.10	-0.56	-2.18	0.71	0.56	0.49	0.43
Waste	*CO2*	0.37	0.37	0.32	0.65	10.40	10.46	10.52	10.56

Sector	Gas	1990	1995	2005	2020	2025	2030	2035	2040
	CH4	58.74	90.92	165.17	151.92	250.85	209.73	201.41	196.92
	N2O	10.19	13.24	12.86	6.84	0.20	0.20	0.21	0.21
	Total	69.30	104.53	178.34	159.41	261.46	220.40	212.14	207.69
National (with LULUCF)		2591.13	2678.31	2979.97	2119.41	2127.01	1449.49	1196.46	862.58
National (without LULUCF)		2599.28	2682.41	2980.54	2121.59	2126.30	1448.94	1195.97	862.15

1.9 Vulnerability assessment, climate change impacts and adaptation measures

(Refer to Chapter 6 for more detailed information.)

The AR6 shows in detail that the Mediterranean Basin is especially vulnerable to climate change due to its geography. Mediterranean Basin has thus far seen an increase in droughts with serious agricultural impacts. The Mediterranean is projected to increase in aridity, temperature extremes, and hence fire conditions. The images and tables in this section reveal in detail how the temperature, precipitation, and sea level conditions of the Mediterranean Basin are set to change according to the high-resolution CORDEX Europe data of the AR6.

The mean temperature conditions (shown in Figure 6.3 and Table 6.1) show a systematic rise in temperature across the entire annual cycle, and good agreement within the model ensemble. The most important impact of this rise in temperature is the corresponding change in temperature extremes. The maximum temperatures (Table 6.2), associated in particular with the summer months (June, July, August) also show consistent increases and suggest that countries of the Mediterranean will be reaching new temperature records as new GWS are reached. This is also expected in the winter months (December, January, February – DJF), which will have a dramatic impact on the flora and fauna of the region, thereby impacting agriculture and economic stability.

The Maltese islands are projected to become more arid (as seen in total precipitation budget of Figure 6.9) in the RCP8.5 scenario (which is most similar to the SSP5-8.5) but may remain somewhat stable for the RCP2.6. Even with a 5-year running mean, the variability of the RCP2.6 scenario is substantial, and it is important to note that precipitation results are highly uncertain especially when small changes are involved (as discussed earlier). This high variability is also visible when assessing the intensity of extreme precipitation events (Figure 6.10), even though both scenarios show a gradual increase in maximum precipitation. One should also note that the downward trend at the end of the century is not evidence of an upcoming shift in trend; this is likely an artefact of the inter-annual variability (as observed for previous years) and the cut-off point of the data. Nevertheless, this warrants more study, ideally with more highly resolved data.

1.10 Financial resources and transfer of technology

(Refer to Chapter 7 for more detailed information.)

Despite the small size of the country, a number of financial contributions are still made by the government in relation to climate change as per table below. In 2017 public financial support was provided for two projects. The Ministry for Energy, the Environment and Enterprise, 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). Malta provides support to developing countries in the sphere of mitigation and adaptation actions and capacity building. Some projects involved the construction of a borehole to provide access to safe water to the inhabitants of Bouar, Central African Republic, through the St. Jeanne Antide Foundation. In 2018, 2019 and 2020, €100,000 per annum were contributed towards the Green Climate Fund.

Table 1.5 gives a summary of the projects funded through Malta's contributions from 2013 till 2020 (Source: annual reporting by Malta pursuant to Article 16 of Regulation (EU) No 525/2013)

Table 1.5 A summary of the projects funded though Malta's contributions from 2013 till 2020

	Bilateral/regional funding channels	Multilateral funding channels
	Euros	
2013	29,637	N/A
2014	30,725	50,000
2015	105,953	54,410
2016	96,704	100,000
2017	69,265	90,000
2018	N/A	100,000
2019	N/A	100,000
2020	N/A	100,000

1.11 Research and systematic observation

(Refer to Chapter 8 for more detailed information.)

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.

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.

In this chapter one will find a detailed explanation on the climate-related research and observation through various entities

1.12 Education, training and public awareness

(Refer to Chapter 9 for more detailed information.)

As was stated in the last National Communications, the sphere of formal education is a prime target for educational initiatives aimed at widening awareness on climate change issues. Topics related to climate change have continued to feature in various educational programmes from pre-school right through tertiary education. Local and international research and innovation projects related to Climate Change have continued to increase significantly at the University of Malta and the Malta Collage of Arts, Science and

Technology. The EkoSkola and GLOBE 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 the Energy and Water Agency (EWA) offers a number of activities for students at Ċentru Għajn. This centre offers a variety of interactive games aimed at raising awareness and to promote water conservation and energy efficiency. EWA also publishes other resources to continue raising awareness about the efficiency and sustainability of natural resources. In 2022 the Ministry for the Environment, Energy and Enterprise launched the second edition of the #ClimateOn campaign. The campaign is a platform that focuses on awareness raising for companies, businesses, families and young people climate friendly practices in relation to sustainable energy use, sustainable mobility, and sustainable financing.

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 ESD professionals in acknowledged and tapped.

2 NATIONAL CIRCUMSTANCES RELEVANT TO GREENHOUSE GAS EMISSIONS AND REMOVALS

2.1 INTRODUCTION

This chapter provides a description of Malta's national circumstances. It explores how the national circumstances affect GHG emissions and removals, historically, presently and in the future. Detailed information and disaggregated indicators that describe these relationships are provided.

2.2 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.

In the current legislature, climate change policy falls under the portfolio of the Minister for Environment, Climate Change and Planning (MECP). Nonetheless, the regulation of the six sectors reported under the IPCC (i.e., Energy, Transport, Industry, Agriculture, LULUCF and Waste) are governed by different ministries (namely the Ministry for Agriculture, Fisheries, food and animal rights (MAFA), Ministry for Energy, Enterprise and Sustainable Development (MESD) and the Ministry for the Economy and Industry (MEI)), highlighting the importance of cooperation between a number of ministries. 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.

Throughout 2020, the desire for a better environment was felt more than ever before. While Malta was fighting the COVID-19 pandemic, the level of economic activity witnessed a considerable drop with the only bright side being the improvement in environmental quality. The decrease in road transport and the rise in number of people working remotely, brought about a major improvement in air quality, clearly indicating that the road to a sustainable future requires a change in lifestyle, where economic growth integrates environmental principles and looks towards the creation of a carbon neutral Malta by 2050. To reflect its willingness to adapt, in January 2020, the government had changed its ministerial portfolio to have a distinct ministry responsible solely on the environment, climate change and planning. This was done to obtain a synergy between these vital sectors and to ensure exclusive attention and more focused work.

Despite the pandemic, there was a big impetus to keep the climate emergency a top priority. On a European level, Malta participated in discussions on action favouring more ambitious targets, which ultimately led to the European Union Council to establish targets that need to be reached by 2030. Locally, Malta declared that it would become a carbon neutral state by 2050, which in return pushed for the completion of the national strategy that aims to tackle these targets. This national strategy, titled the Low Carbon Development Strategy, has been created according to the requirements of the UNFCCC, and was published towards the end of 2021. The measures proposed were characterised by lengthy discussions between ministers, to analyse the economic and social impact of every measure. This was done to ensure that the strategy does not solely focus on the reduction of GHG emissions, but also ensures that the changes required are viable from an economic and financial perspective and that their introduction does not lead to social exclusion. The LCDS is based on an analysis of the marginal abatement cost curve. It has been subject to consultations with various interested parties, such as academia, local and regional government, representatives of associations of commercial and industry sectors, and NGOs, and a wider, extensive public consultation. The completed strategy addresses, amongst others, transport, energy, waste, and agriculture sectors as the primary sources of GHG emissions.

2.3 Population profile

By the end of 2020, the population of the Maltese Islands stood at 516,100 (NSO, 2022), which is more than double the population of a hundred years earlier (Figure 2-1). This produced a population density of around 1,633 persons per km^2, one of the highest country population densities in the world.

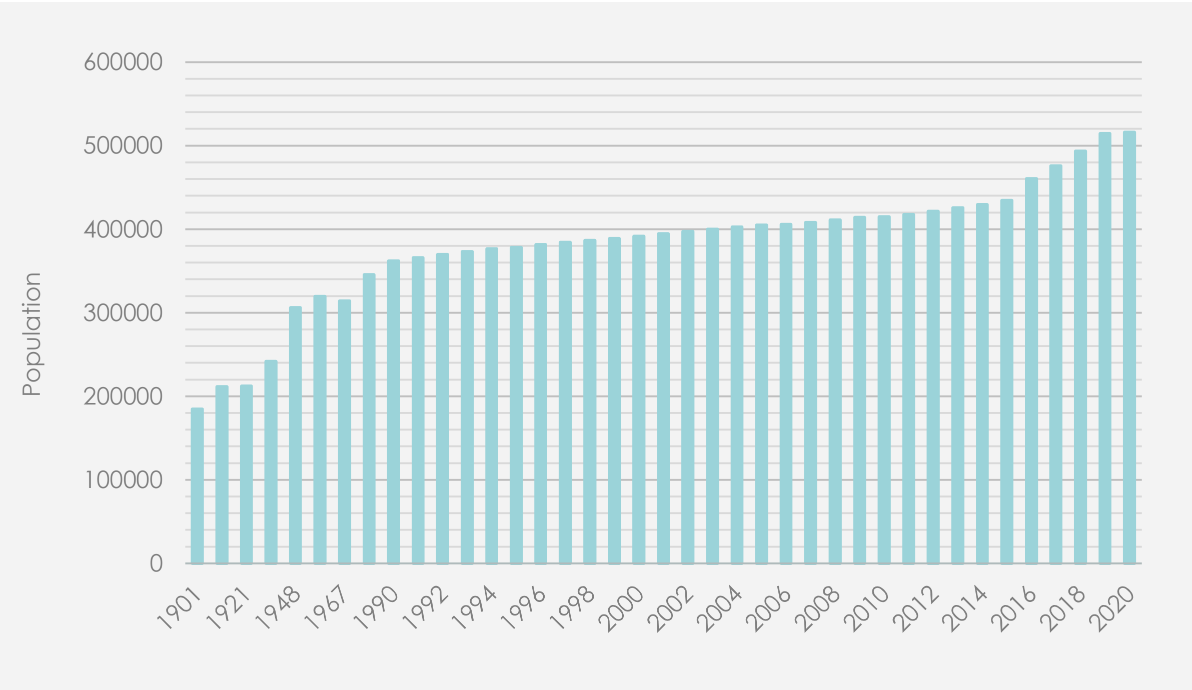


Figure 2-1 Population growth since 1901 (NSO, 2012; NSO, 2021; EUROSTAT, 2021)

Distribution of the population across the islands that make up the Maltese archipelago varies. The largest concentration of the population is found in the relatively low-lying 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, also including 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 6.7% of the total population.

Population density differences between Malta and Gozo are highly contrasting, with the former having a density of 1,952 persons per km^2, and the latter having a density of 514 persons per km². This also correlates with the extent of built-up area on the two islands. The population is projected to reach 588,691 by 2030 and increase further to 668,373 by 2050.

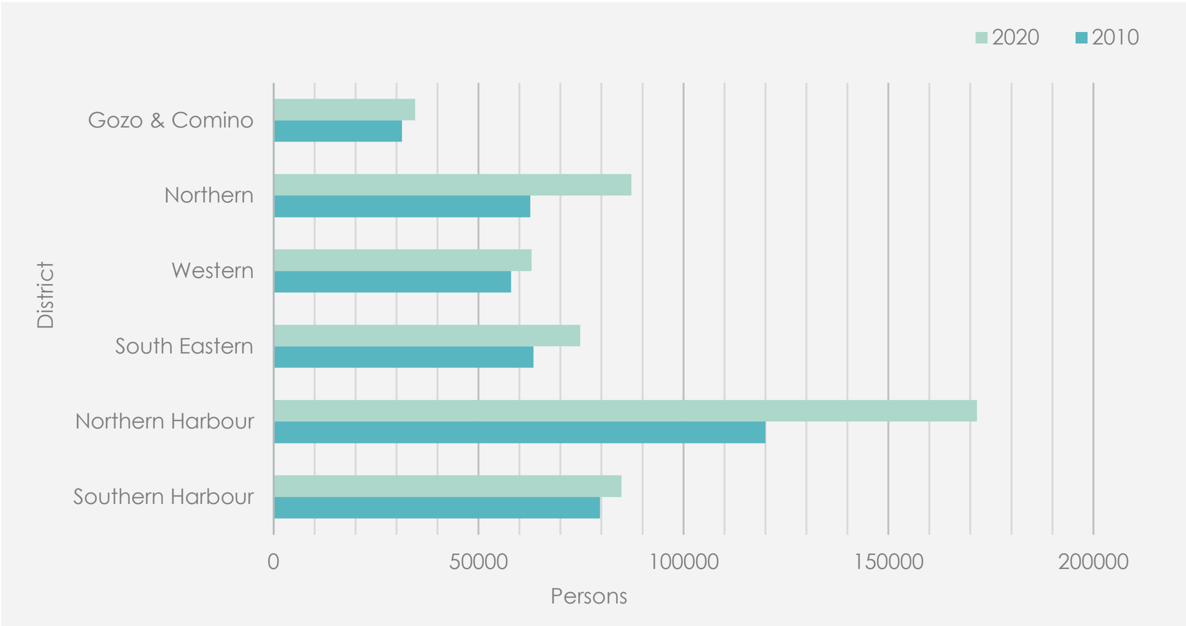


Figure 2-2 Population by district and selected years (NSO, 2021).

Table 2.1 Age Profile for Malta at 5-year intervals (NSO, 2021)

Year	15-24	25-34	35-44	45-54	Over 55
2005	53337	72322	58080	64007	65911
2010	52842	70112	56635	74735	75526
2015	52049	74252	63908	71206	99979
2020	48121	104292	77508	78180	122813

An age profile for the population of Malta (Table 2.1) clearly shows that the population had been aging over time since 2005, with the number of 15–24-year-olds decreasing and the number of over 55s increasing sharply. But it also shows that there has been an influx of younger people in the country in the past 5 years, meaning those in the 25-34 range in particular. Life expectancy at birth in 2020 was 80.3 for males and 84.5 for females (NSO,2021).

Table 2.2 Education Profile for Malta at 5-year intervals (NSO, 2021)

Year	No Schooling	Primary	Secondary	Post-Secondary	Tertiary
2005	10815	80194	57895	145626	31109
2010	6471	73039	76648	143458	43604
2015	4416	63666	92848	148963	62642
2020	4582	54594	119712	155821	104803

Table 2.3 Employment Status in Malta at 5-year intervals (NSO, 2021)

Year	Employed	Inactive	Unemployed
2005	150213	164380	11046
2010	161643	169380	12197
2015	194167	167227	11141
2020	266249	163272	9991

Table 2.4 Employment by Sector in Malta at 5-year intervals (NSO, 2021)

Year	Agriculture	Industry	Services
2005	3024	45833	101214
2010	1791	41019	118504
2015	3177	40451	150539
2020	2608	45324	218317

Table 2.5 Tourist arrivals in Malta at regular intervals (NSO, 2021)

2001	2005	2010	2015	2018
1146258	1165206	1338842	1783365	2598693

An education profile for Malta (Table 2.2) shows that participation in higher levels of education has drastically increased over the time period looked at. Table 2.3 and Table 2.4 showcase the employment activity of the country, and what we see is more people employed over time, but also that this growth has been confined to the service industry. The number of tourists arriving in Malta has also risen dramatically in the period looked at (Table 2.5).

Relationship between population and greenhouse gas emissions is explained in section 3.3.2.

2.4 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. The service sector now serves as the mainstay of the country's economy, with manufacturing also contributing.

Apart from traditional activities in tourism, education, health, retailing and banking, the services industry has in recent decades expanded towards some higher value-added activities. These incorporate the financial services sector, more specialised forms of tourism, such as that associated with language schools and diving centres, maritime and aviation activity, information technology and gaming. Large scale industrial establishments are few, with the largest, and the most relevant from a greenhouse gas emissions perspective, being the electricity generation plants. The manufacturing sector has largely developed into high value areas, such as microelectronics and pharmaceuticals.

Malta's economy has strong trade ties with the European Union. 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 €2.749 billion in 1990 to €14.056 billion in 2019 (NSO, 2021). Per capita GDP, moreover, stood at around €27,316 in 2019 (NSO, 2021), with this indicator also showing a steady increase over time.

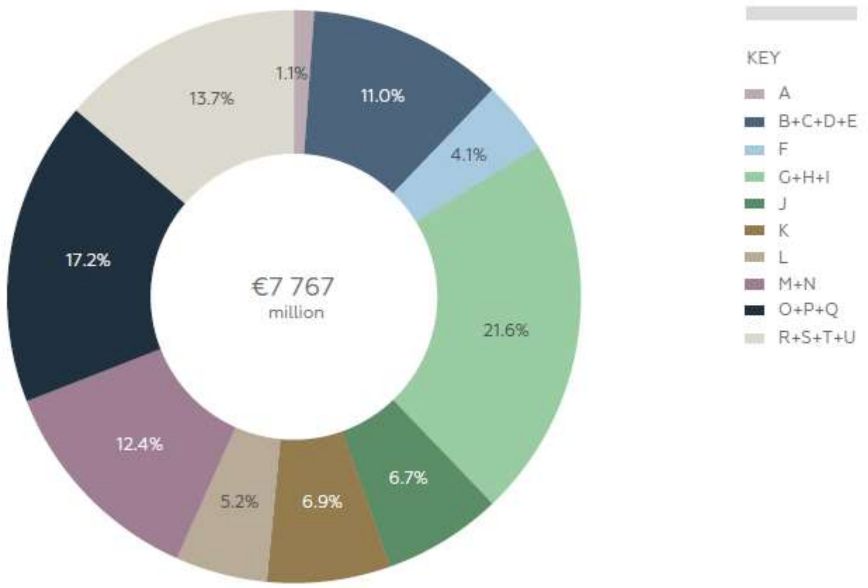


Figure 2-3 Percentage contribution of economic sectors (by NACE code[16]) to Gross Added Value for 2015 (NSO, 2021).

In 2019, Malta had a Gini Coefficient of 28.0 (EUROSTAT, 2021), making it the 15th most equal country in the world in terms of equivalised disposable income. Malta also has a high Human Development index of 0.895, 28th in the world, this being an indicator that takes into account health and education outcomes as well as per capita income. Energy intensity level of primary energy (MJ/$2011 PPP GDP) in Malta was reported at 1.37 MJ/USD in 2019, according to the World Bank collection of development indicators, compiled from officially recognized sources as seen in the table below.

Table 2.6 Energy intensity (Energy Supply in kWh / GDP at PPP in $) of Maltese and EU economies at 5-year intervals (World Bank, Energy intensity level of primary energy (MJ/$2011 PPP GDP), 2021)

Year	Malta	EU
1990	4.948688	5.635148
1995	3.868557	5.404335
2000	2.869931	4.805636
2005	3.579704	4.598516
2010	3.019066	4.209793

[16] 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;

Year	Malta	EU
2015	1.808454	3.661781
2019	1.37	

Table 2.7 Emissions intensity (CO2 emissions in kg / GDP at PPP in $) of Maltese and EU economies at 5-year intervals (World Bank, 2022).

Year	Malta	EU
1990	0.73	0.57
1995	0.51	0.45
2000	0.29	0.35
2005	0.29	0.30
2010	0.22	0.22
2015	0.10	0.17
2018	0.07	0.14

Table 2.6 and Table 2.7 showcase the energy and emissions intensity of the Maltese economy alongside the EU average. The energy intensity of the Maltese economy is consistently lower, presumably due to the major focus on the service sector, but emissions intensity has been fairly in line with the EU average overall, at least until recently. Table 2.8 also shows that government spending forms a smaller part of the economy in Malta than in other EU countries.

Table 2.8 Government spending as percentage of GDP at regular intervals (EUROSTAT, 2021)

Year	Malta	EU
1995	38.9	51.1
2000	40.1	44.9
2005	42.4	46
2010	39.8	50.1
2015	38.3	47.1
2019	37.2	45.8

Table 2.9 Trade Balance of goods in millions of euros (EUROSTAT, 2021)

Year	Exports	Imports	Trade Balance
2010	2704.9	3818.4	-1113.5
2011	3150.5	4520.5	-1370
2012	3308.1	5135.2	-1827.1
2013	2752.6	4628.3	-1875.7
2014	2205.6	5132.1	-2926.5
2015	2355	5442.7	-3087.7
2016	2879.2	5811.1	-2931.9
2017	2523.8	5311.9	-2788.1
2018	2704.5	5734.3	-3029.8
2019	2839.2	6594.3	-3755.1
2020	2343.8	4588.7	-2244.9

Table 2.9 gives the trade balance of goods for the Maltese islands for recent years. As previously noted, the Maltese economy is focused on services, so most agricultural and manufactured goods must be imported. This leads to a consistent trade imbalance.

Relationship between economic profile and greenhouse gas emissions is given in section 3.3.3.

2.5 GEOGRAPHIC PROFILE

Malta is an archipelago consisting of three main inhabited islands, namely Malta, Gozo and 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 2-4), approximately 90 kilometres from Sicily and 290 kilometres from the North African mainland. Towards the west, the Straits of Gibraltar are at a distance of almost 1,850 kilometres, while the Suez Canal is around 1,500 km towards the southeast.

Figure 2-4 Map of the Mediterranean Sea and the Maltese islands showing the geographical location of Malta (adapted from Google Maps and NASA Earth Observatory).

The total area of the Maltese islands is 316 square kilometres, with a total shoreline of slightly more than 271 kilometres. Table 2.10 presents more detailed geographical data for the Maltese Islands. Being a small island state presents specific policy issues when dealing with climate change.

Table 2.10 Geographical data for the Maltese Islands (NSO, 2021).

	Malta	Gozo	Comino	Total
Area (km^2)	247	66	3	316
Shoreline (km)	200	71 (combined)		271
Max. length (km)	27.4	14.5	-	-
Max. width (km)	14.5	7.2	-	-

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. Around 95% of the land area is urbanised, either in terms of being built-up or agricultural land, and much of the landscape consists of low hills with terraced fields.

There are a total of 318 protected areas in Malta, 55 Natura 2000 sites, as well as 263 sites designated under national laws. The protected area network in Malta is strongly influenced by national sites and their interaction with Natura 2000 sites, with nearly 100% of the total area covered by nationally designated protected areas and their overlap with Natura 2000 sites. Natura 2000 sites in Malta cover 183 species and 30 habitats from nature directives (EU Habitats Directive). 31.03% of habitats in Malta are coastal and salt-tolerant habitats, 20.69% are forests, 17.24% are sclerophyllous scrub, 10.34% are rocky habitats and 10.34% are coastal and inland dunes. From an ecosystem perspective, 58% are agroecosystems 3% Forest, 31% Urban, and 10% heathlands (Malta (europa.eu)).

2.6 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 2.11. . The most common wind direction continues to be north-westerly (292.5° -337.5° , centred at 315°), followed by westerly (247.5° -292.5° , centred at 270°) and the easterly (67.5° -112.5° , centred at 90°)(NSO 2022) The National Statistics Office published a report *'The State of Climate 2022'* where is states that Malta's mean maximum ambient temperature has increased by 1.5°C since 1952, equivalent to a warming of 0.2°C per decade. This is due to an increase in the frequency of months that are much warmer than average. The report elaborates more in discussing the occurrence of dry years which as this is very likely to be due to a combination of long-term natural variability and changes in regional circulation caused by increased greenhouse gas levels in the atmosphere.

Table 2.11 Mean air temperature, sunshine, wind velocity and total rainfall for the years 2005 to 2020 (NSO, 2021; 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)
2005	22.	18	15.3	8	7.9	505.
2010	22.6	19.3	16.1	8.1	8.2	513.1
2015	23.3	19.6	16	8.5	8.2	491.2
2020	23.3	19.9	16.2	8.3	8.8	386.9

2.7 Energy

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

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

There is a close correlation between national circumstances and the trend in greenhouse gas emissions generated from the energy sector. Aspects such as population dynamics, the prevalent energy mix at any point in time, the technologies available and that are most appropriate for the local situation, among others, all have an impact.

Population and economic growth are key parameters that impact the demand for electricity, and thus has a close correlation to GHG emissions from that activity. An increasing population over the years, coupled with increased tourism, represents an increase in demand for electricity, that must be sourced from the available sources. To the extent that such sources are limited to indigenous conventional, fossil fuel-based generation, than GHG emissions would be expected to increase. A growing share of renewable sources may counteract, to some extent, that trend. Alternative sourcing of electricity, such as through an interconnector, can also have a direct impact on national emissions, subject, however, to prevalent international circumstances that may have an impact on the viability of sourcing energy from outside the country.

Malta relies heavily on imported fossil fuels for its energy needs, including electricity generation. Historically, Malta depended on coal (up to the mid-1990s), heavy fuel oil and gasoil for its power generation. In recent years, Malta has been gradually shifting towards the use of natural gas as a cleaner alternative to heavy fuel oil and gas oil. The country has built an LNG regasification terminal, enabling the importation and use of LNG for power generation. An interconnector with Sicily provides another alternative for the sourcing of electricity, and an opportunity to also transfer electricity to the European grid. Malta's aim to introduce an additional second interconnector in the future, among other plans in this sector, would further help the country reach its energy demands as well as reduce its indigenous fossil fuel combustion.

Malta has also made use of renewable energy for some time, namely PVs and solar water heater. The country's climate, being sunny the majority of the year, with relatively long hours of sunshine especially in the summer period, makes it an obvious choice as a source of energy for Malta. The continuation of government grants and schemes to encourage the public and private sectors in investing in these technologies has helped and will continue to help Malta benefit in its reduction of emissions targets.

Malta's industrial sector is small, in fact its contribution to the country's greenhouse gas emissions for 2020 amounted to around 3% of total energy emissions. These are largely manufacturing operations which mostly consume energy in the form of electricity. In this respect, investing in modern, more-efficient equipment and adopt new processes can help inhibit emissions.

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

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

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 2-5 for 2013.

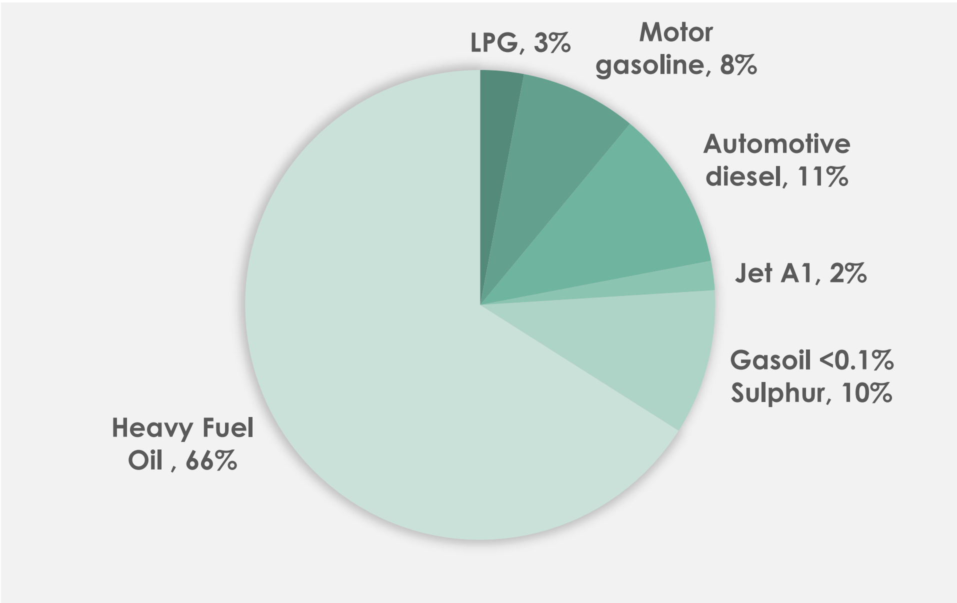


Figure 2-5 Fuel consumption by type (percent of total) in 2013 (NSO, 2014).

2.8 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.

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.

Despite improvements in emissions intensity, in 2020 transport related GHG emissions total 571 kt, accounting for about 27% of Malta's total GHG emissions.

2.8.1 FUEL PRICES

Fuel prices were highest in 2019, however, no significant fluctuations in fuel prices were observed during the period 2017-2021 as seen in graph Figure 2-6.

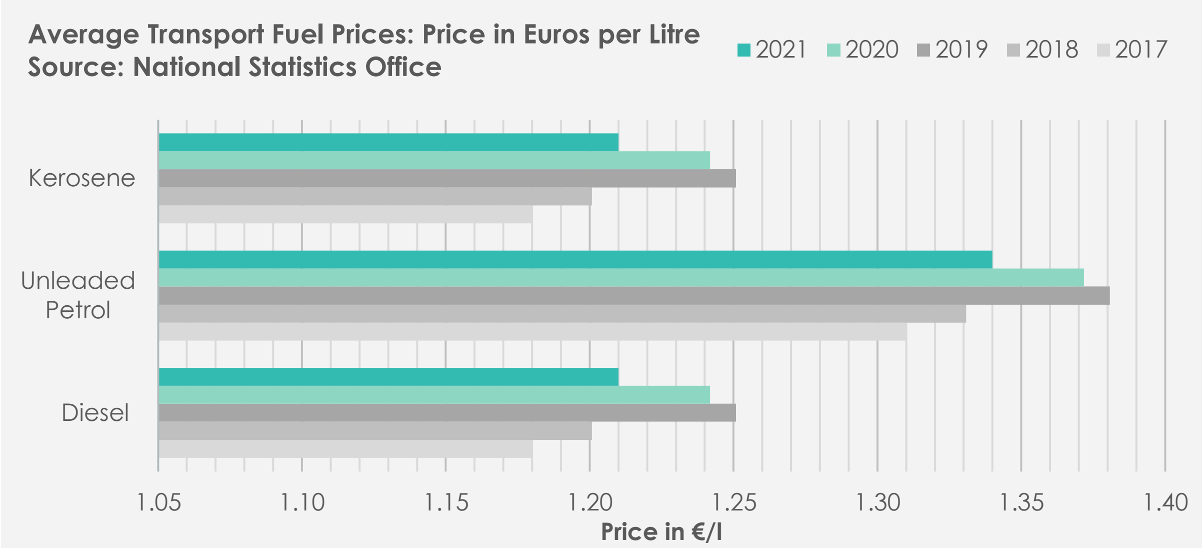


Figure 2-6 Average transport fuel prices (2017-2021)

2.8.2 *ROAD TRANSPORTATION*

Road transport is the main contributor to the transport sector. It is also the main source of particulate matter and a number of other air pollutants (NOx, NMVOCs, S_2O, etc) having severe effects in Malta due to the high car dependency and relatively old car fleet. Economic development and improved living standards of the previous decade have had a significant effect on the ownership of passenger cars.

The total number of licensed motor vehicles in Malta, as of the end of 2020 was 402,427, a net increase of 1.2%, compared to 2019 (NSO, Transport Statistics 2021). There is a 16% increase in the number of licensed motor vehicles compared to 2015. The following graph presents the increasing trend in licensed motor vehicles between 2015 and 2020 (Figure 2-7).

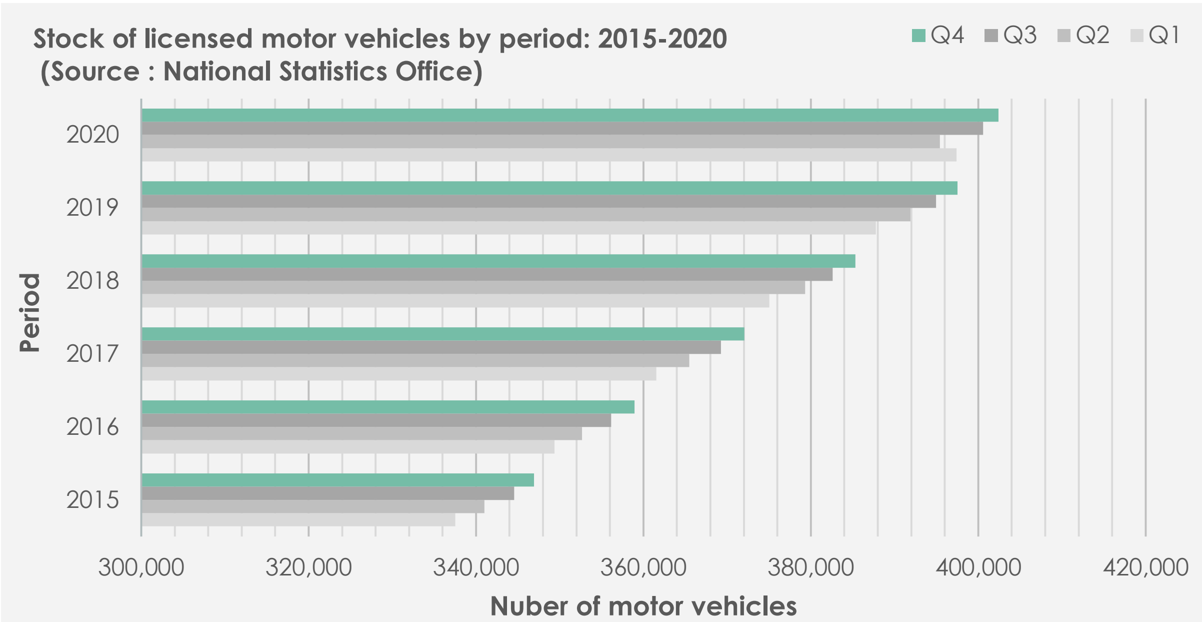


Figure 2-7 Stock of licensed motor vehicles by period (2000-2020)

The share of petrol-powered vehicles in 2020 was 59.3%, followed by Diesel-powered motor vehicles (Figure 2-8). Motor vehicles with an alternative motor energy type amounted to 7,788 by the end of 2020 (an increase of 26.5% over 2019). The number of passenger cars increased by 0.4% over 2019, reaching a total of 308,358 cars (NSO, Transport statistics 2021).

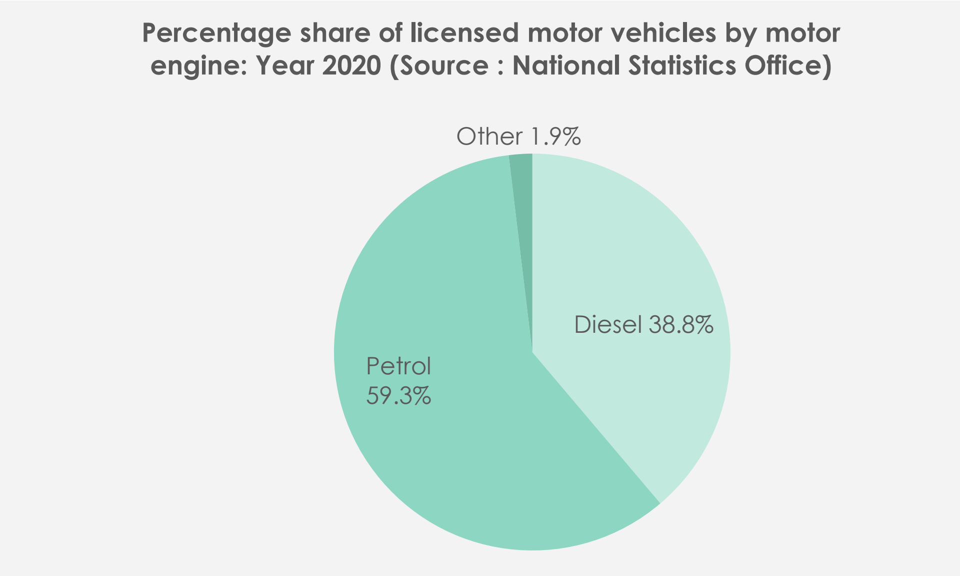


Figure 2-8 Percentage share of licensed motor vehicles by engine type in 2020

National circumstances, including population growth, economic development measured by GDP, and the tourism industry, collectively impact greenhouse gas (GHG) emissions in road transportation.

Population growth directly affects the demand for road transportation services. As the population of a country increases, commuting intensifies. Commuting in Malta remains highly dependent on the use of private vehicles, leading to a higher number of vehicles on the roads, resulting in increased GHG emissions from road transport, especially to the extent that mobility remains largely dependent on vehicles that rely on fossil fuels.

Economic development, often measured by changes in GDP, is another crucial factor. As a country experiences economic growth, industrial activities expand, and the standard of living improves. Economic development leads to increased production, consumption, and trade, which in turn generates a higher demand for transportation services. In light of the data presented in the NSO document[17], it is evident that the utilization of private vehicles in our country is high. The statistics for 2019 reveal that an overwhelming 80% of the total distance travelled was attributed to private cars. This significant figure emphasizes the dominant role private vehicles play in our transportation landscape.

In addition, the tourism industry also significantly influences the demand for road transportation. Malta heavily relies on tourism as a major contributor to their GDP. The influx of tourists requires an extensive transportation network to cater to their travel needs, both within cities and to tourist destinations. This includes airport transfers, sightseeing trips, and transportation between various attractions and accommodations.

[17] NSO, 2021 - Transport Statistics, 2021. Reference year 2020 https://nso.gov.mt/wp-content/uploads/Transport-2021.pdf

Moreover, the tourism industry can affect the demand for road transportation by influencing individual travel behaviour. Tourists often prefer the flexibility and convenience of private transportation, such as rental cars or taxis, to explore destinations at their own pace. This preference for individual modes of transportation can further contribute to increased emissions in the road transportation sector.

Changes in the local climate also contribute to increased emissions, primarily due to higher evaporation rates and the impact on emissions of non-methane volatile organic compounds (NMVOCs; so-called precursor gases). Over the years, there has been a noticeable shift in temperature patterns. Since 1952, the mean maximum air temperature increased by 1.54 °C, while the mean minimum air temperature increased by 1.37 °C. The mean highest maximum air temperature increased by 1.20 °C and the mean lowest minimum air temperature increased by 1.67 °C. The local climatic conditions also mean that an increasingly higher share of vehicles in Malta are equipped with air-conditioning, thus a potential growing source of emissions of hydrofluorocarbons.

2.8.3 AIR TRANSPORTATION

In 2020, passenger traffic at the Malta International Airport reached a total of 1,752,779, a decrease of 76 per cent when compared to 2019. All quarters registered decreases when compared to the previous year (Figure 2-9). The highest decreases in air passenger traffic were recorded in the second quarter and the fourth quarter with decreases of 99.6 percent and 88.2 percent respectively (NSO, Transport statistics 2021, published in 2022). Figure 2-10 presents the total weight of cargo and mail processes by the Malta International Airport.

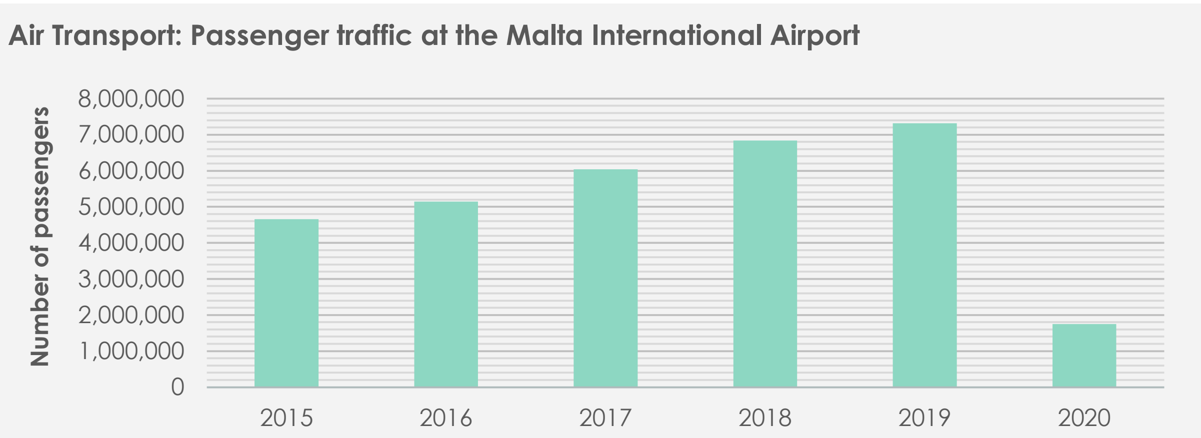


Figure 2-9 Passenger traffic at the Malta International airport (2015-2020)

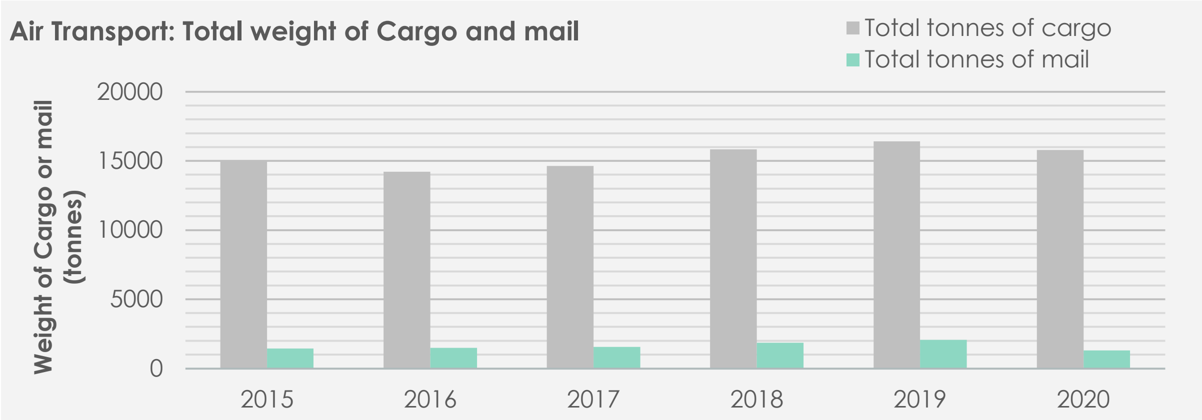


Figure 2-10: Total weight of cargo and mail (2015-2020)

It is important to note that there is only one national airport on the Maltese islands and thus domestic flights mainly include flights from small aircrafts used by training schools, helicopters for search and rescue operations and emergency medical transport between the two main islands, and small aircraft recreational flights.

2.8.4 Sea Transport

The two main Maltese harbours, serve as vital links and gateways that facilitate domestic and international economic activities. The number of vessels that arrived at Malta's ports in 2020 decreased by 18.5% over 2019. As at end of 2020, the number of vessels registered under the Maltese flag amounted to 8,168 (Figure 2-11). The stock of fishing vessels stood at 2,701(NSO, Transport Statistics 2021).

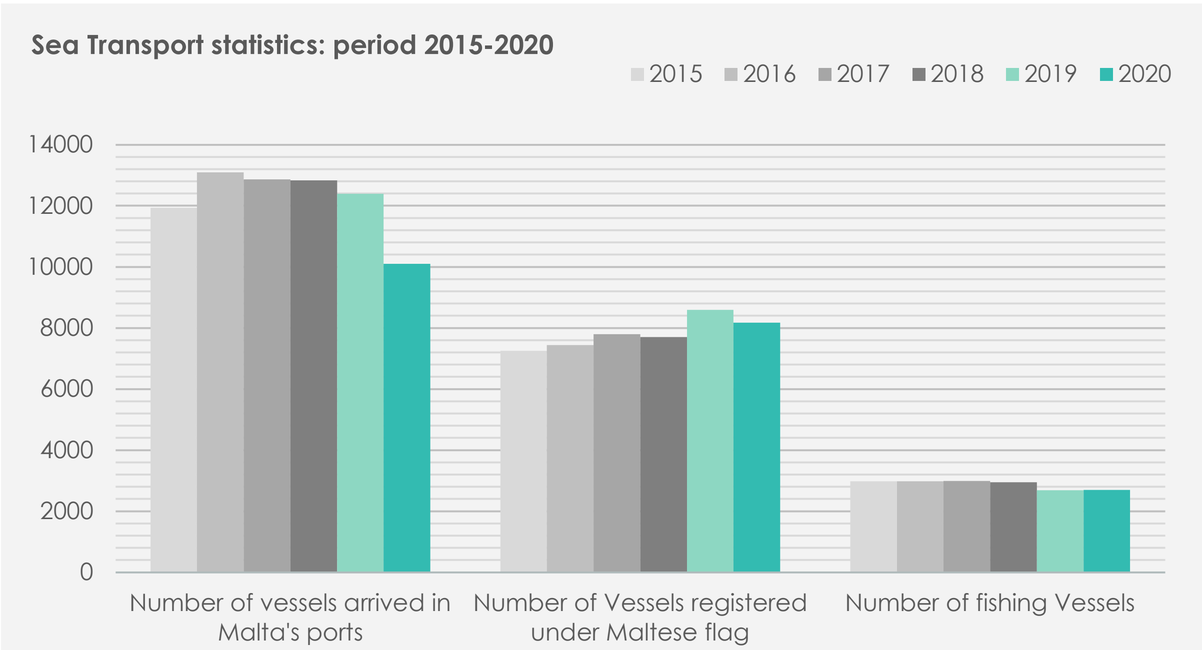


Figure 2-11: Sea transport statistics (2015-2016)

During 2020, unitised cargo unloaded and loaded locally, at Malta main ports (Valletta Grand Harbour and Freeport) amounted to 4.10 million tonnes and 3.37 million tonnes respectively (Figure 2-12).

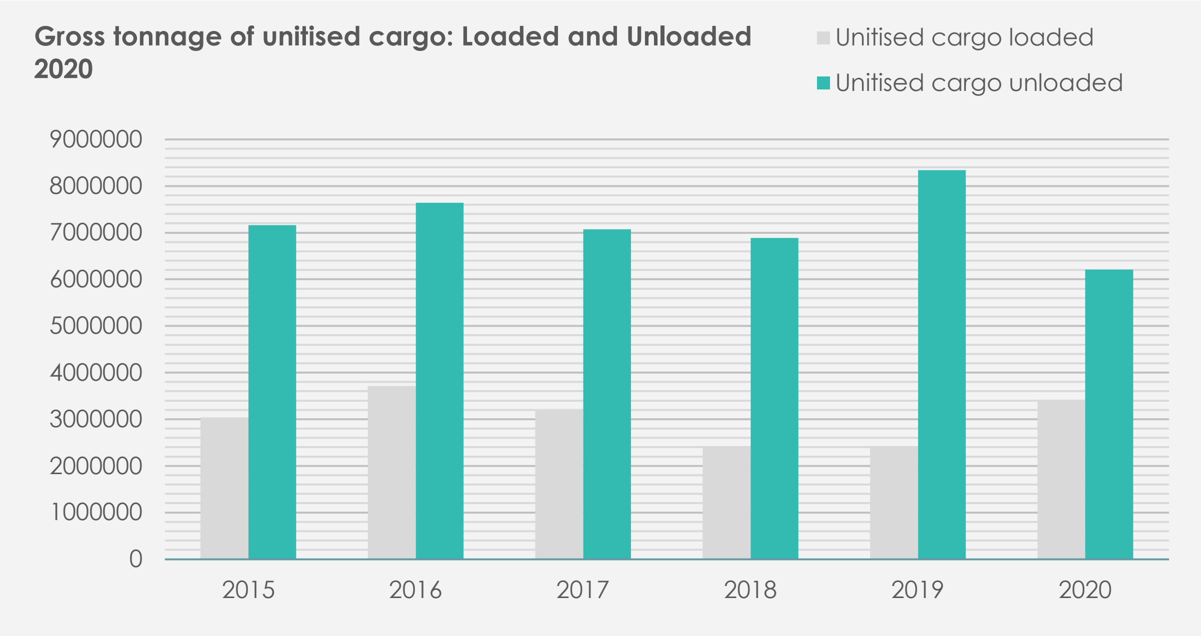


Figure 2-12: Gross tonnage of unitised cargo (2020).

The marine industry is mainly comprised of domestic marine service operators, who provide domestic shipping services, and public transportation services (passenger ferries) between the main two islands. The average rate of passengers and vehicles per trip crossing between Malta and Gozo amounted to 130 and 53 respectively (NSO, Transport Statistics 2021).

Domestic navigation showed the most significant emission growth since 1990, among transport subcategories, with the growth of 329% (40 kt) in 2019 and 208% (25kt) in 2020.

2.9 INDUSTRY

A preliminary analysis of the industrial sectors in Malta shows the relatively low presence of industrial production of significant GHG sources. In fact, a number of production sub-sectors/categories/sub-categories are considered to be not occurring. Thus, GHGs are mainly emitted from the use of products, rather than from production processes.

The main source of GHGs is the use of fluorinated gases (F-gases), mainly as refrigerants in refrigeration and air conditioning equipment. In terms of carbon dioxide equivalent, F-gases are the main contributor to the direct GHG emissions in this sector, especially due to their high GWPs.

The activity data used in the estimation of emissions of GHGs from this sector and, consequently, the emissions themselves, are driven by the increase in population, the rate of growth of the GDP and disposable income. Especially, but not only, in the case of category Refrigeration and Air Conditioning, the increase in the mean maximum ambient temperature of Malta, referred to in section 2.6 above, is another driver.

2.9.1 MINERAL PRODUCTS

Since 1999, lime production activities no longer take place and any lime used in Malta is imported. However, in the past, lime production (quick lime) was commonplace in Malta.

The lime produced was of the high calcium type. Up to 1994, two lime production plants were operational.

Soda ash is neither mined nor produced in Malta but imported. Moreover, emissive uses of carbonates occur from soda ash (sodium carbonate, Na_2CO_3), as a raw material and in acid neutralisation (desulphurisation) in energy generation and in waste incineration. The data indicates that, locally, the desulphurisation process started in waste incineration in the year 2009, and, in energy generation, from 2012 onwards. Moreover, it should be pointed out that in 2017, an energy generation plant that does not make use of the technology utilising sodium bicarbonate, started operation.

It is the understanding of the Inventory Agency that locally there are no GHG-emitting glass production processes, but only shaping and colouring of glass. Finally, it should also be pointed out that since 1990, cement production has not occurred in Malta.

2.9.2 *CHEMICAL INDUSTRY*

From the chemical production sub-categories included in category 2B of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Malta does not have any activity. Nonetheless, Malta imports calcium carbide for the production of acetylene. Whereas the production process used emits no greenhouse gases, the use of acetylene in metal welding and cutting is a source of CO_2 emissions.

2.9.3 *METAL INDUSTRY*

Category 2C of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories covers a wide variety of metal and alloy production activities, none of which, however, occur in Malta.

2.9.4 *NON-ENERGY PRODUCTS FROM FUEL AND SOLVENT USE*

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

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

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

Organic solvents and solvent-containing products used in Malta are imported. Solvents and related compounds include chemical cleaning substances used in a variety of industrial applications as well as household uses. All of these activities and applications make use of chemicals that contain significant amounts of NMVOCs. Emissions are produced through evaporation of the volatile chemicals when these products are exposed to air.

Imported urea is used in denoxification in energy generation, waste incineration and in selective catalytic reduction (SCR) in road transport. Urea was originally used in energy generation when part of the power station used to be operated using heavy fuel oil and gasoil as the fuels for the generation of electricity. During 2017, the plant was converted to natural gas and gasoil. Due to the greater utilisation of natural gas, the amount of urea used for denoxification (of gasoil) had decreased. The denoxification process has been used in waste incineration in Malta since the year 2011, when the Marsa thermal treatment plant was upgraded with the installation of a deNOx facility which utilises urea in liquid form (AdBlue or ISO 22241 compliant fluid) to reduce NOx emissions. During this process of denoxification, CO_2 is released as a by-product. CO_2 is emitted from the use of urea in road transport only from vehicles equipped with SCR. Such technology is used only for diesel-engined vehicles.

2.9.5 Electronics Industry

The local electronics industry is relatively limited in scope. Most of the processes that have been identified as emissive are not carried out locally. Local manufacturing of electronics, as defined in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, generally does not occur in Malta. Only the final stages of semiconductor manufacture are performed in the semi-conductor manufacturing sub-sector that is present locally. Throughout the time-series, the use of HFC-23 and SF_6 are reported.

2.9.6 Product Uses as Substitutes for Ozone Depleting Substances (ODS)

Current areas of application for the products in subject include refrigeration and air conditioning equipment, foam blowing applications, fire protection equipment and metered dose inhalers. The F-gases consumed locally are imported.

The main source of emissions of F-gases, locally, is category Refrigeration and AirConditioning (CRF 2.F.1), with emissions of hydrofluorocarbons (HFCs). Emissions of HFCs have increased from the early 2000s. However, importation of F-gases for local blowing of closed-cell foam has been interrupted based on legal quotas, while emissions of HFC-134a from imported closed-cell foam panels continue.

2.9.7 Other Product Manufacture and Use

Switchgear used locally in electricity generation plants and in the electricity distribution network (substations and distribution centres)makes use of sulphur hexafluoride (SF_6). Locally, this is the main use of SF_6. This sector is identified as being also the main contributor to local emissions of SF_6. SF_6 has unique properties that allow the optimised operation of electrical switchgear and electricity networks. However, 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. Very small quantities of SF_6 and PFC-218 (perfluoropropane, C_3F_8) are also used in Malta during hospital operations. Moreover, locally, medical grade N_2O is used for anaesthetic, analgesic use and veterinary use. Another use of N_2O is as a propellant in whipped cream preparations (in aerosol cans).

2.10 Waste

2.10.1 Solid Waste Disposal

The general profile of the trend of emissions from sector Waste is evidently greatly influenced by the profile of emissions for category Solid Waste Disposal category. This category was, for a long time, simply a matter of disposal in unmanaged landfills (Magħtab and Wied Fulija in Malta; Qortin in Gozo). In 2004, 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.

2.10.2 Biological Treatment of Solid Waste

The Sant'Antnin Solid Waste Treatment Plant started operating in 1993. The composting plant stopped operating in early 2007 and was replaced by a mechanical biological anaerobic treatment plant, the activity of which is accounted for. Between the decommissioning of this plant, in 2007, and the commissioning of the new plant, in 2010, no plant scale biological treatment of solid waste was operational in Malta.

2.10.3 Waste incineration

In Malta, to date, the emissions from waste incineration are minimal (<5% of the total emissions in the waste sector). This category includes emissions from municipal, clinical and industrial waste incineration.

Since the Għallis non-hazardous managed landfill is set to reach its waste capacity within a few years, it was recently proposed that a 5,000 square meter Waste-to-Energy (WtE) plant will be built in Malta to reduce the amount of municipal solid waste disposed into the landfill. The plant will manage around 40% of the overall waste generated in the Maltese Islands, equivalent to 114,000 tonnes and recover a substantial amount of energy of about 69000 MWh per year.

2.10.4 Wastewater

Wastewater 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 wastewater treatment facility, which has been operating for over 30 years.

Malta's sewerage infrastructure consists of two main geographically separate networks that collect both domestic and industrial wastewaters, as well as a portion of stormwater runoff. The collection treatment and discharge system has recently undergone major upgrades with the building of three new sewage treatment plants to address all the wastewater generated on the Maltese Islands. These infrastructural developments represent a decrease in untreated wastewater (disposed to sea) - to under 20% of wastewater is untreated and an increase of treated wastewater – with over 80% of wastewater is treated of all wastewater generated.

With a rise in population, one can observe an increase in the wastewater generated as well. Due to infrastructural developments aimed to deal with all the wastewater generated in the Maltese Islands, while the generation of wastewater is increasing, more wastewater is being treated rather than being disposed of in an untreated form.

The construction of new wastewater 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 m3 of sewage, with the bulk of the treated effluent utilised for irrigation purposes in agriculture. The Gozo wastewater treatment plant, operational as of 2007, treated a total of 1.52 million m3 in 2011, while a more recently commissioned (2008) plant situated at iċ-Ċumnija in the north of Malta treated 2.98 million m3 in the same year. The largest wastewater 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 m3 of wastewater. 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).

2.10.5 MUNICIPAL WASTE TREATMENT

During 2020, the total amount of treated municipal waste decreased by 12.5 per cent when compared with the previous year, 2019. The share that went to landfilling from the total treated municipal waste stood at 88.7 per cent, which is also lower than it was recorded a year before (NSO, 2021) (refer to the below figure 2.13).

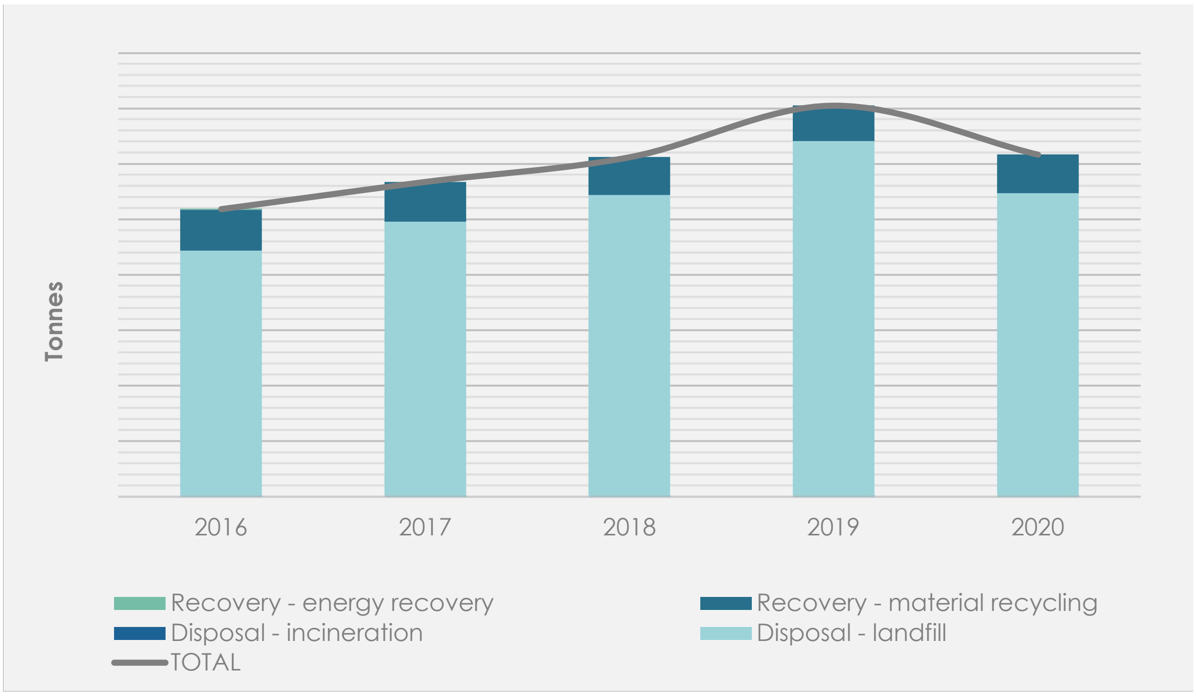


Figure 2-13 Municipal waste treatment (NSO, 2021).

National circumstances relevant to the waste sector in Malta, is influenced by a higher population demand being both local population and tourism.

In fact, it is indicated that, "*on average, a tourist generates almost double the waste generated by a Maltese resident. While a Maltese resident living in a household generates an average of 0.68 kg of waste daily, a tourist residing in a hotel produces an average 1.25 kg of waste each day*" EEA (2013). Tourism in 2019 reached 2.8 million inbound tourists and has seen continuous increases over the years, a 5.9% increase from the previous year (NSO, 2020), prior to the Covid pandemic. This represents an additional burden on national efforts to deal with waste (and thus, waste generated GHG emissions). As tourist number increase, waste generation is expected to increase.

Also, due to population growth, one can notice a rise in the solid waste disposal that is landfilled. This will also result to an increase in methane emissions generated from organic waste.

Moreover, due to developments such as the Waste-to-Energy facility, which was recently proposed to be built, this will process waste in the most sustainable and resource-efficient way possible while also turning it into a resource. The facility will be treating the generated non-recyclable waste by diverting it away from landfill disposal and generating energy and heat. Therefore, the aim of the WtE facility is to reduce the amount of waste that is disposed in the landfill.

2.11 BUILDING STOCK AND URBAN STRUCTURE

The land use profile of the country shows that more than 33% of total land area is built-up, which together with other urban development (e.g. airport, ports, industrial and commercial sites, mineral extraction sites) LUCAS 2015 survey.

In Census 2021, 59.2 per cent of all inhabited dwellings in Malta and Gozo were either apartments or maisonettes, while 36.1 per cent were semi-detached or terraced houses. Home ownership was the most common type of tenure status in 2020, with 78.6 per cent of all households owning their main dwelling. Of these, 57.0 per cent were outright owners, meaning that they either never had a mortgage on their main dwelling or have repaid their debt in full. A different trend was observed among rented main dwellings, whereby 19.5 per cent of households without dependent children were tenants, against 10.3 per cent of households with dependent children.

According to NSO in the 2022 the number of approved dwellings increased 60% over the same period of 2021 when compared to the corresponding quarter of 2021, the number of building permits and approved new dwellings increased by 25.8% and 59.6% respectively.

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. NSO reported a total of 206,868 dwellings of which 59.2% are apartments and other dwellings 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 in respect of the type of dwellings preferred, reflecting a change in attitudes and lifestyle and a reaction to property prices.

A variety of factors shape Malta's building sector and influence its energy consumption and efficiency. These circumstances include, amongst others. the composition and age of buildings, the sources of energy used for heating and cooling, energy efficiency standards and practices and well as climate and weather conditions. Factors that can have an effect include the inherent energy efficiency performance of buildings, to what extent are they insulated or are built in a manner that improves, or otherwise, their efficiency, and the extent to which energy saving technologies and practices are applied. Multiple initiatives have been attributed to the buildings sector in Malta, such the installation of roof and window insulation and switching to the use of LEDs and light sensors, has helped the building sector in Malta in reducing its emissions generated for spatial heating and cooling and lighting.

In addition, Malta's shift towards energy efficient appliances is encouraged through government schemes and initiatives in supporting vulnerable and energy poor households to replace old appliances with new efficient units. Also, considering the growing construction activity in Malta, for new buildings that have not yet been constructed, it is planned to implement energy efficient standards to drive up performance in building, for both electricity and heat.

2.12 AGRICULTURE

In the last agriculture census conducted by the National Statistics Office, it was found that during 2020, the total number of agricultural holdings in Malta amounted to 10,449. Most of the agricultural holdings (98.7 %) were found to be run by sole holders. Holdings that were found to be managed by groups, partnerships and companies accounted for 1.3%. Farmers who were both the farm manager and the sole holder of the activity accounted for 93.8 % of all the sole-holder agricultural holdings. Agricultural managers were mostly male, with 11.1 % being female. Moreover, managers aged 44 years and younger amounted to 17.6 % of the total, compared to 16.8 % in 2010. Managers aged 65 years and over accounted for 35.9 % of the total. The Census revealed that most of the holdings in MALTA were relatively small, with 7,280 holdings (69.7 %) managed a Utilised Agricultural Area (UAA) of less than one hectare. Medium-sized agricultural holdings that managed between one to five hectares of land amounted to 2,904 (27.8 %), while 265 holdings (2.5 %) were considered large, managing over five hectares of UAA. Moreover, it resulted that a total of 4,327 agricultural holdings, accounting for 41.4 % of all holdings, produced products for their own consumption while the remaining 6,122 holdings, or 58.6 %, sold all or a share of their produce through the various available market niches.

In 2020, the total UAA in Malta amounted to 10,730 hectares. A total of 3,252 hectares or 30.3 % of the entire UAA, were found to be situated in the Western, followed by the Northern and Gozo and Comino districts with 2,541 (23.7 %) and 2,449 hectares (22.8 %) respectively. Arable land accounted for 72.5 % of the total UAA, while permanent crops and kitchen gardens made up the remaining 8.9 and 18.6 % of the UAA respectively. Over the last 10 years, there has been a downward trend in arable land and permanent crops cultivation areas, while the area used for kitchen gardens has increased. The cultivation of forage crops (67.5 %) was predominant in the use of arable land. The total area designated for permanent crops in 2020 amounted to 953 hectares, of which 456 hectares were dedicated to vineyards and whose cultivation declined by 158 hectares when compared to 2010. Similarly, areas of fruit and berry plantations decreased by an area of 143 hectares over the 10-year span. On the contrary, areas of olive plantations increased by 14 hectares.

In 2020, Malta had a total of 241 cattle farms with a cattle population of 14,447 heads of which, 5,996 were dairy cows. This figure represents a decline of 7.9 % in the cattle population from 15,688 heads in 2010. A decrease of 17.2 % was also recorded over the 10-year period in the number of cattle farms, from 291 farms in 2010 to 241 in 2020. Moreover, during 2020, the number of reared sheep stood at 16,177 heads. Although there was a decline of 11.8 % in the holdings engaged in this activity from 1,081 holdings in 2010 to 953 holdings in 2020, the sheep population increased by 36.3 % over this 10-year span. During 2022 farmers have had to cull many of their sheep due to a rise in forage prices following the Russia's invasion of Ukraine. The number of reared goats increased by 31.5 %, from 4,384 heads in 2010 to 5,764 in 2020, whereas the number of holdings in this activity declined by 15.5 %, from 595 holdings in 2010 to 503 in 2020. On a similar trend, the pig population stood at 40,090 in 2020, marking a decline of 43.2 % over 2010. Also, the number of pig farms in Malta declined by 29.5 % over the same 10-year period, from 132 farms in 2010 to 93 farms in 2020.

A total of one million poultry heads was recorded in 2020; of which, 696,010 (67.3 %) were broilers. This figure decreased by 17.7 % over that of 2010 when 846,143 heads were recorded. A similar decline of 27.9 % was also registered in the number of holdings in this agricultural activity, from 154 in 2010 to 111 in 2020. On the contrary, however, the number of laying hens increased by 12.6 % in the 10-year period under review, from 300,667 in 2010 to 338,516 in 2020. Notwithstanding this, the number of holdings engaged in the latter agricultural activity dropped by 27.1 %, from 652 in 2010 to 475 in 2020. A total of 7,326 breeding female rabbits were recorded as being reared in 2020.

Changes that took place in the agricultural sector over the 10-year period (2010-2020) have been a continuation of the trend for many years. These changes in livestock and land area have led to an overall drop in emissions as seen in the trend of emissions below, where emissions have dropped by 33% since 1990. The effect of the treatment of cattle and poultry manure at the Malta North Mechanical Biological treatment plant, an implemented measure that is being considered in the WOM scenario, has also been affecting the emissions from manure management, despite the fact that less than 39,000t of manure are being treated, contrary to what was outlined in the proposed measure.

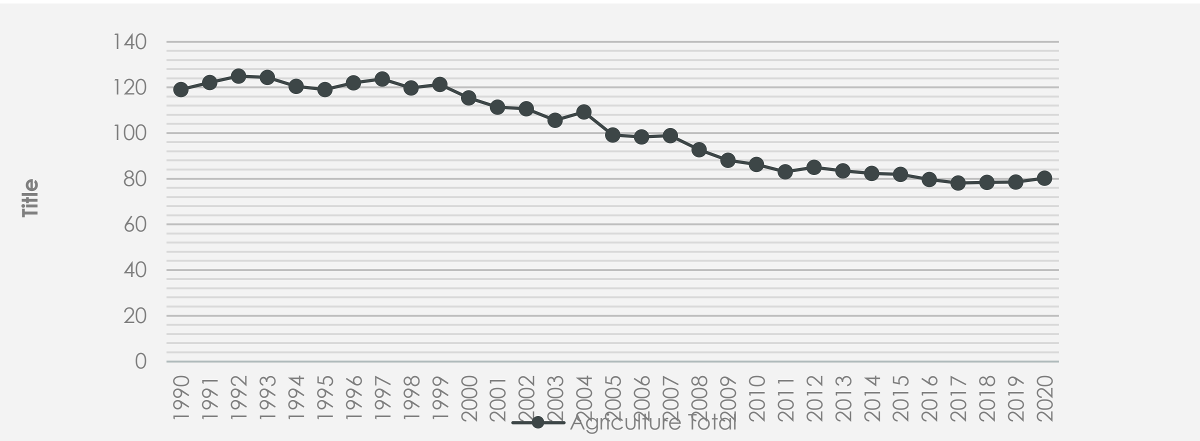


Figure 2-14. Trend of agriculture emissions showing a decrease over time.

2.13 Forest

Within the Mediterranean region, Malta has one of the lowest levels of forest coverage (FAO, 2014), presumably a combined result of the country's small size, extraordinary high population density, and long history of human habitation, leading to a large human footprint and extensive anthropicization of the land. The only remaining forest remnants occur in localized pockets, with four particular copses of significant age. It is thought that, prior to being settled by humans, the Maltese Islands would have supported relatively extensive tracts of Mediterranean sclerophyll forest, dominated by species such as the Holm Oak (Quercus ilex) and Aleppo Pine (Pinus halepensis). Fossil evidence of this theory has been cited by several authors (e.g. Zammit Maempel, 1977, 1982; Pedley, 1980; Hunt, 1997). Once the Islands were settled, however, extensive deforestation took place to make space for farmland and habitation, and to provide timber as fuel. Meantime, grazing by domestic animals made it extremely difficult for young tree growth to survive, with these factors resulting in a near complete loss of Maltese forests.

Typically, Quercus ilex forests would normally support an undergrowth of smaller tree species and shrubs of various dimensions, many of which are also characteristic of maquis assemblages, while coniferous woodlands would tend to lack a significant understorey. Maquis assemblages, which, in the Maltese Islands, typically occur in somewhat sheltered environments such as valley slopes and boulder screes, do not constitute woodlands in the strict sense of the term, but consist of smaller trees and tall shrubs; these assemblages, which may occur naturally but also a result of secondary succession following deforestation and subsequent re-growth of woodlands (Cassar & Conrad, 2014).

Due to the small size of the Maltese islands, as well as privatisation of the agricultural land, the protection of certain lands, and significant urban development, the area for plantations and afforestation is as a result highly restrained. Noting the small-scale projects introduced within the Maltese islands the resultant removal rate in the woodlands/forest is very low, as can be seen from the mitigation impact in chapter 4, and the potential to further enhance the removal rate is limited in this case. More often, due to the inherent circumstances of Malta, projects are proposed and implemented in areas that are under some other type of use or within development areas to provide publicly accessible open spaces, or which involve the upgrade of existing, but run-down gardens, or on derelict sites, thus representing an increase in land-use change rather than new forested area.

As regards the abatement potential of the current afforestation projects implemented, the contribution of these projects will lead to a reduction of around 0.05kt CO_2 eq by 2025, and 0.2kt CO_2 eq by 2040. This abatement rate indicates that the potential reduction from afforestation projects, and future ones, will lead to significantly low reduction contributions from such measures.

None of the woodland areas in Malta are utilised for logging (MEAIM, 2009). In Malta there is no relevant harvest commercialized for material use, and wood for material use is currently imported from other countries. Furthermore, Malta addresses the conservation of trees and woodland sites strictly through the Trees and Woodland Protection Regulations (Legal Notice 12 of 2001). Additionally, FAOSTAT information sourced from the Forestry Production and Trade indicate that the production quantity has never been produced in Malta.

The only significant extent of mature woodland in the Maltese Islands now occurs within the Buskett region, the naturally occurring woodland was enlarged through afforestation efforts during the rule of the Knights of St. John. It was during the rule of Grand Master La Valette (1557-1568) that the Bosketto area began to be used for the rearing of local falcons in connection with an inpart fulfillment to a condition, laid by the Viceroy of Sicily, to present him with a falcon on an annual basis (Cassar & Conrad, 2014).

The Buskett area is found in the western part of Malta and is located within Ir-Rabat, Ħad-Dingli and Is-Siġġiewi locality boundaries. The area includes both a Special Area of Conservation (SAC) and a Special Protection Area (SPA). L-Inħawi tal-Buskett SAC is one of the largest SACs in the Maltese Islands. It consists of three valley systems, Wied l-Isqof, Wied il-Luq and Wied il-Girgenti, each of which has a permanent watercourse running through it, supporting the highest concentration of riparian woodlands in the Maltese Islands. This SAC is also one of the most diverse and richest in biodiversity, supporting a variety of rare and endemic species. It also hosts the largest woodland in the Maltese Islands, at Buskett, which in turn supports the largest concentration of woodland-associated species of invertebrates and mycoflora in Malta. Buskett is also a popular site with both Maltese and foreigners, recording a high footfall, particularly in winter. Buskett, and the area around it, is also important as a concentration point for birds of prey, many of which are of international importance. This has allowed the area to receive designation both as a Special Area of Conservation (SAC) and a Special Protection Area (SPA).

Il-Ballut tal-Wardija Special Area of Conservation (SAC) is found in the north-east coast of Malta. The site is found in an area between Wardija and St. Paul's Bay. To the north of the site there is St. Paul's Bay and there are views of Xemxija Bay whilst to the west there are views of the Pwales Valley. The Wardija settlement is found to the east of the SAC. To the south west there is the San Martin Valley. Il-Ballut tal-Wardija SAC is a small SAC that is characterised by a variety of woodland habitats, one of which is the most important Holm Oak woodlands in the Maltese Islands. The latter is a Holm Oak forest remnant supporting the oldest known population of such trees in the country. It also supports a self-regenerating coniferous woodland and an olive and carob maquis. Most of the SAC is private land. The only government property that is found on site is limited to the path leading to the residential units, the south-western area and the north-eastern corner situated beneath the Wardija Village. There is evidence of land abandonment throughout the site. Land that was used for agricultural purposes in the 1950s and 1960s are now covered in scrub. A number of the Annex I habitats are actually occupying agricultural land that has since been abandoned. Throughout the SAC, there is evidence of habitat alteration by private individuals. This includes the planting of Eucalyptus trees in various pockets throughout the site by hunters.

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.

Foresta 2000 is an area of natural habitat which has been restored as a Mediterranean woodland. Foresta 2000 is a long-term project, commenced in 2003 with the aim to recover an area and plant a Mediterranean forest that would become an attraction for both Maltese and foreigners wanting to explore and enjoy nature. The Foresta 2000 initiative is being run by BirdLife Malta, in collaboration with Din l-Art Helwa and the former PARKS which was the afforestation department of the Ministry for Sustainable Development, Environment and Climate Change (now 'Ambjent Malta' Agency), and involves the environmental improvement of a site of approximately 104 ha located on the west slope of Marfa Ridge, with the project aiming to establish a Mediterranean forest on site (Cassar & Conrad, 2014). Planting of tree species and shrubs in the Foresta 2000 afforestation site began in 2004, which up until now amounts to a total of 44 hectares of afforested land. The project has drawn on the participation of several individuals, schools and corporations, and on the work of volunteers. It has also benefited from contributions of external partners – the project website mentions, for example, that the Italian Corpo Forestale dello Stato have provided 8000 trees and shrubs over three years. As per details provided on the same website, the project has succeeded in planting some 20,000 trees and shrubs.

2.14 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 desalinised water is stored in 24 reservoirs around the Maltese Islands, which have a total capacity of 400,000 m^3. The water distribution system in Malta a network of over 2136 km of pipes, pumps, reservoirs and valves, that lead to approximately 142,000 water service connections to homes, business, industries, hotels, schools and so on (Water production - Water Services Corporation (wsc.com.mt)). The households sector accounts for the bulk of the demand for water, accounting for almost 70% of total billed consumption.

In an attempt to achieve good groundwater status in all groundwater bodies in the Maltese islands by 2021, the 'New Water' programme was launched with the aim of producing a capacity of 7 million m3 of high-quality water suitable for crop irrigation, thus potentially addressing up to 35% of the current total water demand of the agriculture sector (wsc.com.mt). New Water is created from treated waste-water which is filtered from bacteria, chemicals and any remaining pollutants.

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.

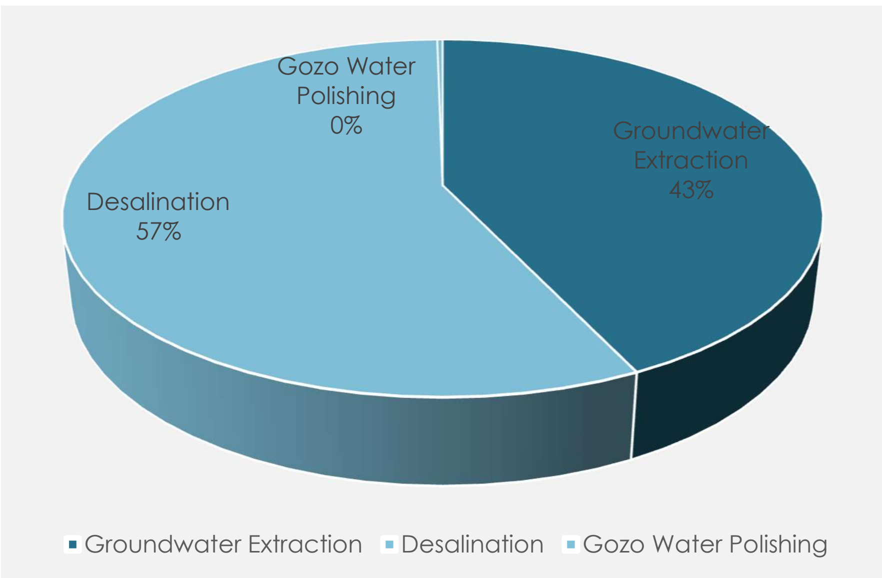


Figure 2-15 Production of potable water in Malta (% of total) for 2011 (NSO, 2021).

3 GREENHOUSE GAS INVENTORY INFORMATION

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[18], 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. Summary tables of the CRF have been annexed in Section 10.1 Information on National Inventory arrangements can be found under sections 3.2 and 3.7.

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,

[18] 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.

- 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.
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[19] 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*

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

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[20]. The legal notice (LN 259/2015) forms part of a wider legislative framework being established specifically for climate action in Malta, with the main underpinning legal instrument being the Climate Action Act, 2015 (Chap. 543)[21].

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.

As a national Inventory Agency, MRA is responsible for the planning, preparation and management of the national GHG inventory. There were no changes in the national inventory arrangements since National Communication 7 and Biennial Report 4. 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.

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

[20] 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.

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

previous inventory cycle, and will itself be the starting point of the subsequent inventory cycle.

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

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

Data gathering is another area where efforts must continue to ensure that reliable data is sourced from the most appropriate sources and in an effective manner. As will be seen in later sections of this report, data is gathered from a diverse range of sources, both public and private. So far, the data gathering process has depended largely either on access to publicly available official data, or on one-to-one relationships built with organisations, or individuals within organisations, in a relatively informal manner. The MRA has identified the need to establish formal channels of data gathering to ensure timely provision of reliable data, including, where appropriate, through formal written agreements with key data providers. Work on this aspect has started. The current approach to greenhouse gas inventory compilation in Malta is pictorially presented in Figure 3-1and Figure 3-2.

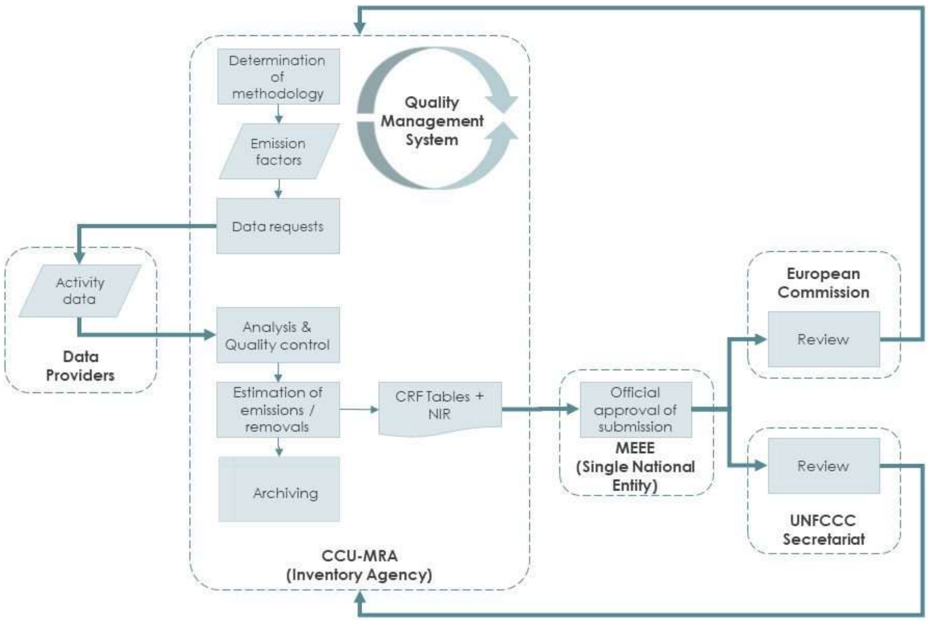


Figure 3-1 Schematic representation of the institutional and procedural arrangements for the preparation and submission of national greenhouse gas inventories of Malta.

Figure 3-2 GHG inventory annual submission cycle.

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.

3.3.1 *Overview of emission trends*

National emissions of greenhouse gases for select years over the period 1990 to 2020 ("with" and "without" LULUCF) are presented in Table 3.1 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 (2020) for the without-LULUCF estimates show a decrease of 18.38%, while for the with-LULUCF estimates this represents a decrease of 18.21%.

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 3-3.

Table 3.1 Total emissions with/without LULUCF for the period 1990 to 2015 (Gg CO2 equivalent).

	Total (with LULUCF)	Total (without LULUCF)	Difference from base year (with LULUCF)	Difference from base year (without LULUCF)
	Gg CO2 eq.	Gg CO2 eq.	%	%
1990	2591.13	2599.28		
1991	2443.82	2452.20	-5.69%	-5.66%
1992	2512.05	2517.18	-3.05%	-3.16%

	Total (with LULUCF)	Total (without LULUCF)	Difference from base year (with LULUCF)	Difference from base year (without LULUCF)
	Gg CO2 eq.	Gg CO2 eq.	%	%
1993	3100.29	3105.26	19.65%	19.47%
1994	2881.92	2886.55	11.22%	11.05%
1995	2678.31	2682.41	3.36%	3.20%
1996	2797.32	2801.45	7.96%	7.78%
1997	2811.58	2815.94	8.51%	8.34%
1998	2774.32	2778.45	7.07%	6.89%
1999	2858.84	2863.79	10.33%	10.18%
2000	2784.67	2789.72	7.47%	7.33%
2001	2933.73	2936.20	13.22%	12.96%
2002	3007.30	2986.06	16.06%	14.88%
2003	3286.72	3265.49	26.85%	25.63%
2004	3143.53	3143.89	21.32%	20.95%
2005	2979.97	2980.54	15.01%	14.67%
2006	3039.45	3041.21	17.30%	17.00%
2007	3132.00	3133.52	20.87%	20.55%
2008	3083.79	3071.84	19.01%	18.18%
2009	2899.25	2887.88	11.89%	11.10%
2010	2956.11	2944.94	14.09%	13.30%
2011	2947.95	2949.96	13.77%	13.49%
2012	3130.58	3132.39	20.82%	20.51%
2013	2793.52	2795.16	7.81%	7.54%
2014	2796.46	2800.66	7.92%	7.75%
2015	2118.58	2122.41	-18.24%	-18.35%
2016	1831.96	1835.78	-29.30%	-29.37%
2017	2016.17	2018.05	-22.19%	-22.36%
2018	2028.88	2030.02	-21.70%	-21.90%
2019	2130.39	2131.76	-17.78%	-17.99%
2020	2119.41	2121.59	-18.21%	-18.38%

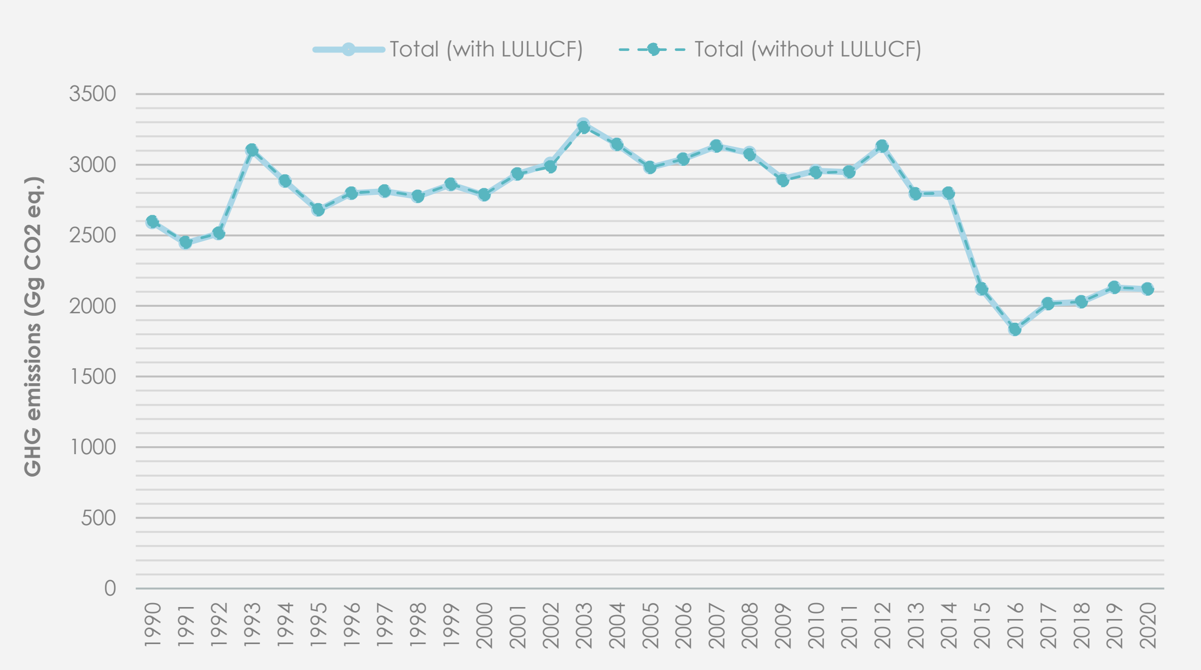


Figure 3-3 Total Emissions of greenhouse gases, with and without LULUCF, for 1990 – 2015. Note: The difference between these categories is very small and is not clear in the graph.

The year-on-year increases (or decreases) in the overall emissions (with-LULUCF) are illustrated in Figure 3-4. It reflects the overall trend in total emissions as shown in Figure 3-3, for the years up to and including 2020. 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 2014-2015 (-24.24%) and 2015-2016 (-13.53%) to the extent that they are also significantly larger than any year-on-year change observed in previous years. The highest increase in year-on-year emissions can be observed for the years 1992-1993 (23.42%).

Figure 3-4 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 onwards, as shown in Figure 3-5. This reduction has been reflected in per capita emissions, whereby 2016 has seen the lowest per capita emissions since the base year (1990).

In 1990, the per capita emissions stood at 7.16 tCO2eq. During the period 1990 – 2012, per capita emissions fluctuated between a maximum of 8.31 tCO2eq. (1993) and a minimum of 6.68 tCO2eq. (1991). However, this trend was reversed in 2013, where emissions started decreasing from 6.51 tCO2eq. (in 2013), while population started rapidly increasing. Per capita emissions plummeted to 3.98 tCO2eq. in 2015, where they remained relatively constant until 2020 (4.11 tCO2eq.). The level of per capita emissions in 2016 is the lowest since 1990 and stood at 3.98 tCO2eq. per capita.

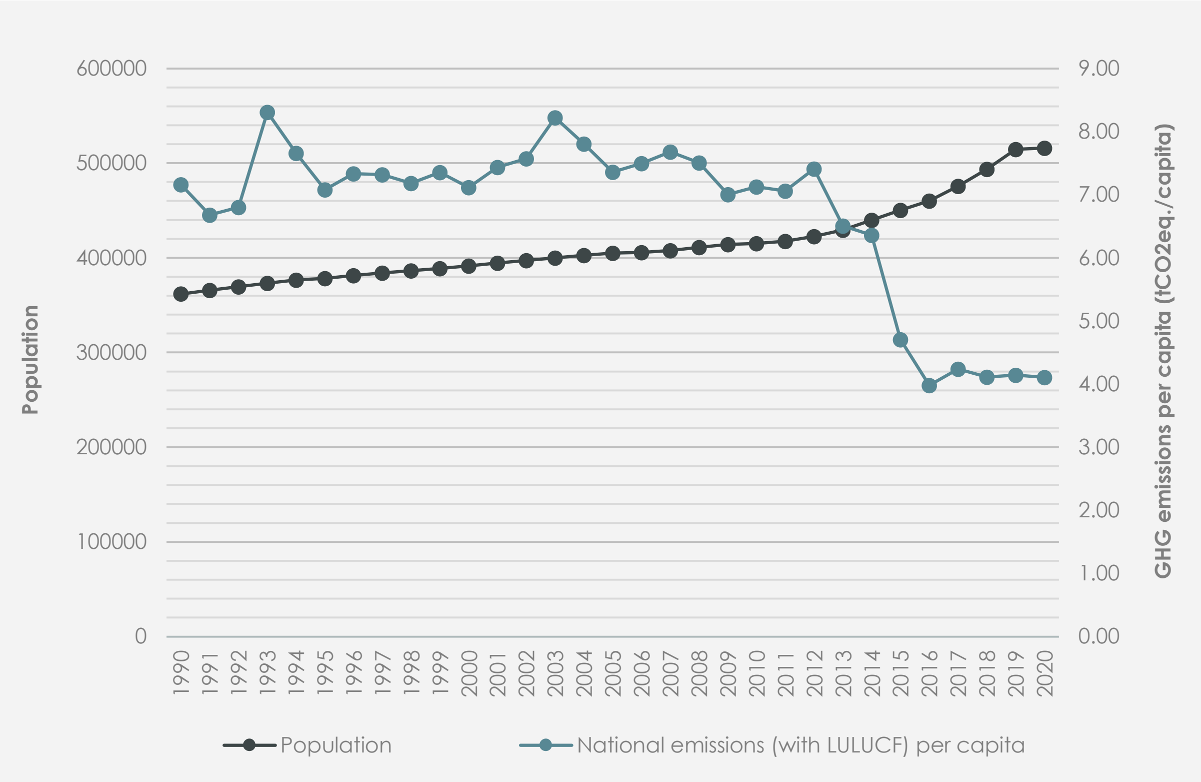


Figure 3-5 GHG emissions per capita [Source of population data: Eurostat].

This decoupling between GHG emissions and population in the later years implies that population statistics alone cannot directly explain the changes in GHG emissions over the whole period under consideration. However, it could be that greater demand for major emitting activities in Malta, particularly energy generation and mobility (road transport), as population grew, could have contributed to increasing emissions at least until 2012, as these activities have been the major contributors to overall national total emissions in absolute terms. But it is true to say that, up to this point, a fast-increasing population has not precluded emissions reductions.

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. 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, in particularly, electricity generation, the biggest contributor to national GHG emissions, as well as a push to a more service-based economy, which is associated with less emissions compared to economic output, replacing relatively energy intensive manufacture of earlier periods.

Table 3.2 GHG emissions per unit of GDP (tCO2 eq./GDP) at 5-year intervals (with/without LULUCF).

	1990	1995	2000	2005	2010	2015	2020
Emissions/GDP (with LULUCF)	942.42	875.36	670.46	577.60	433.71	211.93	162.28
Emissions/GDP (without LULUCF)	945.39	876.70	671.68	577.71	432.08	212.31	162.45

Figure 3-6 Trend in emissions per GDP compared to GDP trend

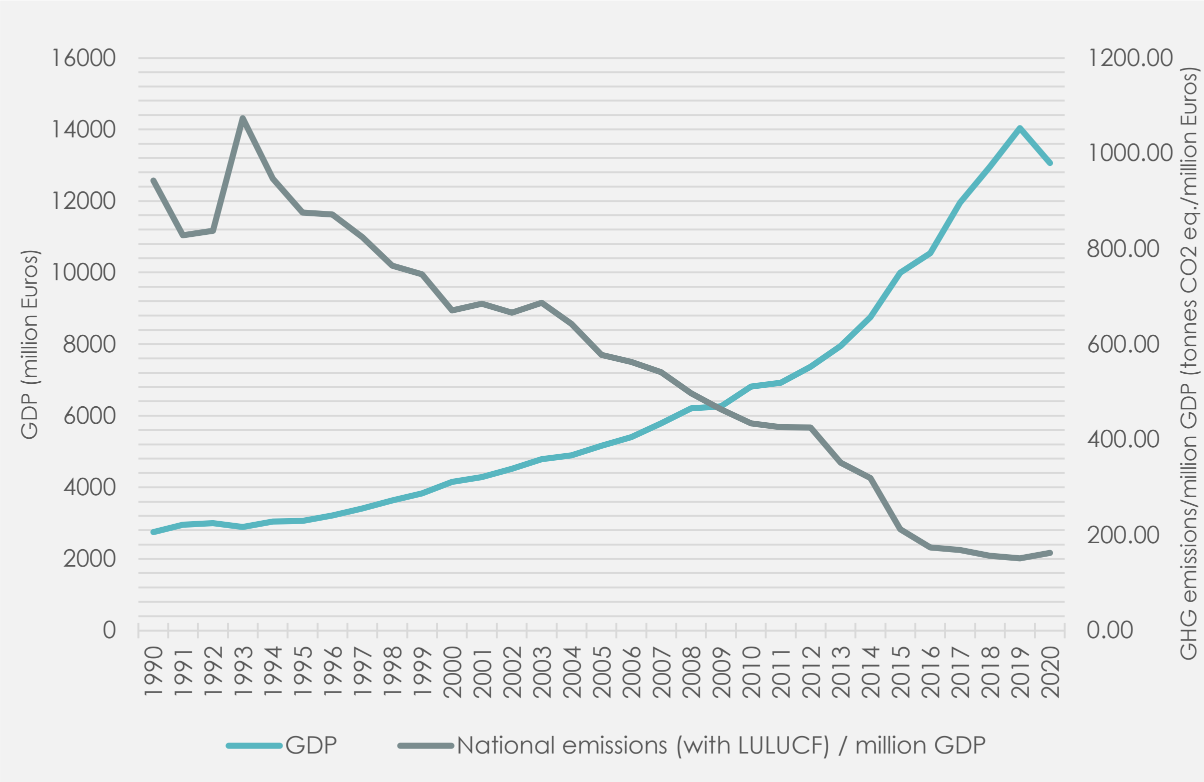


Figure 3-6 (and Table 3.2) shows how GHG emissions per unit million GDP changes over the 1990-2020 time-series. Figure 3.5 below also gives the trend for GDP. Overall, apart from the years 1990 to 1995, the trend is a continuous decrease in the emissions intensity of Malta's economy. Between 1990 and 2020, Malta's GDP saw an overall increase of 375%, while GHG emissions per unit million GDP in 2020 were 82.8% lower than in 1990.

While overall GDP has been decoupled from total emissions, some industries still show a correlation with GDP, whose emissions have continued to grow in line with GDP over time. This is mainly seen in the transport and IPPU sectors, and is significantly so when international bunkers, (which includes international maritime and aviation emissions) are included in the assessment. Figure 3-7 shows this correlation; GDP and emissions were scaled, relative to their own average, to obtain a clearer comparison of the two.

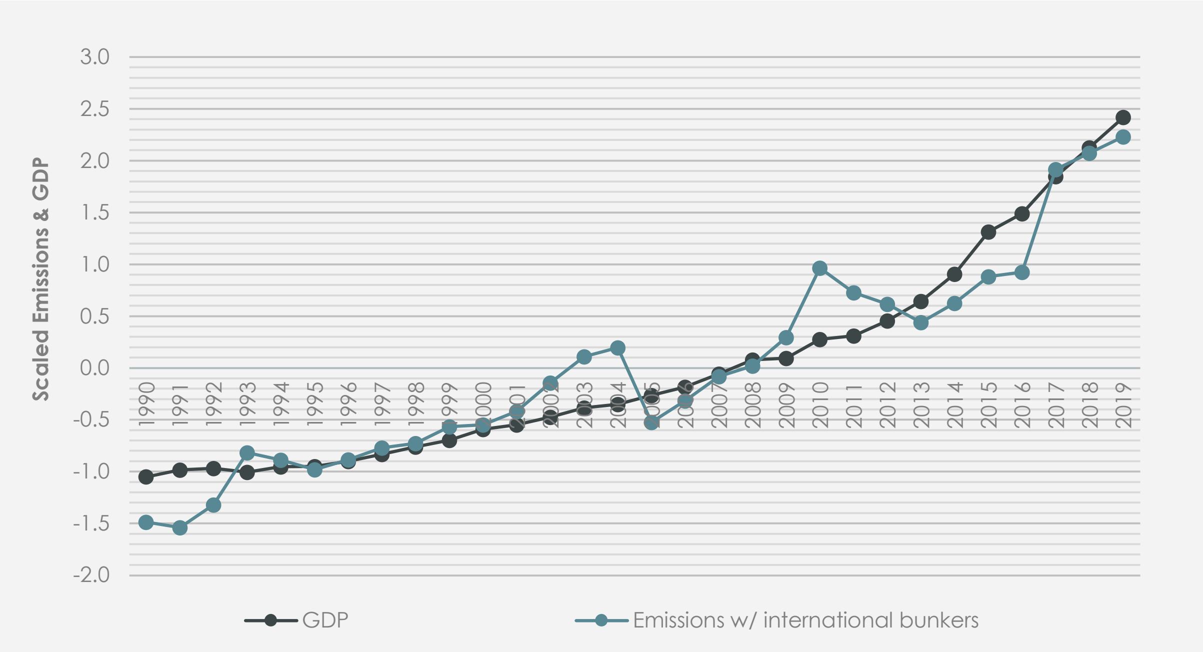


Figure 3-7 GDP vs national emissions including international bunkers (standardised) from 1990-2019 [Source of GDP data: Eurostat].

Therefore, while overall, decoupling has been managed through policy intervention, this will need to continue in earnest to counteract the potential impact of sectors where decoupling is not yet seen, in order to maintain an emissions decoupled economy in future.

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 3.3 below. Table 3.4 provides an overview of the changes in emissions between the latest year covered by this inventory and the base year 1990.

Table 3.4 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 3-8 and Figure 3-9. 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 3.3 Greenhouse gas emission trends by gas for 1990-2020 (Gg CO_2 equivalent).

	1990	1995	2000	2005	2010	2015	2020
CO2	2385.86	2435.10	2502.02	2643.89	2600.14	1661.32	1597.28
CO2 (without LULUCF)	2394.19	2439.42	2507.26	2644.67	2589.13	1665.29	1599.58
CH4	125.21	157.25	190.46	219.56	147.76	171.09	193.81
CH4 (without LULUCF)	125.19	157.23	190.44	219.54	147.76	171.09	193.81
N2O	80.04	84.52	84.01	76.60	65.36	55.64	55.58
N2O (without LULUCF)	79.89	84.32	83.85	76.40	65.20	55.51	55.47
HFC	0.00	0.00	6.70	38.36	141.07	230.25	272.34
PFC	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	0.01	1.44	1.47	1.56	1.79	0.28	0.40
National (with LULUCF)	2591.13	2678.31	2784.67	2979.97	2956.11	2118.58	2119.41
National (without LULUCF)	2599.28	2682.41	2789.72	2980.54	2944.94	2122.41	2121.59

[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)]

Table 3.4 Emissions of greenhouse gases by gas for the years 1990 and 2020 (Gg CO_2 equivalent).

	1990			2020			**% Change in emissions (1990-2020)**
	Emissions	% Share (without-LULUCF)	% Share (with-LULUCF)	Emissions	% Share (without-LULUCF)	% Share (with-LULUCF)	
CO2	2,385.86	-	92%	1597.28	-	75%	-33%
CO2 (without LULUCF)	2,394.19	92%	-	1599.58	75%	-	-33%
CH4	125.21	-	5%	193.81	-	9%	55%
CH4 (without LULUCF)	125.19	5%	-	193.81	9%	-	55%
N2O	80.04	-	3%	55.58	-	3%	-31%
N2O (without LULUCF)	79.89	3%	-	55.47	3%	-	-31%
HFC	0.00	0%	0%	272.34	13%	13%	
PFC	0.00	0%	0%	0.00	0%	0%	
SF6	0.01	0%	0%	0.40	0%	0%	3684%
National (with LULUCF)	2,591.13		100%	2119.41		100%	-18%
National (without LULUCF)	2,599.28	100%		2121.59	100%		-18%

[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)]

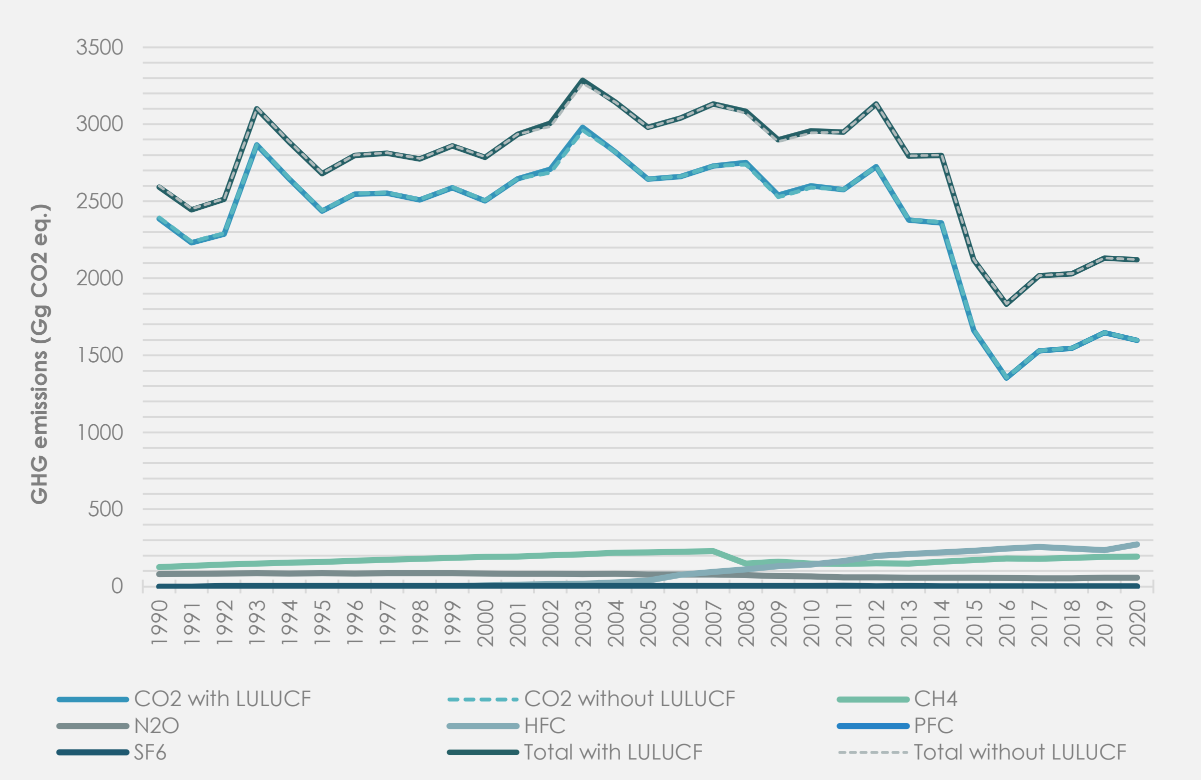


Figure 3-8 Emissions of greenhouse gases by type of gas, including LULUCF, for 1990 – 2020.

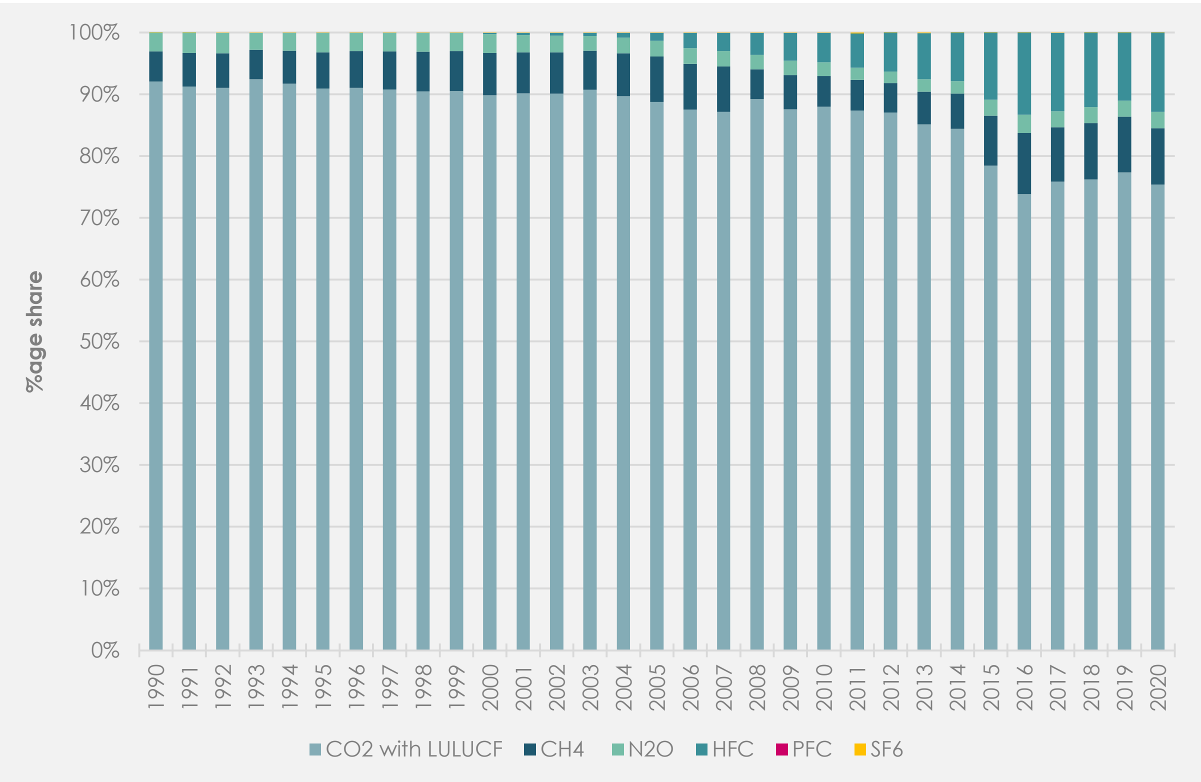


Figure 3-9 Percentage contribution of each greenhouse gas to total national greenhouse gas emissions (with-LULUCF).

3.4.2 Carbon dioxide

The overall profile of carbon dioxide emissions by sources and removals by sinks is presented in Figure 3.8. 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.

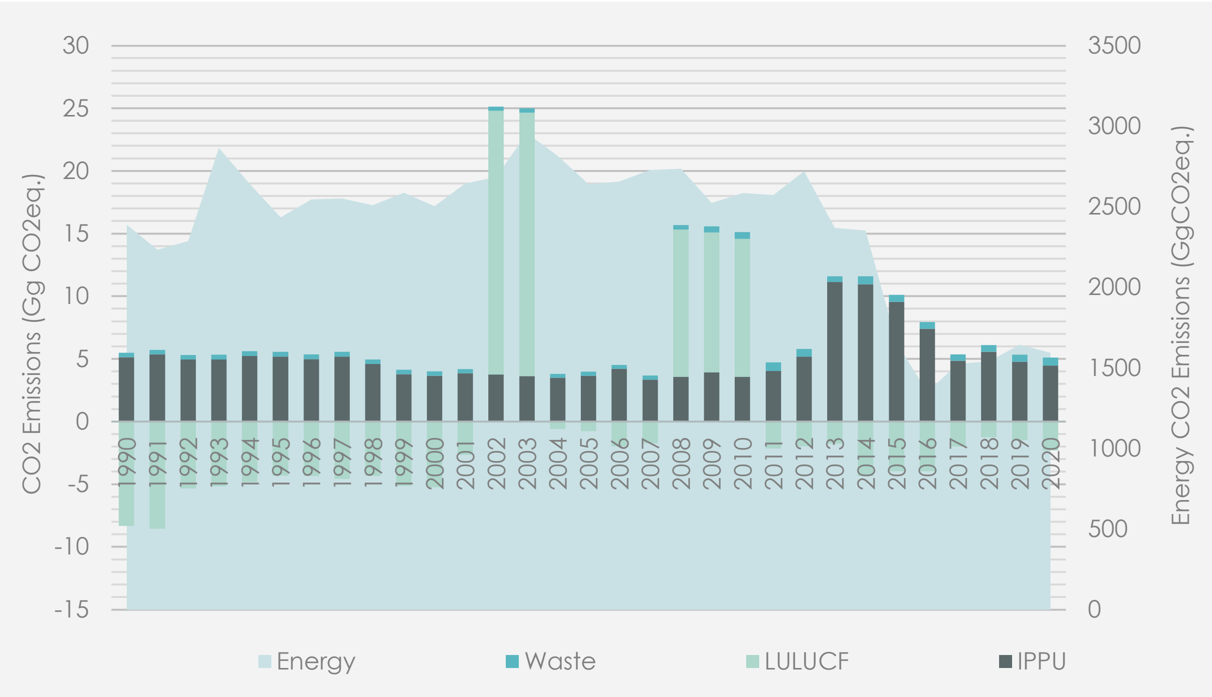


Figure 3-10 Trends in emissions by sources and removals by sinks for carbon dioxide.

(CO2 emissions from Waste, LULUCF and IPPU are shown on the primary y-axis, while CO2 emissions from Energy are shown on the secondary y-axis).

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 3-9).

Figure 3-11 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 (3A) and Manure Management (3B). Estimated absolute emissions of methane from this sector peaked in 1992, with estimated emissions in 2017 being the lowest recorded since 1990.

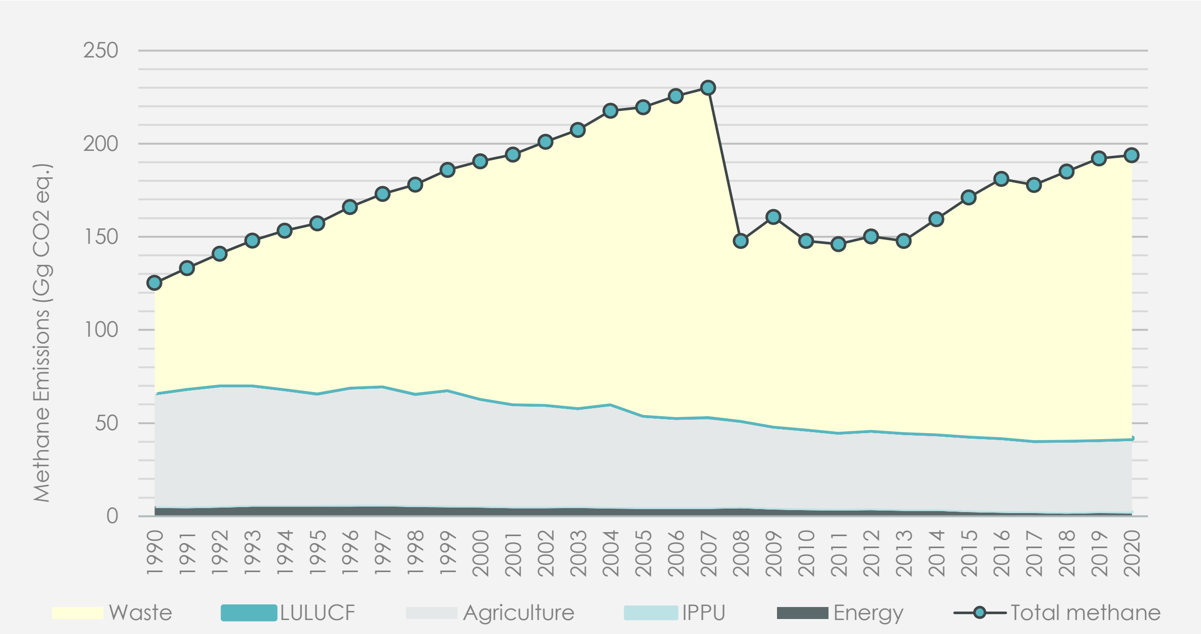


Figure 3-11 Trend in total and sectoral emissions of methane.

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 3-9).

Figure 3-12 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 3-13) 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.

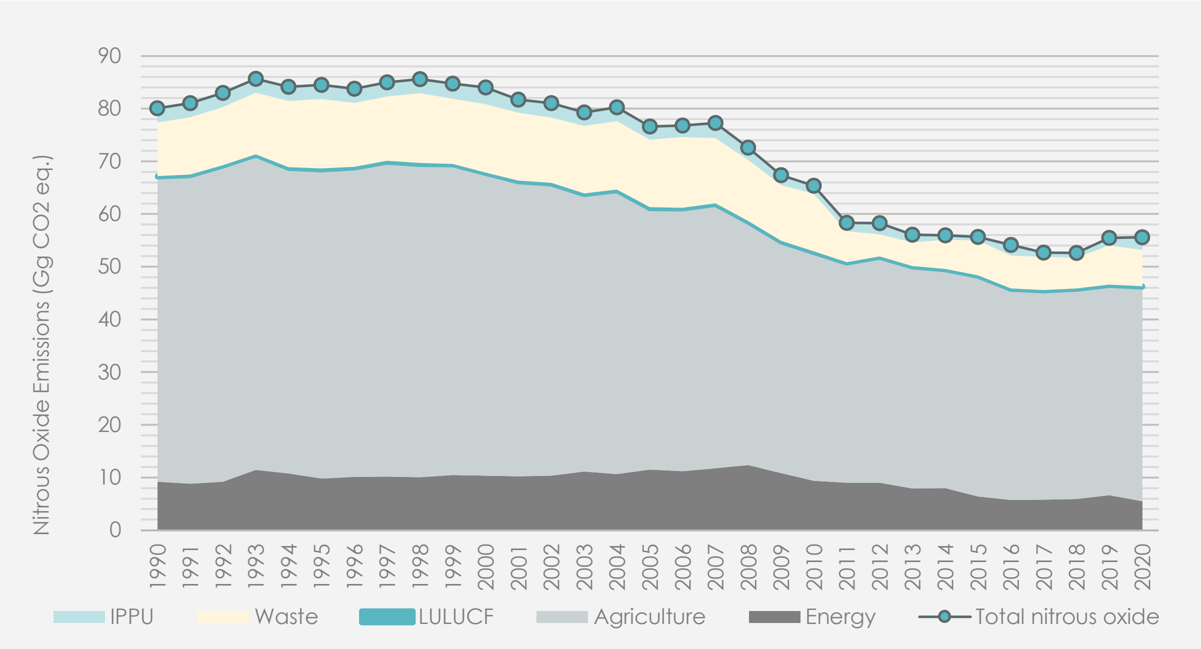


Figure 3-12 Trends in total and sectoral emissions of nitrous oxide.

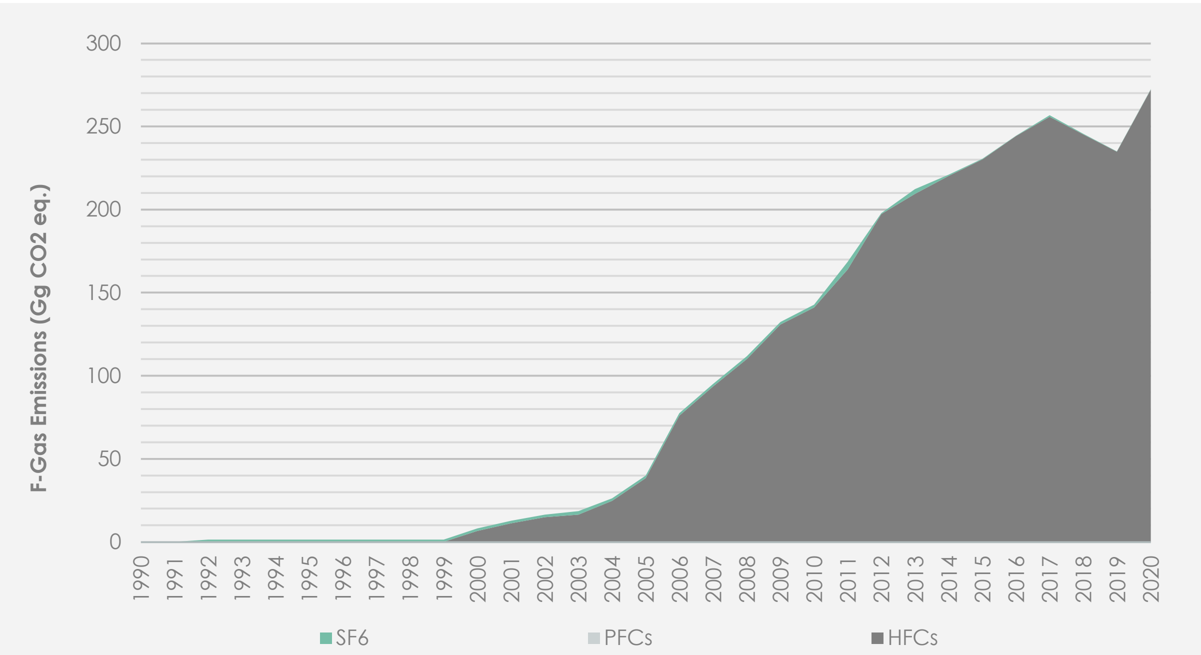


Figure 3-13 Trends in emissions of fluorinated greenhouse gases.

3.4.6 Indirect greenhouse gases

Emissions of indirect greenhouse gases are illustrated in Figure 3-14.

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).

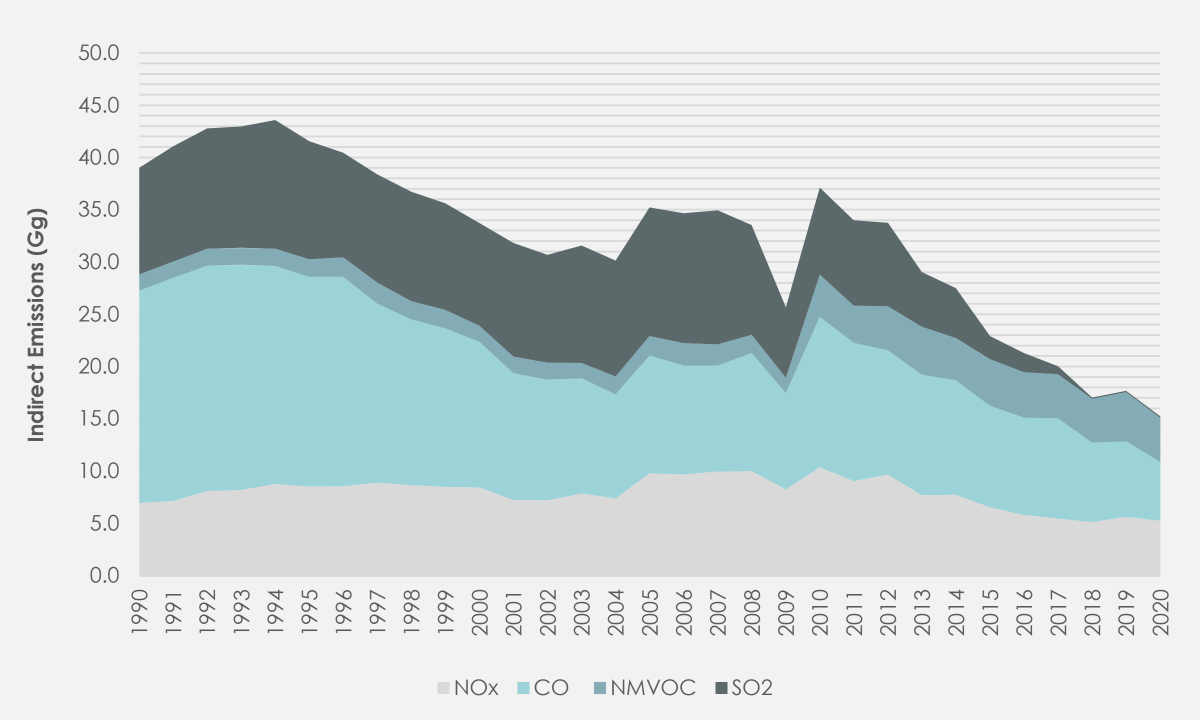


Figure 3-14 Emission trends for indirect greenhouse gases.

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 over the time series concerned are presented in Table 3.5 and illustrated in Figure 3-16 and Figure 3-17.

Table 3.5 Emissions of greenhouse gases by sector for the years 1990 to 2020 (Gg CO_2 equivalent).

	Energy	IPPU	Agriculture	LULUCF	Waste	Total with LULUCF	Total without LULUCF
				Gg CO2 eq.			
1990	2403.14	7.78	119.07	-8.15	69.30	2591.13	2599.28
1995	2449.55	9.29	119.04	-4.10	104.53	2678.31	2682.41
2000	2519.12	14.99	115.41	-5.05	140.20	2784.67	2789.72
2005	2657.05	46.03	99.11	-0.56	178.34	2979.97	2980.54
2010	2598.51	147.96	86.21	11.17	112.26	2956.11	2944.94
2011	2585.43	174.13	83.08	-2.00	107.31	2947.95	2949.95
2012	2733.55	205.18	85.04	-1.81	108.62	3130.58	3132.39

	Energy	IPPU	Agriculture	LULUCF	Waste	Total with LULUCF	Total without LULUCF
			Gg CO2 eq.				
2013	2379.19	224.81	83.48	-1.63	107.68	2793.53	2795.16
2014	2364.46	232.78	82.25	-4.20	121.17	2796.46	2800.66
2015	1664.68	241.26	81.95	-3.84	135.05	2119.11	2122.95
2016	1356.84	253.84	79.65	-3.82	145.45	1831.96	1835.78
2017	1533.82	262.41	78.12	-1.88	143.70	2016.17	2018.05
2018	1549.09	252.06	78.44	-1.14	150.43	2028.87	2030.01
2019	1653.05	241.25	78.58	-1.37	158.87	2130.39	2131.76
2020	1602.33	279.62	80.24	-2.18	159.41	2119.41	2121.59

The overall impact that the Energy sector has on total national emissions has already been mentioned. In recent years, emissions of this sector have started to decrease in general. On the other hand, emissions from the IPPU sector, strongly represented by emissions of HFCs, are showing a substantial rate of increase, particularly since 2000. The relative share of emissions of IPPU has therefore grown compared to those of the Energy sector as shown in Figure 3-15. The table below provides a summary of the percentage contribution of Malta's total GHG emissions by sector for the reporting year 2020.

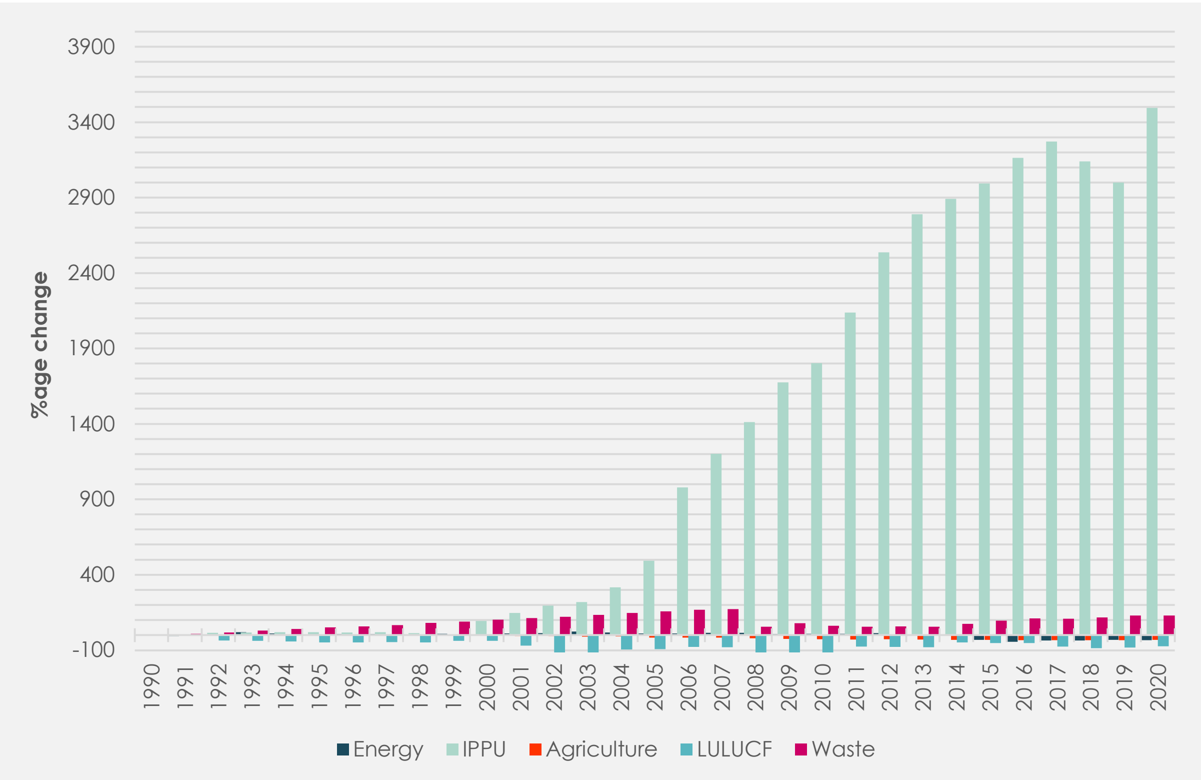


Figure 3-15 Annual Percentage change compared to 1990, by sector.

The most obvious feature that comes out of Figure 3-16 and Figure 3-17 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.

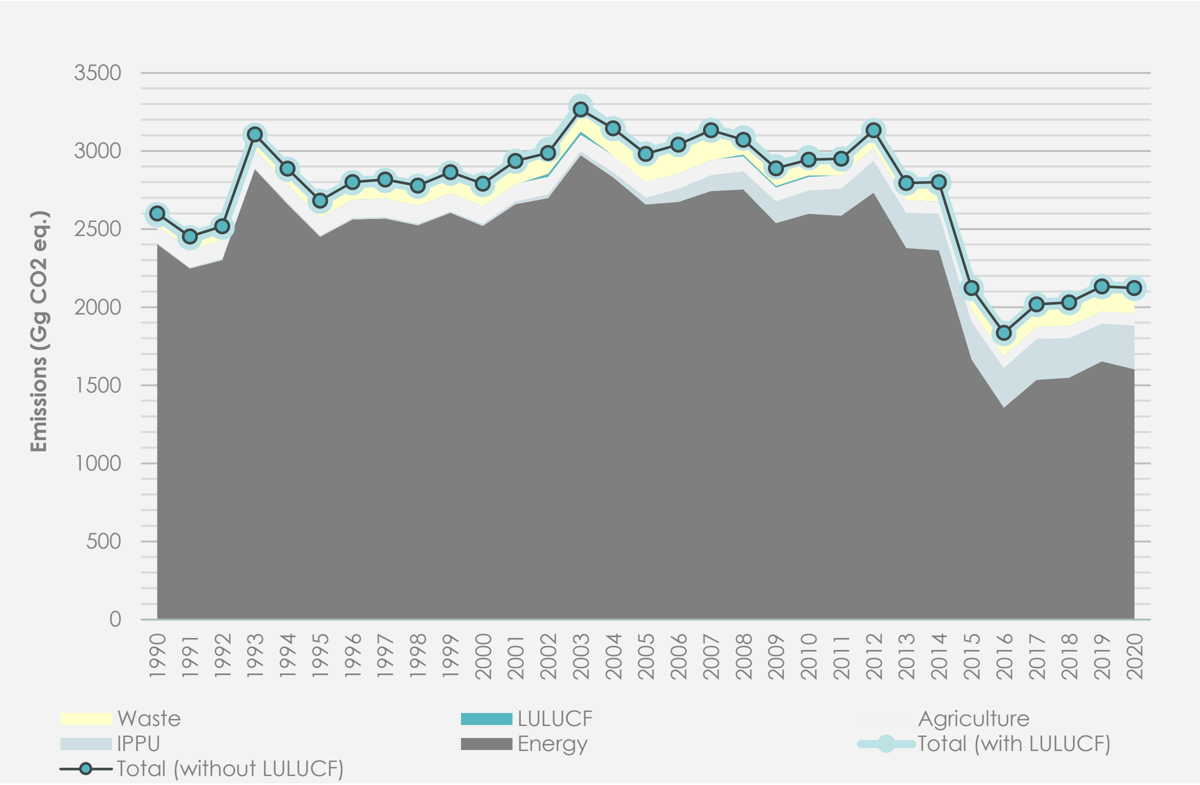


Figure 3-16 National total greenhouse gas emission trends (total; by sector)

Overall sectoral trends as a percentage change between year 1990 and year 2020 are provided in Figure 3-17. 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.

Table 3.6 Emissions of greenhouse gases by sector for the years 1990 and 2015 and the corresponding change between the two years (Gg CO2 equivalent).

	1990			2020			% Change in emissions (1990-2020)
	Emissions $GgCO_2eq.$	% Share (without-LULUCF)	% Share (with-LULUCF)	Emissions $GgCO_2eq.$	% Share (without-LULUCF)	% Share (with-LULUCF)	
Energy	2,403.14	92%	93%	1,602.33	76%	76%	-33%
Industrial Processes and other product use	7.78	0%	0%	279.62	13%	13%	3494%
Agriculture	119.07	5%	5%	80.24	4%	4%	-33%
LULUCF	-8.15		0%	-2.18	0%	0%	-73%
Waste	69.30	3%	3%	159.41	8%	8%	130%
Total (with LULUCF)	2591.13		100%	2119.41	100%	100%	-18%
Total (without LULUCF)	2599.28	100%		2121.59	100%	100%	-18%

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.

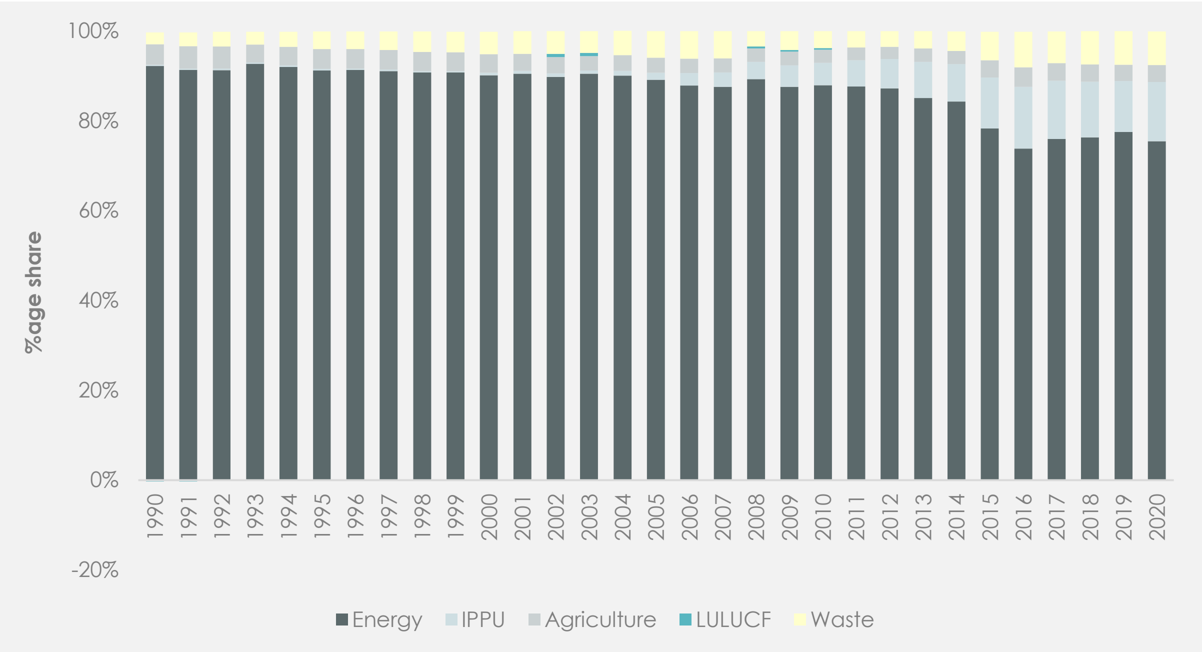


Figure 3-17 Annual percentage share of national emissions for each sector.

3.5.1 Energy (CRF sector 1)

The trend profile for the Energy sector can be split into two main sub-trends, namely a general increase in emissions up to 2012, followed by a rapid decrease over the space of the subsequent few years until 2016, with emissions growing again in 2017. As estimated for year 2020, the energy sector contributes to 75.60% of Malta's total GHG emissions.

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

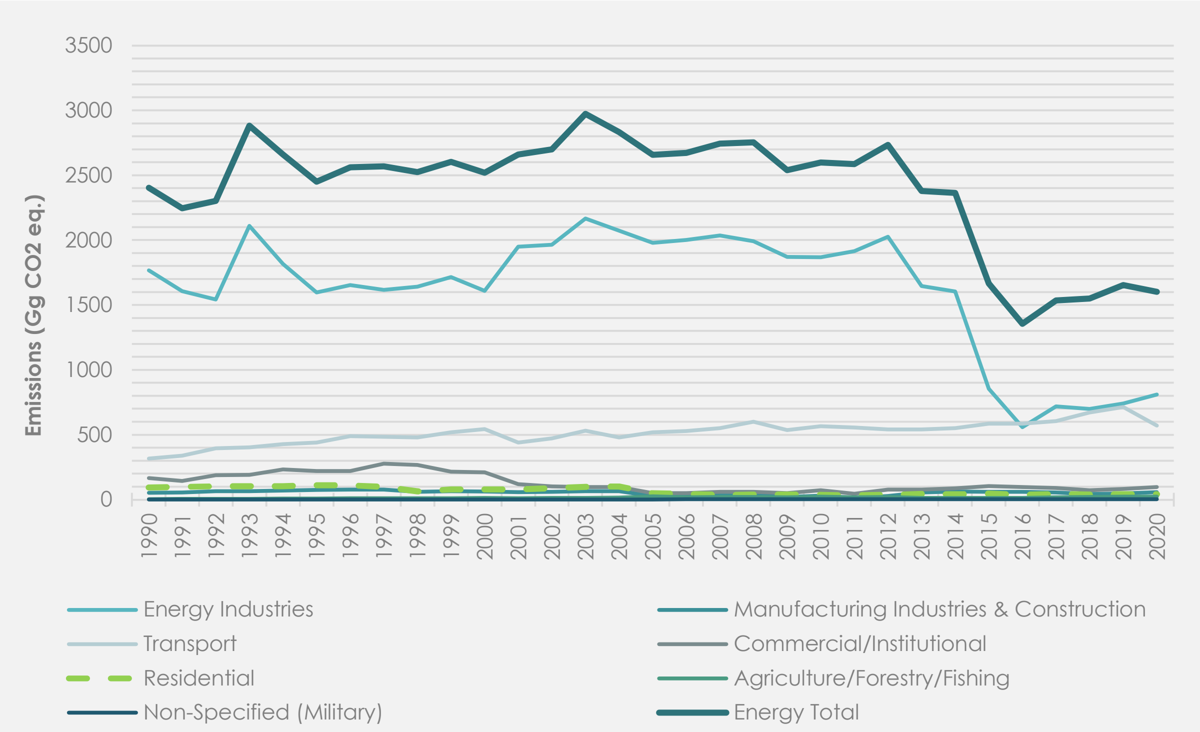


Figure 3-18 Emission trends for sector Energy

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

Emissions from the Transport category (1.A.3) include road transportation, civil aviation and national navigation within the Maltese Islands. Emissions estimated from International Bunker activities are considered as "Memo Items" and are not considered in terms of Malta's emissions of greenhouse gases. These memo items refer to fuels used for international marine navigation and for international aviation purposes that are combusted outside of Maltese territory, territorial waters, or airspace respectively. This category also includes CO_2 emitted from biofuel used for 1.A.3.b.i Cars, 1.A.3.b.ii Light-Commercial Vehicles, 1.A.3.b.iii Heavy Duty Vehicles and buses and for 1.A.3.d Domestic Navigation (thus such emissions are excluded from the respective categories).

The contribution of the transport sector towards total national emissions in recent years is comparable to that of category Energy Industries. In general, Transport emissions show a sustained gradual increase over the whole time series (Figure 3-18). In 2020 a decrease of 20% in total transport emissions, compared to 2019, was observed mainly due to the covid-19 pandemic.

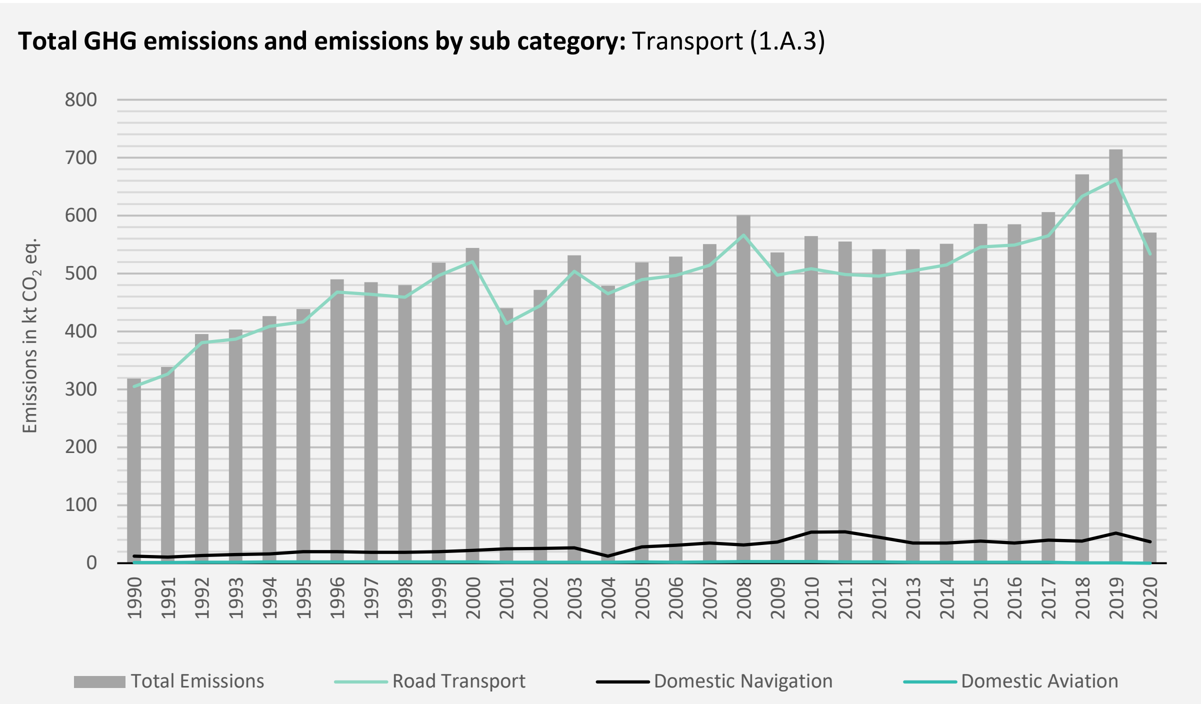


Figure 3-19: Total Greenhouse gas emissions (Transport 1.A.3)

Table 3.7 Total GHG emissions in kt CO_2 eq from category 1.A.3-Tranport

1.A.3 Transport											
GHG Source Category	**Greenhouse Gas Emissions (in kt CO_2 eq.)**										
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
1.A.3. Transport	**318.45**	**438.63**	**544.17**	**519.39**	**564.52**	**585.46**	**585.25**	**606.15**	**671.39**	**714.37**	**570.59**
a. Domestic Aviation [a]	1.21	2.04	2.08	1.87	2.71	1.44	1.73	1.69	0.55	0.27	0.15
b. Road Transportation [a,c]	305.23	416.61	520.36	489.51	508.05	546.02	549.07	564.92	632.82	662.49	533.37
Passenger Cars	211.54	269.81	329.24	309.95	331.40	365.74	371.08	379.07	405.96	432.01	355.84
Light-Duty Vehicles	37.37	59.35	72.33	67.08	74.81	70.99	73.97	76.59	92.53	94.58	73.16
Heavy Duty Vehicles & Buses	52.04	79.50	112.03	108.40	98.88	106.00	100.34	105.33	130.08	131.41	100.58
Motorcycles	4.28	7.95	6.76	4.09	2.96	3.29	3.68	3.92	4.25	4.49	3.78
c. Railways	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
d. Domestic Navigation [a,b]	12.02	19.98	21.73	28.00	53.75	37.99	34.46	39.54	38.02	51.61	37.07
e. Other Transportation (Off-Road)	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Notes:

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

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

c.) Includes off-road emissions.

Sub-category Road Transport (1A3b) is by far the biggest contributor to national total emissions among the three Transport sub-categories mentioned above. This reflects primarily the continued growth in the number of road vehicles. The bulk of emissions from the Transport sector are carbon dioxide; in 2020, emissions of methane and nitrous oxide for this sector accounted for 0.17% and 0.65% respectively. Figure 3-20 shows the emissions by gas for road transportation for the period 1990-2020.

The trend of road transport emissions has increased proportionally with the increase in Malta's car fleet. The stock of licenced vehicles in Malta stood at 402,427 by Q4 of 2020. According to a National Statistics Office News Release entitled 'Motor Vehicles: Q4/2020', a total of 5,373 newly licensed vehicles were added to Maltese roads in 2020 with the majority or 70% being passenger cars.

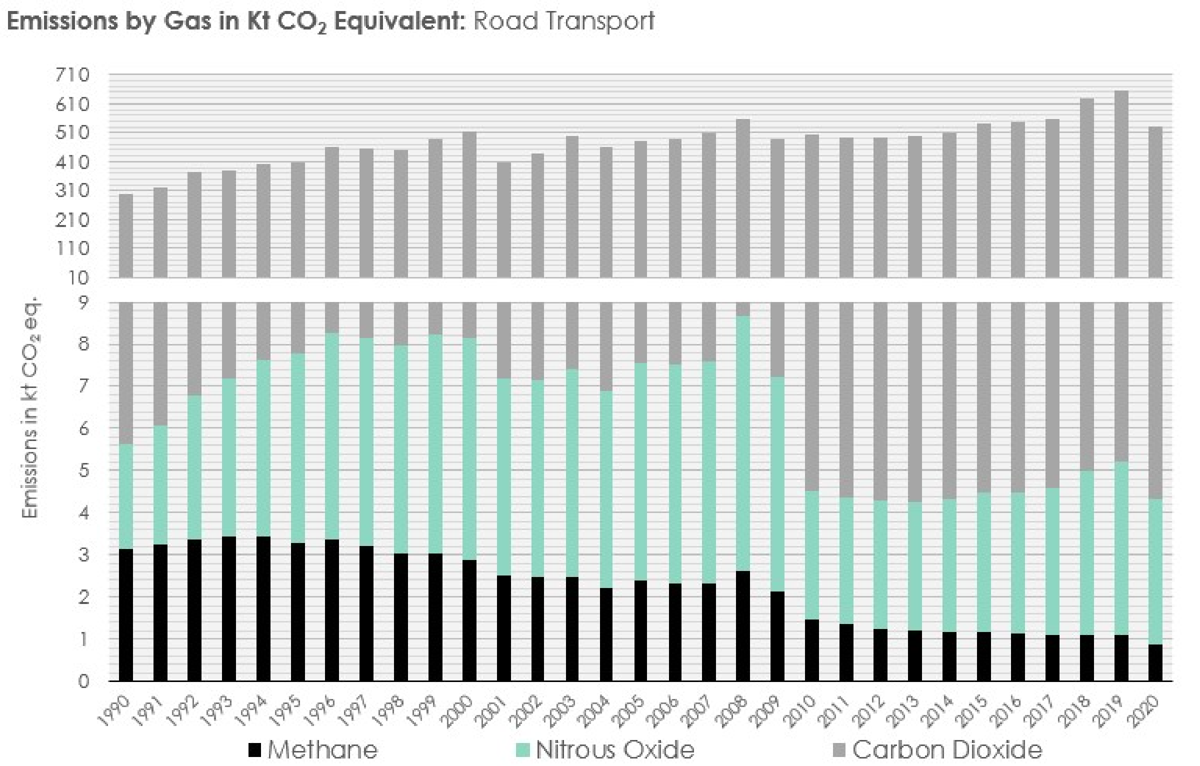


Figure 3-20: Greenhouse gas emissions by Gas (Road Transport)

The total emissions arising from domestic navigation in 2020 was 37 kt of CO_2 eq. (6.5% of total transport emissions). This sub-category includes all GHG emissions from domestic marine transport (including boats, yachts, pleasure craft, jet skis) and passenger ferries. Emissions from fuel-consumed by fishing vessels are not included under this category. Emissions from domestic navigation are presented in Figure 3-21.

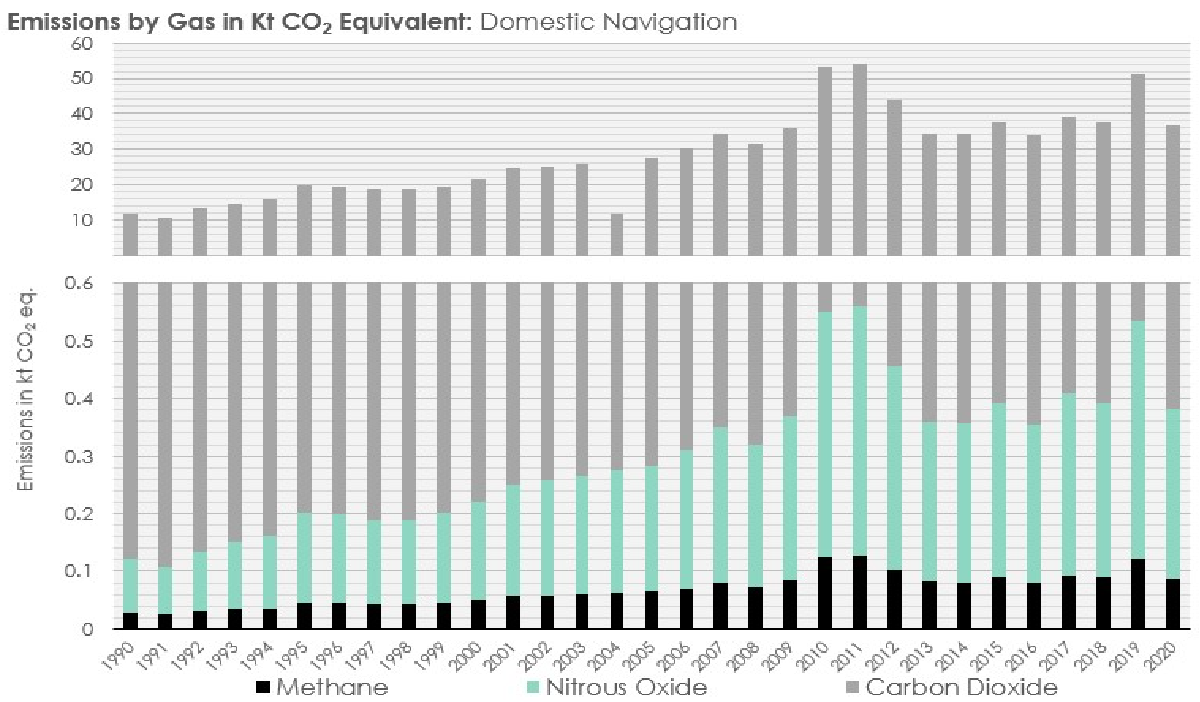


Figure 3-21: Greenhouse gas emissions by Gas (Domestic Navigation)

Domestic Aviation is a very small contributor to the total transport emissions, accounted for 0.15 kt of CO_2 eq. in 2020. Emission by gas for domestic aviation are presented in Figure 3-22.

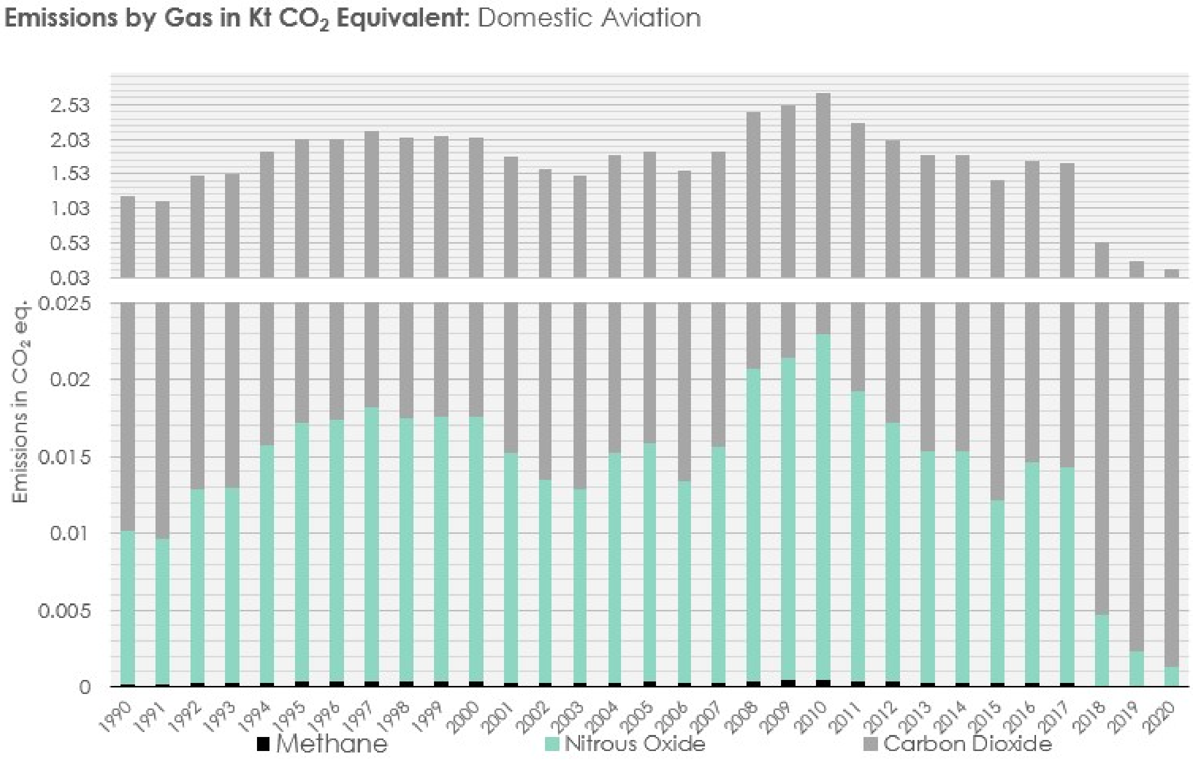


Figure 3-22: Greenhouse gas emissions by Gas (Domestic Aviation)

3.5.2 *INDUSTRIAL PROCESSES AND OTHER PRODUCT USE (IPPU; CRF SECTOR 2)*

The trend profile for sector IPPU (Figure 3-23) is clearly dominated by the emissions trend of HFCs, particularly from category Refrigeration and Air-conditioning (CRF 2.F.1). Emissions of HFCs, and, consequently, IPPU emissions, have increased from the early 2000s. The main contributor towards HFC emissions, category Refrigeration and Air-conditioning, accounted for 94.64% of all direct greenhouse gas emissions estimated for the IPPU sector in 2020. Emissions from other industrial processes are minimal or even non-existent, considering the nature of the industrial sector in Malta, where industrial activities found in other countries either do not exist or only take place at very small scales.

The emissions contribution from the IPPU sector to the total national GHG emissions in Malta amounted to 13.19% in 2020.

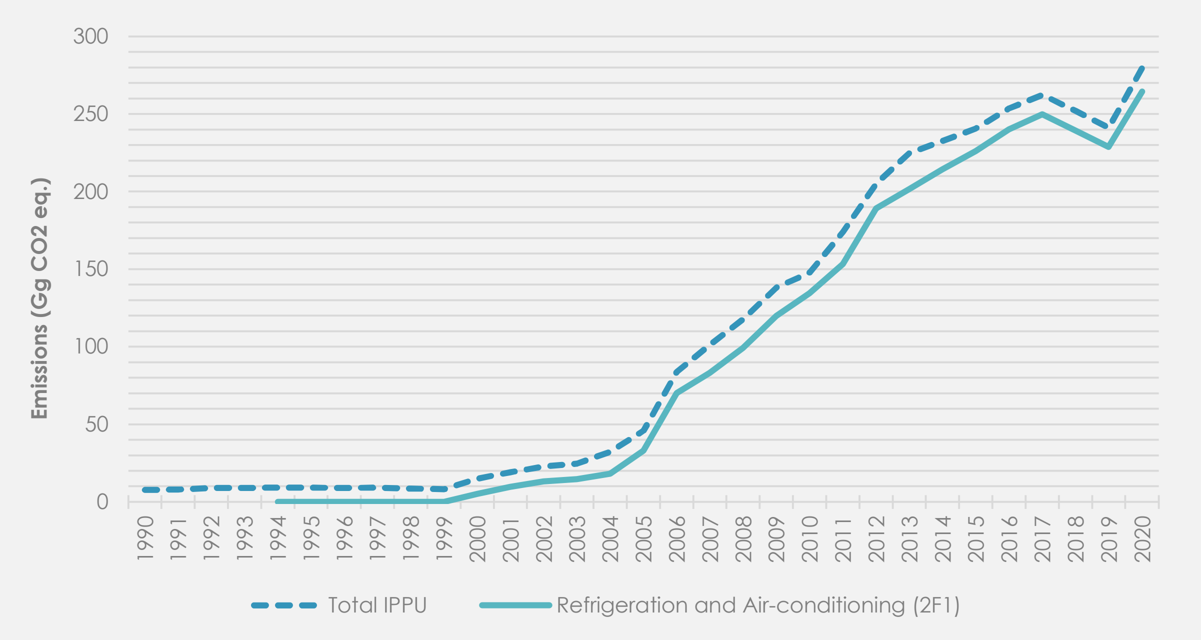


Figure 3-23 Emission trends for the sector IPPU

3.5.3 Agriculture (CRF sector 3)

In general, the agriculture sector is certainly not a major contributor towards total national emissions. The trend in emissions is highly influenced by changes in livestock population and land, as described in section 2.12. The sector has seen a decrease in emissions of around 33% over the 1990-2020 period. Within this sector (Figure 3-24) the category Enteric Fermentation (3A) has always had the highest share of total sector emissions. In 2020, Enteric Fermentation accounted for less than half of the agriculture emissions (43%) (Figure 3-25), while manure management accounted for 27% and agricultural soils accounted for 30% of total emissions. In agriculture only two gases are being reported, Nitrous oxide and methane. Methane emissions originate from enteric fermentation and manure management, while nitrous oxide emissions are emitted from manure management and agricultural soils.

Methane emissions accounted for 49% of total agriculture emissions, while nitrous oxide accounted for 51% respectively. Enteric fermentation accounted for 87% of total methane emissions, whereas those coming from the management of manure accounted for 13%. Manure management was responsible for 40% of nitrous oxide emissions, while 60% of N2O emissions originated from Agricultural soils.

GHGs from manure management and agricultural soils are emitted both directly and indirectly, the latter of which occurs through atmospheric deposition and through leaching and runoff. During 2020, indirect emissions from atmospheric deposition and leaching/runoff totalled to 6.50 GgCO2eq, while direct emissions amounted to 17.74 GgCO2eq. Although in the Maltese agricultural sector both inorganic (synthetic fertilizer) and organic fertilizer (animal manure) is applied to soils, animal manure is applied for the most part. In 2020, it estimated that around 2385528 KgN of animal manure were applied per hectare, while 586140.09 KgN of synthetic fertilizer were applied per hectare, equating to a total of 13.92 GgCO2eq.

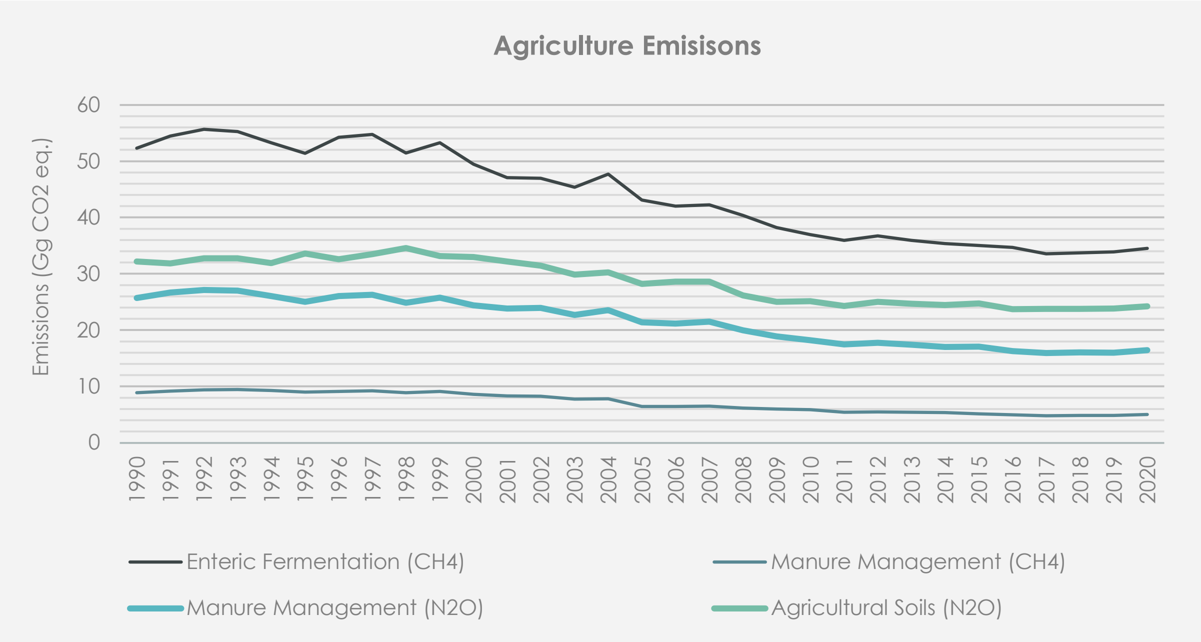


Figure 3-24 Emissions from Agriculture.

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

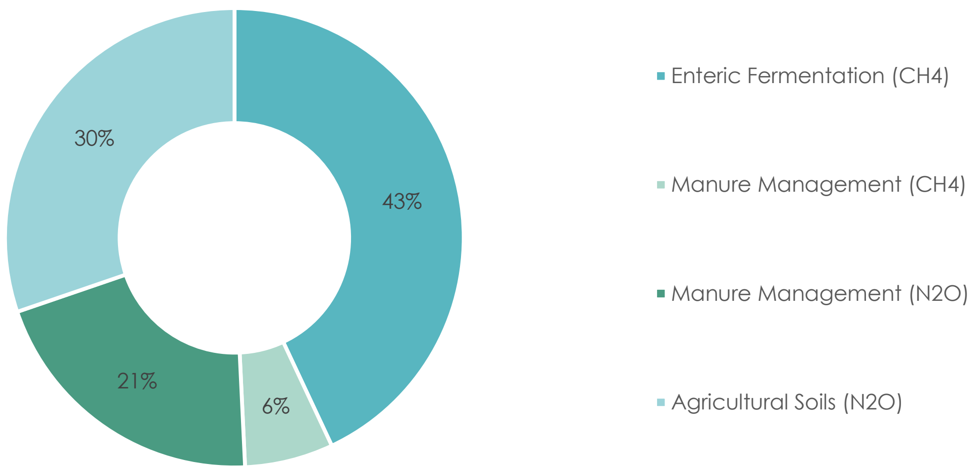


Figure 3-25 Percentage share of agriculture emissions by gas and category.

Methodological and activity data changes took place in the agriculture sector since the NC7, which have resulted in a change in the emissions. Methodological changes were due to the revision to 2019 IPCC Refinements and data gap filling methodology changes. On the other hand, changes in the data occurred for livestock heads and other characteristics. In the 2023 submission of the inventory more recalculations have been done given that a consultation with NSO was carried out upon comparing livestock head data form 4 different sources that did not match and the availability of fertilizer application data becoming available. For more information on recalculations, please refer to the 2022 and 2023 submissions of Malta's National GHG Inventory.

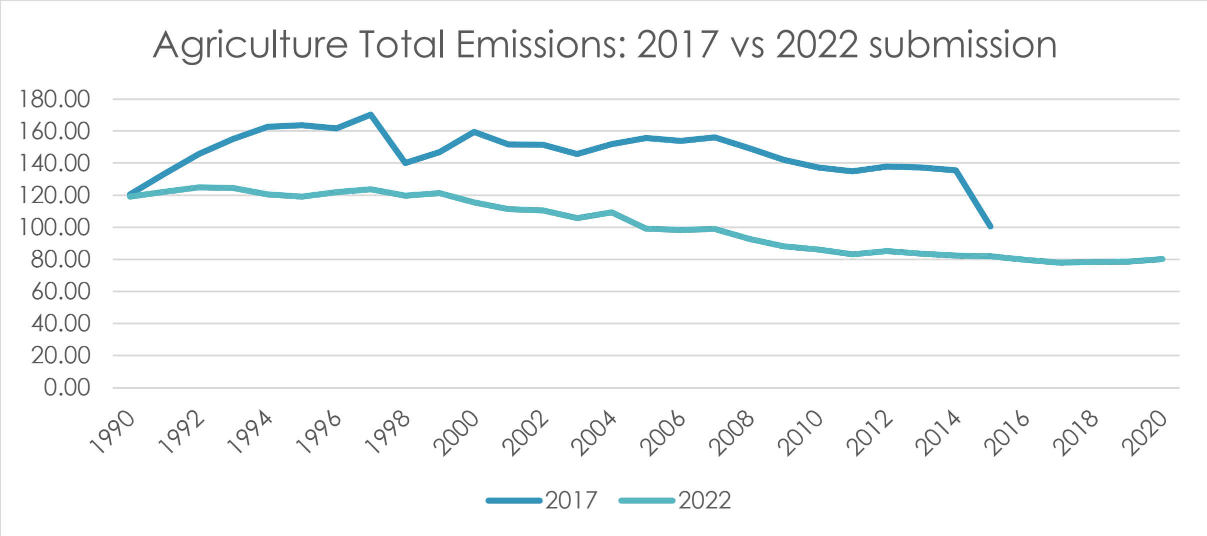


Figure 3-26. Comparison between 2020 and 2022 agriculture inventory.

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

For the latest submission, the LULUCF sector has undergone updates with regards to the land use matrix, to better represent the land use representation, in view of the addition of estimates in the Forest Land and Wetland categories. Moreover, the methodology related to biomass was revised to address a recommendation for an issue which was raised in the Centralized Review of the 2021 annual submission of Malta. As a result of these updates, the estimations were recalculated for the whole timeseries of the LULUCF sector.

The LULUCF sector is the lowest contributor to the total profile of the GHG Inventory of Malta. CO2 is the main greenhouse gas emission source and sink from the various categories. Non- CO2 emissions also occur in the sector including N2O and CH4. The sector trend in Malta represents a net removal of -8.15 ktCO2 eq. in 1990, decreasing to -2.182 ktCO2 eq. by 2020. The sector accounted for –0.10% of Malta's total GHG emissions in 2020.

CO2 is the main greenhouse gas emission source and sink from the various categories. Non- CO2 emissions also occur in the sector including N2O and CH4. From the figure one can notice the trend for Cropland varying throughout the years. This is mainly due to some large area conversions occurring in the Cropland sector, which lead to high emissions in certain years, where these Cropland areas are based on national statistics received and do vary from year to year. The spikes that are occurring in the estimations in the sector, to the category Land Converted to Cropland in some of the years, are due to the big annual changes occurring in Annual Cropland, where in some of the years, national statistics for 2001, 2003, 2005, 2007 and 2010 etc. are present, while assuming a linear interpolation for the years without data. Unfortunately, this presents an issue and is very challenging to solve, since getting rid of these spikes would mean changing national statistics data. Although the compilers are aware of these big annual changes, work is currently ongoing on the collaboration project with MCAST to acquire an improved land use representation data, and thus update the land use time series as necessary.

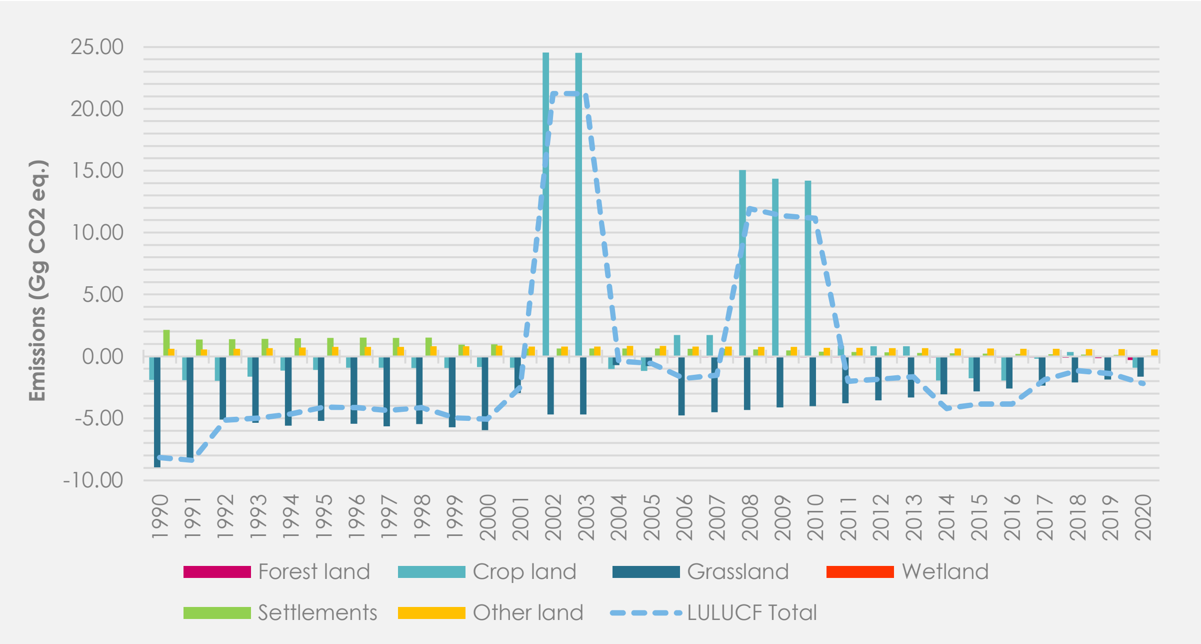


Figure 3-27 Emission Trends for sector LULUCF.

3.5.5 *WASTE (CRF SECTOR 5)*

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

In 2020, 91.26% of all sector Waste emissions were generated by the category Solid Waste Disposal (Figure 3.25). Methane emissions from this category are also the predominantly emitted greenhouse gas in this sector; emissions of nitrous oxide and carbon dioxide have relatively small shares of total sector emissions. In fact, a relatively large proportion of emissions reported are emitted from landfill operations.

As estimated for year 2020, the Waste sector contributes to 7.52% of Malta's total GHG emissions.

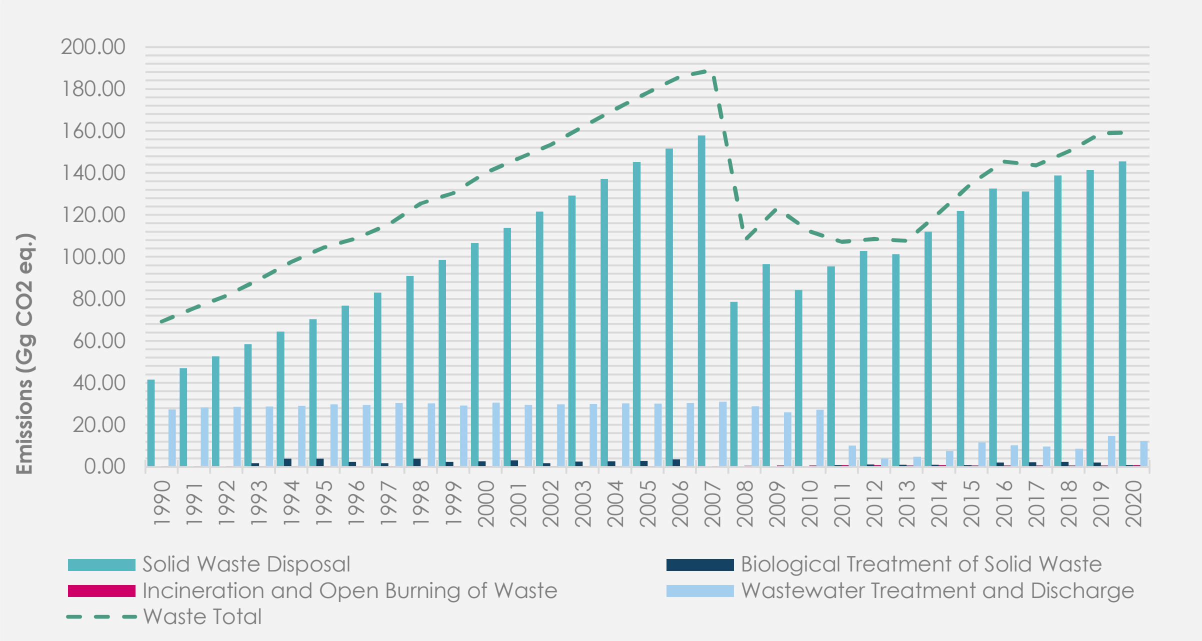


Figure 3-28 Emission trends for the Waste sector

As presented in Figure 3-29 below, the trend in the waste sector displays a growth of emissions throughout the period up to year 2007. However, a drastic decrease in emissions is manifest in year 2008, mainly in the Solid Waste Disposal on Land category (5.A). The reasons behind this abrupt change of trends are further explained in detail in the sector-specific sections describing the respective categories (refer to section 7.2). However, the rapid change can be summarised as the effect of the entry in operation of specific installations aimed at reducing emissions from these sectors. Nonetheless, and despite showing a number of year-to-year fluctuations, emissions from the waste sector continue to show a general increase over the years following 2009, mainly due to the continuation of landfilling practices.

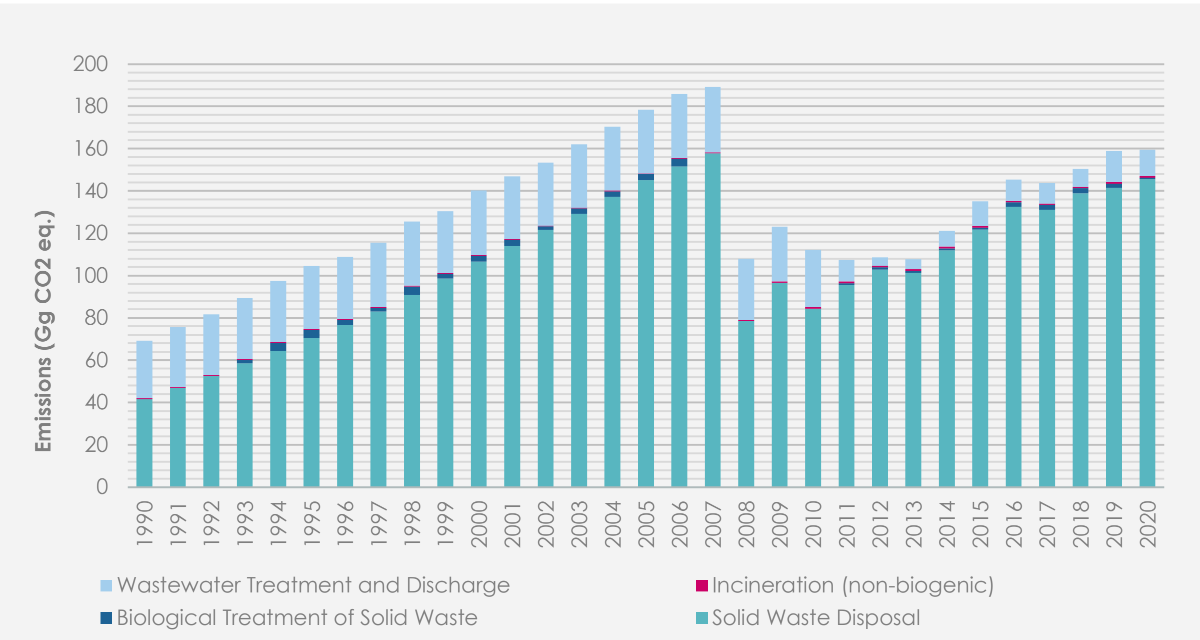


Figure 3-29 Total GHG emissions from waste management overview by activity for sector Waste.

Furthermore, Figure 3-30 below shows the contribution in carbon dioxide equivalents (CO2 eq.) of carbon dioxide, methane and nitrous oxide emissions in the latest inventory year. As shown, a large proportion of percentage share is from CH4 emissions resulting mostly from solid waste disposal on land category. SWD on land is then followed by methane emissions in wastewater treatment and discharge category, biological treatment of solid waste, and incineration. The second percentage share of emissions are N2O from wastewater treatment and discharge category and incineration, and then followed by CO2 emissions from incineration.

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

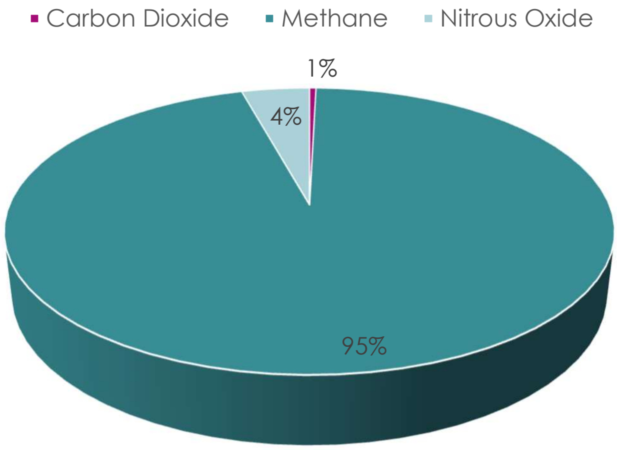


Figure 3-30 Share of emissions, by gas, for sector Waste (% share by gas, based on CO2 equivalents).

The direct greenhouse gases estimated for the waste sector, as presented in the inventory, are illustrated in Table 3.8 GHG emissions from the Waste sector. Table 3.8 below, including the base year (1990) and the reporting year (2020), according to the GHG emissions and the source category or sub-sector, as applicable.

Table 3.8 GHG emissions from the Waste sector.

		Year								
		1990	1995	2000	2005	2010	2015	2018	2019	2020
		Gg								
GHG	CO2	0.37	0.37	0.35	0.32	0.52	0.57	0.55	0.55	0.65
	CH4	2.35	3.64	5.08	6.61	4.03	5.11	5.76	6.03	6.08
	N2O	0.03	0.04	0.04	0.04	0.04	0.02	0.02	0.03	0.02
	Total	2.75	4.05	5.46	6.97	4.59	5.71	6.34	6.61	6.74
		Gg CO2 eq.								

Waste sector category	**Solid Waste Disposal**	41.50	70.41	106.66	145.12	84.22	121.83	138.82	141.42	145.47
	Biological Treatment of Solid Waste	0.00	3.92	2.66	2.75	0.15	0.83	2.40	2.01	0.81
	Incineration and Open Burning of Waste	0.43	0.43	0.40	0.32	0.73	0.73	0.69	0.69	0.81
	Wastewater Treatment and Discharge	27.37	29.77	30.48	30.15	27.15	11.67	8.52	14.75	12.31
	Total	69.30	104.53	140.20	178.34	112.26	135.05	150.43	158.87	159.41

3.6 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, contribution to uncertainty, or any combination of these. There are two approaches to identify key categories described in the 2006 IPCC Guidelines (Volume 1, Chapter 4), named “approach 1” and “approach 2”.

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

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

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

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

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

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

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

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

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

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

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

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

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

3.6.1 KEY CATEGORIES: LEVEL ASSESSMENT

The level assessment of key categories represents the contribution of each source or sink category to the total national inventory.
A detailed level assessment of the key categories, as derived from the KCA tool, is presented in Annex I to this report.

As illustrated in Annex 1, the sub-category with the highest key category for both the base year (1990) and the latest year (2020) with and without LULUCF, for approach 1, refers to the public electricity and heat production category from the Energy sector; liquid fuels and gaseous fuels CO_2.

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

3.6.2 KEY CATEGORIES: TREND ASSESSMENT

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

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

Similarly, to the level assessment, as illustrated in Annex 1, for the trend assessment, the sub-category with the highest trend key category score for the latest year (2020) with and without LULUCF is 'Public electricity and heat production' from Liquid Fuels from the Energy sector.

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

3.6.3 KEY CATEGORIES: WITH LULUCF ASSESSMENT

The below Table 3.9 refers to the key categories with LULUCF both for year 1990 and 2020 including level and trend assessment both from approach 1 and approach 2.

Table 3.9 KCA including Approach 1 for base year (1990) and latest year (2020) with LULUCF both Level and Trend Assessment

CRF Code	Category	Classification	GHG	Identification Criteria	
				1990	2020
1A1	Public electricity and heat production	Liquid fuels	CO_2	L1	L1, T1
1A1	Public electricity and heat production	Solid fuels	CO_2	L1	T1
1A1	Public electricity and heat production	Gaseous fuels	CO_2		L1
1A2	Manufacturing industries and construction	Liquid fuels	CO_2	L1	L1
1A3b	Road Transportation	Liquid Fuels	CO_2	L1	L1, T1
1A3d	Domestic Navigation	Liquid fuels	CO_2	L1	L1, T1
1A4a	Commercial/Institutional	Liquid fuels	CO_2	L1	L1, T1
1A4b	Residential	Liquid fuels	CO_2	L1	L1, T1
1A4c	Agriculture/Forestry/Fishing	Liquid fuels	CO_2		L1
2F1	Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning		HFC		L1
3A	Enteric Fermentation	Cattle	CH_4	L1	L1
3D1	Direct N2O Emissions from Managed soils	Organic N/Manure	N2O	L1	
5A1	Managed Waste Disposal Sites (Anaerobic)		CH_4		L1
5A2	Unmanaged Waste Disposal Sites		CH_4	L1	T1
5D1	Wastewater Treatment and Discharge - Domestic wastewater		CH4	L1	

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

3.6.4 KEY CATEGORIES: WITHOUT LULUCF ASSESSMENT

The below Table 3.10 refers to the key categories without LULUCF both for year 1990 and 2020 including level and trend assessment from approach 1.

Table 3.10 KCA including Approach 1 for base year (1990) and latest year (2020) without LULUCF both Level and Trend Assessment

CRF Code	Category	Classification	GHG	Identification Criteria	
				1990	2020
1A1	Public electricity and heat production	Liquid fuels	CO_2	L1	L1, T1
1A1	Public electricity and heat production	Solid fuels	CO_2	L1	T1
1A1	Public electricity and heat production	Gaseous fuels	CO_2		L1
1A2	Manufacturing industries and construction	Liquid fuels	CO_2	L1	L1
1A3b	Road Transportation	Liquid Fuels	CO_2	L1	L1, T1
1A3d	Domestic Navigation	Liquid fuels	CO_2		L1, T1
1A4a	Commercial/Institutional	Liquid fuels	CO_2	L1	L1, T1
1A4b	Residential	Liquid fuels	CO_2	L1	L1, T1
1A4c	Agriculture/Forestry/Fishing	Liquid fuels	CO_2		L1
2F1	Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning		HFC		L1
3A	Enteric Fermentation	Cattle	CH_4	L1	L1
4E	Settlements	Total	CO_2		
5A1	Managed Waste Disposal Sites (Anaerobic)		CH_4		L1
5A2	Unmanaged Waste Disposal Sites		CH_4	L1	T1
5D1	Wastewater Treatment and Discharge - Domestic wastewater		CH4	L1	

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

3.7 NATIONAL SYSTEMS IN ACCORDANCE WITH ARTICLE 5, PARAGRAPH 1, OF THE KYOTO PROTOCOL

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

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

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

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

Political ownership and overall responsibility of the national GHG inventory is vested in the Ministry responsible for climate change policy, this being the Ministry for the Environment, Energy and Enterprise (MEEE).

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

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

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

259 of 2015, National System for the Estimation of Anthropogenic Greenhouse Gas Emissions by Sources and Removals by Sinks Regulations, 2015 (Subsidiary Legislation 543.01).

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

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

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

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

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

3.8 National Registry

According to the Kyoto Protocol reporting guidelines (para 32), each Annex I Party shall provide a description of how its national registry performs functions defined in the annexes to decisions 13/CMP.1[22] and 5/CMP.1[23], and conformity with the requirements of the technical standards for data exchange (DES).

The Malta Resources Authority is designated as Malta's National Registry Administrator; the present Registry Administrators responsible to maintain the national registry are Mr. Saviour Vassallo and Mr. Alexander Said.

The Maltese National Registry Administrator may be contacted by email at 'emissions_trading_scheme@mra.org.mt' or on (+356) 21220720 / (+356) 21240290. The Internet address of the interface to its national registry is https://unionregistry.ec.europa.eu/euregistry/MT/index.xhtml.

Publicly accessible information relating to the registry may be accessed at: https://unionregistry.ec.europa.eu/euregistry/MT/public/reports/publicReports.xhtml.

Further information on accounts opened in the Maltese registry may also be accessed through the public page of the European Union Transaction Log (EUTL), at: https://ec.europa.eu/clima/ets/welcome.do;EUROPA_EUTLPUBLI001_PRD_JSESSIONID=dH87SEbDD6CKyHh3R2zy9f_zWJ3eeparkVa8U0gvRot7kisDw8W3!-1210492530.

[22] Decision 13/CMP.1. Modalities for the accounting of assigned amounts under Article 7, paragraph 4, of the Kyoto Protocol.

[23] Decision 5/CMP.1. Modalities and procedures for afforestation and reforestation project activities under the clean development
mechanism in the first commitment period of the Kyoto Protocol.

4 POLICIES AND MEASURES

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 2021.

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.

Malta's strategy under the decarbonisation dimension promotes the transition to a low-carbon economy, primarily through the pursuit of upholding national GHG emissions reduction commitments, and by continuing to deploy all viable indigenous renewable energy sources.

The Climate Action Act of 2015 (CAP 543[24]), establishes the main legal framework for climate change mitigation and adaptation in Malta. It aims to provide for action that contributes to the mitigation of climate change by limiting anthropogenic emissions of greenhouse gases and protecting and enhancing greenhouse gas sinks and reservoirs, and to contribute to the prevention, avoidance, and reduction of the adverse impacts of climate change and the reduction of vulnerability, enhancement of resilience, and adaptation to the adverse effects of climate change.

The Climate Action Act defines the duties and obligations of citizens and of the Government of Malta with respect to climate action, together with guiding principles for the fulfilment of such duties and obligations. *Inter alia*, the Act makes it 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*". The Government shall also "*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*

[24] http://www.justiceservices.gov.mt/DownloadDocument.aspx?app=lom&itemid=12336&l=1

by sinks".The Act requires the periodic preparation 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.

Since accession to the European Union, Malta's climate change policy direction is strongly linked with that of the Union. To this effect, a brief overview of the evolution of EU GHG mitigation policy in recent years is useful to provide the background to the policy activities of Malta.

Going back to 2007, it was in March of that year that the European Council adopted a strategic objective of a 20% reduction in overall EU GHG emissions, by 2020, compared to 1990 levels, which consequently led to the adoption by the European Commission, and eventual agreement on by the EU institutions, of the so-called 20 20 by 2020 Climate and Energy Package. This package included legislation enhancing the already existing Emissions Trading Scheme of the EU, the adoption, for the first time, of binding emission limitation or reduction targets for each Member State in the Effort-Sharing Decision, legislation enhancing the EU's ambitions with regards to renewable energy sources, and, subsequently, on energy efficiency, and the adoption of a legislative framework for carbon capture and storage in geological formations.

Two years later, in October 2009, the European Council adopted a long-term policy perspective, with an objective of a reduction in EU emissions of between 80% and 95% by 2050, compared to 1990 levels. On the basis of this long-term perspective, the European Commission, in its communication 'A Roadmap for moving to a competitive low carbon economy in 2050' (COM(2011) 112[25]) proposed a roadmap towards the 2050 ambition, with interim reduction milestones of 40% and 60% by 2030 and 2040 respectively.

The next logical step was the adoption by the European Council of a binding EU target of 40% reduction in Union-wide GHG emissions, by 2030, compared to 1990 levels; a new significant element in this decision was that this target was meant to be achieved by domestic action only, that is by actual emissions reduction within the European Union and without the contribution of international credits from outside the EU. The 2030 objective was transposed into a new suite of legislative proposals, forming the 2030 Climate and Energy package, which, at the time of preparing this National Communication, constitutes the key legislative framework currently in force.

The progress of EU emissions mitigation policy did not stop here, however. In its communication 'A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy' (COM(2015) 80[26]), the European Commission elaborated the concept of an energy system for the Union that is secure, sustainable, competitive and affordable, requiring a fundamental transformation of Europe's energy system that ensures the development of sustainable, low-carbon and climate-friendly European economy. This would be based on an ambitious EU climate policy framework coupled with the Union becoming the leader in renewable energy.

[25] Communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A Roadmap for moving to a competitive low carbon economy in 2050; COM(2011) 112 final.
[26] Communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank, A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy; COM2015) 80 final.

The Commission's communication 'The European Green Deal' of 2019 (COM(2019) 640[27]) was another significant step forward. The aim of the Green Deal is to transform the Union into a fair and prosperous society, built on a modern, resource-efficient and competitive economy, where economic growth is decoupled from the use of resources, and crucially for climate policy, an economy where there are no net GHG emissions by 2050: that is, a climate neutral European economy. The climate neutrality objective has now been inscribed in EU law through the European Climate Law[28] (Regulation (EU) 2021/1119).

The enhanced 2050 ambition necessarily requires the recalibration of the roadmap towards that goal. To this effect, in December 2020, the European Council adopted an enhanced target for 2030, raising the objective to a reduction target of -55% compared to 1990 levels. This led to the subsequent adoption, by the European Commission, of an extensive suite of legislative proposals, the so-called Fit-for-55 Package, which are undergoing the relevant co-decision process at the time of preparing this report. It is expected that between the end of 2022 and the beginning of 2030, key elements of this Package will have been formally agreed by the three European Union institutions, with their implementation to start immediately afterwards.

The Fit-for-55 (FF55) package is a comprehensive, highly interlinked, framework, tackling most of the GHG emitting activities in the EU and raising the ambition of carbon removal. Among the elements of this package are: the enhancement of the ambition of the European emissions trading system, by increasing its overall emission reduction impact, extending the EU ETS to the maritime sector, and introducing a new ETS for fuels released for combustion in buildings and road transport; strengthening the objectives of the existing Effort-sharing Regulation, including the increase in the reduction efforts of Member States; enhancing the removal effectiveness of the LULUCF Regulation framework; the adoption of a date for the ban on the placement of internal-combustion-engine cars in the Union; enhancing the ambitions of the EU with regards to sourcing of energy from renewable energy sources and energy efficiency; incentivizing the uptake of sustainable fuels in the maritime and aviation sectors; setting an EU-wide framework for improved infrastructure for the effective and efficient supply of alternative fuels; and, adapting the EU taxation regime for fuels; among others.

Malta's contribution towards the EU's 2020 and 2030 emission reduction objectives of the European Union is achieved through the compliance by a number of large local installations and by a number of aircraft operators under the EU Emissions Trading System (ETS), and by compliance with the obligations for Malta under the Effort-sharing Decision[29] (ESD; in respect of the period 2013-2020), and the Effort-sharing Regulation[30] (ESR; in respect of the period 2021-2030).

The quantified target inscribed for Malta in the ESD is a limit of 5% increase on emissions (excluding emissions covered by the EU ETS, emissions from domestic aviation, and emissions/removals related to LULUCF) by 2020 compared to 2005 levels. The iteration of

[27] Communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, The European Green Deal; COM(2019) 640 final.
[28] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ("European Climate Law"); OJ L 243, 9.7.2021, p. 1-17.
[29] Decision No 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.
[30] Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013.

the ESR that is presently in force reflects the EU's collective target of 40% reduction of GHG emissions by 2030 compared to 1990 levels, adopted by the European Council in 2014. This translates into a target for Malta of 19% reduction in non-EU ETS emissions by 2030 compared to 2005 emission levels. In recognition of the special circumstances of Malta with regards to cost-efficiency of its mitigation potential, the FF55 envisages this target to remain the same despite the enhanced overall ESR ambitions.

With regards to renewable energy, Malta will strive to extend its current policy framework in the area of RES to 2030 and launch new initiatives tailored to local specificities to ensure that all technically and economically viable indigenous sources of Renewable Energy Sources (RES) are exploited. Malta's energy system and market are characterised by its small nature, the existence of a single electricity distributor/supplier, the absence of natural gas and district heating and cooling networks, and the small size of petroleum distribution companies. This, together with an ever-growing population and GDP, has made limiting the consumption of energy and the formulation of measures to meet energy savings, difficult. Nonetheless, Malta's efforts in improving energy efficiency post-2020 seek to achieve energy savings in proportion to the final energy consumption of respective sectors.

The Government's commitment towards achieving greater security of energy supply is emphasized through efforts of diversification of energy sources and contingency planning in case of disruption of supply. In this context, Malta's energy supply will be strengthened through the realisation of the Gas Pipeline project with Italy which will connect Malta to the Trans-European Natural Gas Network by 2024. Since Malta's electricity network is linked to Italy through an interconnector, the level of Malta's electricity interconnectivity is expected to remain well above the EU-wide target of 15%. The interconnector contributes to the robustness of the electricity system, which stands at the edge of the EU grid.

The newest LCDS, which was published toward the end of 2021, lays out the country's decarbonisation journey up to 2050. The strategy is spearheaded by the Ministry for Environment, Energy and Enterprise (MEEE), with inter-ministerial collaboration. For this strategy, several mitigation measures were researched, possible abatement levels were quantified through a Marginal Abatement Cost Curve (MACC) modelling, and stakeholders were consulted to finally arrive to a list of realistic and cost-effective measures. This strategy is set to help in reaching the targets and obligations set by the Effort Sharing Regulation, as well as other obligations under the EU and Paris Agreement. The LCDS sets out a set of attainable measures, designed with Malta's specificities in mind, to achieve significant reductions by 2050, and meeting the current ESR target in 2030. The national target under the ESR in 2030 is set at 826,687 tCO2eq., equating to a 19% reduction in emissions since 2005. The measures and initiatives have been set to meet this target; indicative milestones in 2040 and 2050 reflect 60% and 80% reductions from 1990 levels, respectively.

4.3 POLICY-MAKING PROCESS

The Malta Resources Authority (MRA) is the entity currently holding the role of compiling biennial Policies and Measures (PAMs) and Projections Reports. The Ministry for the Environment, Energy and Enterprise (MEEE) has overall official responsibility for the reporting.

Information for the preparation of such reports is sourced from various sources, including publicly available policy documents, entities responsible for sectoral policy planning and implementation, and, as already mentioned above, national policy planning documents such as the National Energy and Climate Plan and the Low Carbon Development Strategy (LCDS).

Projections for the Energy sector are the responsibility of the Energy and Water Agency (EWA) and Transport Malta (TM). The MRA has responsibility for the modelling of activity and emissions projections for the sectors IPPU, Agriculture and LULUCF. The MEEE is responsible for the modelling of activity projections related to solid waste management, with the MRA the converting activity data projections into the greenhouse gas emissions projections.

The modelling of emission sources and sinks in the various economic sectors and the estimation of emission projections are based on macroeconomic factors and on the proposed PAMs. Over the past years, these modelling efforts have benefitted from extensive capacity building support provided through projects of the European Commission in the context of initiatives such as those related to the compilation of Member States' first NECPs. These projects have focused primarily on ensuring the building of national capacity for the preparation of the first NECP, including through development of tools for projections, and subsequent review of these tools.

The other functions of the Climate Action Board are listed in the Climate Action Act with the main aim being to supervise the implementation of the Act and the duties of the government within it. The monitoring of the progress in terms of policies and measures is co-ordinated through an inter-ministerial committee set up for the purpose of the National Energy and Climate Plan and Low Carbon Development Strategy with the support of the Ministry responsible for climate.

Capacity building support on modelling tools is envisaged to continue during the next years. This will often be linked to capacity building support efforts related to the compilation of annual greenhouse gas emissions inventories. Among these efforts, the emphasis should be not only on the technical aspects of reporting but also on establishing, to the extent desirable, a formalized national system for reporting on policies and measures and on projections. Such a national system would preferably integrate the different policy planning and reporting efforts arising from the obligations of the Governance Regulation, such as the preparation of integrated NECPs and Long-term Strategies, the reporting of biennial integrated progress reports and the biennial reporting under Article 18 of the Governance Regulation (i.e. this report and the accompanying documentation).

One must appreciate that the reporting obligations arising from the EU acquis, especially where it relates to climate and energy matters is very extensive and places a significant burden on the limited human resources available in a small country like Malta. The emphasis has been on ensuring quality reporting in a timely manner. For the future, the lessons learnt from the structures adopted for the preparation of Malta's NECP, the comprehensive approach used for the ongoing preparation of such policy documents and the LCDS and the national environment strategy, and the experience gained with the establishment and maintaining of a national system for the reporting of national greenhouse gas inventories, should provide the building blocks for a sound national system for reporting on policies and measures and on projections.

4.3.1 DOMESTIC AND REGIONAL PROGRAMMES AND/OR LEGISLATIVE ARRANGEMENTS AND ENFORCEMENT AND ADMINISTRATIVE PROCEDURES

Malta's commitments up to, and for, 2020, under the Convention and under the Kyoto Protocol should be seen in the context of the European Union approach to these treaties.

The EU and its Member States made a pledge (the Cancun pledge) of a quantified economy-wide target of a 20% reduction in total Union GHG emissions by 2020 compared to 1990 levels. This is a joint pledge with no separate targets for the individual Member States. This target does not include the LULUCF sector but does include emissions from outgoing international flights.

The 20% reduction pledge was accompanied by an offer, by the EU, to increase its reduction commitment to 30% reduction by 2020, compared to 1990 levels, on condition that other developed countries commit themselves to comparable emission reduction objectives, while more advanced developing countries contribute adequately in accordance with the responsibilities and respective capabilities. The conditions for taking on the higher objective were not met, and thus, this more ambitious conditional target is not applicable for the compliance of the EU under the Cancun Pledge.

The Cancun target will be met jointly by the EU and its Member States via legislation adopted in the 2020 climate and energy package, already mentioned in an earlier section. This package provides for a reduction in emissions of 21% below 2005 levels from installations covered by the EU Emissions Trading System and a complementary 10% reduction in emissions from sectors included in the Effort-sharing Decision (Malta's target here is a limit on ESD emissions of 5% over 2005 levels, including any use of the flexibility mechanisms provided for in the Decision). Compliance with the EU internal distribution of efforts under the ESD is independent of the commitments under the Convention.

For the Kyoto Protocol second commitment period (2013-2020), the EU and its Member States, and also including the UK[31] and Iceland, agreed to jointly fulfil their quantified emissions limitation and reduction commitments pursuant to Article 3 of the Kyoto Protocol. The commitment in this instance is to limit average annual greenhouse gas emissions during the second commitment period to 80% of the sum of base year emissions, this commitment being inscribed in the Doha Amendment. Council Decision (EU) 2015/1339[32] sets out the terms for this joint fulfilment. Initial Reports[33] were submitted by the EU and the respective States in order to provide for the calculation of the respective assigned amounts under the second commitment period.

The Doha Amendment target covers all emissions from national sectors, including LULUCF (according to KP-LULUCF accounting rules) but excludes international aviation.

From a national perspective, another key compliance element, closely linked to the commitments mentioned above, is the Effort-sharing Decision. This Decision sets out quantified emission reduction targets for each individual Member State in respect of emissions not covered by the EU ETS, and excluding LULUCF and civil aviation. The Member States' targets are presented as 2020 percentage changes (either a reduction, or in some

[31] The United Kingdom is referred to separately by virtue of its withdrawal from the Union, though, for the purposes of the Cancun Pledge and the Kyoto Protocol 2nd commitment period target, it forms part of the joint commitments.

[32] Council Decision (EU) 2015/1339 of 13 July 2015 on the conclusion, on behalf of the European Union, of the Doha Amendment to the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfilment of commitments thereunder; OJ L 207, 4.8.2015, p. 1-5.

[33] The Initial Reports submitted by the European Union and all States parties to the joint fulfilment, and the reports of the reviews of the Initial Reports, may be accessed at https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-the-kyoto-protocol/second-commitment-period/initial-reports.

instances, such as in the case of Malta, a possible limited increase) from 2005 levels. Furthermore, for each Member State, the ESD determines a trajectory of binding annual limits for the years 2013 to 2019. The 2020 target and the interim annual limits are transposed into annual emission allocations (AEAs). Compliance is based on a process of annual reporting of States' emissions, and review by the European Commission. Where the annual reporting by a Member State shows that for a particular year, emissions from activities covered by the ESD of that Member State have exceeded that year's limit (i.e. the State has emitted a quantity of GHGs that is greater than the quantity of AEAs attributed to it for that year, the Member State has the possibility to use a number of flexibility mechanisms, provided by the Effort-sharing Decision, to facilitate compliance. These flexibility mechanisms include, among others, the possibility of acquiring additional AEAs from other Member States who may have a surplus (because their emissions are lower than their inscribed trajectory limits).

The quantity of AEAs attributed for each year to each Member State were set out by Commission Decision 2013/162[34] and Commission Decision 2013/634[35]. The quantities of AEAs for the years from 2017 till 2020 were subsequently updated by Commission Decision (EU) 2017/1471[36] to appropriately reflect the 2006 IPCC Guidelines and updated UNFCCC reporting guidelines.

The European Union climate action acquis is built around an extensive array of key legislative instruments, of which, the Emissions Trading System Directive, the Effort-sharing Decision and Effort-sharing Regulation, and the LULUCF Regulation are worth mentioning.

The EU ETS is established via Directive 2003/87/EC[37]. The Directive establishes the key elements for the implementation and enforcement of the ETS for stationary installations and for aviation activities. Legislative acts subsidiary to the Directive includes rules on free allocation, on auctioning of allowances, on the registry system (Union Registry System), on monitoring and reporting of emissions and other activity data, and on verification of annual reports and accreditation of verifiers.

The Effort-sharing Decision, already mentioned in an earlier section, sets out the individual Member States' targets and interim limits for the years 2013 to 2020, and provides for flexibility mechanisms (banking and borrowing of AEAs; selling and buying of AEAs; use of international credits) to facilitate the fulfilment of targets. The Decision is now superseded by a Regulation, which defines the targets for Member States for 2030, the interim limits for the years 2021 to 2029, and, again, provides for flexibility mechanisms. Relevant provisions in both the Decision and the Regulation also provide for monitoring of compliance by Member States and any enforcement action and corrective action that may be required in case a Member State is not able to comply, even when taking into account the available flexibility mechanisms.

[34] Commission Decision of 26 March 2013 on determining Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC of the European Parliament and of the Council; OJ L 90, 28.3.2013, p. 106-110.

[35] Commission Implementing Decision of 31 October 2013 on the adjustments to Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC of the European Parliament and of the Council; OJ L 292, 1.11.2013, p. 19-22.

[36] Commission Decision (EU) 2017/1471 of 10 August 2017 amending Decision 2013/162/EU to revise Member States' annual emission allocations for the period from 2017 to 2020; OJ L 209, 12.8. 2017, p 53-55.

[37] 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, p. 32-46; consolidated versions that incorporates subsequent amendments may be found at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02003L0087-20210101

The LULUCF Decision[38] sets out the accounting rules applicable to emissions and removals of GHGs resulting from land use, land-use change and forestry activities. This was meant as a first step towards including the LULUCF sector in the EU's emissions reduction commitment. The integration of the LULUCF sector in the EU's emission reduction goals was achieved by the adoption of Regulation (EU) 29018/841[39]. The LULUCF Regulation sets out tangible commitments for individual Member States for the sector that contribute towards the achievement of the objectives of the Paris Agreement and meeting the GHG emissions reduction target of the EU for the period 2013 to 2020, and also included rules in accounting of emissions and removals at Member States' level and for checking compliance with States' commitments. A key aspect of the LULUCF Regulation is the so-called 'no debit rule' which requires Member States to ensure that for the period 2021-2025 and 2026-2030 and taking into account flexibilities provided for in the same Regulation, emissions related to the LULUCF sector do not exceed removals.

The above-mentioned legislative instruments (ETS Directive, Effort-sharing Regulation and LULUCF Regulation) are all currently subject to revisions in the context of the enhanced EU emission reduction objective of -55% compared to 1990 levels by 2030. Thus, proposals for amending these legislative instruments form part of the FF55 package and are, at the time of preparing this report, in an advanced stage of inter-institutional negotiations.

On a domestic level, the Climate Action Act (Chap 543), establishing a framework for climate action, sets out the idea that it 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. The Act sets out duties and obligations on the Government, including to periodically compile national inventories of anthropogenic emissions by sources and removals by sinks, to formulate and implement policies regarding measures tom mitigate climate change and measures to prevent, avoid, reduce adverse impacts of climate change, to reduce vulnerability and enhance resilience to adverse impacts of climate change and to facilitate adaptation to climate change, among others. The Act also establishes a number of guiding principles that underpin Government's exercise of its duties and obligations under the Act. Furthermore, the Act requires Government to prepare national ow carbon development strategy and a national adaptation strategy. It also establishes a Climate Action Board, whose duties include the supervision of the implementation of the Climate Action Act, the monitoring of Malta's fulfilment of its obligations under the UNFCCC and relevant obligations arising from Malta's membership in the European Union, and to advise the Minster responsible for the climate action portfolio on matters pertaining to climate action as set out in the Act. The Act also gives powers to the relevant Minister to make regulations (national subsidiary legislation) relating to matters in respect of functions and activities which affect climate action.

The first subsidiary legislation adopted under the Climate Action Act was Legal Notice 259 of 2015 (Subsidiary Legislation 543.01 [40]), 'National System for the Estimation of Anthropogenic Greenhouse Gas Emissions by Sources and Removals by Sinks Regulations'.

---

[38] Decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities, OJ L 165, 18.6.2013, p. 80-97. A consolidated version that incorporates subsequent amendments to the original legislation may be accessed at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02013D0529-20180709.

[39] Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU, OJ L 156, 19.6.2018, p. 1-25. A consolidated version that incorporates subsequent amendments to the original legislation may be accessed at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02018R0841-20210314.

[40] https://legislation.mt/eli/sl/543.1/eng/pdf

These regulations establish a national system for the reporting of national GHG inventories, defining the roles of Single National Entity (the Minister responsible for climate action) and the Inventory Agency, and obligations on data providers.

The EU ETS is implemented in Malta by two subsidiary legislations, S.L. 423.50[41] (for stationary installations) and S.L. 423.51[42] (for aviation). The national competent authority in both cases is the Malta Resources Authority, which also holds the role of National Registry Administrator. The respective legal notices provide for the implementation elements relating to the EU ETS, including rules on permitting (for stationary installations), monitoring, reporting and verification of annual reports, surrender of allowances in respect of verified emissions and penalties due in case of non-compliance with provisions of the law.

The EU ETS in Malta covers the four public electricity generation installations and a number of aircraft operators that are holders of an Aircraft Operating Certificate (AOC) issued by Malta. As an administering State for the purposes of the EU ETS in respect of aviation, Malta may also be attributed non-EU aircraft operators that would also be subject to the obligations of the EU ETS Directive by virtue of their activities to, from and between EU aerodromes. At present, there are no such operators attributed to Malta that have compliance obligations under the EU ETS.

In view of their legal nature, the Effort-sharing Decision and Regulation, and the LULUCF Decision and Regulation are not transposed into national law. Malta's compliance with these instruments is monitored directly by the European Commission, using the compliance monitoring provisions of the respective legal instruments, among others, annual national inventories of GHG emissions and removals.

4.4 Policies and measures and their effect

This section provides an overview of a number of policies and measures 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. Such policies and measures may include, in certain instances, actions that are not necessarily intentionally or explicitly intended towards reducing or limiting GHG emissions, but by virtue of the measures taken, lead to mitigation of emissions of greenhouse gases from the activities or sectors concerned as an important co-benefit. Measures included in this section come out of the LCDS have been included under the WEM scenario. Other measures listed, such as in the case of the IPPU and LULUCF sector have been included under the WOM scenario. The measures discussed here are considered as still on going.

4.4.1 Energy Sector

This section presents an overview of the measures considered in the WEM scenario as well as a summary of the measures considered in the WOM scenario. Measures considered under the WEM scenario come out of the Low Carbon Development Strategy and are disaggregated under 3 categories: Energy production and use, Industry and Buildings. The main measures falling under energy production and use include:

- A continued uptake of solar PVs and initiatives in offshore PVs

[41] European Union Greenhouse Gas Emissions Trading System for Stationary Installations Regulations, Legal Notice 434 of 2013 (as amended).

[42] European Union Greenhouse Gas Emissions Trading System for Aviation Regulations, Legal Notice 403 of 2012 (as amended).

- A continued update of solar water heaters and other renewable heating technologies (pre- and post-2030)
- Continued use of existing interconnector and additional use of interconnectors in the future
- Installation of offshore floating wind turbines when feasible
- Use of hydrogen fuel to operate CCGT power plants.

The LCDS sets out measures on buildings, aligned with Malta's Long Term Renovation Strategy (LTRS), which was launched in 2021). Main measures falling under the building sector include:

- EE single measures and retrofitting to achieve Nearly Zero Energy Building (NZEB) level
- Measures, supported by schemes, for deep renovation
- EE measures in buildings

The LCDS also sets out 2 more measures under the industry sector, related to SME energy efficiency and industrial energy efficiency.

Measure 1: Domestic LEDs

Malta's aim in implementing a shift in lighting to LEDs is to promote energy efficiency, through a transition to more efficient lighting . LEDs are known for their lower energy consumption, longer lifespan, and reduced environmental impact.

Measure 2: Domestic Non-solar AWHPs

By implementing this measure, the goal is to enhance energy efficiency. Encouraging the use of non-solar AWHPs allows for a diversified approach to heating and cooling systems, providing households with alternative, eco-friendly options that can contribute to overall energy savings and sustainability.

Measure 3: Energy Efficient Domestic Refrigeration, Measure 4: Energy Efficient Domestic Dishwashing

The objective of these measures is to promote the adoption of efficient domestic appliances, contributing towards reducing overall electricity consumption, and, in the case of more efficient dishwashers, also a reduction in water consumption. These measures promote sustainable practices in the residential sector.

Measure 5: Single-family building roof insulation, Measure 6: Multi-family Building roof insulation, Measure 7: Office Building roof insulation

The aim of roof insulation in private and public buildings in Malta is to improve energy efficiency and reduce heat transfer in buildings. By promoting roof insulation, Malta seeks to minimize the amount of heat gained or lost through the building's roof, leading to lower energy consumption for cooling and heating purposes. This measure aims to enhance thermal comfort, reduce reliance on air conditioning and heating systems, and decrease carbon emissions associated with energy use in buildings, by 2030.

Measure 8: Non-Residential LEDs

Similar to the shift in LEDs in the residential sector, Malta's government initiative to shift to LEDs by 2030 also applies to non-residential buildings, such as offices and public buildings.

Measure 9: Non-Residential Light Sensors

The use of light sensors in various non-residential buildings and spaces promotes energy efficiency and reduces unnecessary electricity consumption in lighting systems by optimising lighting usage.

Measure 10: Energy efficient office appliances

This measure aims to raise awareness about the importance of energy efficiency, encourage the adoption of energy-saving technologies, and contribute to the overall goal of sustainable resource management. By using energy-efficient office appliances, Malta aims to create more environmentally friendly workplaces and reduce energy costs for businesses, by 2030.

Measure 11: Solar PV

By encouraging the use of solar PVs, Malta seeks to harness the abundant solar resource available in the country and utilize it for generating electricity to the widest extent possible allowable by available space. This measure aims to diversify the energy mix, decrease reliance on imported fossil fuels, and contribute to the overall transition to a cleaner and more sustainable energy sector. The objective is to continue incentivizing the installation of solar PV systems in residential, commercial, and industrial sectors, promoting energy independence, and mitigating climate change by reducing carbon emissions associated with electricity generation.

Measure 12: Additional Interconnector

Malta's aim in introducing a second interconnector is to enhance energy security, increase supply reliability, and promote energy security. By establishing an additional interconnector, Malta seeks to strengthen its connection to the European grid, enabling the import of electricity. This measure aims to enhance the resilience of the power grid whilst supporting the stability and efficiency of the energy market. The introduction of an additional interconnector aligns with Malta's goals of ensuring a stable and sustainable energy supply for the country.

Measure 13: Floating Offshore Wind

To the extent that floating offshore wind farms become feasible for Malta, these would increase the potential for harnessing renewable energy and promote a transition towards a greener and more sustainable energy sector. This measure aims to diversify Malta's energy mix, reduce reliance on fossil fuels, and contribute to the country's efforts in mitigating climate change and achieving carbon neutrality. Introducing floating offshore wind farms aligns with Malta's commitment to renewable energy development, fostering energy independence, and creating a cleaner and more sustainable future. Unfortunately, there are several limitations for Malta in investing in offshore wind farms such as its geographic location, water depth, grid infrastructure and environmental impacts.

Measure 14: Solar Water heaters

By encouraging the use of solar water heaters, Malta seeks to harness the abundant solar energy available in the country and utilize it for heating water in residential, commercial, and industrial settings. This measure aims to lower greenhouse gas emissions, decrease energy costs for water heating, and contribute to the overall transition to a more sustainable and environmentally friendly energy system. The objective is to increase the deployment of solar water heaters, thereby reducing the use of conventional water heating systems that rely on non-renewable energy sources.

Measure 15: Industrial Energy Efficiency

Malta's aim in implementing a measure encouraging industrial energy efficiency is to promote sustainable industrial practices, reduce energy consumption, and enhance competitiveness in the industrial sector. By encouraging industrial energy efficiency, Malta seeks to minimize energy waste. This measure aims to improve the overall energy performance of industrial facilities, promote the adoption of energy-efficient technologies and practices, and drive innovation in industrial processes. The objective is to create a more sustainable and resilient industrial sector that not only reduces its environmental impact but also improves cost-effectiveness and competitiveness in the global market.

Measure 16: SME Energy Efficiency

A large number of SMEs, due to their small size, find it not cost-effective to invest EE measures or may find difficulties with the initial funding outlay required. The aim is to support SMEs to make changes in their operations so as to achieve energy efficiency, to promote sustainable industrial practices, drive innovation and enhance competitiveness.

Measure 17: Blended Zero Carbon Generation

Blended Zero Carbon Generation brings together three key approaches for delivering low carbon energy for Malta by 2050, these being offshore floating wind, a third interconnector and hydrogen power. The measures would address the remaining gap in ensuring the Maltese grid achieves zero carbon emissions.

Table 4.1. Energy LCDS Measures Abatement Potentials (LCDS, 2021)

	Abatement Potential (KtCO2eq./yr)		
	2030	**2040**	**2050**
Energy Production & use	825.033	1158.546	1262.117
Industry	82.025	33.769	2.215
Buildings	74.848	35.344	2.706

Table 4.2. A comparison of measures reported in previous reporting and the NC8.

Previous Reporting	National Communications 8
Submarine electrical connection to European electricity network**	Additional Interconnector
Supply of natural gas for electricity generation**	
Share of RES in Electricity**	Solar PV
Share of RES in Heating and Cooling**	Single-family Building Roof Insulation
	Industrial Energy Efficiency
	SME Energy Efficiency
	Domestic Non-solar AWHPs
	Solar Water Heaters
Floating Offshore Wind**	Floating Offshore Wind
Other technologies**	Domestic LEDs (residential)
	Energy-efficient Domestic Refrigeration
	Energy-efficient Domestic Dishwashing
	Non-residential LEDs
	Non-residential Light Sensors
	Energy efficient office Appliances
	Blended Zero Carbon Generation

**Information related to this measure can be found in NC7*
***Information related to this measure can be found in the NECP (2019)*
+ Information related to this measure can be found in NECP & NC7

Table 4.3 Mitigation co-benefits (Energy)

Measures	Positive Impacts	Negative impacts
Solar PV installations Installation of SWHs/SWH Additional electricity interconnector Offshore floating wind turbines	Social • Increased labour opportunities in maintenance and installation • Self-sufficiency of consumers • Participation of civil society • Improved health • Measures that address several SDGs Economic • Greater innovation and research • With RE, less dependence on foreign energy sources	Social • Affordability issues • Potential financial gap for operator • Risks during installations/ maintenance • Reduced available roof space • Negative visual impacts on cultural sites Economic • Increased imports • Administrative burden on public authorities • Initial capital outlay • Increased maintenance costs • Rooftop property right issues • Solar rights issues • Expropriated land

Table 4.4 Mitigation co-benefits (Industry)

Measures	Positive Impacts	Negative impacts
EE industrial measures for large firms and SMEs	Social • Greater efficiency and lower energy bills • Satisfying green consumers • Decoupling energy and industry, bringing more macro-economic stability • Improved air quality, public health and quality of life (residents and workers). • Measures addressing various SDGs Economic • Increased product offering through competition • Increased innovation and research	Social • n/a Economic • Initial capital outlay • Increased administration burden for public authorities

Table 4.5 Mitigation co-benefits (Buildings)

Measures	Positive Impacts	Negative impacts
EE single measures and retrofitting to achieve NZEB level Measures, supported by schemes, for deep renovation EE measures in public buildings The above policy initiatives will lead to the following measures/ technologies: - LED lighting, in the residential and non-residential building sector - Automated lighting in non-residential buildings - EE water heating/ heat pumps - EE appliances - EE office/ IT equipment - Wall/roof insulation and double-glazing	Social • Convenience to family life (EE appliances) • Better indoor room temperatures/living conditions (wall/roof insulation) • Improved employee productivity (automation; better conditions) • Positive impact on safety issues and prevention of accidents (LEDs compared to halogen bulbs; automation) • Improved public health • Public participation from installations in public buildings/ provision of grants or subsidy schemes • Contribution to SDG 11 – sustainable cities and communities Economic • Improved business competitiveness and household purchasing power • Increased sales for EE equipment/ services • Lower maintenance/ replacement costs	Social • Exclusion of vulnerable individuals/ households who cannot afford higher spend - government to provide support • OHS concerns for installation of external condenser unit on roofs • Disruption to family life/ business operations during installations • Aesthetical value of installations close-by heritage sites (roof insulation) Economic • Administration burden for applicants and administrators of grant/ subsidy schemes

Cross-sectoral measures

Two mitigation actions that affect the energy sector, affect also the IPPU sector. The implementation of support schemes promoting the adoption of air-water heat-pumps as substitutes for conventional electric water heaters will increase the use of refrigerants. Moreover, the wider utilisation of roof and wall insulation to maintain optimal building temperatures, thereby reducing the need for space heating/cooling, could potentially reduce the use of air conditioning. However, it is unlikely that the number of new air conditioning units purchased will be reduced by the latter measure.

4.4.2 TRANSPORT SECTOR

The transport sector is the second largest activity category contributing towards national greenhouse gas emissions, after electricity generation and is responsible for around 30% of GHG emissions generated in Malta. Under the LCDS, measures are proposed to support the shift away from private car use in Malta and support electrification. Main measures falling under the transport sector include:

- Support for electrification transition (schemes in place to incentivise purchase of EVs.
- Installation of an extended network of EV charging points.
- Electrification of government fleet and public transport buses.
- Support greater modal shift towards public transport (free public transport and improvements in transport services).
- Support for active transport (e.g., e-bikes, bikes, pedelecs, walking).
- Encouraging remote working and teleworking and promotion of government online services to reduce need to travel, especially during peak hours.

International Aviation and shipping

Although aviation and maritime emissions fall outside the scope of Malta's LCDS, these emission sources are still covered either by national policies or by regional or international policy activities that Malta is implementing and that address these sources.

There is further scope for emissions reductions through considering the potential for reducing the impacts associated with maritime transport, on a domestic level. Malta's emissions inventory suggests impacts of 69 thousand tonnes CO_2 associated with domestic marine navigation, equating to a 12% of the transport total (and 3% of total emissions for Malta). This includes both ferries and some fuel use by fishing vessels.

In this area, the NECP also indicates a plan to develop a tunnel between Malta and Gozo which is assumed to reduce the requirement for gasoil used in internal navigation by around 50%.

Being an island state, Malta is exclusively dependent on aviation and maritime activities for transboundary travel and import and export of goods. To a large extent, these are services provided by third country operators, although in the aviation sector in particular, the number of aircraft operators who are setting up business in Malta is growing. This does not necessarily mean, however, that they contribute directly to increased aviation activity – and thus, emissions - to or from Malta, and therefore, direct intervention by Malta in respect of emissions from international aviation activities remains limited.

Malta implements the EU emissions trading system for aviation and the International Civil Aviation Organisation's (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). These mechanisms both cover a number of the afore-mentioned aircraft operators who are registered in Malta, whereby they are required to monitor and report emissions from flights falling within the respective mechanism's scope and surrender allowances (in the case of the EU ETS) or offset emissions (in the case of CORSIA). Similar to the situation of stationary installations in the EU ETS, the overall emissions impact of the EU ETS derives from the cap on allowances as established by the rules of the Directive. It is also important to note that the EU ETS applies to any aircraft operator that performs aviation activities to, from and within the Union.

With the adoption of the Fit-for-55 amendments to the EU ETS Directive, the aviation sector will see a gradual phasing-out of free allocation to operators with a concurrent shift to full auctioning. The implementation of CORSIA in the EU, and thus in Malta, is legislated for within the EU ETS framework. The revised EU ETS framework for aviation also provides for a mechanism to support greater uptake of sustainable aviation fuels (also known as SAFs) including through the set a side of a quantity of allowances to be allocated by Member

States towards covering part of or all of the price differential between the use of fossil aviation kerosene and the use of eligible sustainable aviation fuels.

The Fit-for-55 package is also extending the application of emissions trading in the EU to shipping activities. This will also apply to all relevant shipping companies that operator to, from and between EU ports, independent of the flag of the ship or where the shipping company is based. No free allocation of allowances is envisaged; however, a gradual phasing-in of the compliance obligations in terms of surrender of allowances will take place over the first few years.

Under the Fit-for-55, other legislative proposals are currently also under negotiation to incentivize greater uptake of sustainable aviation and maritime fuels. This will provide a comprehensive approach by the Union towards improving the environmental credentials of these two sectors. This will in turn have an important impact on the emissions profile of aviation and shipping services that are so critical for the social and economic development of Malta.

In the international maritime context, Malta participates actively in negotiations of the International Maritime Organisation, including those on environmental matters. As an EU Member States and co-sponsor of various submissions to this effect, Malta supports the main target of phasing out GHG emissions from international shipping by 2050 in the revised strategy. Malta will be participating in the negotiations of the next session of the Marine Environment Protection Committee, where the IMO is expected to adopt a revision of the Initial Strategy for the Reduction of GHG emissions from International Shipping. Apart from strengthening the ambition of the Strategy, MEPC 80 will also be expected to continue its work in identifying the candidate GHG reduction measures to be developed as a priority consisting of technical and economic elements; and undertake a comprehensive impact assessment of the basket of candidate measures ahead of their adoption. Malta, in principle supports a combination of a basket of measures consisting namely of a GHG Fuel Standard in conjunction with an international fuel levy, aiming to incentivise the uptake of low or zero GHG fuels.

LCDS Transport measures considered under the WEM scenario

Measure 1 : Electromobility

i.) Electrification of light vehicles – 65k BEVs & PHEVs by 2030

The National Strategy for the Introduction of Electromobility in Malta and Gozo may be considered as a first step towards national policy planning for the electrification of road transport in Malta. The Strategy notes the importance of electric mobility and its relevance to land transport in Malta and Gozo.

The use of electric vehicles start being promoted as an alternative means of transportation, since 2011. The use and purchase of such vehicles was initially encouraged through (i) a decrease in their registration tax and (ii) new owners of M1 electric vehicles may apply for a grant, which was initially set at up to €4,000 of the purchase price per vehicle and is presently at €11,000. The LCDS further supports the electrification transition by enhancing the previous grant scheme in place to incentivise the purchase of electric vehicles. An indicative target of uptake of 5,000 battery electric vehicles (BEVs) by 2020 was set, as a first contribution to the realisation of targets both with respect to air pollution and mitigation of GHG emissions. According to the National Statistics office the total number of Electric and hybrid licensed vehicles by end of 2020 was 6,017.

Several European nations have already declared prohibitions on Internal Combustion Engines (ICE). Malta has also made known its intention to enforce a complete ICE ban or establish a specific date by which ICE vehicles will be phased out. To aid in determining the appropriate timing and details of this decision, a Clean Vehicles Commission will be established. Under consideration is setting a national ICE cut-off date.

In addition to a ban on petrol and diesel cars, the implementation of measures that ensure attitude changes favourably towards EVs is needed for the required level of uptake to be achieved. This can be done through grants and other instruments that bridge the cost differential between technologies as well as ensuring infrastructure is adapted to the uptake of EVs. In this respect, a draft national strategy for EV charging infrastructure has been launched which looks at the installation of charging facilities at multiple venues - publicly, at home, en route and at the final destination. Education and information on the technology and its use (e.g. on battery lifetime and battery-end-of-life disposal/replacement), as well as incentive schemes (for purchase of EVs, purchase of equipment by large fleet operators to repair EVs, and electricity charging tariffs), will be essential to further ensure the targeted uptake is met - ad hoc policy initiatives may subsequently be applied in this regard.

Furthermore, upskilling the workforce and collaborations/ partnerships with educational institutions and automotive companies are being looked into to push further this electrification transition in our local markets (e.g. readiness to repair and maintain EVs).

Under its LCDS, Malta aspires to have c. 65,000 EVs, including plug-in hybrid EVs (PHEV), by 2030. The main limitations for uptake especially in the pre-ICE ban phase include the price convergence between EVs and ICE vehicles, the availability of vehicles and infrastructure (charging infrastructure), and perception of the quality of the vehicle. It is assumed that the availability of c. 6,500 charging points introduced by 2030 will be adequately supporting the infrastructure needed to support the uptake of EVs on a national scale. This transition towards electrification of ICE vehicles across the nation will impact all stakeholders, from government to industry and the private sector, civil society and citizens.

ii.) Electrification of government fleet

In addition to bans on ICE vehicles of private and commercial use, government will be leading by example and commit to the electrification of the government fleet. This would entail the replacement of c. 1,800 government ICE vehicles (c. 1,400 M1 vehicles, c. 400 N1 vehicles) by 2030. Such exercise would also be complemented by the installation of charging points at respective Ministries/ government departments.

iii.) Electrification of Heavy Vehicles – Battery EVs

The decarbonisation of road freight was assumed to take place through the electrification of heavy goods vehicles.

iv.) Electrification of 370 buses by 2030

The first measure to address the environmental impact of traditional public transport was the introduction of electric buses in Gozo, supported by the introduction of solar vehicle charging points and charging infrastructure. In order to further support the national electrification drive and drive down national emissions, this measure is extended to the electrification of all public transport bus fleet (a total of 370 buses) to electric ones by 2030. Similar to the exercise involving the electrification of private EVs and the government fleet, this exercise would be complemented by the installation of the necessary charging infrastructure.

Measure 2: Public Transport (with additional EV buses) and mass transportation.

Additional efforts towards decarbonization involve implementing strategies to encourage greater utilization of public transportation. The Low Carbon Development Strategy (LCDS) includes measures aimed at enhancing the overall public transport system. These measures encompass introducing more bus services, dedicated bus lanes, and implementing traffic priority measures. Furthermore, technology will be leveraged to improve journey times and enhance service reliability, such as through the use of app-driven services.

In conjunction with these logistical improvements, extending free public transport services would serve as an additional incentive to boost usage. However, research indicates that some form of disincentive should also be implemented to drive a significant change in behaviour.

Measures, such as free school transport for all primary and secondary school students and free use of public transport for youths and students between 16-20 years old, took off in October 2018. Although the effect of these measures on emissions reductions has yet to be assessed, it is estimated that this measure has led to a reduction of circa 6,300 cars. Free public transport fares was extended to all full-time students of all ages and it is expected to be extended in 2022 for additional categories.

Further efforts on decarbonization relate to measures to increase public transport uptake. The LCDS assumed that the overall public transport service is further improved through the introduction of more bus services, dedicated bus lanes and the introduction of traffic priority measures designed to improve journey times and service reliability.

The government is currently exploring the development of a Mass Transport System. After completing the initial study phase and conceptual design, the government is now moving forward with the second phase, which will involve a more detailed economic and financial business case. This phase will also consider the impacts of the COVID-19 era. Additionally, further studies will be conducted to confirm the proposed network.

At this stage of the LCDS, no data required to compile its MAC is readily available and the impact of this measure has not yet been modelled. In future LCDS cycles - as new and detailed information becomes available – the performance of such a measure will be analysed further.

Moreover, alternative solutions to address global warming and reduce emissions from transportation, such as hydrogen fuel cells, biofuels, synthetic fuels, ammonia, and sustainable aviation fuel, require further examination. This includes studying these solutions at an international level before considering their adoption and modelling them for the local context. Similarly, retrofitting transport systems is still an ongoing area of study.

Measure 3: Active Transport, remote working & teleworking

The promotion of cycling as an alternative mode of personal transport underpinned initially by a 'National Cycling Strategy and Action Plan for the Maltese Islands' published in 2018/19 is further supported by the LCDS. Two cycle corridors: 1) St. Julians-Sliema-

Valletta and 2) Three Cities-Fgura-Valletta were introduced by 2020. This measure reflects the strong level of support for alternative modes and modal shift from car to other sustainable modes of transport in the hub area. The LCDS supports the shift to active transport by a sustained investment taking place throughout the strategy period in infrastructure to support cycling (e.g. bikes, e-bikes, pedelecs) and walking.

Evidence from other countries (such as Denmark) confirms that the provision of support to both active transport and public transport is likely to result in a larger shift from car use than supporting only one of these areas. Cycling in Malta is assumed to increase as a result of sustained investment in active travel infrastructure taking place over the next 30 years, alongside a large increase in the use of e-bikes and pedelecs (which are deemed key in such a measure given Malta's hilly topography and warm climate). Infrastructure includes cycle tracks and lanes, bike parking facilities, bike charging points, footpaths, pedestrianised areas, widened sidewalks and investment in traffic management systems (and associated signage) to give bikes/pedestrians priority - where practicable - on existing roads. In addition, the promotion of active modes of transport will also be incentivised through the use of marketing tools and the launch of further specific programmes, incentives/grants or schemes (including with and for industry) to sustain a cultural and social shift that would spur citizens away from private car use. These efforts will build on some Government's recent efforts, including the use of smaller vehicles for urban mobility, such as pedelecs and category L vehicles (e.g. mopeds, motorcycles, tricycles and quadricycles), aimed at a lower environmental impact from transport. Active commuting such as walking will also be incentivised, such as implementation of safe routes for students.

Tele- or remote working is a means to ensure that while work continues to be performed, the need to move from the place of residence to the place of work is avoided. This could significantly impact on road traffic, especially in critical times of the day, with an effect on road transport emissions both directly (the saving of emissions from vehicles not utilised) and indirectly (reduced congestion and thus improved traffic flows). The Government leads by example in this area through a teleworking policy that facilitates the uptake of such working arrangements.

In 2008 a teleworking policy was published, 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. Over the years, other institutions have come up with their own initiatives to support sustainable mobility. One example is the University of Malta, the main tertiary institution in Malta hosting thousands of students, academic and administrative staff and situated close to the main urban agglomeration. The University has a number of smart travel initiatives ranging from information on travelling to the University, investment in walking and cycling infrastructure, and flexibility and teleworking opportunities for staff.

In the LCDS this approach is extended by encouraging teleworking, and remote working and further promotion of Government online services. Additional to modes of active transport (that shift movement to a less carbon intensive mode of transport), government will continue to consider initiatives that avoid altogether the need to move. One of the few positive outcomes of the COVID-19 pandemic is that it forced employers, including government, to implement infrastructure that supports teleworking/ remote working, thus decoupling the need to commute from the ability to produce. During COVID-19, it is estimated that around 33% of the local workforce worked remotely, and it is expected that post-COVID-19, half of the time worked will continue be carried out in this way. Studies covering foreign countries show an enormous appetite for remote working from the part of both employers and employees. Government policy has been underlining the need to ensure the possibility of teleworking as a family-friendly measure for decades. This strategy considers the teleworking/remote working possibility as a GHG reduction measure, addressing the dependency of productivity and transport. To support this further, government will be looking into:

i. promoting and incentivising further remote working amongst the workforce, including through remote workspaces for public officials across Malta and Gozo; and

ii. improved provision of online services.

A note on Vehicle Circulation Fees for more efficient vehicles

Circulation fees are calculated depending on the year of registration, based on engine size, year of make, CO2 emissions, particulate matter (PM) emissions and fuel type. For private petrol vehicles, this fee ranges between €100 for a new petrol-powered vehicle with between 0-100g per km CO2 emissions to €1,125 for a vehicle 14 years old or more with over 250g per km CO2 emissions. For private diesel vehicles, the fee ranges between €100 for a new car with 0-100g per km CO2 emissions and with particulate matter emissions up to 0.005g per km, to €1,225 for an old vehicle older than 14 years which emits more than 250g per km with particulate matter emissions exceeding 0.035g per km. These rates have declined over the years. In 2012, the fee on petrol vehicles older than 14 years with over 250g per km CO2 emissions was €1,474, while the fee on diesel vehicles older than 14 years with 250g per km CO2 emissions and PM emissions higher than 0.036g per km was €1,706.

The annual circulation license fee also applies to electric and hybrid electric motor vehicles. Vehicles for disabled persons, vehicles owned by the State or vehicles which belong to official diplomatic staff are exempt from the fee. 3.4.7 Vehicle Registration Tax System Reform26 In the past few years, Government initiated a reform with the aim of having cleaner, smaller and newer 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. Since 2011, registration taxes for commercial vehicles with emission standards lower than EURO 3 were increased to encourage purchase of newer and less polluting vehicles. In January 2012, this measure was extended to non-commercial vehicles.

Exemptions also apply to special purpose vehicles (such as ambulances) and to vehicles brought into Malta with the intention of being re-exported or exported. From April 2013, hybrid cars (M1 vehicles) are subject to the registration tax, but the CO2 value included in the Certificate of Conformity is lowered by 30%.

A note on the National Transport Strategy and Transport Master Plan (2016)

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. Six strategic goals define what the transportation system should achieve. These goals are based on sustainable development principles considering economic, social and environmental factors.

- Transport to support economic development
- Transport to promote environmental and urban sustainability
- Transport to provide accessibility and mobility
- Transport to support social development and inclusion
- Transport to remain safe and secure
- Transport to work towards improved public health

The goal to promote environmental and urban sustainability defines specific aspects, one of which is to reduce and mitigate greenhouse gas emissions. 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 defines clear project pipelines for studies, operational changes, infrastructural and organisational measures and identifies where funds from national, European Union and other financing sources can most effectively be invested, where needed, in our transport system so as to help attain the long-range strategic targets. The Principles Guiding the Master Plan are as follows:

- Efficient utilisation of the existing transport system - traffic management, logistics planning and Enforcement;
- Creating modal shift;
- Integrated approach to planning and design;
- Encouraging use of greener fuels and vehicles;
- Modernisation, development and revitalisation of the strategic transport network to improve territorial cohesion;
- Investment in education, information and human resources;
- Making room for innovation and research;
- Sustainable financing and fair competition. The TMP identifies and prioritises low carbon transport measures. The measures identified relate solely to the short-term measures that have been identified in the Partnership Agreement and Operational Programme I (2014 - 2020). These are:
- Multi-modal transport;
- Other seaports;
- Clean urban transport and infrastructure;
- Intelligent transport systems.

It is to note that the Transport Master Plan is currently under review.

Table 4.6: Abatement potentials (transport)

	Abatement Potential (KtCO2eq./yr)		
	2030	2040	2050
Transport	270.241	711.458	1016.788

Table 4.7 Mitigation measures in Road Transportation as described in reports NC7 ad NC8.

Previous Reporting	National Communications 8
Biofuel substitution obligation+	Extension of the Biofuel substitution obligation (-14% by 2030)
Introduction of autogas*	Part of baseline (WOM)
Uptake of electric vehicles+	Electrification of light vehicles - 65k BEVs & PHEVs by 2030
	Electrification of heavy vehicles - Battery EVs
	Electrification of 370 Buses by 2030
E-working and teleworking*	Active transport & Teleworking: sustained investment taking place throughout the strategy period in infrastructure to support cycling (e.g. bikes, e-bikes, pedelecs) and walking.
Modal shift to public transport and public transport reform+	Public Transport (with additional EV buses) and Mass transport plan.

**Information related to this measure can be found in NC7*
+ Information related to this measure can be found in NECP & NC7

The implementation of the biofuel substation obligation started in 2011. Initially the mandatory substitution obligation by 2020 was 10% of the total energy content petroleum place on the market. In line with Article 25 of the RES Directive recast, Malta extended the substitution obligation to 2030 and increase the obligation to at least 14%.

The introduction of Autogas in road transportation began in 2011 and continues to be utilized as a cleaner fuel option. This initiative was specifically aimed at reducing greenhouse gas (GHG) emissions in the transportation sector.

Since 2011, the promotion of electric vehicles as a sustainable transportation alternative has been a key focus. The Low Carbon Development Strategy (LCDS) has introduced various measures to bolster this transition, including the extension of government grants to encourage the purchase of light electric vehicles. In addition, significant efforts have been made to enhance the road infrastructure and establish a network of charging points, facilitating the widespread adoption of electric vehicles and ensuring convenient access to charging facilities throughout the region. These combined initiatives aim to accelerate the shift towards cleaner and more environmentally friendly modes of transportation. In addition, the government is taking proactive steps to lead by example in the transition to electric vehicles by replacing government-owned internal combustion engine (ICE) vehicles with electric ones. The decarbonisation of road freight was assumed to take place through the electrification of heavy goods vehicles, in order to further decrease GHG emissions from road freight.

In 2008 a teleworking policy was published by government. Government continues to consider initiatives that avoid altogether the need to move. The LCDS considers the teleworking/ remote working possibility as a GHG reduction measure, addressing the dependency of productivity and transport. In order to support this further, government will be looking into promoting and incentivising further remote working amongst the workforce and improving provision of online services.

Efforts towards decarbonization focus on increasing the use of public transport. The strategy includes improving the overall public transport service through additional bus services, dedicated bus lanes, and traffic priority measures. Extending free public transport services serves as an incentive for increased usage.

The electrification of scheduled public transport buses measure started with the introduction of electric buses in the island of GOZO. It is planned to electrify the majority of the route buses fleet, reaching 370 electric buses by 2030.

The following table provides an overview of the social and economic impacts resulting from the implementation of carbon mitigation measures in road transportation, outlining both positive and negative effects.

Table 4.8: Mitigation co-benefits (Transport)

Measures	Positive Impacts	Negative impacts
Electrification measures Public Transport measure Active Transport measures	Social • Health benefits from reduced air and noise pollution, potentially lower traffic accidents and more regular exercising • Increased flexibility for employees • Travel time reductions for individuals and businesses • Improved travel for non-vehicle owners, enabling social and economic participation • Enhancing the efficiency of local components of the TEN-T network • Facilitated access to cultural sites and improved preservation as a result of lower traffic emissions Economic • Incremental investment in the EV market • Reduced traffic congestion contributing to economic productivity	Social • High upfront EV capital cost/ use might exclude some individuals from the personal vehicle ownership market • Risks for public safety in EV accidents • Waste management of EVs/ batteries • Security of supply issues for electricity and batteries (EVs) • Reduced social interaction (and linked health effects and work engagement) resulting from TW/ RW • Higher costs for employees, and potential increased digital divide. Economic • Business costs in connection with EV transition adjustments • Potentially lower market competition in EV market and competitive distortions from public

Measures	Positive Impacts	Negative impacts
	and competitiveness, investment/ employment/ job attractiveness and facilitating trade logistics • New R&I spurred in connection with EV transition implementation and efficient/ safe active transport infrastructure • Facilitation of labour geographical mobility and labour market matching efficiency • Possible reduced costs of operating and managing offices	transport subsidization • Negative knock-on effects on economic activity and employment in traditional personal car travel sectors • Additional tax/ charges burden on businesses and individuals, which can result to be of a regressive nature • Administrative requirements for management of any mechanism to disincentivise undesirable usage • Free public transport may disincentivise innovation/ competition in this market • Negative/ displacement effects on commercial activity of any location-specific disincentive scheme

Cross-sectoral measures

Measures related to the electrification of transport vehicles and the overall transition towards this shift will lead to an increased demand for electricity, thereby necessitating higher energy production. Consequently, this will result in elevated emissions from the energy generation sector. Furthermore, the promotion of public transportation can generate additional electricity demand due to the increased requirement for buses and expanded routes to accommodate passengers.

However, this issue can be effectively addressed by increasing the share of renewable energy sources and sourcing energy through interconnectors. It is important to note that notable progress has already been made in improving emissions intensity. Significant efficiency gains achieved in the energy generation sector primarily through technical developments taking place in recent years, including investment in new, more efficient local generation capacity, the sourcing of electricity through an interconnector with mainland Europe, and fuel switches including the discontinuation of use of heavy fuel oil.

Furthermore, the shift to public and active transportation, could potentially reduce the use of air conditioning in sub-category Mobile Air-Conditioning (under the IPPU sector). However, for both measures to reduce the estimated emissions from sub-category Mobile

Air-Conditioning, they must reduce the number of cars in circulation. The development of road infrastructure, aimed at mitigating traffic congestion and reducing travel durations, may entail a temporary surge in emissions arising from construction activities. However, the aggregate benefits of such projects surpass the emissions generated during their implementation.

4.4.3 INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)

The main contributor to the GHG emissions from the IPPU sector is the refrigeration and air-conditioning category. The main measure that is expected to curb emissions from the IPPU sector and, more specifically, from the refrigeration and air-conditioning category, is the implementation of Regulation (EU) No 517/2014[43] - known as the F-gas Regulation - which should also provide more information on the activity in this sector.

The current F-gas Regulation[44] strengthens the original F-gas Regulation[45] and introduces additional provisions aimed at reducing the emissions of F-gas, as well as their global warming potential (GWP) value. The implementing Regulations of the original F-gas Regulation remain in force and continue to apply until new acts are adopted. One of the requirements of the original F-gas Regulation is the establishment of minimum qualifications for personnel who make use of such substances. This requirement has been implemented through the establishment of sector-specific subsidiary Regulations which have been published locally as follows:

- Minimum qualification course required by Article 12(3) of implementing Regulation (EC) No. 303/2008[46] and Article 4(2) of implementing Regulation (EC) No. 307/2008[47] (Fixed air conditioning and refrigeration equipment, and vehicle air conditioning);
- Minimum qualification course required by Article 7(1) of implementing Regulation (EC) No. 305/2008[48] (High voltage switchgear); and
- Minimum qualifications course required by Article 12(3) of implementing Regulation (EC) No. 304/2008[49] (Fire protection equipment).

The provisions of the current F-gas Regulation have been implemented locally by Legal Notice 143 of 2018[50]. The new F-gas Regulation strengthens the original F-gas Regulation and introduces a phase-down of the consumption of HFCs through the allocation of quotas, which take into consideration the global warming potentials of the respective

[43] Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation EC) No 842/2006
[44] Regulation (EU) No 517/2014: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0517&from=EN
[45] Regulation (EC) No 842/2006: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006R0842&from=EN
[46] Commission Regulation (EC) No 303/2008 of 2 April 2008 establishing, pursuant to Regulation (EC) No 842/2006 of the European Parliament and of the Council, minimum requirements and the conditions for mutual recognition for the certification of companies and personnel as regards stationary refrigeration, air conditioning and heat pump equipment containing certain fluorinated greenhouse gases.
[47] Commission Regulation (EC) No 307/2008 of 2 April 2008 establishing, pursuant to Regulation (EC) No 842/2006 of the European Parliament and of the Council, minimum requirements for training programmes and the conditions for mutual recognition of training attestations for personnel as regards air-conditioning systems in certain motor vehicles containing certain fluorinated greenhouse gases.
[48] Commission Regulation (EC) No 305/2008 of 2 April 2008 establishing, pursuant to Regulation (EC) No 842/2006 of the European Parliament and of the Council, minimum requirements and the conditions for mutual recognition for the certification of personnel recovering certain fluorinated greenhouse gases from high-voltage switchgear.
[49] Commission Regulation (EC) No 304/2008 of 2 April 2008 establishing, pursuant to Regulation (EC) No 842/2006 of the European Parliament and of the Council, minimum requirements and the conditions for mutual recognition for the certification of companies and personnel as regards stationary fire protection systems and fire extinguishers containing certain fluorinated greenhouse gases.
[50] Fluorinated Greenhouse Gases (Implementing) Regulations (Subsidiary Legislation 427.94): http://www.justiceservices.gov.mt/DownloadDocument.aspx?app=lom&itemid=12826&l=1

HFCs. It is expected that this shall result in a transition to refrigerants with a lower GWP, leading to a reduction in HFC consumption and, consequently, in the emissions of F-gas, in the EU.

The regulation focuses on limiting the number of F-gases sold in equipment, banning use of F-gases where less harmful alternatives exist, and preventing emissions of F-gases from existing equipment. Thanks to the F-gas regulation, the EU's F-gas emissions will be cut by two thirds by 2030 compared to 2014 levels.

It should be noted that the LCDS does not refer to any new measures for the IPPU sector.

Table 4.9. A comparison of measures reported in previous reporting and the NC8.

Previous Reporting	National Communications 8
Implementation of the original F-gas Regulation (Regulation (EC) No 842/2006)+	Implementation of the original F-gas Regulation (Regulation (EC) No 842/2006)
	Implementation of the current F-gas Regulation (Regulation (EU) No 517/2014)

\+ *Information related to this measure can be found in NECP & NC7*

4.4.4 Agriculture

Agriculture

Despite agriculture being the second smallest contributor to national greenhouse gas emissions in Malta, the LCDS puts in place the following measures, addressing the decrease of methane emissions from enteric fermentation and nitrous oxide emissions from agricultural soils. To the extent they are feasible, these measures are expected to have implementation timeframes after 2030.

- Aquaponics
- Methane-inhibiting vaccine

Measure 1: Methane-inhibiting vaccines

The LCDS notes that this future option that may be implementable after 2040, targets methane-producing microorganisms in the rumen of livestock (methanogens). Such vaccines are currently in the early stages of development, and a fully developed vaccine is not expected before 2030. However, it should be noted that the emergence of such a technology is, however, not guaranteed. If a vaccine is to be developed and obtain the necessary regulatory approval, it will need to overcome practical challenges such as ensuring the vaccine has no unintended adverse effects (e.g. reduced productivity, different product taste, compromised food safety). Additionally, in the EU, the European Medicines Agency regulates the use of veterinary vaccines, reviewing applications for market authorisation approval. Any prospective vaccine would need to clear this authorisation process. Regarding implementation, the cost to farmers is expected to be low - given that farmers already vaccinate livestock to prevent disease, adding another vaccine would be simple and cheap to administer.

Measure 2: Aquaponics

There are opportunities for Malta's agricultural sector to reduce its emissions through diversification of food production methods, shifting towards forms of agricultural production which require reduced inputs of fertilisers, water resources and energy relative to conventional agriculture. One such method is the use of aquaponics, a portmanteau of aquaculture and hydroponics, which combines these two agricultural techniques. An aquaponic agricultural system involves the recirculation of water from fish tanks through filtration units and into soil-less hydroponic beds in which crops are grown. Locally, the current aquaculture activity will be leveraged in order to feed into aquaponics activities. Features of aquaponics which lead to lower GHG impact per unit yield of fruit and vegetable include:

- no soil loss which might lead to emissions through loss of soil-organic carbon;
- heavily reduced synthetic fertiliser input; and
- reduced water use.

One area where aquaponics is more energy intensive than conventional agriculture is in the use of electricity due to lighting, aeration and pumping requirements. However, it should be noted that as Malta's grid carbon intensity decreases over time, the impact of this difference will be negated. At present, the Maltese Diversification and Competitiveness Directorate is participating in an EU PRIMA Project called Self-sufficient Integrated Multi-Trophic Aquaponics (SIMTAP). The main goal of the project is to define, design, set up and test aquaponics systems that reduce fish feed inputs and other resource consumption including water and energy. The project intends to undertake a Life Cycle Assessment (LCA) to quantify the environmental impacts with greater certainty. Once a system has been defined which can operate successfully in Malta, and with confirmed emissions abatement benefits, then government will provide support. The Diversification and Competitiveness Directorate might consider seeking funding to provide grants or loans for equipment and training programmes for those in horticultural and aqua cultural sectors to upskill so as to consider the use of aquaponics.

Table 4.10. Agriculture LCDS Measures Abatement Potentials (LCDS, 2021)

	Abatement Potential (KtCO2eq./yr)		
	2030	**2040**	**2050**
Total	0	4.933	6.762

The measure that was reported in the NC7 has now been implemented since 2016, and is taken into consideration in the WOM scenario. It is a measure addressing the treatment of 39,000t of cattle and poultry waste at the Malta North Mechanical Biological Treatment Plant. On the other hand, the 2 new measures coming out of the LCDS, have been adopted but are still being researched.

Table 4.11. A comparison of measures reported in previous reporting and the NC8.

Previous Reporting	National Communications 2022 (NC8)
Malta North Biological Treatment Plant (Agriculture Waste Management Plant)+	Methane-inhibiting Vaccine
	Aquaponics

+ *Information related to this measure can be found in NECP & NC7*

Table 4.12. Information on non-GHG mitigation benefits of agriculture measures.

<table>
<tr><th>Measures</th><th>Positive Impacts</th><th>Negative impacts</th></tr>
<tr><td>Commercial scale Aquaponics- based food production</td><td rowspan="2">Social
• New entrepreneurship/ employment opportunities
• Potential for exports
• Improved public health

Economic
• Niche area of economic growth through innovation (aquaponics)
• Increased product offering in the market (aquaponics)
• Lower dependency on imports
• FDI opportunities</td><td rowspan="2">Social
• Food safety issues
• Change to farming practices
• Increased regulation by public authorities
• Need to tackle the negative perception of produce quality

Economic
• Import flows
• High capital and operating costs (aquaponics)
• Affordability issues if any increase in costs is passed onto consumers</td></tr>
<tr><td>Methane inhibiting vaccines</td></tr>
</table>

4.4.5 LAND USE, LAND USE CHANGE AND FORESTRY (LULUCF)

The latest Malta's End of Period Progress Report on Information on Land Use, Land Use Change and Forestry Actions (MRA,2020), submitted in 2020, pursuant to Article 10 (4) of Decision No 529/2013/EU[51] of the European Parliament and of the Council, provides detailed information on actions relating to LULUCF activities and LULUCF actions plans in the Maltese Islands. It provides information on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land use change and forestry and information concerning actions relating to those activities.

Considering the limitations of the Maltese Islands due to its 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 to mitigate emissions and maintain or increase the removals is, as a result, highly restrained. The potential of LULUCF activities aimed to mitigate climate change and enhance or preserve the sinks include;

- Afforestation projects and Forest Management of existing woodlands
- Sustainable activity and management of land.

The success of afforestation projects which can further enhance the sinks and as a result also potentially lead to a reduction in GHG emissions are based on the following factors: the geographic specificities of the Maltese islands need to be taken into account in order to implement the measures; the limiting factors in implementing LULUCF measures to further enhance and safeguard the sector; limited land availability; lack of water; lack of

[51] Decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities

rainfall; and, high population density. Moreover, safeguarding the existing woodlands through sustainable forest management is of equal importance to preserve and maintain the limited remnants and corpses of woodlands which remain today.

Throughout the years Malta has established several afforestation projects implemented around parts of the Maltese Islands. Various restoration projects were carried out in existing public gardens as well as forestation projects in a number of localities in Malta. Projects also included the re-establishment of derelict countryside sites across the Maltese Islands, as well as soil conservation, through the reconstruction of collapsed walls and sites re-instated to their original state. The afforestation projects carried out and their management will be discussed in detail in the following sections. A number of afforestation projects are undertaken by a number of entities as further detailed below. Several budget measures also address restoration of public gardens and parks and afforestation measures.

4.4.5.1 Benghajsa Afforestation

In summer 2019, the Maltese Government announced that an undeveloped area behind the Freeport in Birzebbugia is set to be transformed into around a 3-hectare park with 8,000 trees. The afforestation project, which was announced in May is projected to cost €400,000 and will see the site in Benghajsa turned into an area which can be used for picnics, camping and tourism purposes. The project will be split into three phases: the afforestation itself, the creation of a camping site, and the converting of an underground bunker in the area into a tourist attraction. The management of the planting of 8,000 endemic trees was entrusted to the Ministry for Tourism and Consumer Protection under the auspices of Infrastructure Malta in 2020.

In 2020, Infrastructure Malta was completing the planting of over 2,200 indigenous trees and shrubs in a new grove in Bengħajsa, Birżebbuġa. This new 'green lung' in southern Malta forms part of Infrastructure Malta's long-term environmental commitment to plant thousands of trees in different rural and urban public spaces. After planting 8,719 trees in over 40 locations in 2019, in 2020 it planted 4,130 new trees and some 3,000 shrubs in several other locations. Following a recent public call for location suggestions, Infrastructure Malta was working to add many more new trees and shrubs in several localities by the end of the year.

The new grove in Benghajsa was formed on a 15,000-metre-squared area of disturbed land, more than twice the size of a football ground, next to the Malta Freeport. Infrastructure Malta's contractors planted over 300 aleppo pine trees, 350 olive trees, 260 holm oak trees, 220 sandaric gum trees (gharghar; Malta's national tree) and another 12 species of trees and shrubs such as judas trees, cypresses, carob trees, pomegranate trees, bay laurel and white mulberry trees. It is also installing an irrigation system to facilitate the regular watering of these trees. It will continue taking care of the grove for several years, until it is fully established and can be opened to the public.

The Bengħajsa grove will eventually form part of a larger environmental complex that Government is developing on adjacent lands. This park will include pathways, benches, picnic areas, camping grounds and other outdoor wellbeing and leisure facilities. More trees will be planted in other areas of this complex as well. During the last few months, the agency formed the tree planting areas by depositing and sifting 55,000 tonnes of soil, primarily utilizing soil it had recovered from several ongoing or recently completed road projects. As part of its environmental commitment, Infrastructure Malta keeps all soil excavated during its infrastructural projects so that it can reuse it for other afforestation and landscaping projects. It is currently also providing soil for the development of the new Malta National Park, at Ta' Qali.

4.4.5.2 Ta' Qali National Park

proposed national park in Ta' Qali, which was announced in 2019, will see a tract of land which will be transformed into an open space in an investment of €20 million. The land previously housed an abandoned concrete factory that was demolished by the Planning Authority enforcement section. The park is set to spread over 45 hectares (450,000sqm). The existing national park is prevised to double in size, with 80,000 new trees being planted.

4.4.5.3 Wied Fulija National Park

Another project announced in 2019 is a disused rubbish dump in the outskirts of Zurrieq, which was earmarked to become a wooded park. Around 45,000 plants – mostly indigenous shrubs – will replace tons of glass and construction waste in Wied Fulija. It was announced that "hundreds" of three-metre trees will be included in the Wied Fulija project. The project will not be finalised for another four years. The landfill of Wied Fulija is currently going through rehabilitation transforming into a 95,000 sqm nature park in Żurrieq. The rehabilitation of the site started in March 2019 and they are seen to wind up by December 2020. The rehabilitation is set to cost some €4 million.

The site was first used as a landfill in 1979 and stopped accepting waste in 1996. During its operational period, it is estimated that some 1.85 million tons of waste were deposited in the valley during which every type of waste, including dangerous waste, was dumped and spread by the cliffs and ended up at sea.

An intensive strategy to reduce the spreading of waste at sea and to limit other pollution was implemented. The rehabilitation, apart from visually integrating the landfill with the surrounding landscape, will reduce rain infiltration to minimise the production of leachate which impacts on the water quality.

4.4.5.4 Other Planting Projects

Several other afforestation/planting projects were carried out around locations in Malta in 2018 and 2019. Much of the of the planting projects occurred in valley systems, Natura 2000 sites and protected areas and rural areas for the purpose of habitat restoration. Furthermore, other plantings took place in gardens and parks for landscaping and in urban greening areas. In 2020, numerous planting projects also took place in some of the same sites where planting was performed in 2019, as well as new plantings in various other sites. Habitat restoration planting took place in valleys, Natura 2000 and protected sites and in rural areas. In designated parks and gardens, planting took place for landscaping purposes, whereas in other parks/gardens planting took place for conversion in other land uses changes.

Since Infrastructure Malta launched its nationwide tree-planting programme in summer 2019, it has now introduced over 11,800 indigenous trees in 80 different roadside strips and other urban and rural areas in Malta. Infrastructure Malta aims to extend this initiative in other localities. Through this environmental commitment, the agency also contracted the services required to water and take care of these trees for several years, until they are fully established in their environment. Infrastructure Malta also planted some 1,800 perennial shrubs, some of which can eventually be trained into trees as well. Many of the new trees planted were in green zones along existing roads or new ones being built through the Agency's projects. In February and March 2020, Infrastructure Malta added several trees along the newly rebuilt roads, as well as in roadside green areas.

In another locality the agency planted over 1,000 trees in 11 streets this year, and in addition through similar collaborations, the agency added some 145 trees in two other localities. Infrastructure Malta is planning to plant another 580 trees in these two localities and in one other locality, in and around the arterial road corridor it is upgrading through the Central Link Project. The tree selection for each site includes over 30 indigenous tree species such as tamarisk, olives, cypress, European dwarf palms, lentisk, holm oaks, Aleppo pines, myrtle, sandarac gum trees and carobs, amongst others51.

The planting in other localities such as Natura 2000 and Protected areas sites as well in rural areas will also follow after 2020, continuing in 2021, and some of them planting will also continue until 2024. The main purpose of the planting is habitat restoration and landscaping. It is envisaged that around 17,000 trees and shrubs will be planted around these sites and will be completed by the PARKS Malta and Ambjent Malta entities.

Table 4.13 quantifies the estimates of mitigation impact of the several projects mentioned.

Table 4.13 Mitigation impact of LULUCF policies and measures.

Name of policy or measure	**GHG affected**	**Estimate of mitigation impact, by gas (Kt CO2 eq.)**			
		2025	**2030**	**2035**	**2040**
Afforestation project in location of Benghajsa	CO2	-0.001	-0.001	-0.002	-0.005
Afforestation project in location of Ta' Qali.	CO2	-0.022	-0.044	-0.066	-0.147
Afforestation project in location of Wied Fulija.	CO2	-0.005	-0.009	-0.014	-0.031
Various afforestation/planting projects in sites – Natura 2000 & Protected Areas, Golf il-Kbir, San Anard, Fort Madliena, rural areas & Heritage Malta site, etc.	CO2	-0.002	-0.004	-0.007	-0.014

Table 4.14. A comparison of LULUCF measures reported in previous reporting and the NC8.

Previous Reporting		**National Communications 8**
Afforestation/ Plantings**	Ta' Qali National Park	No new measures.
	Wied Fulija National Park	
	Benghajsa afforestation.	
	Various afforestation/planting projects in sites: including Natura 2000 & Protected Areas, Golf il-Kbir, San Anard, Fort Madliena, rural areas & Heritage Malta site	

***Information related to this measure can be found in the NECP (2019)*

It is to note that between the previous National Communication to the latest submitted National Communication, there were no changes present in terms of policies and measures.

4.4.6 WASTE

Even though the waste sector accounts for less than 10% of the national total greenhouse gases, under the LCDS and in line with the Waste Management Plan (WMP) for the Maltese Islands (2021 to 2030), the following measures are put in place, especially in the areas of recycling and waste prevention; high biowaste capture, incineration pre-sorting and waste prevention.

i. **High biowaste capture**

For the high biowaste capture measure, 80% of municipal biowaste is assumed to be collected for recycling. This takes place via the anaerobic digestion (AD) facility with the captured biowaste mainly comprises of food waste, which is presumed to be sourced from both households and commercial. The avoidance of the disposal of biowaste in landfills results in lowering of methane emissions from such facilities.

ii. **Incineration pre-sorting**

For the incineration pre-sorting measure, the purpose is to improve the municipal recycling rate. By implementing this measure, there will be a significant improvement in the recycling rate of plastic film, which has a notable impact on the environmental consequences associated with incinerating residual waste.

iii. **Waste prevention**

Another waste prevention measure is the ongoing support to reduce particularly food waste, junk mail and the support to adopt to reusable nappies. This in turn reduces the amount of waste to be handled, including in landfills, and a consequential reduction in emissions from landfilling activities, particularly in the case of biodegradable waste.

Waste Management Plan for the Maltese Islands 2021-2030

The Ministry responsible on the Environment has developed a Waste Management Plan for the Maltese Islands 2021-2030, as mandated under the European Union Waste Framework Directive and as transposed in local legislation. The measures set out in the WMP are outlined in the Low Carbon development Strategy.

The Waste Management Plan for the Maltese Islands 2021-2030 has been developed in compliance with Article 28 of the EU Waste Framework Directive, which stipulates that each Member State shall establish a Waste Management Plan which "shall set out an analysis of the current waste management situation in the geographical entity concerned, as well as the measures to be taken to improve environmentally sound preparing for re-use, recycling, recovery and disposal of waste and an evaluation of how the plan will support the implementation of the objectives and provisions of this Directive. This plan will not only support Malta's overall transition towards a circular economy but will also support Malta's compliance with the Waste Framework Directive and the achievement of EU waste and recycling targets.

Key priority areas for the Waste Management Plan 2021-2030 have been identified in alignment with the strategic objectives. These are as follows;Waste Prevention, increasing infrastructural capacity, expanding extended producer responsibility, modernising waste collection, regulating commercial waste, exploring economic instruments, and strengthening compliance and enforcement.

Through the Waste Management Plan, Malta's strategic objectives are to:

- Maximise the resource value in waste through different management options
- Innovate by designing waste prevention initiatives to lower Malta's per capita generation rate
- Reform the collection system to increase economies of scale, harmonise collection practices and modernise the collection fleet
- Build the necessary waste management facilities to treat recyclable, organic and residual waste to achieve Malta's targets
- Study the feasibility of an enhanced producer responsibility framework to complement Malta's transition to a circular economy and reflect further on the true cost of waste management
- Promote further the involvement of the private sector in waste management

The Waste Management Plan sets out a number of key priority areas that are aligned with the strategic objectives in order to ensure a robust and effective waste governance framework. An overview of Malta's obligations under the European Union waste directives is provided, as well as an update on where we stand today. In bridging the gap between Malta's current performance and the 2030 waste targets, a suite of ambitious measures is outlined in the Plan, structured as follows:

- Waste Prevention as a Priority
- Waste Collection Reform
- Waste Management and Resource Optimisation

Measures for improving waste infrastructure

The following measures with respect to waste treatment infrastructure will be implemented over the coming decade to ensure we divert resources away from landfill, with the key initiative being investment in treatment plants at the EcoHive Complex.

- Ensuring recovery of materials
- Improving treatment of organic wastes
- Upgrading Thermal Treatment
- Improving efficiencies of waste management
- Ensuring that we have the best possible infrastructure in place to support deployment of ECOHIVE
- Diversion from landfill and investing in Waste to Energy
- To improve understanding of changing terms in waste composition and inform further decision making on waste management initiatives through waste characterisation exercises.
- A process of review and renewal to maximise operational efficiencies.
- To assess the feasibility of introducing a hierarchy of fees for facility gate fees to ensure full cost recovery for operational and environmental costs.

Waste-to-Energy plant

The investment of a waste-to-energy facility is to be commissioned in 2024 as to enable the increased diversion of residual waste from landfill, hence significantly limit landfilling volumes and therefore emissions, to further lead to compliance with European legislation.

ECOHIVE is the largest ever investment in the waste management sector that will drive Malta towards a circular economy. This project will process waste in the most sustainable and resource-efficient way possible while also turning it into precious resources into energy and agricultural compost (Ecohive, 2020). The name ECOHIVE refers to as the following: "ECO" ties to the environment and sustainability, while "HIVE" reminds us of a beehive which is constantly active. Four new waste management plants will form part of the ECOHIVE project: energy, recycling, organic and hygienics.

A 5,000 square meter Waste-to-Energy (WtE) plant will be built in Malta to reduce the amount of municipal solid waste disposed into the landfill. The plant will manage around 40% of the overall waste generated in the Maltese Islands, equivalent to 114,000 tonnes and recover a substantial amount of energy of about 69000 MWh per year. The WtE plant will use a robust technology known as Moving Grate Incineration and the waste fed in the plant will be non-recyclable waste.

The waste measures make up a smaller contribution to abatement potential. The abatement potentials for the waste LCDS measures are presented in the below table.

Table 4.3. Waste LCDS Measures Abatement Potentials (LCDS, 2021)

	Abatement Potential (KtCO2eq./yr)		
	2030	**2040**	**2050**
Total	31.832	32.779	68.083

The measures proposed in the below table builds on those measures and actions already included in the NECP and are also aligned with the Waste Management Plan. These measures include also the commissioning of new infrastructure.

The need to capture separately the collection of food waste is to be treated in the new infrastructure as to achieve emission reduction from food waste. Under the LCDS, pre-sorting of plastics would be mandatory at the Waste-to-Energy facility. The implementation of this measure necessitates the development of plant specification. Such facility will ensure the capability to effectively sort all types of plastics including plastic film for recycling purposes. The waste prevention plan measure aims to facilitate the prevention of waste and the reuse of materials. The target waste streams will be tackled through measures that include for instance, awareness-raising campaigns.

Table 4.4. A comparison of measures reported in previous reporting and the NC8.

Previous Reporting	National Communications 8
Separation of organic waste*	High biowaste capture
The design and commissioning of new end-of-pipe infrastructural solutions to treat separately collected organic waste from which biogas is generated as a by-product and Recovering energy from waste*.	Incineration pre-sorting
Focusing awareness campaigns on better quality recycling, together with increasing the enforcement capacity*.	Waste prevention
Waste Management Plan for the Maltese Islands 2014-2020 and Waste Management Plan for the Maltese Islands 2021-2030+	Waste Management Plan for the Maltese Islands 2021-2030

***Information related to this measure can be found in NC7**
+ Information related to this measure can be found in NECP & NC7*

The measures proposed for the waste sector according to their positive and negative impacts in relation to social and economic impacts are presented in the table below.

Table 4.5. Mitigation co-benefits (Waste).

Measures	Positive Impacts	Negative impacts
Sorting of Residual Waste at incinerators 80% Capture of Municipal Biowaste and Biogas Upgrade Household waste prevention measures	Social • Creation of additional green jobs • Increased public awareness on waste management issues and facilitated responsible participation. Increased awareness in homes enables food cost savings • Improved public health • Improved security for incinerator workers & neighborhoods • Better job conditions for EfW plant workers • Lower nuisance effects on individuals residing near the EfW facility Economic • Cost savings for commercial businesses and more customer profile insights for tailored offerings • Potential reduction in costs, capacity issues and adverse externalities experienced in the sector • Economic efficiency and resiliency gains from a more circular economy • Creation of additional raw material input into secondary economic markets • R&I in connection with change in biogas use and development of efficient waste sorting management processes	Social • Change in household behavior requires more attention and effort, against time and space constraints • Potential disincentive for households to sort recyclable waste at source (from semi-mixed waste separation measure Economic • Higher administrative burden on Local Councils • Higher cost of collection • Administrative burden on entities such as WasteServ and ERA • Change in demand for printing houses • Macroeconomic impacts from household behavior changes (e.g. purchases, saving)

Measures	Positive Impacts	Negative impacts
	• Indirect contribution to lowering food insecurity and malnutrition goals • Positive impacts on reaching national recycling targets	

Instruments

The below tables give a summary of the measures considered under the WOM and the WEM scenarios respectively. Cross-cutting measures are reported in these tables and not in the text.

Moreover, it should be noted that Policies and Measures considered under the WOM scenario (i.e. as part of baseline) have not changed; hence none of the measures previously reported are no longer in place.

The type of instrument allocated to measures in the tables below have been chosen according to the following definitions.

Table 4.15. Type of instrument definitions.

Type of instrument	Definition
Regulatory	A measure of general application related to any matter covered by this Agreement adopted by regulatory agencies with which compliance is mandatory. Measures would require a change in the regulation
Economic	Private or Government investment or government monetary support.
Fiscal	Measures enforcing tax or excise duty (indirect taxes on sale or use of specific products)
Voluntary/negotiated agreements	An agreement between a government authority and private parties with the aim of achieving environmental objectives or improving environmental performance beyond compliance to regulated obligations.
Information	Required public disclosure of environmentally related information, generally by industry to consumers. These include labelling programmes and rating and certification systems.
Other/Planning	Any policy instrument that does not fall under any other type of instrument. Includes planning (Large-scale measures that need to be instituted by the government and for which the exact type of instrument has not been as yet defined, such as measures related to infrastructure).

Table 4.16 Summary of Policies and measures by sector (WOM)

Name of mitigation action	Sectors affected	GHGs affected	Objective and/or activity affected	Type of instrument	Aim of the Measure	Start year of implementation	Implementing entity or entities	2020
Submarine electrical connection to European electricity network	Energy	CO2, CH4, N2O	Efficiency improvement in the energy transformation sector.	Economic	To help Malta to diversify its energy source.	2015	Enemalta p.l.c.	65.33
Promotion of Solar water heating	Energy	CO2, CH4, N2O	Electricity demand management and reduction.	Economic	To encourage households and the business community to invest in these solar technologies	2006	Regulator for Energy and Water Services.	8.32
Incentives for photovoltaic systems	Energy	CO2, CH4, N2O	Electricity demand management and reduction.	Economic	To encourage electricity generation from alternative and renewable sources	2006	Regulator for Energy and Water Services.	21.56
Grant on purchase of micro wind-turbines	Energy	CO2, CH4, N2O	Demand management and reduction.	Economic	To help Malta to diversify its energy source.	2006	Government	0.06
Biofuel substitution obligation.	Transport	CO2	Alternative fuels in transport.	Regulatory	The aim is to meet the target of a 10% share of RES in transport in 2020 as per Article 3(4) of Directive 2009/28/EC.	2011	Malta Resources Authority.	24.00
Introduction of autogas	Transport	CO2	Low carbon fuels.	Regulatory	Utilization of cleaner fuels with lower emission factors, specifically targeting the reduction of greenhouse gas (GHG) emissions in road transportation.	2011	Malta Resources Authority.	0.68
Uptake of electric vehicles	Transport	CO2	Electric vehicles in road transport.	Fiscal	The aim is to promote a significant shift away from ICE vehicles in Malta. The overarching objective is to effectively mitigate emissions within the transportation sector and achieve a substantial reduction in environmental impact.	2011	Transport Malta.	2.12
E-working and teleworking	Transport	CO2	Demand management in transport.	Voluntary Agreement	The aim is to actively minimize the frequency of trips or the necessity for transportation, leading to a consequent reduction in greenhouse gas (GHG) emissions arising from road transport.	2010	Government.	0.66
Modal shift to public transport and public transport reform.	Transport	CO2	Modal shift in transport.	Voluntary Agreement	The aim is to further enhance public transport utilization with the intention of reducing reliance on private vehicles, thereby effectively targeting a reduction in greenhouse gas (GHG) emissions.	2012	Transport Malta.	38.71
Aerial emissions control in landfills	Waste management/waste	CH4	Methane emissions control and use, in landfills.	Economic	The aim is to treat odour and noxious gas emissions, to improve stability, control of emissions and	2008	Wasteserv.	45.14

Name of mitigation action	Sectors affected	GHGs affected	Objective and/or activity affected	Type of instrument	Aim of the Measure	Start year of implementation	Implementing entity or entities	2020
					aesthetics. Extracted gases to be utilised for power.			
Sant' Antnin Mechanical Biological Treatment Plant	Waste management/waste	CH4	Improved waste management.	Economic	The aim of the treatment of organic waste is to obtain energy and divert waste from landfill hence, waste becoming a resource.	2011	Wasteserv.	32.21
Urban Wastewater treatment	Waste management/waste	N2O	Improvement of wastewater management.	Economic	The aim is to reduce the amount of untreated wastewater being disposed to the sea hence, reducing emissions from the wastewater category from untreated wastewater.	2011	Water Services Corporation.	45.97
Wastewater sludge treatment	Waste management/waste	CH4	Improved management of wastewater.	Economic	The aim is to reduce the amount of untreated sludge being disposed of in the landfill.	2012	Water Services Corporation.	1.07
Supply of natural gas for electricity generation.	Energy	CO2, CH4, N2O	Switch to less carbon-intensive fuels.	Economic	To help Malta to diversify its energy source.	2016	Ministry for Energy and Water Conservation.	463.20
EU F-gases Regulation	Industry/industrial processes	HFCs	Reduction of emissions of F-gases.	Regulatory, Education	The reduction of emissions of F-gases through the limitation of emission of F-gases, especially from refrigeration and air-conditioning systems, including through training and certification of technical personnel, improved reporting, and eventual bans of high GWP gases in accordance with timeframes established in the Regulation.	2012	Government: Malta Competition and Consumer Affairs Authority.	10.37
PV Grant Scheme	Energy	CO2, CH4, N2O	Demand management and reduction; increase in renewable energy.	Economic	To encourage households and the business community to invest in these solar technologies	2014	Energy and Water Agency (formerly Sustainable Energy and Water Conservation Unit (SEWCU))	32.48
PV Feed-in-Tariff Schee	Energy	CO2, CH4, N2O	Demand management and reduction; increase in renewable energy.	Economic	To encourage households and the business community to invest in these solar technologies	2014	Energy and Water Agency (formerly SEWCU)	30.63
PV: Communal PV Farms	Energy	CO2, CH4, N2O	Increase in renewable energy.	Economic	To encourage households and the business community to invest in these solar technologies	2014	Energy and Water Agency (formerly SEWCU)	42.29
Waste Management Plan for the Maltese Islands 2014-2020	Waste management/waste	CO2, CH4, N2O	Waste management plan.	Regulatory	The aim is to move waste management up the waste hierarchy through increased prevention, re-use, recycling and	2014	Government: Ministry for the Environment, Sustainable Development and Climate Change.	0.27

Name of mitigation action	Sectors affected	GHGs affected	Objective and/or activity affected	Type of instrument	Aim of the Measure	Start year of implementation	Implementing entity or entities	2020
					recovery and hence reducing waste going to the landfilling.			
Mechanical Biological Treatment Plant (Malta North)	Agriculture	CH_4, N_2O	Improved animal waste management.	Economic		2016	Wasteserv	0.45

Measures included in this table fall under the WOM scenario and have all been implemented.

Table 4.17 Summary of Policies and measures by sector (WEM)

*at present, it is not possible to identify a start year of implementation for the measures indicated here. The start year of implementation will be provided in a next National Communication.

Name of mitigation action	Sectors affected	GHGs affected	Objective and/or activity affected	Type of instrument	Status of implementation	Start year of implementation	Implementing entity	2030	2040	Cost (mEUR/NPV)	Cross-cutting measures
Aquaponics	Agriculture	N_2O	Diversification of food production methods	Economic, Other	Adopted	*	MAFA	NE	0	Not available.	
The aim is to reduce emissions from managed agricultural soils through SOC loss, fertilizer application to soil and water use. Aquaponics would involve the recirculation of water from fish tanks through filtration units and into soil-less hydroponic beds in which crops are grown.											
Vaccination (Cattle)	Agriculture	CH_4	Reduction of methane production during enteric fermentation	Other	Adopted	*	MAFA	NE	4.93	Not available.	
A vaccine targeting methane producing microorganisms in the rumen of livestock. It is implementable post-2040. such vaccines are currently in the early stages of development and fully developed vaccine is not expected before 2030. Given that farmers already vaccinate livestock to prevent disease, implementation would be simple and cost would be low.											
Domestic LEDs	Energy	CO_2, CH_4, N_2O	Increase in Energy Efficient lighting	Economic	Adopted	*	MEEE	2.41	0.99	14.85	
The aim is to achieve a wholesale shift to LEDs by 2030. This would equally apply to bulbs used in residential and non-residential buildings.											
Domestic Non-solar AWHPs	Energy	CO_2, CH_4, N_2O	Continued update of renewable heating technologies	Economic	Adopted	*	MEEE	2.3	9.01	882.55	Interaction with IPPU - This measure could increase the use of refrigerants
Support schemes aimed at the installation of Air-Water heat-pumps preplacing traditional electric water heaters.											
Energy-efficient Domestic Refrigeration	Energy	CO_2, CH_4, N_2O	Increase in Energy Efficient appliances in the residential sector	Economic	Adopted	*	MEEE	15.19	6.25	591.13	
Energy-efficient Domestic Dishwashing	Energy	CO_2, CH_4, N_2O	Increase in Energy Efficient appliances in the residential sector	Economic	Adopted	*	MEEE	34.48	14.19	240.65	
Government incentives to vulnerable and energy poor households to replace old appliances with new efficient units by 2030. Grant funding be would be capped on an annual basis and increased over time as necessary to ensure the maximum switch possible by 2030. Alternatively, grants could be implemented using discount vouchers for EE appliances until these achieve parity with the inefficient appliances.											
Single-family Building Roof Insulation	Energy	CO_2, CH_4, N_2O	Reduced energy consumption	Economic	Adopted	*	MEEE	5.04	2.07	99.35	Interaction with IPPU - These measures could potentially reduce the use of ACs, but it is highly unlikely that the number of new units purchased will be reduced.
Multi-family Building Roof Insulation	Energy	CO_2, CH_4, N_2O	Reduced energy consumption	Economic	Adopted	*	MEEE	1.7	0.7	4.71	
Office Building Roof Insulation	Energy	CO_2, CH_4, N_2O	Reduced energy consumption	Economic	Adopted	*	MEEE	0.19	0.08	1.35	
Additional abatement will be provided through greater usage of roof and wall insulation to ensure buildings stay cool, minimised need and use of air-conditioning during summer months, as well as maximising any heating required during winter months.											
Non-residential LEDs	Energy	CO_2, CH_4, N_2O	Increase in Energy Efficient lighting	Economic	Adopted	*	MEEE	3.33	1.37	Not available.	
The aim is to achieve a wholesale shift to LEDs. This would equally apply to bulbs used in residential and non-residential buildings. Measures to drive a full switch to LED lighting could provide some additional abatement; however the levels are not significant as other types of EE bulbs are highly pervasive in the market by 2030 and the savings from a switch of such bulbs to LEDS are not as significant as they would be where the switch is made from incandescent light bulbs.											

Name of mitigation action	Sectors affected	GHGs affected	Objective and/or activity affected	Type of instrument	Status of implementation	Start year of implementation	Implementing entity	2030	2040	Cost (mEUR/NPV)	Cross-cutting measures
Non-residential Light Sensors	Energy	CO_2, CH_4, N_2O	Reduced energy consumption	Economic	Adopted	*	MEEE	10.57	4.35	16.84	
Energy-efficient Office Appliances	Energy	CO_2, CH_4, N_2O	Reduced energy consumption	Economic	Adopted	*	MEEE	9.12	3.75	29.92	
The use of EE office equipment and the installation of light sensors (mainly in non-residential buildings) to optimise lighting usage would be expected to generate further abatement. Some additional abatement could be achieved through greater usage of roof and wall insulation to ensure buildings stay cool and air-conditioning use is minimised during summer months, as well as maximising any heating required during winter months as the grid decarbonises this becomes less impactful in emission terms.											
Solar PV	Energy	CO_2, CH_4, N_2O	Increase in Renewable Energy	Economic	Adopted	*	MEEE	72.16	92.78	292.87	
New PV systems by 2030 will enable Malta to reach the 11.5% target share of RES in gross final energy consumption (by 2030). The technical limitation of solar PV will be reached by 2030 where circa 9,127 new PV systems will enable Malta to reah the 11.5% target share of RES in gross final energy consumption. The technical limitation should be reviewed every 5 years to assess if further expansion is possible.											
Additional Interconnector	Energy	CO_2, CH_4, N_2O	Facilitate the decarbonization of energy generation	Planning/Economic	Adopted	*	MEEE	703.22	703.22	807.63	
The proposed scenario considers the installation of an additional interconnector as an alternative source of supply to decarbonise the energy grid and gradually move away from use of gas. Grid decarbonisation would be achieved since emissions from power generation would take place outside of the territory of Malta, and would thus not be accounted for in the national emissions inventory. The current estimation is that this would be sized at around 200MW. This would allow Malta to shift away from CCGT and reduce significantly territorial emissions from electricity generation.											
Floating Offshore Wind	Energy	CO_2, CH_4, N_2O	Increase in Renewable Energy	Planning/Economic	Adopted	*	MEEE	43.94	343.27	1,026.55	
In addition to some additional capacity of land-based solar PV consideration was given to offshore floating technologies (offshore floating wind (OFW).With technology breakthrough in offshore marine renewables (coupled with other instruments and measures), Malta could aim to target higher RE shares beyond 2030. Studies are underway to identify the ideal zones for the development of offshore farms according to risk levels and wind speeds.											
Solar Water Heaters	Energy	CO_2, CH_4, N_2O	Increase in Renewable Energy	Economic	Adopted	*	MEEE	3.42	10.27	809.76	
In conjunction to solar pv systems, increase in use of solar water heaters provide additional abetment of cost and emissions.											
Industrial Energy Efficiency	Energy	CO_2, CH_4, N_2O	Reduced energy consumption	Economic	Adopted	*	MEEE	54.43	25.7	547.21	
An improved energy efficiency in the industrial sector will be implemented through the implementation of switch-off routines for machinery, replacement of moulds with state of the art designs, introduction of variable speed drives on motors, utilisation of waste heat from air compression processes and the use of LED lighting.											
High Biowaste Capture and Biogas Upgrade	Waste	CH_4	Anaerobic digestion of food waste to produce heat and electricity	Economic/Planning	Adopted	*	MEEE	2.52	2.62	15.12	Interaction with Energy -This measure increases, though marginally, the share of renewable energy.
This measure assumes that 80% of municipal biowaste is captured for recycling, which takes place via an anaerobic digestion (AD) facility. Since locally there is little in the way of garden waste, the captured material consists largely of food waste – assumed to be collected from both households and commercial facilities.											
Incineration Pre-sorting	Waste	CO_2, CH_4, N_2O	Producing electricity and heat from non-recyclable waste	Economic/Planning	Adopted	*	MEEE	21.97	22.81	7.2	Interaction with Energy - The installation of the Waste-to-Energy facility will affect both the waste and energy sectors (increases the share of renewable energy).
This measure assumes that additional sorting equipment is put in place to ensure the efficient removal of a wide range of recyclables from residual waste, thereby further improving the municipal recycling rate. In this way, the recycling rate for plastic film – which makes a reasonably significant contribution to the impacts of incinerating residual waste – is improved substantially.											
Waste Prevention	Waste	CH_4	Reduction of food waste, junk mail, and support a switch to reusable nappies.	Economic/Planning	Adopted	*	MEEE	7.31	7.33	Not available.	
Measures will continue to be put in place to support waste reduction, in particular reducing food waste, junk mail, and support a switch to reusable nappies.											

Name of mitigation action	Sectors affected	GHGs affected	Objective and/or activity affected	Type of instrument	Status of implementation	Start year of implementation	Implementing entity	2030	2040	Cost (mEUR/NPV)	Cross-cutting measures
Active Transport, teleworking and remote working	Transport	CO_2, CH_4, N_2O	Reducing energy demand through active mobility	Voluntary agreements	Adopted	*	MTIP	59.26	136.44	477.42	Interaction with IPPU - This measure could potentially reduce the use of ACs in sub-category Mobile Air Conditioning. However, for this measure to reduce the emissions from sub-category Mobile Air Conditioning, it must reduce the number of cars registered in Malta.
The goal of this measure is to reduce energy demand and GHG emissions by promoting a shift from car use to active transportation, particularly cycling, in Malta. This involves investing in infrastructure (taking place in the next 30 years) such as cycle tracks, bike parking facilities, and pedestrianized areas, while also promoting the use of e-bikes and pedelecs. Marketing tools and specific programs will be utilized to encourage a cultural and social shift away from private car use.											
Electrification of heavy vehicles - Battery Evs	Transport	CO_2, CH_4, N_2O	Reduction of emissions from ICE HDV replaced with EVs	Fiscal, Economic	Adopted	*	MTIP	NE	66.94	2,781.42	
The decarbonisation of road freight was assumed to take place through the electrification of heavy goods vehicles, in order to further decrease GHG emissions from road freight.											
Electrification of light vehicles - 65k BEVs & PHEVs by 2030	Transport	CO_2, CH_4, N_2O	Reduction of emissions from ICE LDVs replaced with EVs	Fiscal, planning, economic	Adopted	*	MTIP	58.9	357.28	2,406.91	
The aim is to promote a significant shift away from private car usage in Malta while simultaneously implementing additional measures to facilitate a rapid transition to electric vehicles (EVs). A draft national strategy for EV charging infrastructure has been launched, considering the installation of charging facilities at various locations. Education, incentives, and collaborations with educational institutions and automotive companies are crucial for ensuring successful adoption of EVs. Malta aims to have around 65,000 EVs, including plug-in hybrid EVs (PHEVs), by 2030. The government plans to lead by example by electrifying the government fleet, replacing approximately 1,800 ICE vehicles by 2030 and installing charging points at relevant ministries and departments.											
Public Transport (with additional EV buses)	Transport	CO_2, CH_4, N_2O	Reduction of emissions from ICE buses replaced with Evs	Planning, economic	Adopted	*	MTIP	65.8	55.07	Not available.	Interaction with IPPU - This measure could potentially reduce the use of ACs in sub-category Mobile Air Conditioning. However, for this measure to reduce the emissions from sub-category Mobile Air Conditioning, it must reduce the number of cars registered in Malta.
Efforts towards decarbonization focus on increasing the use of public transport. The strategy includes improving the overall public transport service through additional bus services, dedicated bus lanes, and traffic priority measures. Extending free public transport services serves as an incentive for increased usage.											Interaction with Electricity generation - This measure increase demand of electricity generation

Name of mitigation action	Sectors affected	GHGs affected	Objective and/or activity affected	Type of instrument	Status of implementation	Start year of implementation	Implementing entity	2030	2040	Cost (mEUR/NPV)	Cross-cutting measures
Electrification of 370 Buses by 2030	Transport	CO2, CH4, N2O	Reduction of emissions from ICE buses replaced with Evs	Planning	Adopted	*	MTIP	86.29	95.72	Not available.	
To further strengthen the national electrification efforts and contribute to a decrease in national emissions, there are plans to replace the majority of ICE route buses with electric. The target is to replace a total of 370 buses with electric alternatives by 2030.											
SME Energy Efficiency	Energy	CO2, CH4, N2O	Reduced energy consumption	Economic	Adopted	*	MEEE	20.41	9.64	Not available.	
A large number of SMEs, due to their small size, find it not cost-effective to invest in such technologies (including EE measures) or may find difficulties with the initial funding outlay required. Within this sector, examples of positive efficiency actions include: „implementing switch-off routines for machinery; replacing moulds with state-of-the-art designs;„introducing variable speed drives on motors;„utilising waste heat from air compression processes; and„use of LED lighting. The available technology for each of these processes is improving every year. For example, the base load consumption of electric injection equipment is a fraction of that of the hydraulic alternative, providing significant overall energy savings.											
Blended Zero Carbon Generation	Energy	CO2, CH4, N2O	Decarbonization of energy generation	Planning	Adopted	*	MEEE	NE	0	Not available.	
Blended Zero Carbon Generation - brings together the 3 methods for delivering low carbon energy for Malta by 2050, these being offshore floating wind, a third interconnector and hydrogen power. The measure would address the remaining gap in ensuring the Maltese grid achieves zero carbon emissions. In theory, Malta could build a supply pipeline to power hydrogen power stations on the island or build a hydrogen-ready gas pipeline that could switch from gas to hydrogen at the time any EU supply network is commissioned.											

The measures listed in this table have been included in the WEM scenario. Additional measures (WAM) are not available.
Cost refers to the Total Net Marginal investment in mEUR in 2020-2050.
Measures listed are not deemed to be innovative, however are deemed to be effectively replicable by other parties.

4.5 Use of Market-based mechanisms

In the context of the joint approach to GHG emissions reduction of the European Union, domestic action is here understood as the collective domestic effort of the Union.

The overarching EU GHG emissions reduction strategy of the European Union is based on domestic action, even for the period 2013 to 2020, when a strictly limited quantity of international project credits could be used for compliance with internal obligations.

Furthermore, future fulfilment of new climate action ambitions of the Union is based solely on domestic (EU-level) mitigation action. This is clearly inscribed in the decisions adopted by the European Council on the future objectives of the Union e.g. European Council Conclusions, October 2014: "*The European Council endorsed a binding EU target of an at least 40% <u>domestic</u> reduction in greenhouse gas emissions by 2030 compared to 1990* […]". This principle of domestic achievement of EU objectives is also reflected in the December 2020 decision of the European Council to increase the EU emission reduction target for 2030 to 55%.

The internal distribution of effort among the EU Member States is based on the principles of fairness and solidarity, meaning that all Member States are expected to contribute effectively and tangibly, within the parameters of cost-effectiveness, but also with a spirit of solidarity between the States. In this respect, all Member States are set emission reduction targets under the Effort-sharing regime, which provides for a combination of domestic effort by each State complemented by support between the States to the extent that if one State cannot fully achieve its set targets it can then make use of the flexibility mechanisms including the possibility of purchasing additional AEAs from other States who were able to limit emissions to a level below their respective original allocation.

Under the emissions trading system of the EU, the use of external units for the purposes of accounting of emissions, which was already strictly limited in previous iterations of the EU ETS Directive. As of 2021, the fulfilment of entities' obligations is only possible within the constraints of the cap on emissions set by law and use of international credits is no longer allowed – this therefore means that the reduction in emissions covered by the EU ETS is domestic (EU-level) in nature.

No entities in Malta were or are engaged in the Kyoto Protocol project mechanisms, the Clean Development Mechanism or the Joint Implementation mechanism.

4.6 Assessment of the economic and social consequences of response measures

As a small country, Malta's policy action would not, in itself, be expected to have major adverse impacts on third counties, including developing countries. Notwithstanding, Malta takes a proactive approach through actions that offset, to the highest extent possible, any adverse impacts that may occur.

Malta is a fully committed participant in the global action on climate mitigation. The Kyoto Protocol, in its very nature, aims at addressing in tangible terms the anthropogenic causes of observed climate change, through emission reduction or limitation efforts that contribute towards alleviating the harmful consequences of climate change for, among others, developing countries. Malta is an Annex I Party to the UNFCCC and thus has taken on emission limitation obligations under the Protocol as part of the joint fulfilment of the European Union's overall commitments. Though not a Party inscribed into Annex II of the Convention, still, Malta provides financial support to developing countries through both bilateral and multilateral channels (refer to chapter 'Provision of Financial, Technological and Capacity-building Support to Developing Country Parties' below for more details).

One may also reflect on the fact that Malta's contribution towards international climate action started at the very beginning of the international political process that eventually led to the adoption of the UNFCCC, the Kyoto Protocol and the more recent Paris Agreement. In 1988, Malta had introduced an item on the agenda of the General Assembly of the United Nations entitled 'Conservation of Climate as part of the Common Heritage of Mankind', eventually leading to the adoption of Resolution 43/53 on the 'Protection of Global Climate for Present and Future Generations of Mankind'. The resolution requested that action be taken that would eventually lead to recommendations on elements for inclusion in a future international convention on climate; the Framework Convention on Climate Change was eventually adopted in 1992.

As already noted in a previous chapter, Malta's climate policy and legislative framework reflects, to a large extent, and builds on, policy and legislation enacted within the European Union. Any legislation proposed at EU level is subject to a formal process of impact assessment, that also looks at economic and social impacts of the proposed legislation. EU climate policy provides for emission mitigation action across all economic activities. All classes of Kyoto Protocol greenhouse gases are addressed.

Apart from the overarching policy framework at EU level ensuring the proper assessment of impacts of policy decisions, there are also important examples of sector-specific legislation that incorporate requirements that directly or indirectly may safeguard against adverse impacts to third countries. One such example is that for biofuels to count towards mandatory national renewable energy targets under EU law, they must comply with sustainability criteria that include that biofuels cannot be grown in areas converted from land with previously high carbon stock such as wetlands or forests and cannot be produced from raw materials obtained from land with high biodiversity such as primary forests or highly biodiverse grasslands. These conditions are, among other, aimed at protecting these important ecosystems, including in developing countries.

Further to its participation in international and EU efforts that already strive to be in line with the principle in Article 3, paragraph 4, of the Kyoto Protocol, Malta also undertakes direct action with developing third countries in areas of capacity building and transfer of technology and knowledge. Such action includes financial support for the implementation of alternative technologies, adaptation and capacity building and education, the latter including the provision of post-graduate scholarships in climate action at a major Maltese tertiary education institution (refer to chapter 7 'Financial, Technological and Capacity-building Support').

.

5 PROJECTIONS AND TOTAL EFFECT OF POLICIES AND MEASURES

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 2021 - 2040.

As already mentioned in the introductory chapter of this report, the elaboration of projections of greenhouse gas emissions is a responsibility distributed among different entities, according to the sector concerned. Recent years have seen several important changes in modelling approaches and capacity across all sectors and within all entities involved, and the work to improve Malta's capabilities in this area are expected to continue, driven by a combination of new reporting obligations, ongoing work in policy planning (NECP), the need to cater for important new sectoral developments in recent and forthcoming years, and access to capacity building opportunities.

The development of capacity for the elaboration of projections of activity data and emissions is a continuous process that has yet to reach maturity. Because of this, changes in the approaches used have occurred in recent years and are expected to continue in the foreseeable future. This includes updating of modelling tools. Malta has benefited and continues to benefit from a number of initiatives, at all levels, that lead to improved capabilities to project activity data and associated emission trends. Such initiatives include the Structural Reform Support Services programme of the European Commission, which targeted work related to the preparation of National Energy and Climate Plans and the Commission's Projections Support Project wherein a number of models were reviewed and revised.

For the purpose of this submission, historic data presented in the March 2022 National Greenhouse Gas Inventory Submission (time series 1990-2020) feeds into the sectoral models for the estimation of GHG emissions projections. Projections start from the year 2021 onwards. Two policy scenarios have been projected: a 'without measures' (WOM) scenario, which assumes that no further measures are implemented after a defined reference or base year and a 'with existing measures' (WEM) scenario, which considers the abatement potentials reported in the LCDS (2021). Measures that were previously reported as WEM scenario have been included under the WOM scenario. Recently published projections in the Low Carbon Development Strategy are also included in the WEM scenario.

Note: A sensitivity analysis could not be reported given that the data necessary for computation of a sensitivity analysis was not available.

Note: Additional measures in the LCDS which have not been quantified have not been included in the WEM scenario.

5.2 PROJECTIONS

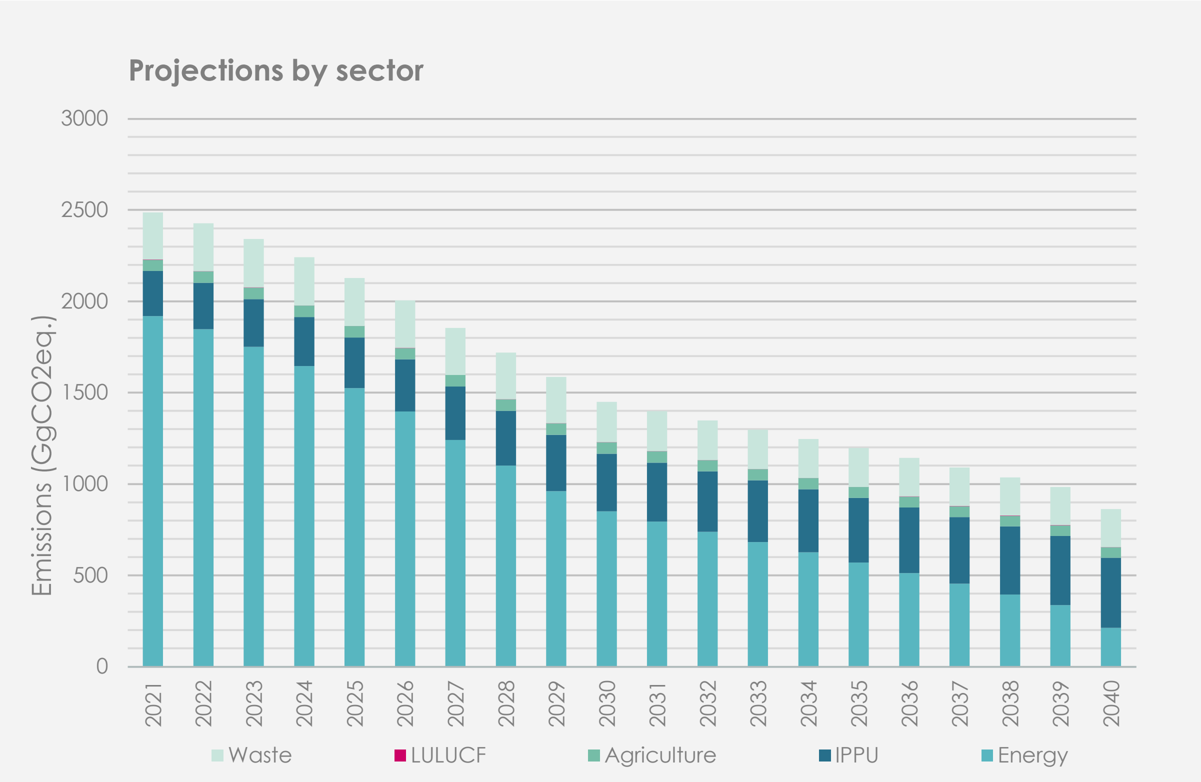
Emission projections by sector and gas are given in Table 5.1 and Figure 5.1. The measures implemented in the energy sector have a significant impact on total national emissions as clearly reflected in the drop in projected emissions from 2030 onwards. This downwards shift in emissions is largely due to various electrification measures in the transport sector, the installation of additional interconnectors, and increased use of renewables and energy efficient appliances in both the residential and non-residential buildings.

Table 5.1 Emissions projections by sector and by gas for the 'with existing measures' scenario

Sector	Gas	1990	2005	2020	2025	2030	2035	2040
Energy total	CO2	2388.70	2640.70	1594.47	1515.41	839.79	559.92	201.61
	CH4	5.24	4.85	2.37	4.48	4.48	4.47	4.42
	N2O	9.20	11.49	5.49	5.57	5.70	5.80	5.86
	Total	2403.14	2657.05	1602.33	1525.47	849.97	570.18	211.89
IPPU	CO2	5.13	3.65	4.46	NE	NE	NE	NE
	CH4	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
	N2O	2.64	2.46	2.42	NE	NE	NE	NE
	HFC	NO	38.36	272.34	276.85	315.55	353.10	384.48
	PFCs	NO	NO	NO	NE	NE	NE	NE
	SF6	0.01	1.56	0.40	NE	NE	NE	NE
	Total	7.78	46.03	279.62	276.85	315.55	353.10	384.48
Agriculture	CO2	NO	NO	NO	NO	NO	NO	NO
	CH4	61.21	49.52	39.53	33.32	33.53	31.06	28.60
	N2O	57.86	49.59	40.71	29.20	29.48	29.49	29.49
	Total	119.07	99.11	80.24	62.52	63.01	60.55	58.08
LULUCF	CO2	-8.33	-0.78	-2.29	0.71	0.56	0.49	0.43
	CH4	0.02	0.02	0.00	NO	NO	NO	NO
	N2O	0.15	0.19	0.11	NO	NO	NO	NO
	Total	-8.15	-0.56	-2.18	0.71	0.56	0.49	0.43
Waste	CO2	0.37	0.32	0.65	10.40	10.46	10.52	10.56
	CH4	58.74	165.17	151.92	250.85	209.73	201.41	196.92
	N2O	10.19	12.86	6.84	0.20	0.20	0.21	0.21
	Total	69.30	178.34	159.41	261.46	220.40	212.14	207.69
National (with LULUCF)		2591.13	2979.97	2119.41	2127.01	1449.49	1196.46	862.58
National (without LULUCF)		2599.28	2980.54	2121.59	2126.30	1448.94	1195.97	862.15

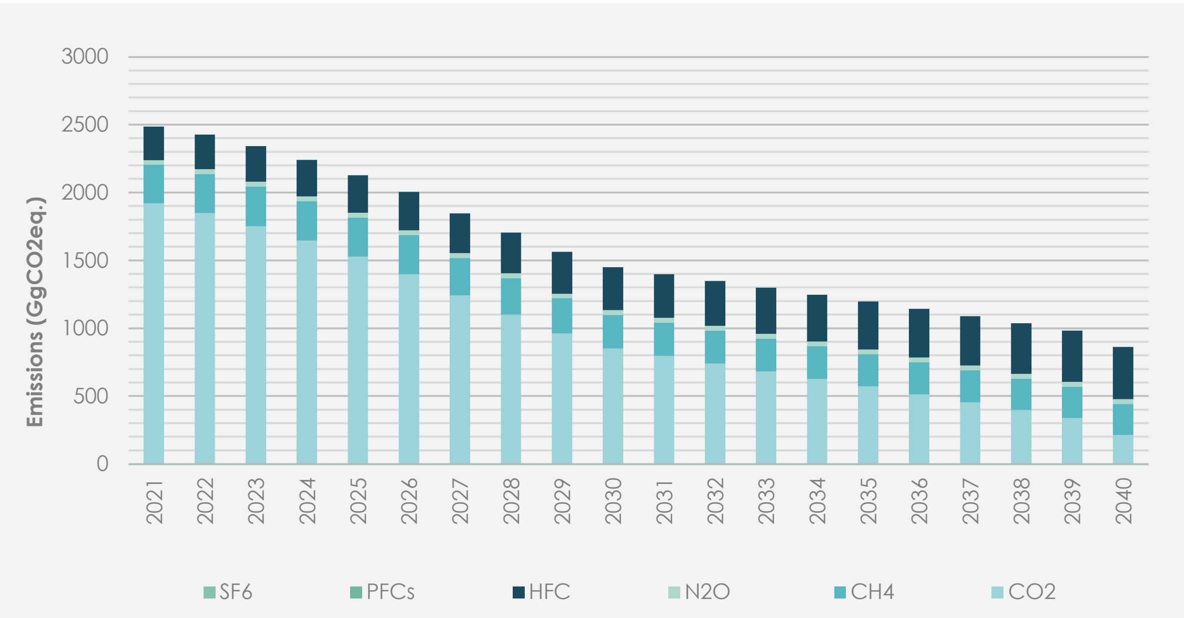
As shown in Figure 5-1 the highest decrease will be in the energy sector, while drops in emissions in the agriculture and waste sectors are not expected to be significant. No further changes are expected in IPPU and LULUCF, since no measures have been included in the LCDS for these 2 sectors.

Figure 5-1 Projections (WEM) of total emissions differentiated by sector.



As shown in Figure 5.2, the gas which is expected to experience the biggest change is carbon dioxide. This is due to the fact that most carbon dioxide is emitted from the energy sector, which happens to be the sector with the most measures, and the largest drop in total emissions. HFCs are expected to increase over time, however the implementation of the F-gas regulation is expected to curb emissions from this sector.

Figure 5-2 Projections (WEM) of total emissions differentiated by gas.



5.3 Projections by sector

This section provides an analysis of the sectoral projections.

Note on indirect gases: Projections of indirect emissions of CO, NOx, NMVOCs and Sox are not being included in this report, despite their availability under the NERCD, because the projections provided therein are based upon different measures and methodologies than those used for the purposes of GHG projections reported in the NC8, which would lead to inconsistencies in our reporting. Moreover, based upon our current mode of projections and data availability, the provision of projections of indirect emissions is not possible. Nonetheless, the party will strive to report projections from indirect emissions in its next submission, subject to the availability.

5.3.1 Energy

Table 5.2 gives a summary of the projected WEM emissions for the Energy sector, by gas.

It should be highlighted that domestic aviation is not accounted for in the projected scenarios. It is worth noting that Malta has only one national airport, and domestic flights primarily involve small aircraft used for training, helicopters for search and rescue, and emergency medical transport between the main islands. Since 2015, domestic aviation emissions have comprised less than 0.3% of the total transport emissions.

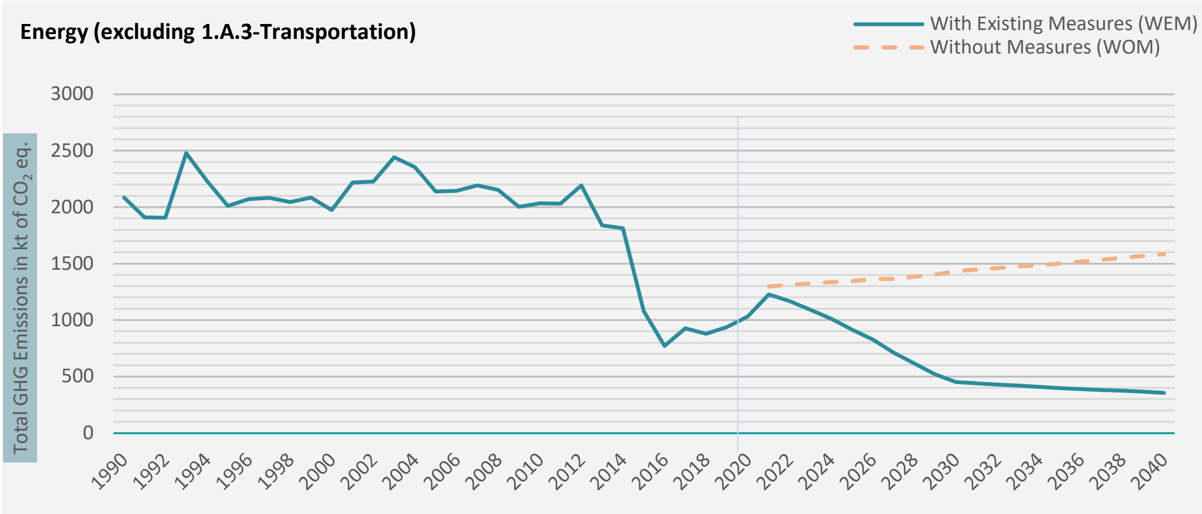
This report, in addition to not including projections for domestic aviation, does not incorporate projections for international aviation and international navigation.

Table 5.2 Projected emissions in GgCO2eq. for sector energy, by gas (WEM)

Sector	Gas	1990	2005	2020	2025	2030	2035	2040
Energy Total	CO_2	2388.70	2640.70	1594.47	1515.41	839.79	559.92	201.61
	CH_4	5.24	4.85	2.37	4.48	4.48	4.47	4.42
	N_2O	9.20	11.49	5.49	5.57	5.70	5.80	5.86
	Total	**2403.14**	**2657.05**	**1602.33**	**1525.47**	**849.97**	**570.18**	**211.89**

Emissions are expected to decrease significantly from 2030 onwards, as a result of the LCDS measures. The drop will be most significant in CO_2 emissions, leading to the energy sector emissions to drop to 211.89GgCO2 eq. in 2040.

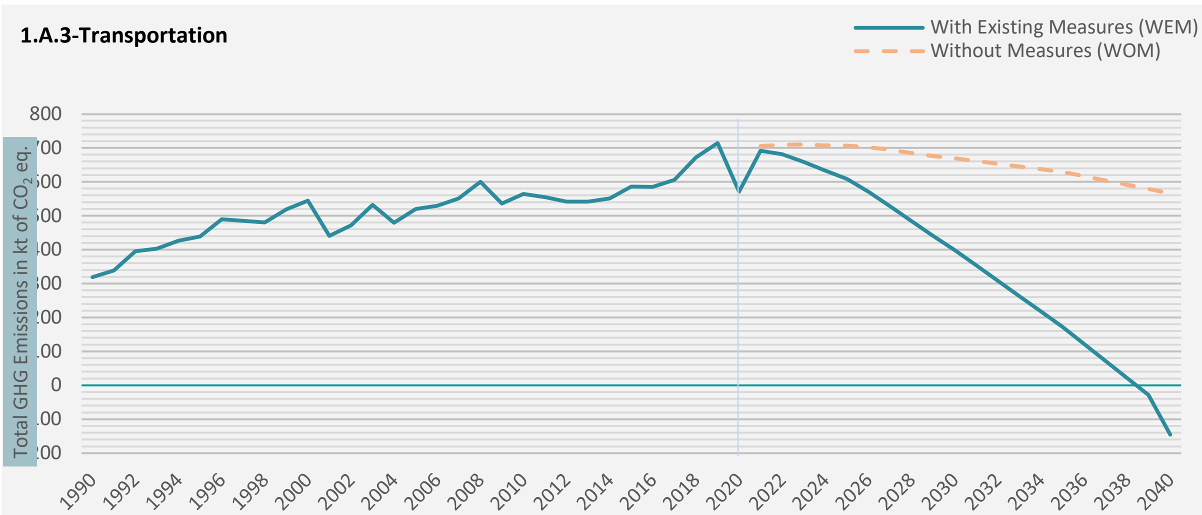
Figure 5-3 Projected emissions scenarios for the energy sector (excl. transport)



The drop in transport emissions is due to the measures given in the national Low Carbon Development Strategy, which can be summarized in three main categories:

- Support of electrification transition: (Electrification of private vehicles supported by grant schemes, government fleet, goods carrying vans, route buses, installation of extended network of EV charging spots)
- Public and Active transport: This is assumed to arise from a suite of measures, including the extension of free public transport services, and improvements in public transport services. Regarding active transport, sustained investment taking place throughout the strategy period in infrastructure will support cycling (e.g. bikes, e-bikes, pedelecs) and walking.
- Teleworking: Encouraging teleworking, and remote working and further promotion of Government online services to reduce and avoid the need to travel, especially to and from specific ‘traffic hotspots’, and especially during peak hours

Figure 5-4 Projected emissions scenarios for the transport sector



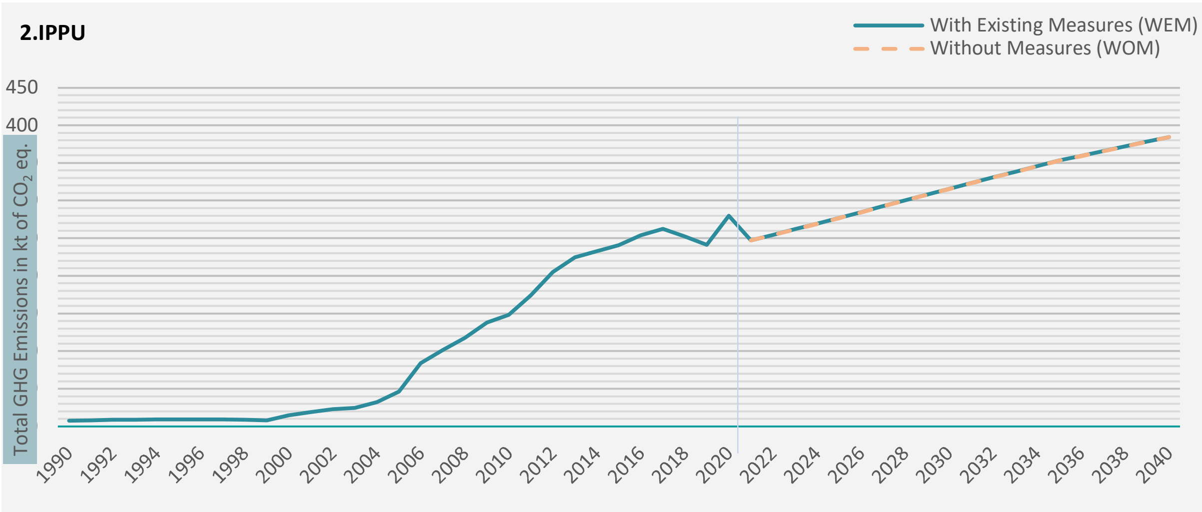
5.3.2 Industrial Processes and Product Use (IPPU)

The main measure that is expected to curb emissions from this sector is the implementation of the F-gas Regulation. This is expected to have a considerable positive influence on the manner and the extent to which fluorinated gases are used in the future. However, the implementation of this measure has not been analysed quantitatively, as yet. Consequently, the BAU scenario and the WEM scenario are identical. No measure was included in the LCDS for the IPPU sector.

Table 5.3 Projected emissions in Kt CO_2eq. for sector IPPU, by gas (WEM)

	Gas	1990	2005	2020	2025	2030	2035	2040
IPPU	CO2	5.13	3.65	4.46	NE	NE	NE	NE
	CH4	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA	NO, NA
	N2O	2.64	2.46	2.42	NE	NE	NE	NE
	HFC	NO	38.36	272.34	276.85	315.55	353.10	384.48
	PFCs	NO	NO	1×10^{-6}	NE	NE	NE	NE
	SF6	0.01	1.56	0.40	NE	NE	NE	NE
	Total	**7.78**	**46.03**	**279.62**	**276.85**	**315.55**	**353.10**	**384.48**

Figure 5-5 Projected HFC scenario for sector IPPU



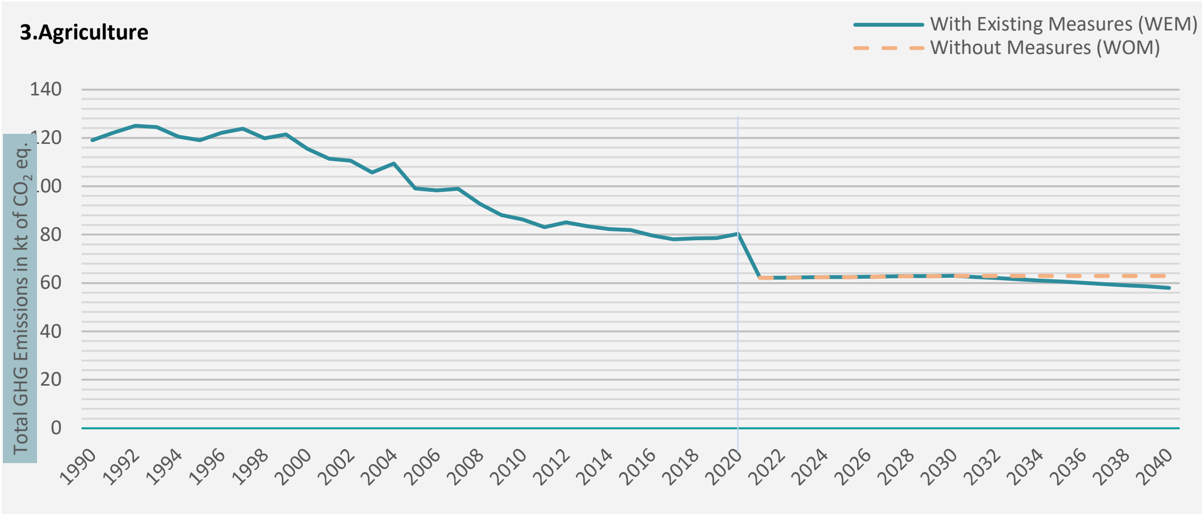
5.3.3 Agriculture

Measures listed in the Malta LCDS (2021) are expected to contribute to a decrease of around 8% (~5 GgCO2eq.) in emissions by 2040. The measures are expected to impact both methane and nitrous oxide. The application of aquaponics is expected to reduce N2O emissions caused due to soil carbon loss and application of synthetic fertiliser to land, while the administration of methane inhibiting vaccines is expected to reduce methane emissions from livestock.

Table 5.4 Projected emissions in Kt CO2eq. for sector Agriculture, by gas (WEM)

	Gas	1990	2005	2020	2025	2030	2035	2040
Agriculture	CO2	0.00	0.00	0.00	NO	NO	NO	NO
	CH4	61.21	49.52	39.53	33.32	33.53	31.06	28.60
	N2O	57.86	49.59	40.71	29.20	29.48	29.49	29.49
	Total	**119.07**	**99.11**	**80.24**	**62.52**	**63.01**	**60.55**	**58.08**

Figure 5-6 Projection of emissions by scenario for the agriculture sector



5.3.4 LULUCF

Much of the projections arise from projects related to afforestation and plantations, noting the fact that there are limitations. This is due to the high population density of the Maltese Islands and the limited land availability, as well as the unfavourable local climatic conditions, where the potential to mitigate emissions and maintain or increase the removals is, as a result, highly restrained.

The series of projections in the LULUCF sector are as follows:

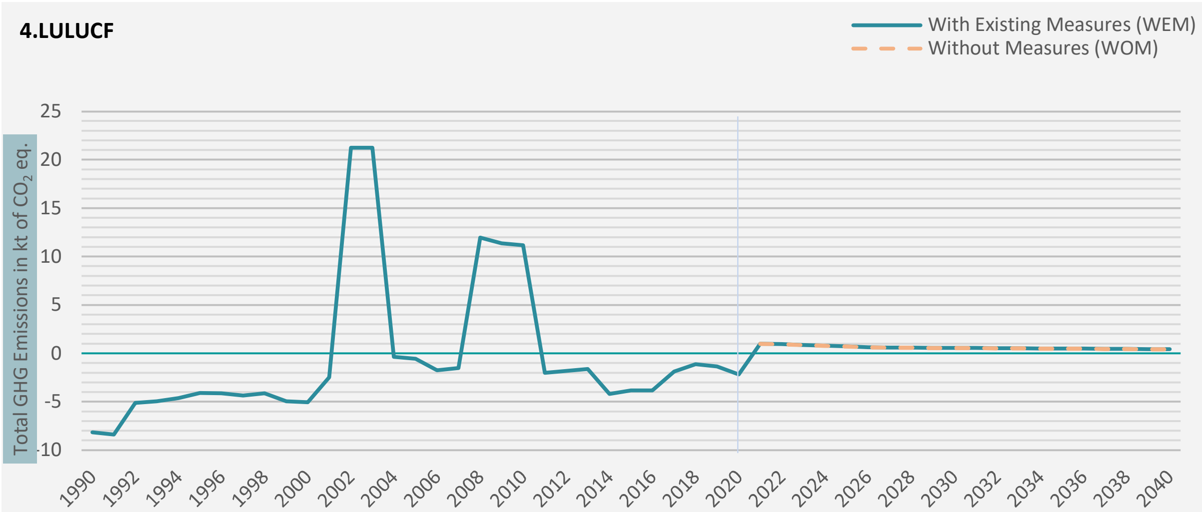
- The 'Without Measures' or 'Business-as-Usual' (BAU) projection was developed to analyse the impact of the upcoming national afforestation projects discussed which have begun to be implemented or implemented in the coming years. It is to note that some of the projects could not be quantified in the projection since some of the plantations will be implemented on a small scale or else planned to be planted separately in groups around several different locations. As a result, these are not foreseen to fall under the Forest Land criteria or threshold. As already stated not all measures could be quantified in this projection in the LULUCF model due that the extent of the projects implemented do not cover a large tract of land, and when comparing the extent of the area of these plantations to the other categories in the LULUCF sector. Moreover, in relation to other projects, entities did not have enough relevant information at this stage, such as area of project or total trees planted, that could be utilised to develop the projection. The series of projects included in this projection are: Ta' Qali National Park project; Wied Fulija National Park project; Various afforestation/planting projects in sites, including Natura 2000 & Protected Areas, Golf il-Kbir, San Anard, Fort Madliena, rural areas & Heritage Malta site; Tree 4U Campaign afforestation, afforestation in Foresta 2000 sites; and Benghajsa afforestation. Measures that have been adopted or implemented before the adoption of the LCDS have been included in the Without Measures scenario. A WEM projection scenario does not exist for LULUCF given that no measures were included in the LCDS for the LULUCF sector.

The figure below shows the series of projections developed and analysed in the LULUCF model.

Table 5.5 Projected emissions and removals in Kt CO2eq. for sector LULUCF, by gas (BAU)

	Gas	2018	2019	2020	2025	2030	2035	2040
LULUCF	CO2	-8.33	-0.78	-2.29	0.71	0.56	0.49	0.43
	CH4	0.02	0.02	0.00	NO	NO	NO	NO
	N2O	0.15	0.19	0.11	NO	NO	NO	NO
	Total	**-8.15**	**-0.56**	**-2.18**	**0.71**	**0.56**	**0.49**	**0.43**

Figure 5-7 Projections of greenhouse gas emissions for LULUCF



5.3.5 WASTE

The categories within the waste sector which are applicable for projections include landfilling, incineration, and biological treatment. There are no projections for the wastewater category. As a result, the historical emission trajectory in the BAU scenario does not include emissions from wastewater.

Landfill emissions are projected to decrease whereas the incineration and biological treatment emissions will increase. However, the increase in the incineration and biological treatment categories is expected to occur from year 2023 onwards, where waste will be diverted into the Waste-to-Energy (WtE) facility. Moreover, the treatment of waste in the biodigester (Anaerobic Digestion (AD)), is considered to be more effective.

Table 5.6 Projected emissions in Kt CO2eq. for sector Waste, by gas (WEM)

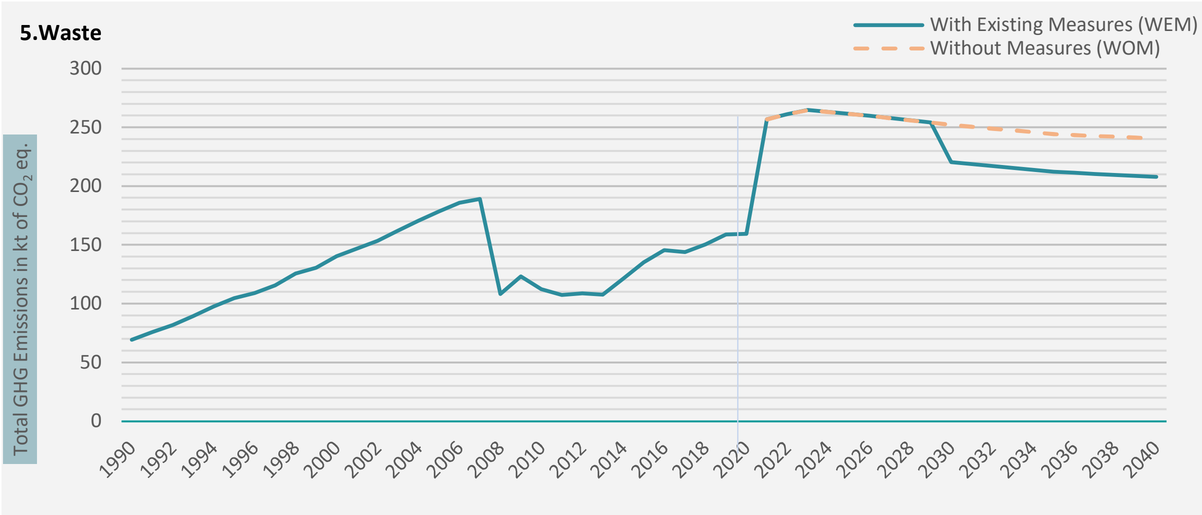
	Gas	1990	2005	2020	2025	2030	2035	2040
Waste	**CO2**	0.37	0.32	0.65	10.40	10.46	10.52	10.56
	CH4	58.74	165.17	151.92	250.85	209.73	201.41	196.92
	N2O	10.19	12.86	6.84	0.20	0.20	0.21	0.21
	Total	**69.30**	**178.34**	**159.41**	**261.46**	**220.40**	**212.14**	**207.69**

The projections of BAU 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 landfilling, respectively according to their capacity. A number of assumptions have been taken into consideration, including the following:

- The trend in MSW/Capita and Industrial Waste/GDP are maintained throughout the projected time;
- MSW composition values (%) for landfilling have been updated;
- 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 solid waste. It is projected that the biggest saving will be due to saved methane emissions from landfills.

On the other hand, the WEM projections are based on abatement potentials presented in the Malta LCDS (2021), from 3 measures (High Biowaste capture, and Biogas upgrade; Incineration pre-sorting; and waste prevention). The below graph shows that the projected WEM scenario for the waste sector will decrease when compared with the Business as Usual (BAU) scenario (a decrease of 14% in year 2040).

Figure 5-8 Projection of emissions by scenario for the Waste Sector



5.4 Table 5.7 Information on updated greenhouse gas projections under a ‘without measures scenario’

		GHG emissions and removals (kt CO2 eq.)							GHG emission projections (kt CO2 eq.)				
	2018	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	2019	**2020**	**2025**	**2030**	**2035**	**2040**
Energy Total	1549.09	2403.14	2449.55	2519.12	2657.05	2598.51	1664.68	1653.05	1602.33	2051.58	2102.12	2132.34	2151.01
IPPU	252.06	7.78	9.29	14.99	46.03	147.96	240.72	241.26	279.62	276.85	315.55	353.10	384.48
Agriculture	78.44	119.07	119.04	115.41	99.11	86.21	81.95	78.58	80.24	62.52	63.01	63.02	63.02
LULUCF	-1.14	-8.15	-4.10	-5.05	-0.56	11.17	-3.84	-1.37	-2.18	0.71	0.56	0.49	0.43
Waste	150.43	69.30	104.53	140.20	178.34	112.26	135.05	158.87	159.41	261.46	252.19	244.41	240.44
CO2 emissions including net CO2 from LULUCF	1545.69	2385.86	2435.10	2502.02	2643.89	2600.14	1661.32	1647.70	1597.28	2052.64	2102.96	2133.09	2151.72
CO2 emissions excluding net CO2 from LULUCF	1546.95	2394.19	2439.42	2507.26	2644.67	2589.13	1665.29	1649.19	1599.58	2051.93	2102.40	2132.59	2151.29
CH4 emissions including net CH4 from LULUCF	184.95	125.21	157.25	190.46	219.56	147.76	171.09	192.11	193.81	288.66	279.54	271.69	267.62
CH4 emissions excluding net CH4 from LULUCF	184.95	125.19	157.23	190.44	219.54	147.76	171.09	192.11	193.81	288.66	279.54	271.69	267.62
N2O emissions including net N2O from LULUCF	52.65	80.04	84.52	84.01	76.60	65.36	55.64	55.49	55.58	34.97	35.38	35.49	35.56
N2O emissions excluding net N2O from LULUCF	46.79	79.89	84.32	83.85	76.40	65.20	55.51	55.37	55.47	34.97	35.38	35.49	35.56
HFCs	245.29	0.00	0.00	6.70	38.36	141.07	230.25	234.77	272.34	276.85	315.55	353.10	384.48
PFCs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NE	NE	NE	NE
SF6	0.30	0.01	1.44	1.47	1.56	1.79	0.28	0.33	0.40	NE	NE	NE	NE
Other (specify)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total with LULUCF	2028.88	2591.13	2678.31	2784.67	2979.97	2956.11	2118.58	2130.39	2119.41	2653.12	2733.43	2793.36	2839.38
Total without LULUCF	2030.02	2599.28	2682.41	2789.72	2980.54	2944.94	2122.41	2121.59	2652.41	2732.87	2792.87	2838.95	2831.65

Table 5.8 Information on updated greenhouse gas projections under a 'with measures scenario'

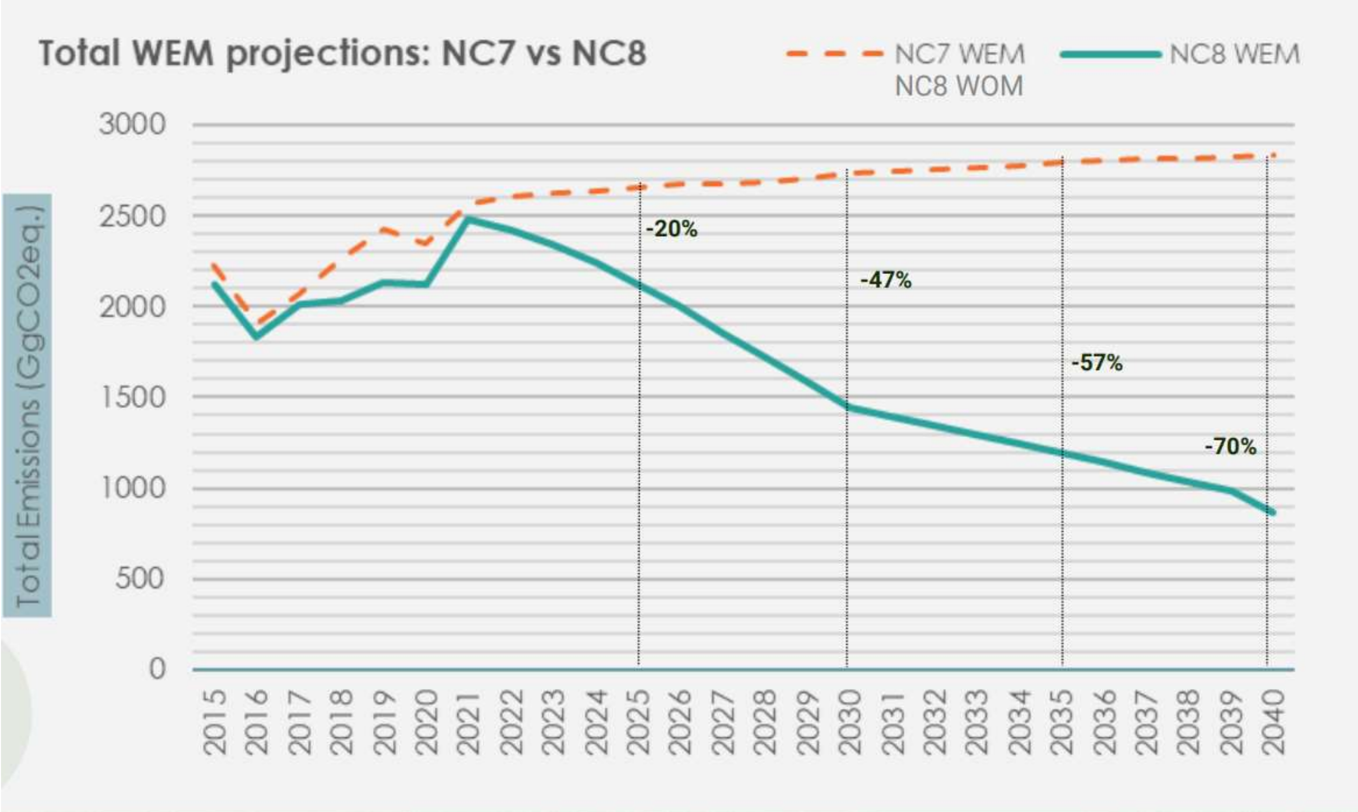
	GHG emissions and removals (kt CO2 eq.)								GHG emission projections (kt CO2 eq.)				
	2018	1990	1995	2000	2005	2010	2015	2019	2020	2025	2030	2035	2040
Energy Total	*1549.09*	2403.14	2449.55	2519.12	2657.05	2598.51	1664.68	1653.05	1602.33	1525.47	849.97	570.18	211.89
IPPU	*252.06*	7.78	9.29	14.99	46.03	147.96	240.72	241.26	279.62	276.85	315.55	353.10	384.48
Agriculture	*78.44*	119.07	119.04	115.41	99.11	86.21	81.95	78.58	80.24	62.52	63.01	60.55	58.08
LULUCF	*-1.14*	-8.15	-4.10	-5.05	-0.56	11.17	-3.84	-1.37	-2.18	0.71	0.56	0.49	0.43
Waste	*150.43*	69.30	104.53	140.20	178.34	112.26	135.05	158.87	159.41	261.46	220.40	212.14	207.69
CO2 emissions including net CO2 from LULUCF	*1545.69*	2385.86	2435.10	2502.02	2643.89	2600.14	1661.32	1647.70	1597.28	1526.53	850.82	570.93	212.60
CO2 emissions excluding net CO2 from LULUCF	*1546.95*	2394.19	2439.42	2507.26	2644.67	2589.13	1665.29	1649.19	1599.58	1525.82	850.26	570.43	212.17
CH4 emissions including net CH4 from LULUCF	*184.95*	125.21	157.25	190.46	219.56	147.76	171.09	192.11	193.81	288.66	247.74	236.95	229.94
CH4 emissions excluding net CH4 from LULUCF	*184.95*	125.19	157.23	190.44	219.54	147.76	171.09	192.11	193.81	288.66	247.74	236.95	229.94
N2O emissions including net N2O from LULUCF	*52.65*	80.04	84.52	84.01	76.60	65.36	55.64	55.49	55.58	34.97	35.38	35.49	35.56
N2O emissions excluding net N2O from LULUCF	*52.53*	79.89	84.32	83.85	76.40	65.20	55.51	55.37	55.47	34.97	35.38	35.49	35.56
HFCs	*245.29*	0.00	0.00	6.70	38.36	141.07	230.25	234.77	272.34	276.85	315.55	353.10	384.48
PFCs	*0.00*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SF6	*0.30*	0.01	1.44	1.47	1.56	1.79	0.28	0.33	0.40	0.00	0.00	0.00	0.00
Other (specify)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total with LULUCF	2028.88	2591.13	2678.31	2784.67	2979.97	2956.11	2118.58	2130.39	2119.41	2127.01	1449.49	1196.46	862.58
Total without LULUCF	2030.02	2599.28	2682.41	2789.72	2980.54	2944.94	2122.41	2131.76	2121.59	2126.30	1448.94	1195.97	862.15

5.5 Assessment of aggregate effects of policies and measures

Table 5.9 shows the aggregated effect of policies and measures by sector. By 2040, Energy and transport measures are estimated to contribute towards a staggering 90% decrease in sectoral emissions. Waste measures are expected to contribute 8% decrease towards the sector's emissions, while agriculture measure are only expected to contribute towards 8%. In total, the LCDS measures projected in the WEM scenario will contribute towards a 70% decrease in total emissions.

Table 5.9 Estimated aggregate effect of Policies and measures

		2020	2025	2030	2035	2040
	WM	1602.33	1525.47	849.97	570.18	211.89
Energy Total	WOM	1602.33	2051.58	2102.12	2132.34	2151.01
	Difference	***0%***	***-26%***	***-60%***	***-73%***	***-90%***
	WM	279.62	276.85	315.55	353.10	384.48
IPPU	WOM	279.62	276.85	315.55	353.10	384.48
	Difference	***0%***	***0%***	***0%***	***0%***	***0%***
	WM	80.24	62.52	63.01	60.55	58.08
Agriculture	WOM	80.24	62.52	63.01	63.02	63.02
	Difference	***0%***	***0%***	***0%***	***-4%***	***-8%***
	WM	-2.18	0.71	0.56	0.49	0.43
LULUCF	WOM	-2.18	0.71	0.56	0.49	0.43
	Difference	***0%***	***0%***	***0%***	***0%***	***0%***
	WM	159.41	261.46	220.40	212.14	207.69
Waste	WOM	159.41	261.46	252.19	244.41	240.44
	Difference	***0%***	***0%***	***-13%***	***-13%***	***-14%***
	WM	***2119.4***	***2127.0***	***1449.5***	***1196.5***	***862.6***
Total	WOM	***2119.4***	***2653.1***	***2733.4***	***2793.4***	***2839.4***
	Difference	***0%***	***-20%***	***-47%***	***-57%***	***-70%***



5.6 MEETING GREENHOUSE GAS EMISSION COMMITMENTS

The primary focus of this section's discussion is Malta's compliance with the obligations for the period 2013 to 2020.

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, which , in the case of Malta, is 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. in the case of Malta, CO_2 emissions from the power plants), emissions or removals from the LULUCF sector, and CO_2 emissions from civil aviation (by virtue of the inclusion of aviation in the EU ETS). Emissions from international marine bunkering and international aviation are also excluded. Figure 5-9 compares the total emissions and projections covered by the sectors falling within the Effort Sharing Decision with the trajectory under this Decision.

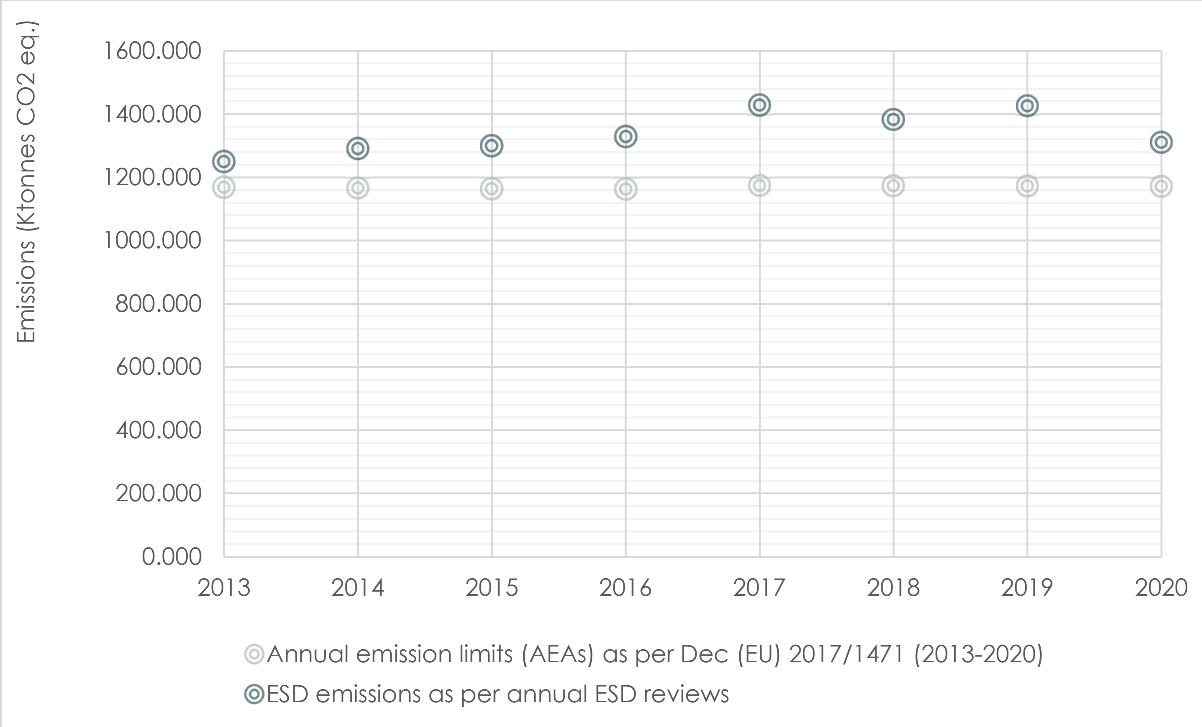


Figure 5-9 Comparison of Malta's emissions covered by the Effort -sharing Decision with annual emission limits.

As shown in Figure 5-9 throughout the period 2013 to 2020, Malta was not able to limit ESD emissions to levels below the annual limits applicable to it. However, Malta has used the flexibility mechanisms that the Decision provides for, and namely the acquisition of additional AEAs from other Member States. Thus, Malta has always achieved compliance with the obligations of the ESD. Malta did not use any units from the Kyoto Protocol project mechanisms for compliance with its ESD obligations.

5.7 DETAILED INFORMATION ON THE METHODOLOGY AND APPROACHED USED FOR PROJECTIONS

5.7.1 DESCRIPTION OF MODELLING FRAMEWORK

The following section gives the description of models used for the projection of WEM and WOM Scenarios. LCDS measures projected under the WEM scenario are projected using the MACC model, for all sectors and gases as applicable by sector (and depending on measures). The starting date and ending date of implementation of each measure was kept in mind when calculating the projections, to make sure no under/over underestimation is done. It should also be noted that no measures, and hence, no abatement potentials were presented in the LCDS for the IPPU and LULUCF sectors, thus, WEM scenario projections are available only for Energy, Transport, Waste and Agriculture. On the other hand, WOM scenario measures were projected using different models for different sectors. An in-depth description of the methodology for each model is given in section 12 Annex 3: Information on methodologies used for the WOM projections.

Projecting the WEM Scenario

The WEM scenario was projected using abatement potentials estimated through the MACC model (description provided below). The Abatement potentials were subtracted from the WOM scenario (or baseline).

The Marginal Abatement Cost Curve (MACC) Model

A Marginal Abatement Cost Curve (MACC) is a tool which allows a country to progress towards decarbonisation in a politically and economically efficient manner. This is achieved by ranking a range of GHG-abating measures in order of cost effectiveness. A MACC model is intended to establish the possible routes to decarbonisation and is used alongside socio-economic assessments to assess the implications of these routes. Used together, a MACC and socio-economic impact assessments allow governments to strategically plan activities across all sectors of society, futureproofing for climate change requirements and developing effective mitigation strategies.

The metric of cost effectiveness is called the marginal abatement cost (MAC). The MAC of each measure is calculated from two other values:
- its cost and
- its abatement potential,
as follows.

Cost (EUR/yr) / Abatement Potential (tCO_2e/yr) = Marginal Abatement Cost (EUR/tCO_2e)
The lower the MAC, the more cost-effective the measure. Thus, the MACC itself is a visually intuitive way of displaying this information.

Abatement potential = Emissions from high carbon process abated – Emissions from Low carbon process

The following is a breakdown of a MACC i.e., the chart generated by the MACC model:

- The x-axis represents the cumulative abatement potential (tCO_2e/yr) and the y-axis represents the marginal abatement costs (MACs) (EUR/tCO_2e).
- Each measure is presented as a box above or below a horizontal axis.
- Boxes above the x-axis indicate that there is a cost to the measure it represents. Boxes below the x-axis indicate that the respective measure generates negative economic costs (or savings to society) upon implementation.
- The width of the box indicates the potential annual abatement potential of the respective measure. The height of the box indicates the cost of or the saving from the respective measure. This facilitates the comparison of measures.
- Measures with the lowest MACs are ranked first and so are found to the left. This generates the shape of the curve.

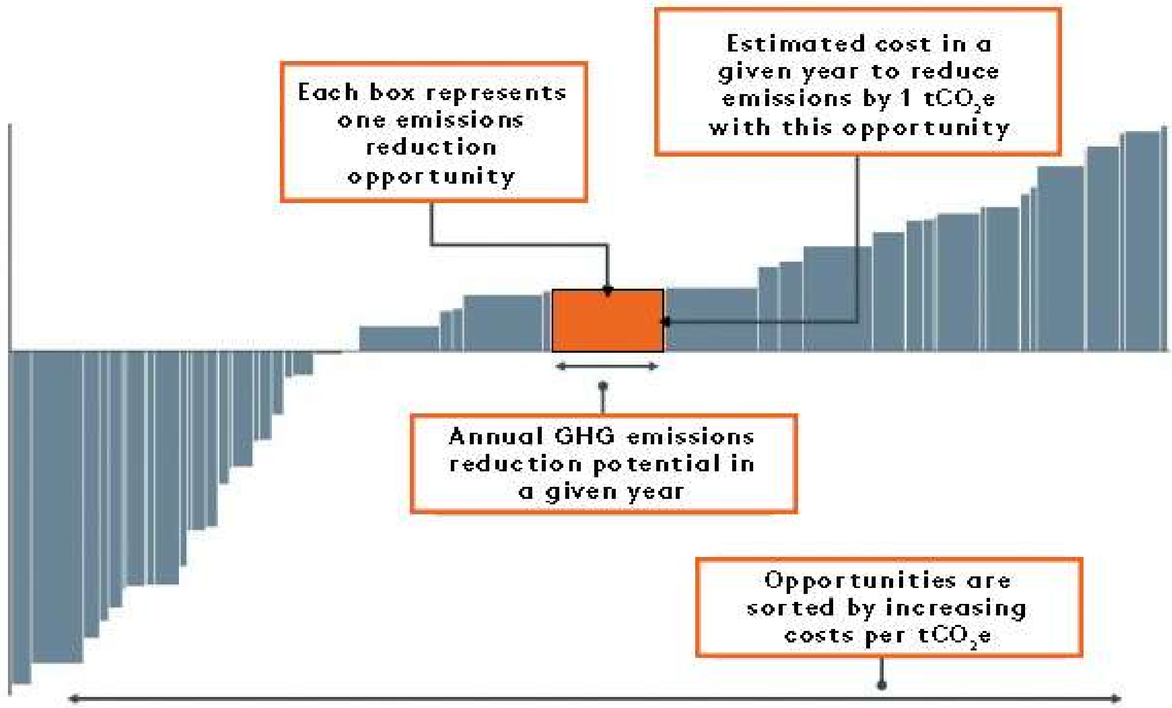


Figure 1: An example of a marginal abatement cost curve (MACC) (Source: https://www.climateworkscentre.org/resource/how-to-read-a-marginal-abatement-cost-curve/#:~:text=A%20marginal%20abatement%20cost%20curve%20%E2%80%93%20or%20MACC%20%E2%80%93%20is%20simple%20to,could%20be%20reduced%20if%20implemented)

The MACC modelling has been used in the Low Carbon Development Strategy (LCDS) to quantify possible abatement levels (i.e., ratio of abatement potential against incremental cost of measure) and ensure cost effectiveness and a balance between carbon abatement and economic cost. Social and environmental impact assessments of these measures have also been carried out. The use of MACC modelling allows government to predict the likely economic impacts and benefits of reducing greenhouse gas (GHG) emissions, including overall economic investment costs and operational cost/savings over the baseline (i.e., a situation without LCDS measures). The social and environmental effects and the cost to society from taking such measures are considered in specific assessments and thus allow policy to be designed in a way that is beneficial to society in economic and environmental terms.

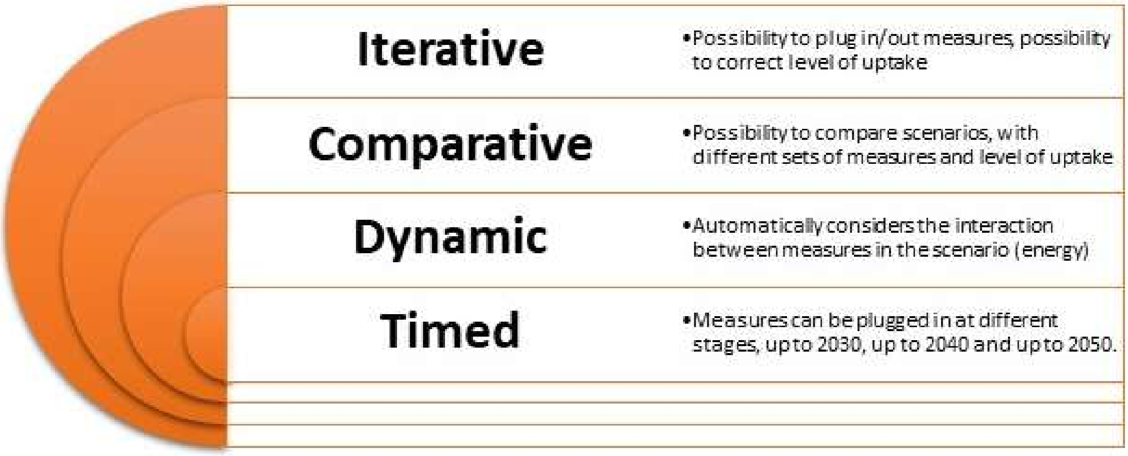


Figure 2: Features of the development of the MACC model

Approach to MACC Modelling

The MACC developed for the LCDS is a detailed bottom-up MACC relying on the principle that each measure seeks to replace one process with another process. Often, this will involve the phasing out of a carbon-intensive process in favour of a low(er)-carbon process. A measure can be thought of as a combination of two processes – where the net difference describes the impact of the measure. For the cost figures, this is described economically as the opportunity cost, but a similar logic applies to emissions and utility consumption calculations. For example, if 1kWh of electricity generated by a combined cycle gas turbine plant (CCGT; a process) emits 400gCO_2e, but 1kWh of electricity generated by solar photovoltaics (PV; another process) is zero-carbon, then the net impact of replacing CCGT with PV (a measure) is 400gCO_2e/kWh. The calculations are often more complicated than this example, mainly to more adequately account for inter-measure dynamics.

A MACC model includes various inputs/outputs, with the following structure being followed for the LCDS:
- process consumption (electricity, water, gas, etc.);
- process generation (electricity, water, gas, etc.);
- process direct emissions (fossil, non-fossil); and
- process cost (allowing for technology learning over time).

These values are recorded on a per unit basis; for energy this operational unit may be per GWh (electricity generated) or for transport it may be per Gt.km (transported). In addition to these inputs, the MACC model records:
- the (high-carbon) processes being replaced and the (low-carbon) processes that take their place: whether the process relates to supply or demand of the given operational unit;
- the low-carbon processes: the maximum technical potential that the processes can achieve over time, accounting for technical constraints such as availability of space or demand levels. Again, this is recorded in terms of the given operational unit for that process. Optimistic, central, and pessimistic estimates of the technical potential are derived. Local considerations regarding acceptance and likely rates of market penetration are also considered in the technical potential.

The outcome of several computations resulted in one set of measures or 'Pathway' that would fulfil Malta's 2030 climate targets as well as move as close as possible to carbon-neutrality.

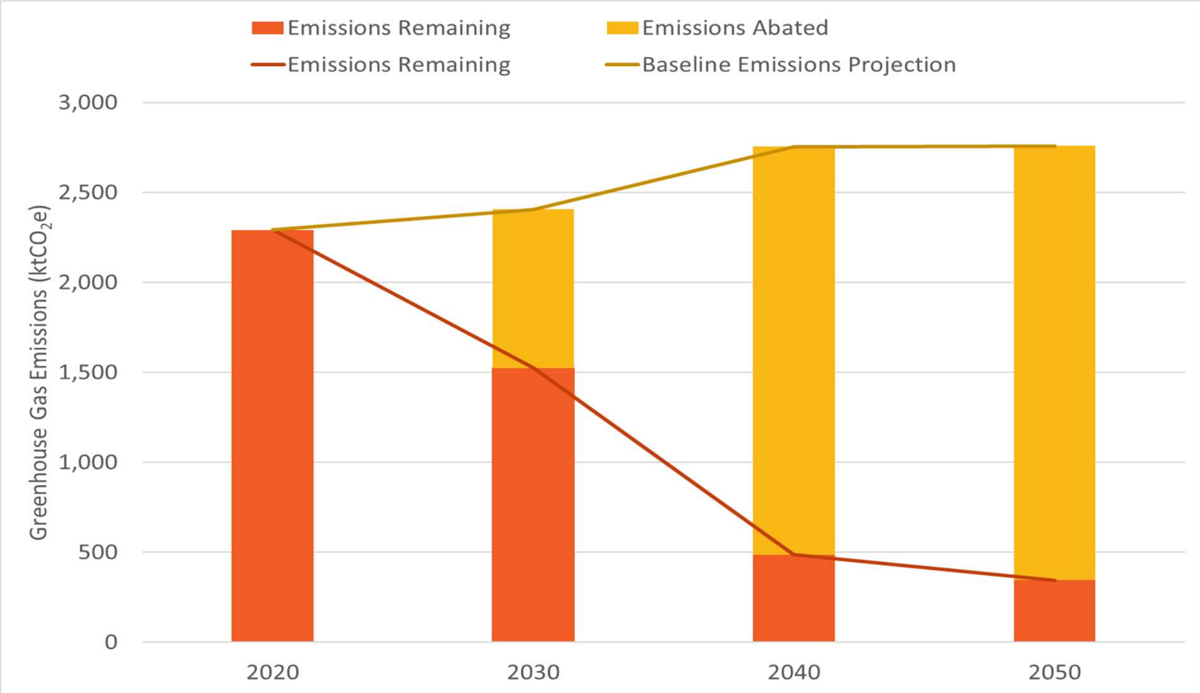


Figure 6: Total GHG emission reductions

Projecting the WOM Scenario

The below subsections give information on the models used and their methodologies (where available). It is to note that the models used in the past for the then WEM scenario are the models that now represent the WOM scenario as discussed in this submission.

Key weaknesses of the modelling efforts arise due to gaps in activity data for parameters used and that would impact on the projected trends. To the extent that models used are Excel based (example IPPU, Agriculture, LULUCF and Waste), there may be inherent weaknesses that may also result from limitations with the software. On the other hand, projected trends can be validated on a yearly basis against updated historic emissions data from the national greenhouse gas inventory, that reflect actual historic activity data.

Model Descriptions

Model 1	
Full model name	Electricity dispatch model
Model version and status	V3 (under revision)
Latest date of revision	Jun-21
URL to model description	N/A
Model type	Excel based
Summary	An electricity dispatch model for the sector power generation, projecting the hourly electricity profile and dispatch for the period 2018 - 2040. Fuel affected: natural gas, gasoil, electricity;
Intended field of application	Power generation - Energy
Description of main input data categories and data sources	Energy demand model; hourly electricity profile; electricity and gas prices;
Validation and evaluation	N/A
Output quantities	GWh; MMBtu (natural gas); MW (capacity and power)
GHG covered	CO2, CH4, N2O
Sectoral coverage	Energy - Energy Industries (Public electricity and heat prodution)
Geographical coverage	National
Temporal coverage (e.g. time steps, time span)	2018-2040
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	*Linked to Energy Demand Model (direct input of energy demand) and Road Transport Model (for Electric vehicles) and PV model*
Input from other models	Linked to Energy Demand Model (direct input of energy demand) and Road Transport Model (for Electric vehicles) and PV model
References to the assessment and the technical reports that underpin the projections and the models used	N.A.
Model structure (if diagram please attach to your submission in Reportnet)	N/A
Comments or other relevant information	N.A.

Model 2	
Full model name	Industry Fuel Consumption model (non-transport)
Model version and status	V1 (under revision)
Latest date of revision	Dec-18
URL to model description	N/A
Model type	N/A
Summary	A non-transport fuel consumption model for the industry sector, projecting the fuel demand for the period 2017 - 2030. Fuel affected: All non-transport fuels Driver: GVA.
Intended field of application	Industry Fuel Consumption
Description of main input data categories and data sources	GVA
Validation and evaluation	N/A
Output quantities	N/A
GHG covered	CO_2, CH_4, N_2O
Sectoral coverage	Energy - Manufacturing Industries
Geographical coverage	National
Temporal coverage (e.g. time steps, time span)	2017-2030
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	N/A
Input from other models	N/A
References to the assessment and the technical reports that underpin the projections and the models used	N/A
Model structure (if diagram please attach to your submission in Reportnet)	N/A
Comments or other relevant information	N/A

Model 3	
Full model name	Energy Demand Model
Model version and status	v2 (Under Revision)
Latest date of revision	Dec-21
URL to model description	N/A
Model type	Excel based
Summary	Model providing projections for sectoral energy demand (electricity and fuel) based on activity indicators Fuel affected: All non-transport fuels, renewable fuels and electricity. *includes heat pumps
Intended field of application	End use sectors: Industry, Services, Residential, Agriculture & Fisheries
Description of main input data categories and data sources	National macroeconomic projections
Validation and evaluation	N/A
Output quantities	Annual GWh of fuel and electricity
GHG covered	CO_2, CH_4, N_2O
Sectoral coverage	Energy - end-use sectors
Geographical coverage	National
Temporal coverage (e.g. time steps, time span)	2010-2040
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	*Electricity dispatch model;*
Input from other models	N/A
References to the assessment and the technical reports that underpin the projections and the models used	N/A
Model structure (if diagram please attach to your submission in Reportnet)	N/A
Comments or other relevant information	N/A

Model 4	
Full model name	Road transport Biofuels S/O Model
Model version and status	V2 (final)
Latest date of revision	Dec-21
URL to model description	N/A
Model type	Excel based
Summary	A Road transport model projecting the biofuel mix for transport fuels for the period 2018 - 2040. Fuel affected: Diesel and petrol Driver: Substitution obligation -14% by 2030
Intended field of application	Road Transport
Description of main input data categories and data sources	Substitution obligation -14% by 2030;
Validation and evaluation	N/A
Output quantities	GWh and litres; EUR
GHG covered	CO_2, CH_4, N_2O
Sectoral coverage	Energy- Transport - Road Transport
Geographical coverage	National
Temporal coverage (e.g. time steps, time span)	2018-2040
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	*Road Transport Model*
Input from other models	Road Transport Model (total road transport fuel consumption)
References to the assessment and the technical reports that underpin the projections and the models used	N/A
Model structure (if diagram please attach to your submission in Reportnet)	N/A
Comments or other relevant information	N/A

Model 5	
Full model name	PV model
Model version and status	V3 (Under Revision)
Latest date of revision	Dec-21
URL to model description	N/A
Model type	Excel based
Summary	A model estimating the potential, the uptake and costs of residential and non-residential PVs for the period 2018 - 2040. Fuel affected: Electricity; Driver:Past trends, cost projections, and PV technical potential study (under revision - Energy and Water Agency (EWA)).
Intended field of application	Energy - Energy Industries (Public electricity and heat prodution)
Description of main input data categories and data sources	Past trends, cost projections, and PV technical potential study (under revision - Energy and Water Agency (EWA)
Validation and evaluation	N/A
Output quantities	GWh; MW; EUR
GHG covered	CO2, CH4, N2O
Sectoral coverage	Energy - Energy Industries (Public electricity and heat prodution)
Geographical coverage	National
Temporal coverage (e.g. time steps, time span)	2018-2040
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	*Electricity Dispatch Model*
Input from other models	N/A
References to the assessment and the technical reports that underpin the projections and the models used	PV Technical Potential Study by Energy and Water Agency (Under Revision)
Model structure (if diagram please attach to your submission in Reportnet)	N/A
Comments or other relevant information	N/A

Model 6	
Full model name	Road Transport Model
Model version and status	V2 (Under Revision)
Latest date of revision	Dec-21
URL to model description	N/A
Model type	Excel based
Summary	A transport model projecting the fuel and electricity consumption of the road transport sector for the period 2018 - 2040. Fuel affected: Diesel, Petrol, Electricity Driver: Population and GVA, CO2 emission standards for vehicles
Intended field of application	Road Transport
Description of main input data categories and data sources	Population and GVA, CO2 emission standards for vehicles
Validation and evaluation	N/A
Output quantities	GWh, vehicle-kilometers, vehicle stock
GHG covered	CO2, CH4, N2O
Sectoral coverage	Energy - Transport - Road Transport
Geographical coverage	National
Temporal coverage (e.g. time steps, time span)	2018-2040
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	*Electricity Dispatch Model (for EVs); Road Transport Biofuels Model*
Input from other models	N/A
References to the assessment and the technical reports that underpin the projections and the models used	N/A
Model structure (if diagram please attach to your submission in Reportnet)	N/A
Comments or other relevant information	N/A

Model 7	
Full model name	Modelling of IPPU for the Estimation of GHG Emissions Projections (1990-2050)
Model version and status	IPPU model for NECP 2018_11_15 MRA_DECC-3v2-21_20_18-2F1f_updated
Latest date of revision	2/23/2021
URL to model description	not applicable
Model type	excel file
Summary	The IPPU model was developed (in the year 2015) to project GHG emissions from the industrial processes and product use sector over the time-period 1990-2050. The emissions of HFCs from CRF category 2.F.1 Refrigeration and Air conditioning add up to almost the entirety of the GHG emissions from the IPPU sector. Thus, the said model is limited to project emissions from this category alone.
Intended field of application	The IPPU sector, for the purposes of reporting on Policies and Measures and Projections
Description of main input data categories and data sources	historical data: demand, imports, stock, emissions; factors: emission factor, reuse factor, efficiency improvement factor; drivers: disposable income, GDP
Validation and evaluation	not applicable
Output quantities	imports, stock, emissions
GHG covered	HFCs
Sectoral coverage	2.F.1
Geographical coverage	The Maltese Islands
Temporal coverage (e.g. time steps, time span)	1990-2050, annual
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	not applicable
Input from other models	Model used to estimate historic emissions from category 2.F.1; The EWA Heat-Pumps Model
References to the assessment and the technical reports that underpin the projections and the models used	not applicable
Model structure (if diagram please attach to your submission in Reportnet)	Please refer to the Policies and Measures and Projections Report
Comments or other relevant information	The IPPU model was developed (in the year 2015) to project GHG emissions from the industrial processes and product use sector over the time-period 1990-2050. Since, in recent years, the emissions of HFCs from CRF category 2.F.1 Refrigeration and Air conditioning add up to almost the entirety of the GHG emissions from the IPPU sector, the said model is limited to project emissions from this category alone. The model takes into consideration five different groups, namely, residential (domestic), commercial, ships, transport and stationary. Based on historical data, including demand, imports, stock and emissions, the model estimates the stock and imports of a list of refrigerants (imported and used in the groups listed above) the emissions of which contribute to global warming. The IPPU model includes two scenarios, namely the BAU and WEM scenarios. This model allows for the introduction of new measures affecting the generation

	of GHG emissions in the category refrigeration and air conditioning. The results obtained for the WEM scenario are identical to those obtained for the BAU, the only difference being the impact of the new measures, thus allowing the identification of the incremental impact relative to the BAU scenario.

Model 8	
Full model name	Inland Navigation Fuel Consumption Model
Model version and status	V2 (Under Revision)
Latest date of revision	Dec-21
URL to model description	N/A
Model type	Excel based
Summary	An inland navigation fuel consumption model, projecting Gasoil, diesel and petrol consumption for the period 2018 - 2040. Fuel affected: Gasoil, Diesel & Petrol Driver: Macroeconomic projections (also takes into account fast ferry and gozo tunnel passenger rates).
Intended field of application	National Navigation
Description of main input data categories and data sources	Macroeconomic projections (also takes into account fast ferry and gozo tunnel passenger rates).
Validation and evaluation	N/A
Output quantities	GWh and litres;
GHG covered	CO_2, CH_4, N_2O
Sectoral coverage	Energy - Transport - Navigation
Geographical coverage	National
Temporal coverage (e.g. time steps, time span)	2018-2040
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	*Road Transport Biofuels*
Input from other models	N/A
References to the assessment and the technical reports that underpin the projections and the models used	N/A
Model structure (if diagram please attach to your submission in Reportnet)	N/A
Comments or other relevant information	N/A

Model 9	
Full model name	Agriculture Model
Model version and status	v1
Latest date of revision	11/16/2018
URL to model description	N/A
Model type	Excel-based .XML
Summary	The Agriculture Model is used to forecast emissions associated with the agriculture sector of Malta’s GHG inventory under different scenarios for individual years running until 2050.
Intended field of application	Agriculture
Description of main input data categories and data sources	Livestock Population, Aniimal Weight, Feed proportions, Milk Production, Manure production, N content, N excretion, Agricultural Land
Validation and evaluation	N/A
Output quantities	Kt CO2 eq.
GHG covered	CH4, N2O
Sectoral coverage	Enteric Fermentation, Manure Management and Managed Agriculutral Soils
Geographical coverage	National
Temporal coverage (e.g. time steps, time span)	1990 - 2050, Annual basis
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	N/A
Input from other models	N/A
References to the assessment and the technical reports that underpin the projections and the models used	N.A.
Model structure (if diagram please attach to your submission in Reportnet)	Refer to PAMs Report
Comments or other relevant information	The Agriculture Model is used to forecast emissions associated with Malta's Agriculture Sector under different scenarios for individual years running until 2050. These modelled scenarios are based on specific assumptions regarding framework conditions or trend analysis of historic data. BAU projections are made made using 3-year moving averages, while other projections are based on input parameters such as livestock population, feed, milk production and other livestock and agricultural land related parameters. The MBT (WEM) scenario is based on the measure given in the Malta agriculture Waste Management Plan. (more details are provided in the Report).

Model 10	
Full model name	LULUCF model
Model version and status	V2
Latest date of revision	Oct-18
URL to model description	N/A
Model type	Excel based
Summary	The LULCF model provides a tool to develop the projections of LULUCF emissions and removals and assist to analyse and construct scenario based projections.
Intended field of application	Land Use, Land Use Change and Forestry
Description of main input data categories and data sources	Covers all LULUCF categories, all carbon pools. Data sources include data input of C stock change as Implied Emission Factor, and area as Activity data.
Validation and evaluation	N/A
Output quantities	kt eq.
GHG covered	CO2, CH4, N2O
Sectoral coverage	All categories
Geographical coverage	National
Temporal coverage (e.g. time steps, time span)	1990-2050
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	Forest Land Model - model to project the biomass increment and total growth in Forests. Data inputs to this model are stratum and description of tree species, age class, total area and, if required when area is not present the number of trees. The parameters are utilised to create an age dynamic model of the forests in Malta. The model makes use of species increments and the relevant conversion parameters to construct an age dynamic model and calculating the total growth in tCO2 per year. The total growth projections in the FL model are incorporated in the Forest Land category of the LULUCF model.
Input from other models	As described in cell C71
References to the assessment and the technical reports that underpin the projections and the models used	N.A.
Model structure (if diagram please attach to your submission in Reportnet)	Refer to PAMs Report
Comments or other relevant information	The LULCF model provides a tool to develop the projections of LULUCF emissions and removals. The spreadsheet has been created to analyse and construct scenario-based projections. No modeling or simulation algorithms are hidden in the background of the spreadsheet. The LULUCF model aims in achieving to construct projections of emissions/removals based on estimates of activity rates and emission factors, and also to analyse trends in historical activity rates on national reporting. The scenarios considered for the projections are all described in the PAMs report.

Model 11	
Full model name	Waste generation and treatment model (Waste sector)
Model version and status	v1
Latest date of revision	Oct-18
URL to model description	N.A.
Model type	Excel-based
Summary	The Waste Model is used to project emissions under both BAU and WEM scenarios between years 2017 and 2050.
Intended field of application	Waste; Landfilling, Incineration and Biological Treatment
Description of main input data categories and data sources	Gross Domestic Product, population and disposable income
Validation and evaluation	N.A.
Output quantities	tonnes
GHG covered	CO2, CH4, N2O
Sectoral coverage	Waste; Landfilling, Incineration and Biological Treatment
Geographical coverage	National
Temporal coverage (e.g. time steps, time span)	2017-2050
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	N.A.
Input from other models	N.A.
References to the assessment and the technical reports that underpin the projections and the models used	N.A.
Model structure (if diagram please attach to your submission in Reportnet)	refer to PaMs report
Comments or other relevant information	The Waste generation and treatment model is based on the relation between a relevant driver trend between years 2013 and 2016, and the actual trend in waste generation between 2013 and 2016. This relation is represented by a constant which is multiplied by the projected macroeconomic driver to result in a projected waste generation for that particular year. The drivers used for the waste projections, both BAU and WEM, are the GDP, population and disposable income.

Variables and Assumptions used in the projection of WEM Scenario

Key underlying assumptions	Unit	2020	2030	2040	2050
Irrigated Farmland	ha	3,600.00	3,600.00	3,600.00	3,600.00
Other Land	ha	28,000.00	28,000.00	28,000.00	28,000.00
Land sub-total	ha	31,600.00	31,600.00	31,600.00	31,600.00
Population	cap	496,789.62	554,822.12	573,530.92	580,654.42
GDP	MEUR	12,778.61	18,824.00	24,568.77	24,873.92
GDP Per Capita	MEUR/cap	25.72	33.93	42.84	42.84
Household Size	cap/hhld	2.70	2.60	2.60	2.60
Households	hhld	183,996.16	213,393.12	220,588.81	223,328.62
Offices	office	2,890.00	3,227.60	3,336.43	3,377.87
Refrigerated Commercial Buildings	buildings	480.50	536.63	554.72	561.61
Single-family Housing	m2 (sfh)	13,860,604	15,479,731	16,001,713	16,200,462
Multi-family Housing	m2 (mfh)	7,254,985	8,102,476	8,375,695	8,479,724
Office Floorspace	m2 (office)	814,869.57	910,058.59	940,746	952,430.56
Annual Milk Consumption	litres	60,673,906	67,761,530	70,046,473	70,916,480
Electricity	GWh	3,214.56	4,206.45	5,057.57	5,057.57
Waste Generation	kt	268.00	288.00	299.00	299.00
Water	million-m3	56.50	65.47	66.27	67.24
Territorial Crop Production	tonne (crop)	33,154.08	33,154.08	33,154.08	33,154.08
Herd Population	head (cow)	14,352.00	14,380.00	14,380.00	14,380.00
Annual Milk Consumption	litre (milk)	60,673,906	67,761,530	70,046,473	70,916,480
Irrigated Land	ha	3,600.00	3,600.00	3,600.00	3,600.00
Industrial Energy Consumption	GWh (industry)	877.64	1,163.35	1,379.34	1,379.34
Housing Stock (2020 = 1)	housing stock	1.00	1.16	1.20	1.21
Non Residential Building Stock (2020 = 1)	non-res stock	1.00	1.12	1.15	1.17
Personal and Public Transport	Gp.km	4.61	5.55	6.33	6.46
Heavy Vehicle Transport	Gp.km (H)	0.69	1.02	1.16	1.18
Electricity emission factor*	tCO2e/GWh				
Electricity Cost	EUR/GWh	142,500	142,500	142,500	142,500
Water emission factor	tCO2e/ million-m3				
Water cost	EUR/ million-m3	2,375,000	2,375,000	2,375,000	2,375,000
Diesel emission factor	tCO2e/ML	2,867	2,867	2,867	2,867
Diesel cost	EUR/ML	1,008,600	1,008,600	1,008,600	1,008,600
Petrol emission factor	tCO2e/ML	2,466	2,466	2,466	2,466
Petrol cost	EUR/ML	1,115,200	1,115,200	1,115,200	1,115,200
Gas emission factor	tCO2e/ktoe	2,494	2,494	2,494	2,494
Gas costs	EUR/ktoe	569,870	569,870	569,870	569,870
Heat emission factor	tCO2e/GWh	220	220	220	220
Heat cost	EUR/GWh	54,444	54,444	54,444	54,444

Assumptions and notes:

- The variables listed in the above have been used for the projection of both WEM and WOM scenarios.
- Data is not available for all historic/projected years
- 2020 is projected data.

The emissions impact of:

- Water is calculated dynamically in the MACC model, multiplying the 0.8 factor given by the emissions impact of electricity. The 0.8 factor was calculated in the water sectoral research.
- Diesel is taken from the Malta 2019 Inventory submission to UNFCCC (tCO_2e/TJ), scaled by diesel density of 39 TJ/ML.
- Petrol is taken from the Malta 2019 Inventory submission to UNFCCC (tCO_2e/TJ), scaled by petrol density of 34 TJ/ML.
- Gas is taken from the green book supplementary guidance, converting units based on 1 ktoe = 11.63 GWh.
- Heat is based on UK research from 2016.
- Capital costs are discounted using relevant discount rates for the different sectors of the Maltese economy.
- * Electricity emission factor is dynamically calculated through the model and not extractable per year.

6 VULNERABILITY ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

6.1 INTRODUCTION

Carrying out climate change impact studies requires assessment of vulnerability by identifying past and ongoing changes as well as extrapolate the potential for future change. Modelling such changes applying well defined emission scenarios must 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 research associated with observing and forecasting climate change as well as its impacts. It also 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 (AR5; 2013) claims that many aspects of the climate system are showing evidence of a changing climate (Stocker, et al. 2013), and the Sixth Assessment Report (AR6; 2021) claims that the changes in greenhouse gasses, and consequently, the climate changes are "unequivocally caused by human activities" (IPCC 2021). Global mean surface temperature has increased since the late 19th century and each of the past decades has been successively warmer than any previous decade. The globally averaged surface temperature data shows a warming of 1.09 (0.95 to 1.20) °C in the last decade (2011-2020) when compared to 1850-1900. The increase in average land surface temperatures was found to be higher, 1.59 (1.34 to 1.83) °C, compensating for the smaller increase in ocean surface temperatures, 0.88 (0.68 to 1.01) °C. The global increase (+0.19 [0.16 to 0.22] °C) since the AR5 was attributed to the increased warming following 2012. Globally, hot extremes, such as heatwaves, have increased in frequency and intensity since the 1950s unlike cold extremes, which have become less severe and frequent.

Globally averaged land precipitation has been increasing since 1950, with a larger increase since the 1980s. Climate change has also caused an increase in frequency and intensity for extreme precipitation events over land, thereby effecting local seasonal trends, and agriculture.

It is also virtually certain that the upper ocean (above 700 m) has warmed from the 1970s, and extremely likely that this is due to human influence. Global mean sea level has risen by 0.20 (0.15 to 0.25) m between 1901 and 2018, with the mean rate of sea level rise reaching 3.7 (3.2 to 4.2) mm/yr between 2006 and 2018, from an average rate of 1.3 (0.6 to 2.1) mm/yr between 1901 and 1971.

Climate change is inducing changes in the biosphere due to shifting climate zones, which are gradually shifting poleward in both hemispheres, effecting even the growing seasons. These changes however, are not the same in every region, where some places are warming faster than others.

The AR6 also assesses simulations of potential future changes to the world's climate using the Shared Socio-economic Pathways (SSPs) for the Coupled Model Intercomparison Project Phase 6 (CMIP6). Figure 6-1 shows the temperature and precipitation changes expected according to these simulations.

All scenarios reveal that in the near-term (2021-2040), the globe is set to reach the 1.5 °C increase highlighted in the IPCC Special Report on "Global Warming of 1.5 °C" of 2018. This threshold is expected to be crossed between 2030 and 2052, depending on the scenario. The scenarios start diverging in the mid-term (2041-2060) where the temperatures for the SSP1 scenarios start levelling off (and SSP1-1.9 start to decrease), while the remaining scenarios keep on increasing. In the long-term (2081-2100), the average temperatures are expected to reach 0.2-1.0 °C, 0.5-1.5 °C, 1.2-2.6 °C, 2.0-3.7 °C, or 2.4-4.8 °C for the SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5 scenarios respectively. These scenarios will be accompanied by massive changes in extreme temperature conditions that will severely stress the health of the global population, increasing heat-related deaths, as well as strain regional resources, possibly leading to mass migrations.

Changes in the water cycle are projected to occur in a warming climate. The five scenarios also reveal a noticeable change in mean land precipitation, albeit with a greater uncertainty. Nevertheless, the AR6 reports high confidence for an increase in land precipitation by the end of the century with large regional and seasonal differences. Mid-latitude regions, like sub-tropical arid and semi-arid regions will *likely* experience less precipitation. This is explored in greater detail in Section 6.2.

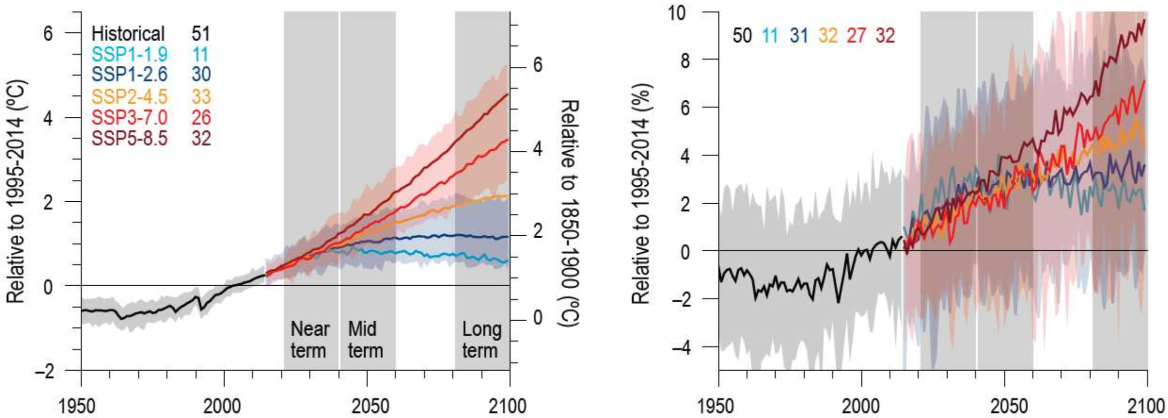


Figure 6-1 Global annual mean changes for temperature (left) and land precipitation (right), according to CMIP6 simulations presented in the AR6 (Lee, et al. 2021). The SSP scenarios are described in the top left with different colours, together with the number of models making up each ensemble. The solid line describes the ensemble mean while the accompanying shaded section describes the 5-95% range of the models. Periods defined as Near-, Mid-, and Long-term are also highlighted with shaded vertical columns.

The global mean sea level rise is virtually certain to continue rising under all five scenarios (as shown in Figure 6-2). This is driven by a positive feedback loop where higher temperatures result in increased land-ice melting (which contributes to sea level rise), which in turn decreases the reflectivity of the planet's surface, resulting in even higher temperatures. The high temperatures exacerbate the situation through the thermal expansion of water, further contributing to sea level rise, which results in faster rates of rise by the end of the century. The AR6 describes a rise of 0.30-0.54 m under the SSP1-2.6 and 0.46-0.74 m under the SSP3-7.0. With a very small difference between the two SSP1 scenarios, the difference "best-" and "worst-case" at the end of the 20th Century varies between dangerous and devastating for coastal communities, with an especially greater risk for small island nations such as Malta.

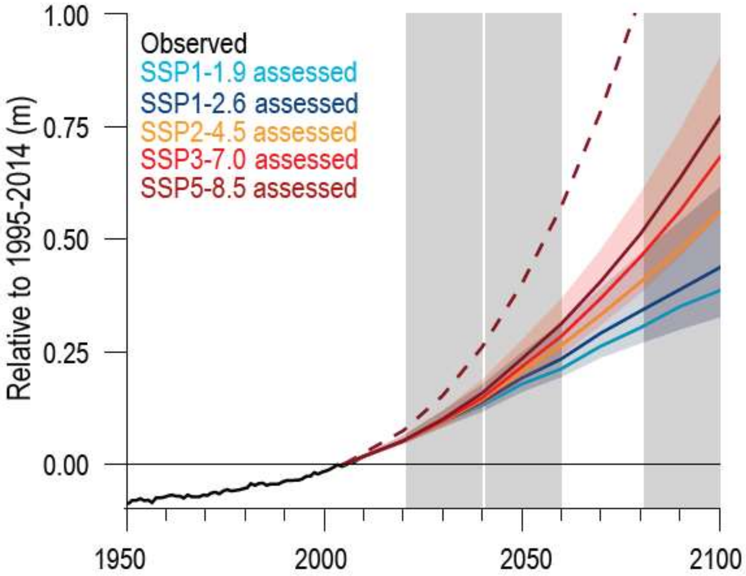


Figure 6-2 Global annual mean changes for temperature (left) and land precipitation (right), according to CMIP6 simulations presented in the AR6 (Lee, et al. 2021). The SSP scenarios are described in the top left with different colours, together with the number of models making up each ensemble. The solid line describes the ensemble mean while the accompanying shaded section describes the 5-95% range of the models. Periods defined as Near-, Mid-, and Long-term are also highlighted with shaded vertical columns.

6.2 Expected impacts of climate change

6.2.1 The Mediterranean Basin

The AR6 also includes high-resolution regional analysis scenarios using Representative Concentration Pathways (RCPs) from the Coupled Model Intercomparison Project Phase 5 (CMIP5) (Taylor, Stouffer and Meehl 2012). This is especially useful for regional analysis of smaller, more complex regions such as Europe and the Mediterranean Basin. The report also introduces Global Warming Scenarios (GWS) to assess the climate changes and impacts independently from the RCPs or SSPs, and the analysis below is presented according to four GWS.

The Mediterranean Basin is especially vulnerable to climate change due to its geography and the results of the AR6 showcase this in great detail. The Mediterranean Basin has thus far seen an increase in droughts with serious agricultural impacts. With a GWS of at least 2°C, the Mediterranean is projected to increase in aridity, temperature extremes, and hence fire conditions. The images and tables discussed in this section reveal in detail how the temperature, precipitation, and sea level conditions of the Mediterranean Basin are set to change according to the high-resolution CORDEX Europe data of the AR6.

The mean temperature conditions (shown in Table 6.1 and Figure 6-3) show a systematic rise in temperature across the entire annual cycle, and good agreement within the model ensemble. The most important impact of this rise in temperature is the corresponding change in temperature extremes. The maximum temperatures (

Table 6.2), associated in particular with the summer months (June, July, August – JJA) also show consistent increases and suggest that countries of the Mediterranean will be reaching new temperature records as new GWS are reached. This is also expected in the winter months (December, January, February – DJF), which will have a dramatic impact on the flora and fauna of the region, thereby impacting agriculture and economic stability.

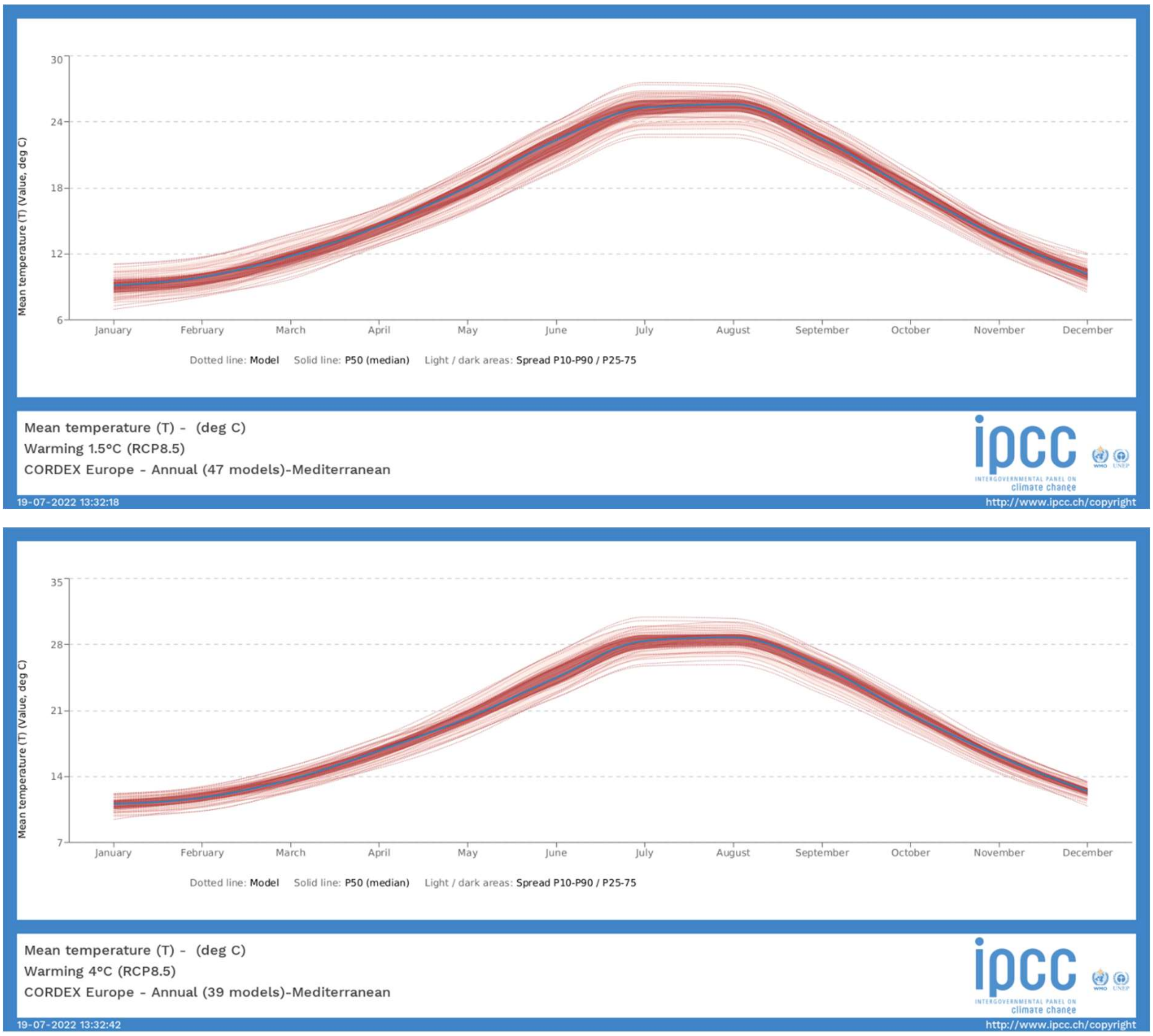


Figure 6-3. Mean temperature annual cycle of the Mediterranean Basin for the 1.5°C GWS (top) and 4°C GWS (bottom), as presented on the AR6 Interactive Atlas[52]. The ensemble consists of 47 and 39 models (top and bottom respectively) from the CORDEX Europe dataset.

Table 6.1 Mean temperature (°C) of the Mediterranean Basin at different GWS, as shown on the AR6 Interactive Atlas. The table shows the values for annual, winter (DJF), and summer (JJA) means. The statistics included are the median, 5th and 95th percentiles (P5, P95). The ensemble consists of 39 models from the CORDEX Europe dataset.

GWS (°C)		1.5	2	3	4
Ann.	P5	15.2	15.7	16.9	17.8
	Median	16.8	17.3	18.4	19.2
	P95	17.8	18.3	19.4	20.2
DJF	P5	8.4	8.8	9.8	10.6
	Median	9.7	10.1	11.0	11.8

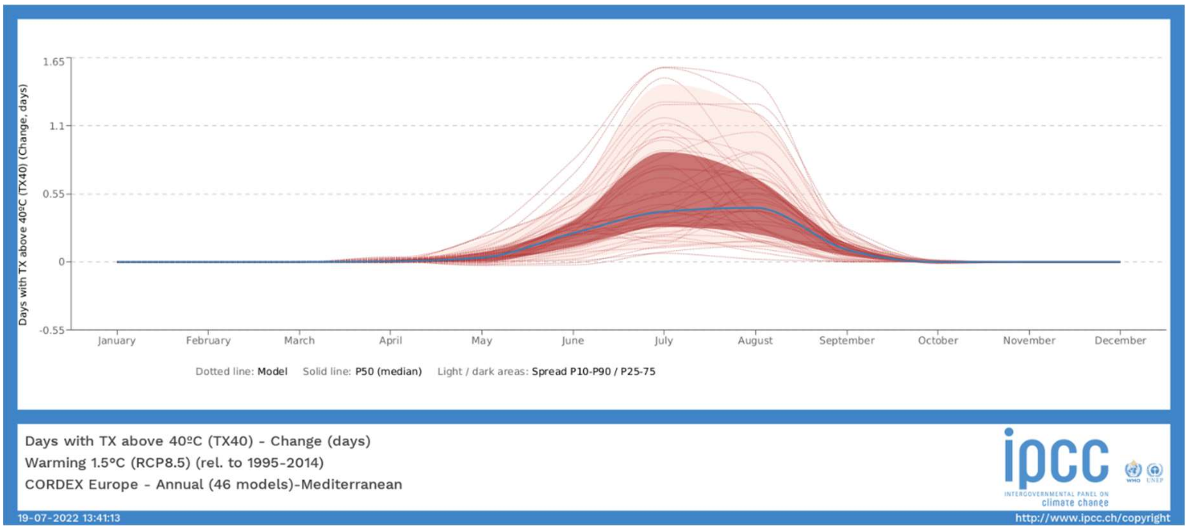
[52] https://interactive-atlas.ipcc.ch/

	P95	11.2	11.6	12.5	12.8
JJA	P5	22.4	22.9	24.3	25.8
	Median	24.4	25.0	26.3	27.2
	P95	25.8	26.4	27.7	29.1

Table 6.2 Maximum annual temperatures (°C) of the Mediterranean Basin at different GWS, as shown on the AR6 Interactive Atlas. The table shows the mean of maximum temperatures as well as the maximum of maximum temperatures. The statistics included are the median, 5th and 95th percentiles (P5, P95). The ensemble consists of 38 models from the CORDEX Europe dataset.

GWS (°C)		**1.5**	**2**	**3**	**4**
Mean	P5	19.0	19.5	20.7	21.6
	Median	20.5	21.0	22.1	23.1
	P95	21.8	22.3	23.4	24.4
Max	P5	32.5	33.2	34.5	36.0
	Median	35.1	35.5	37.0	38.4
	P95	36.9	37.6	39.1	40.7

Even under the GWS of 1.5 °C, which is expected to be reached by 2030-2052, dangerous summer temperatures are expected to rise. Figure 6-4 shows the change in Days above 40 °C expected along the year. While there is less model agreement in the summer months (especially July) in the GWS of 1.5 °C (expected to be reached by 2030-2052), these dangerous temperatures are expected to rise, however slightly. However, the GWS of 4 °C shows a larger rise in days above 40 °C, with the possibility of extending such occurrences to May and September.



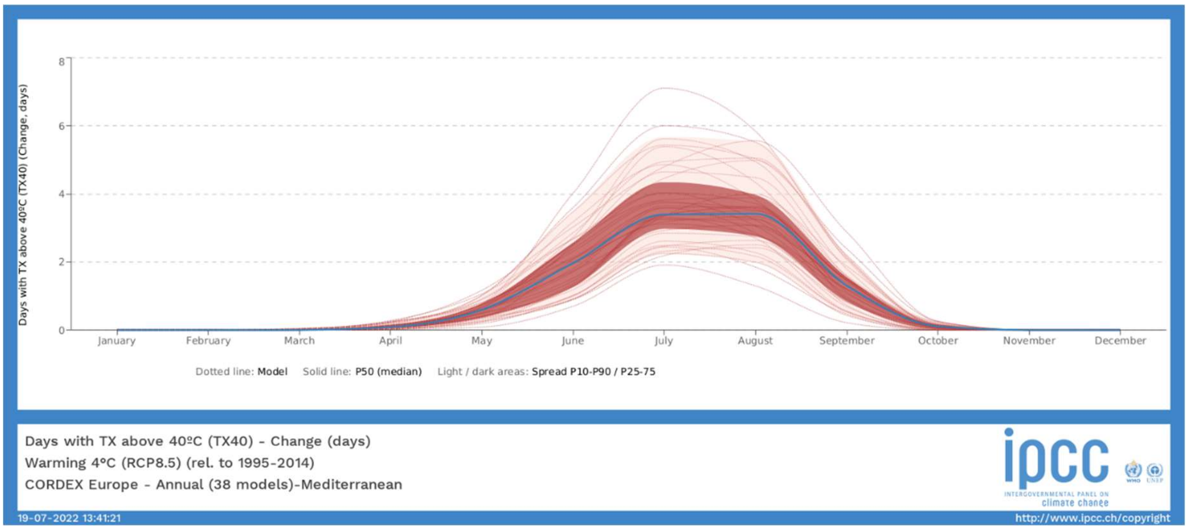
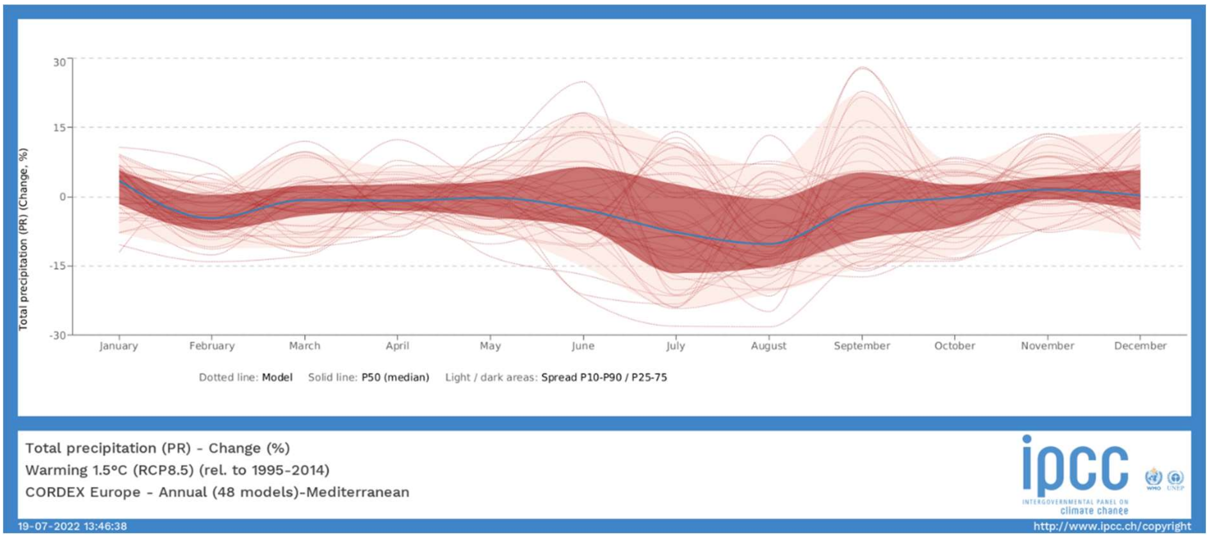


Figure 6-4 Annual cycle of Change in Days with Maximum Temperature above 40°C in the Mediterranean Basin for the 1.5°C GWS (top) and 4°C GWS (bottom), as presented on the AR6 Interactive Atlas. The ensemble consists of 46 and 38 models (top and bottom respectively) from the CORDEX Europe dataset.

The Mediterranean Basin is becoming more arid, and is projected to continue along this change. Figure 6-5 shows a general decrease in mean precipitation that is, once again, more pronounced in summer months. The change is most noticeable in the GWS of 4 °C, and less severe for the GWS of 1.5 °C. The extreme indices (shown in Table 6.3) show a projected increase in drought conditions as showcased in the number of Consecutive Dry Days (CDD), where the GWS of 1.5 °C shows an increase of 1.9 [-0.1 to 6.3] days, and the GWS of 4 °C shows a more dramatic increase of 11.8 [3.6 to 27.9] days. The interlude to these droughts is projected to be more extreme, as the Maximum 1- and 5-day precipitation is also expected to increase.



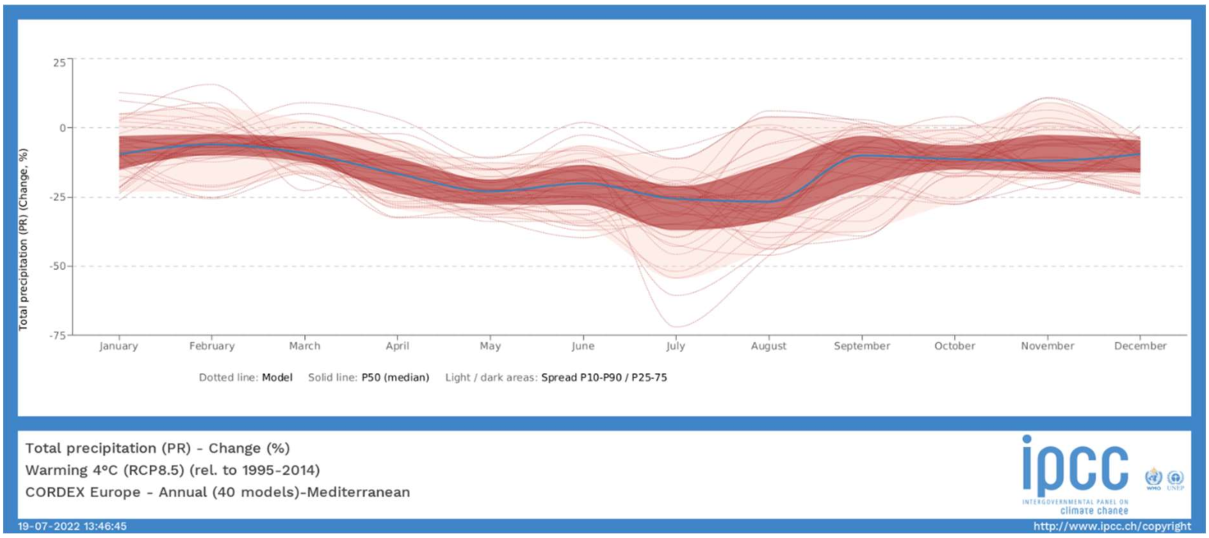


Figure 6-5 Annual cycle of Change (%) in Total Precipitation in the Mediterranean Basin for the 1.5°C GWS (top) and 4°C GWS (bottom), as presented on the AR6 Interactive Atlas. The ensemble consists of 48 and 40 models (top and bottom respectively) from the CORDEX Europe dataset.

Table 6.3 Change (relative to 1995-2014) in precipitation extremes of the Mediterranean Basin at different GWS, as shown on the AR6 Interactive Atlas. The table shows the values for Maximum 1-day precipitation (RX1d in %), Maximum 5-day precipitation (RX5d in %), and Consecutive Dry Days (CDD in days). The statistics included are the median, 5th and 95th percentiles (P5, P95). The ensemble consists of 38 models from the CORDEX Europe dataset.

	GWS (°C)	1.5	2	3	4
RX1d	P5	-0.4	-2.7	0.9	-3.5
	Median	2.5	2.0	5.0	7.6
	P95	4.2	6.5	7.3	13.9
RX5d	P5	-1.2	-5.2	-1.5	-8.6
	Median	1.7	0.6	2.1	2.3
	P95	4.0	4.6	4.7	7.3
CCD	P5	-0.1	1.0	2.3	3.6
	Median	1.9	4.4	8.8	11.8
	P95	6.3	11.0	18.6	27.9

6.2.2 The Maltese Islands

A recent report (NSO 2022) using local observation data on the state of Maltese climate has revealed that, since 1952, Malta's annual mean temperature has risen by about 1.5 °C, equivalent to an increase of 0.2 °C per decade. The number of consecutive drought years (especially noticeable since 2000) has also increased; a change attributed to the rise in temperature. The report also reveals a decline in annual precipitation where during the last 20 years, 2016 had the least rainfall (324.8 mm) followed by 2001 (338.2 mm) and 2020 (386.9 mm). Throughout the entire analysis period (1952-2020) rainfall amount has decreased by 10.3 mm per decade.

Performing climate projections of the nation have proven challenging in the past. The Maltese Islands, a small archipelago where the largest island (Malta) is only 27 km across and 14.5 km wide (with an area of 246 km^2) are too small for most climate simulations to resolve. Local resources could only allow for horizontal resolutions of 50 km and thus improved simulation were not accessible. Furthermore, reliable climate projections require multiple simulations to account for errors and variability within the models. Actions are being planned for the improvement of such models, through the identification of data gaps for their development.

Recently, the EURO-CORDEX (Jacob, Petersen, et al. 2013, Jacob, Teichmann, et al. 2020) community has produced an ensemble of 12km simulation of Europe that is 70+ models large. This takes the burden of producing the simulations away from the users and provides access to small countries with high-quality data. Although this resolution is still very coarse for the Maltese islands, it provides a much-needed improvement of data for local climate analysis. This analysis makes use of the 12 km EURO-CORDEX data averaged over all land-points that correspond to the Maltese Islands for two RCP scenarios (as "best-" and "worst-case").

As reported for the Mediterranean Basin and the rest of the world, temperatures in Malta are expected to keep rising (Figure 6-6). Using the RCP2.6, these should reach a peak after 2030 and remain stable until the end of the century, with an overall rise of about 0.5 °C (compared to 2005). The RCP8.5 however, suggests a temperature rise of over 3 °C (from 2005) by the end of the century with no sign of slowing down. This is especially dangerous since maximum (Figure 6-7) and minimum (Figure 6-8) temperatures are also projected to rise, which will lead to increased health risks and potentially destabilise the local ecosystem, agriculture, and resources.

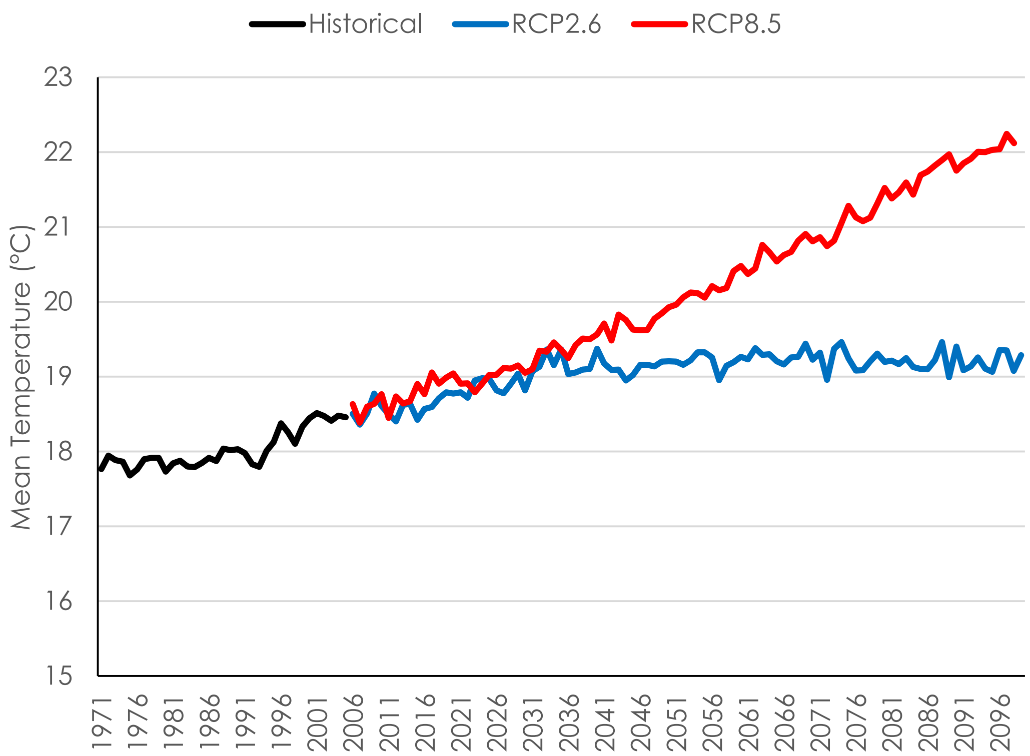


Figure 6-6 Time Series of Mean Annual Temperature (°C) of the Maltese Islands from the 12km CORDEX Europe dataset. The ensemble consists of 70, 30, and 65 models for the Historical, RCP2.6, and RCP8.5 scenarios respectively.

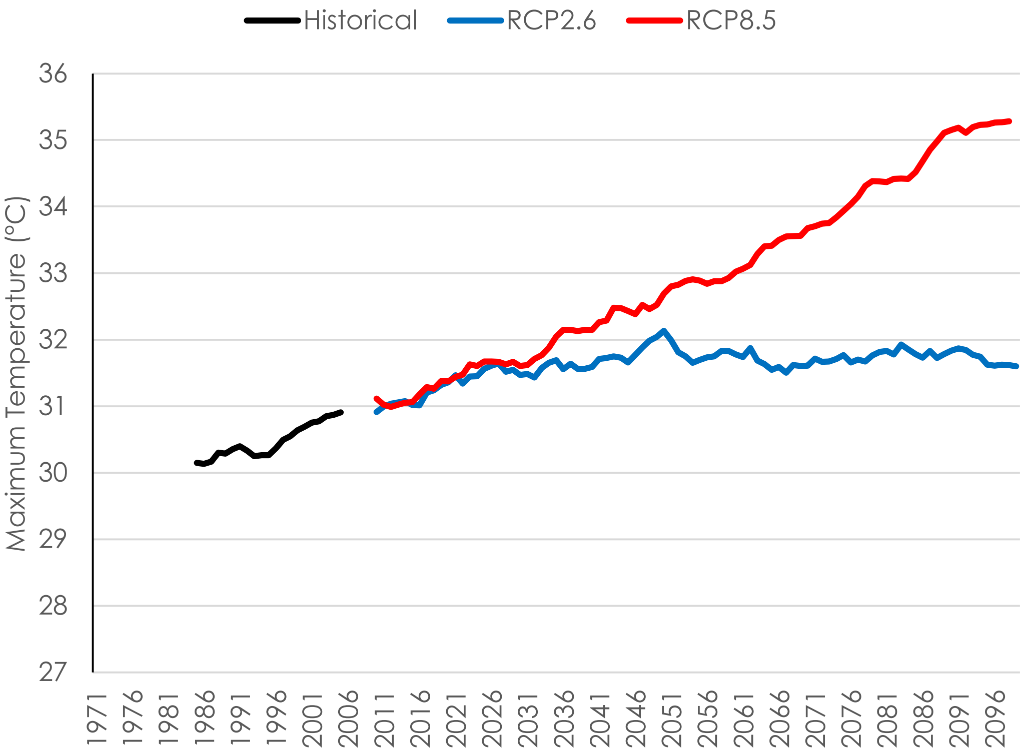


Figure 6-7 Time Series (5-year running mean) of Maximum Annual Temperature (°C) of the Maltese Islands from the 12km CORDEX Europe dataset. The ensemble consists of 65, 29, and 66 models for the Historical, RCP2.6, and RCP8.5 scenarios respectively.

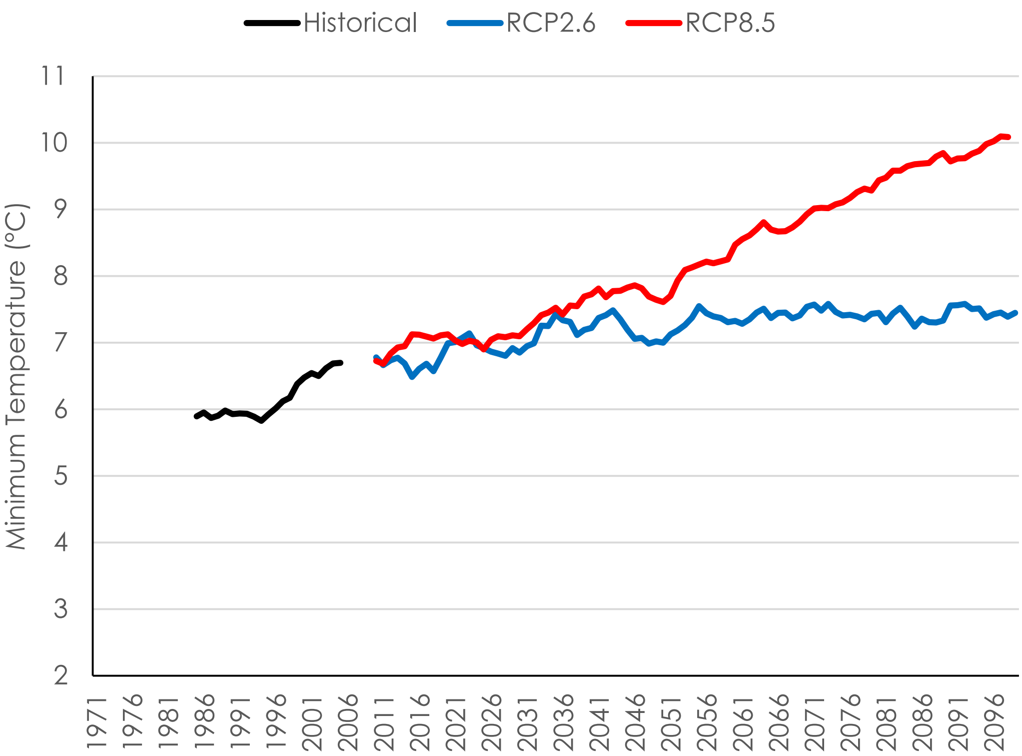


Figure 6-8 Time Series (5-year running mean) of Minimum Annual Temperature (°C) of the Maltese Islands from the 12km CORDEX Europe dataset. The ensemble consists of 66, 29, and 66 models for the Historical, RCP2.6, and RCP8.5 scenarios respectively.

The precipitation trends correspond to those projected for the Mediterranean basin in the AR6. The Maltese islands are projected to become more arid (as seen in total precipitation budget of Figure 6-9) in the RCP8.5 scenario (which is most similar to the SSP5-8.5) but may remain somewhat stable for the RCP2.6. Even with a 5-year running mean, the variability of the RCP2.6 scenario is substantial, and it is important to note that precipitation results are highly uncertain especially when small changes are involved (as discussed earlier). This high variability is also visible when assessing the intensity of extreme precipitation events (Figure 6-10), even though both scenarios show a gradual increase in maximum precipitation. One should also note that the downward trend at the end of the century is not evidence of an upcoming shift in trend; this is likely an artefact of the inter-annual variability (as observed for previous years) and the cut-off point of the data. Nevertheless, this warrants more study, ideally with more highly resolved data.

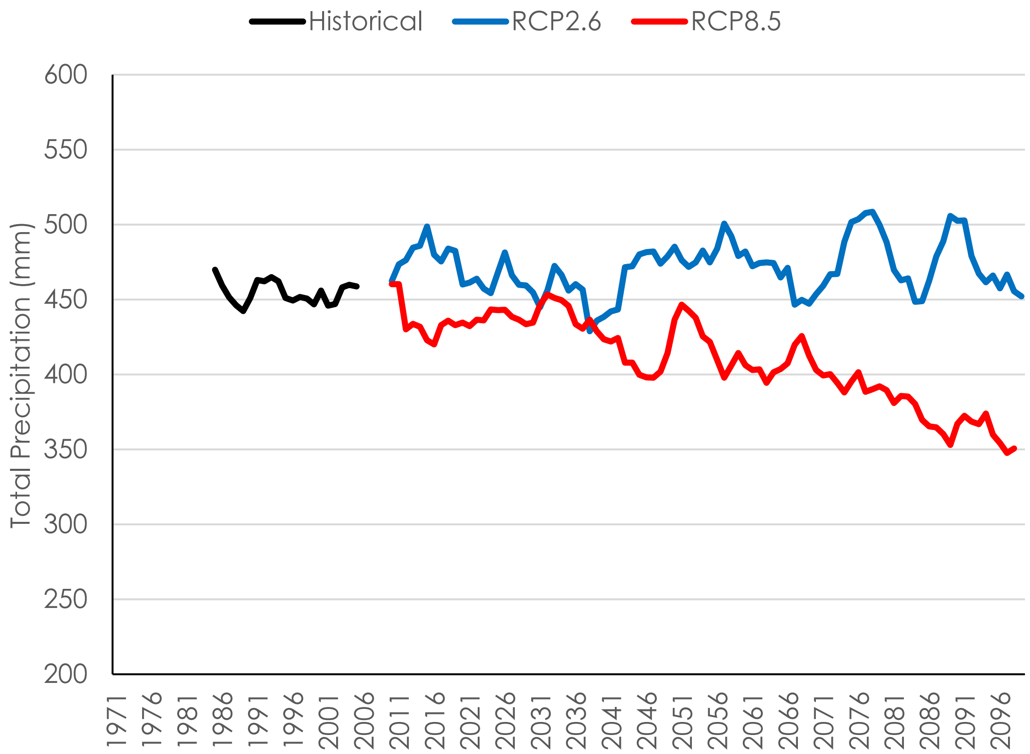


Figure 6-9 Time Series (5-year running mean) of Total Annual Precipitation (mm) of the Maltese Islands from the 12km CORDEX Europe dataset. The ensemble consists of 57, 31, and 67 models for the Historical, RCP2.6, and RCP8.5 scenarios respectively.

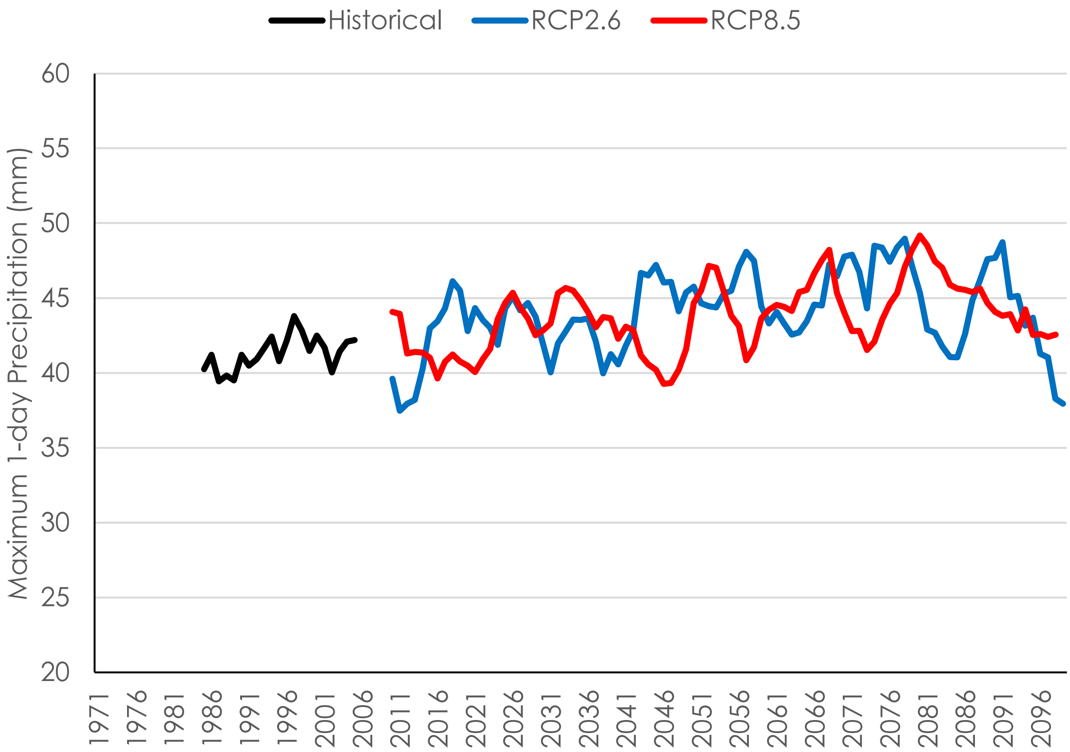


Figure 6-10 Time Series (5-year running mean) of Maximum Annual 1-day Precipitation (mm) of the Maltese Islands from the 12km CORDEX Europe dataset. The ensemble consists of 57, 31, and 67 models for the Historical, RCP2.6, and RCP8.5 scenarios respectively.

6.2.3 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.

The Oceanography Malta Research Group (OMRG, previously known as the Physical Oceanography Research Group) at Department of Geosciences of the University of Malta contributes to the use of Copernicus Marine Environment Monitoring Service (CMEMS) and the update of CMEMCS data by local users. Through these observations and a sea level installation in Mellieħa Bay[53], it could be possible to produce a local assessment of sea level rise.

Modelling activities started using the community Regional Climate Model (RCM), RegCM4 (Giorgi, et al. 2012), in collaboration with the Earth System Physics (ESP) section of the Abdus Salam International Centre for Theoretical Physics (ICTP) that maintains this model. In 2013, 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). Since then, the research group could no longer secure University funding and no RCM studies have been conducted within the Department. The study conducted in Section 6.2.2, was only possible through the available network with the ESP section at the ICTP.

[53] https://gloss-sealevel.org/sites/gloss/files/publications/documents/malta_2001.pdf

Recent development of RCMs has allowed for 3 km climate simulations with the use of Convection Permitting (CP) mode. The EUCP project (Ban, et al. 2021, Pichelli, et al. 2021) has started generating small ensembles of such simulations that will be accessible freely to users worldwide. This may provide Maltese researchers with access to high-resolution climate data. This year, a Maltese early career scientist was awarded a Marie Skłodowska-Curie Fellowship to use the CP mode of the RegCM model for a climatological study of the Circum-Sicilian Islands (which include Malta) and impacts on arthropod habitats within this region.

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[54] finalized in 2012 and the publication of Malta's Low Carbon Development Strategy in October 2021[55]. The Second National Communication, the 2012 National Adaptation Strategy and 2021 Low Carbon Development 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 comprehensive approach to the extent possible. In this respect, the Government is currently carrying out the Climate Vulnerability Risk Assessment of the Maltese Economy. 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.

The section provides a cross-sectoral vulnerability assessment apart from the sectoral one. The Second National Communication and the 2012 National Adaptation Strategy stressed 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. This is still relevant today with the 2021 Low Carbon Development Strategy still identifying the problem related to the lack of local research in climate change forecasting, data and information. The cross-sectoral vulnerability assessments in the 2012 National Adaptation Strategy and the 2021 Low Carbon Development Strategy identified 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 sameThe monitoring of the progress in terms of adaptation measures is co-ordinated through an inter-ministerial committee set up for the purpose of NECP and LCDS with the support of the Ministry responsible for climate. Malta is working on developing its monitoring and evaluation capabilities on adaptation plans and strategies to ensure reporting on these elements in future submissions. This has been taken further through studying one sector at a time in the Climate Vulnerability Risk Assessment.

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

[54] *National Climate Change Adaptation Strategy*, Ministry for Resources and Rural Affairs, 2010.
[55] Malta Low Carbon Development Strategy https://unfccc.int/sites/default/files/resource/MLT_LTS_Nov2021.pdf

- Water Resources;
- Infrastructure and Transport;
- Land-use and Buildings;
- Natural Ecosystems, Agriculture and Fisheries;
- Health issues and Civil Protection;
- Tourism;
- Cross sectoral.

The 2021 Low Carbon Development Strategy identified the major risks and vulnerabilities for each sector, through an impact-likelihood matrix. This allowed for the assessment of the importance of Climate Change risks based on the gravity of their impact and the likelihood of them happening. This enabled the identification of the risks which should be addressed first, in terms of priorities. The Strategy outlines the adaptation priorities per sector.

Delving into the individual sectoral needs of the topics was deemed essential to ensure that measures adopted provide the adequate preparedness to the negative effects of climate change. 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.

The Vulnerability Risk Assessment(VRA) will give further information of Malta's vulnerabilities, and will therefore serve to identify with a greater evidence basis the adaptation priorities in the next iteration of the LCDS. This will be completed in 2023, in time because the next LCDS update is set to happen in 5 years after 2021.

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 higher temperatures, change in precipitation patterns, sea level rise and ocean acidification and warming. These could lead to among other things drought and the resilience of pests derimental to human, animal and plant health.

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 economic growth and development ambitions 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 6.4. and Table 6.5.

Table 6.4. 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
0 = None; 1= Negligible; 2 = Moderate; 3 = Strong

Table 6.5. 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
0 = None; 1= Negligible; 2 = Moderate; 3 = Strong

The 2021 Low Carbon Development Strategy provided a summary of the risks which should be prioritised when looking at the relevant adaptation measures to be implemented (Table 6.6).

Table 6.6. High priority risks and vulnerabilities Invalid source specified..

Sector	Risks
Water Resources	Changing rainfall patterns resulting in flooding, decrease in aquifer recharge and increase in rainwater runoff
Infrastructure and transport	Disruption to air and sea transport and maritime activities Damaged infrastructure Discomfort during road transport Inadequate current infrastructure
Land use and buildings	Coastal erosion leading to more hazardous rocky coastal zones Loss of sandy beaches Low-lying coastal areas affected by sea level rise and storm surges Changes in land use patterns Increased discomfort in homes due to climatic conditions
Natural Ecosystems, Agriculture and Fisheries	Damage to production resources such as farming equipment, glasshouses and buildings Increased soil salinisation, and negative impact on most soil parameters Soil erosion leading to reduced carbon stocks or carbon sequestration in soil Deterioration/loss of biodiversity, native species, ecosystem and habitats Thermal stress for livestock Impacts on post-production and post-harvest processes and profitability Increase in abandoned land by farmers as higher temperatures makes farming unattractive Difficulties in pollination Increased water-use for agriculture
Health and Civil Protection	Increase in illnesses (including mental health illnesses) / infectious and vector-borne diseases and expansion of their habitats Increase in physical ailments such as respiratory diseases, increased risk of developing cancer and chronic diseases such as cardiovascular diseases Dehydration risks, especially in elderly, infants and young children Increased risk of morbidity and death, more hospital admissions, and greater pressure on emergency services Worsening air quality due to increased air pollution from less rain/ increased humidity/ longer pollen season
Tourism	Shift of tourists northbound during the summer months and lengthening of shoulder months Hardship for individuals working in the industry due to greater exposure to higher temperatures Changes in tourists' behaviour during their stay
Cross Sectoral	Increase in regulations and related costs to counteract Climate Change effects

Further detail has been developed in relation to each of the 40 NACE sectors which have been examined through the VRA. Research so far has provided information on the following for each sector: sensitivity, adaptive capacity, vulnerability, hazard and exposure. These studies will evolve even further, and involve an examination of both the macroeconomic and microeconomic effects of climate change.

Among the most impacted NACE code level 2 sectors indicated so far include the following: Tourism, Transport, Manufacture and Agriculture.

6.3.1 Cross-sectoral vulnerability to climate change

6.3.1.1 Institutional organization and the regulatory framework

As an Annex I Party, Malta has formulated a National Mitigation Strategy and a National Adaptation Strategy. It has also published a Low Carbon Development Strategy in 2021, whose Vision Document was published in 2017. Malta has also a cohort of laws that establish emission reduction targets on the sectors that participate in emissions trading, namely power plants and the aviation industry as well as laws imposing targets to generate energy from renewable, including biofuels 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 to address vulnerability to climate change and to implement the requisite adaptation measures.

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 Low Carbon Development Strategy has to be updated at least once every four years. The responsible Minister shall every year report to the House of Representatives the progress registered in implementing the measures published in the Low Carbon Development 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 the 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 cooperation by participating in regional capacity-building programmes. It is also essential to include as a regional legal obligation, the publication of information acquired because 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 denser saline 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 (ERA 2016) 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 European Climate Adaptation Platform (2020)[56] outlines the following impacts as relevant to the Maltese islands:

i. Lower annual precipitation and an increase in heavy precipitation events contributing to a decreased recharge of fresh groundwater resources. The intensity and frequency of extreme rainfall events and reduction of annual rainfalls, will increase flood risk and related hazards;

ii. Decreasing recharge rates will further limit the amount of freshwater available whilst increasing temperatures will increase natural loss of water by evapotranspiration and also result in an increase in the demand for water for irrigative practices in particular; and

iii. Impacts on water quality in particular terms nutrient content arising due to a decrease in the dilutory effect of percolating surface contaminants from a reduced natural recharge depth.

(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 freshwater resources and a high population density, and hence, high water demand. In fact, natural freshwater resources, when used sustainably are only capable of meeting around half of the islands' water demand – even when such demand is maintained under high-efficiency levels. Under these conditions, relying on non-conventional water resources such as sea-water desalination is not a luxury, but a need if security of supply and the sustainability of natural freshwater resources are to be maintained.

Malta's policies in the water sector focus on the development of a pragmatic approach, which recognizes this basic fact that natural water resources are not sufficient to meet the national water demand. Hence water management measures focus on ensuring that water demand is maintained at highly efficient levels, whilst opportunities for the development of increasingly sustainable alternative (or non-conventional) water resources are promoted. The impact of this policy framework can be highlighted through the fact that today the municipal water demand stands at around 60% of what it was in the early 1990's. Furthermore, investments in water production infrastructure have

[56] Malta — Climate-ADAPT (europa.eu)

significantly lowered the energy requirements for sea-water desalination, resulting in a reduction of the electricity demand of the water sector from 12% in the 1990's to less than 6% of the total energy demand today.

Dependence on groundwater, in particular by the agricultural sector is still an important challenge for the future security of both the sector and water resources. In this respect, diversification of water supply for the agricultural sector is another key policy priority for the Maltese islands in particular through the implementation of the New Water (water reclamation) programme which will provide an alternative water supply with a potential of addressing around 30% of the water demand of the sector (Energy and Water Agency 2017).

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[57], 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 impact 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.

Based on the VRA, the main hazards this sector's assets are sensitive to (with varying exposure) are those of marine heatwave, drought, coastal flood, cyclone, windstorm, extreme heat and cold spell.

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 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;

[57] See: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch11s11-3.html.

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.

(3) 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[58];
- 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;
- Providing increased consideration to the energy-water nexus through investments in the optimisation of energy efficiency in the provision of water services;
- Adoption of sustainable strategies for the management of rain water runoff, including the promotion of green urban infrastructures;
- Optimisation of national hydrological monitoring infrastructure which is necessary to enable a reliable assessment of the quantitative and qualitative status of all water resources in the Maltese islands;
- An assessment of the relationship and risks between climate change/water resources/food security/public hygiene; and
- Launching a national water conservation campaign aiming to effectively engage with all water users and promoting water efficient use-practices so as to enable the shift to a more water-conscious society.

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[59]. 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
- 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. Malta's water policy framework starts by acknowledging the fact that groundwater resources are not sufficient to address the national water demand, even if this is maintained at highly efficient levels. Hence the policy framework promotes a "programme of measures" outlined in Malta's Water Catchment Management Plans focuses on the promotion of water demand management measures in conjunction with water supply augmentation measures. Water

[58] http://energywateragency.gov.mt/en/Documents/2nd%20Water%20Catchment%20Management%20Plan%20-%20Malta.pdf

[59] 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.

demand management measures aim to ensure that water use is kept at highly efficient levels by all water users; whilst water supply augmentation measures focus on the development of alternative water resources to supplement groundwater resources and ensure that the utilisation of groundwater can be maintained at sustainable levels. Groundwater cannot be protected in isolation, but only within a comprehensive water management framework.

Key water management measures being implemented under Malta's Water Catchment Management Plan include:

- a National Water Conservation Campaign, promoting efficient water use in households, agriculture and the commercial sector;
- an aggressive leakage identification and control programme by the Water Utility which as significantly reduced leakage levels in the public distribution system;
- the optimisation and augmentation of sea-water desalination capacity, significantly reducing the energy requirements of the desalination plants;
- the launch of the New Water (water reclamation) programme aimed at providing an alternative water resource for the agricultural and commercial sectors;
- enabling a better regulation of groundwater resources, by providing alternative supplies which can support sectors such as agriculture to meet their irrigative demand through a sustainable use of groundwater resources;
- the promotion of green urban infrastructures with the aim of embellishing urban areas whilst providing a mitigation effect against urban flooding and increasing recharge levels to groundwater.

The implementation of measures related to the municipal supply will also see a transformation of the role of Malta's water utility (the Water Services Corporation) into a Net-Zero Public Utility, where the utility will be providing back to the water environment as much as water as it abstracts, through intended and unintended recharge and substitution of supply with New Water. This programme will reduce the impact of water services provision on groundwater resources, enabling a higher protection of groundwater systems.

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 TRANSPORT.

(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.

Within the coastal zone lie 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 Magħtab. 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 work 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 within the Delimara Power Station, 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 (*Currently no storage of petrol is present on site. Diesel storage is still present in view of security of supply.*);
- Wied Dalam Depot (*Currently empty of fuel but the infrastructure is still in place*.);
- Has-Saptan underground and above-ground installation;
- Ras Hanzir underground installation;
- Aviation fuel installation at the Malta International Airport; and
- Tanks at Delimara power station used for fuel storage for third parties.

There are other privately owned storage facilities.

The growing number of private vehicle use has also led to high levels of congestion and subsequent poor air quality within the inner harbour region of the main island. This region is characterised by heavy daily traffic and high population density and although efforts have been made to alleviate congestion, in terms of major road infrastructural changes and a drive to shift to other modes of transport, including providing financial incentives to convert to electric vehicle use, the problem still persists. Advances in air quality as a result of improvements in Malta's vehicle fleet is being counter balanced by the number of vehicles registered on a daily basis.

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 6.7) (Attard, Von Brockdorff and Bezzina 2015). A 2019 report drawn up by a consortium led by CE Delft for the European Commission estimated external costs of transport in Malta to be close to €400 million (European Commission, Directorate-General for Mobility and Transport 2020).

Table 6.7. External Costs of Transport by Category (2012) (Attard, Von Brockdorff and Bezzina, The External Costs of Passenger and Commercial Vehicle Use in Malta 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**

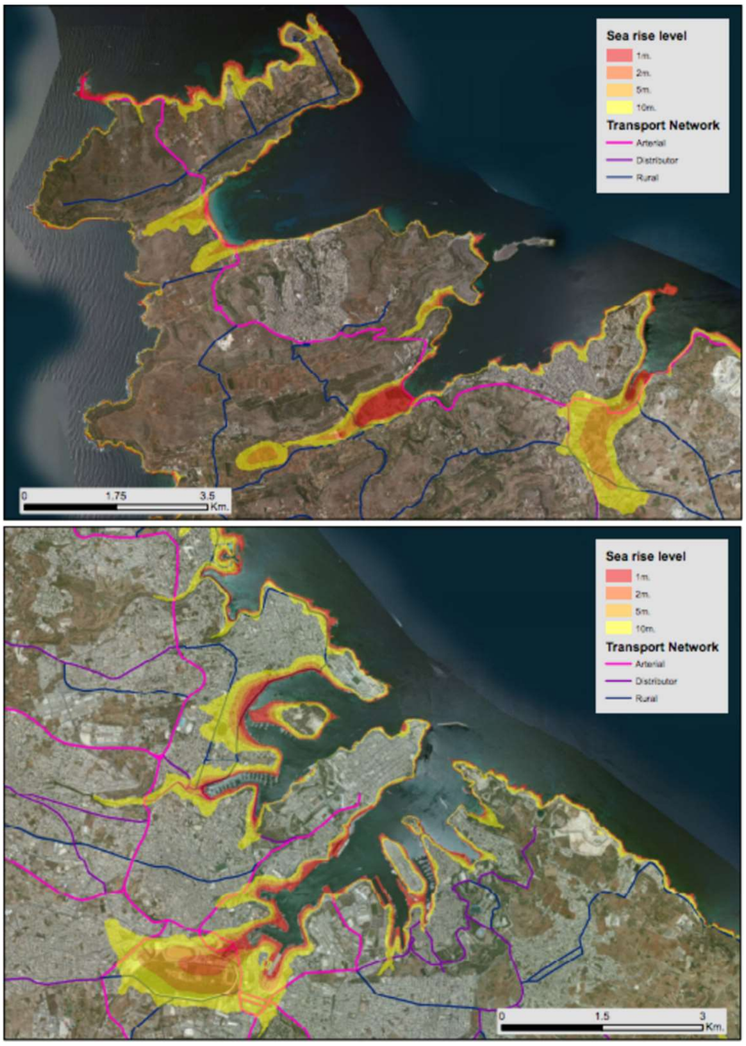
Some of the major link roads in the network have been constructed in low lying areas (valleys) which are naturally prone to flooding and will be impacted by sea level rise. The increase in the number of surfaced roads (and therefore run-off following rain) compound the flooding problem by removing any 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 was 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 6-11) 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.



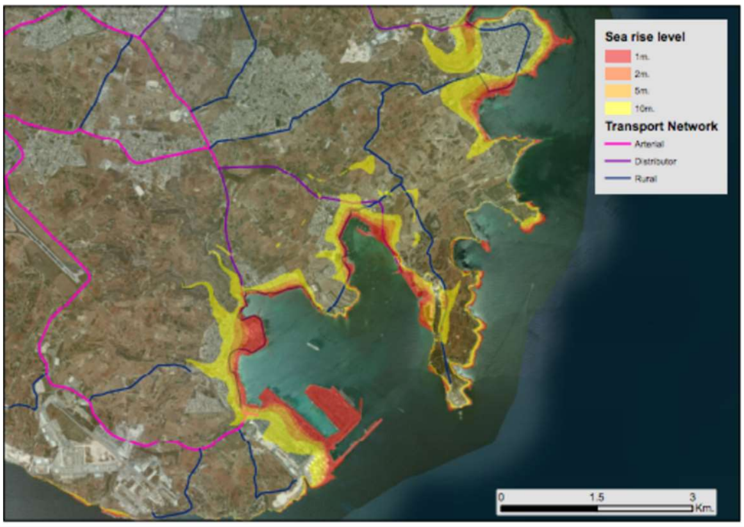


Figure 6-11. Sea level rise scenarios along the main island's coastline (Attard, 2015).

(2) VULNERABILITY TO CLIMATE CHANGE AND ITS IMPACTS ON THE INFRASTRUCTURE AND TRANSPORT

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 6-12).

The above has also been confirmed through the VRA, where the main hazards this sector's assets are sensitive to (with varying exposure) are those of windstorm, precipitation and fluvial flood, and extreme heat.

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.

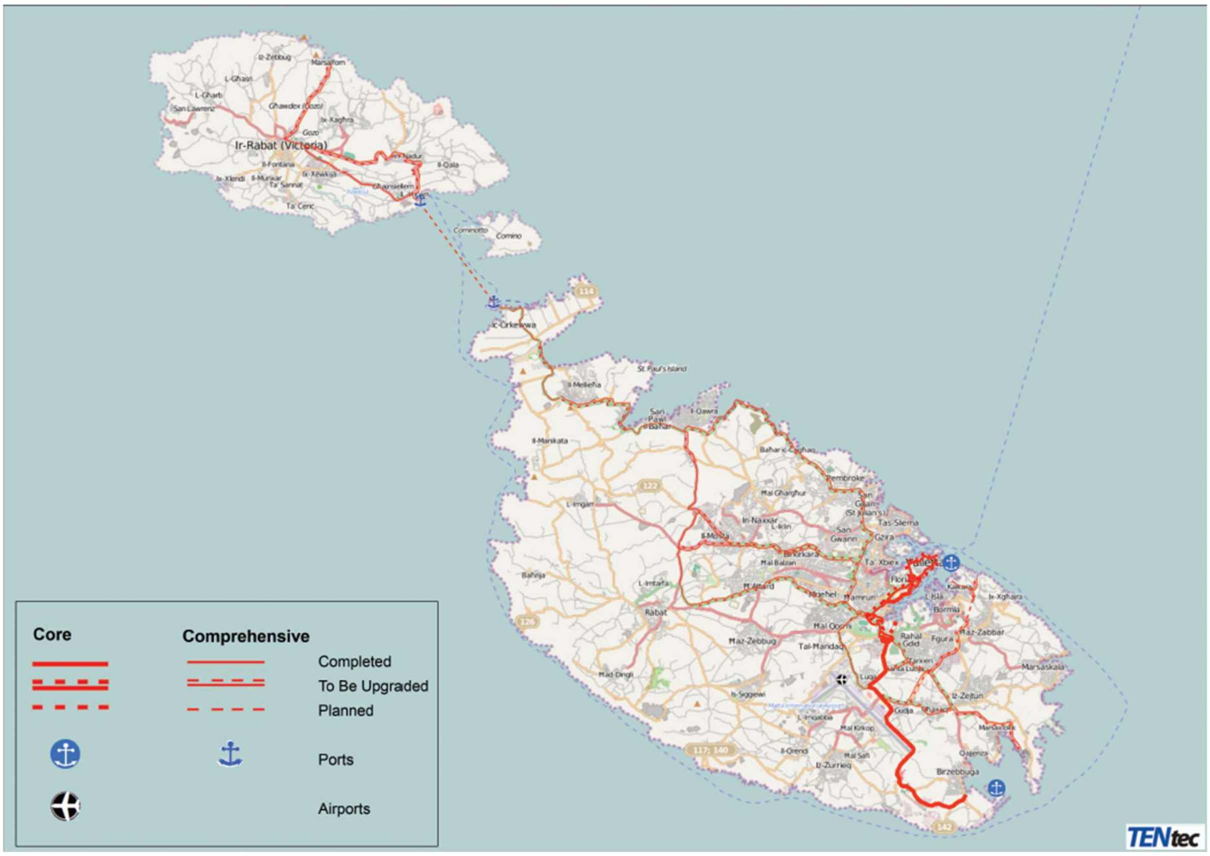


Figure 6-12. Malta TEN-T Core and Comprehensive Network as identified by the TEN-T Regulations 1315/2013 (European Commission, 2014).

(3) ADDRESSING VULNERABILITY OF INFRASTRUCTURE AND TRANSPORT

The 2021 Low Carbon Development Strategy identify a number of measures linked to the Infrastructure and Transport sectors. These include:

- Energy Efficiency Standards (infrastructure);
- Study on green infrastructure in Malta;
- Review of Storm Water Master Plan;
- Ongoing assessment to optimise flooding pathways and "energy water ways";
- Modify standards for road materials to be able to cope with higher temperatures and extreme precipitation events;
- Modify technical standards for capacity of flood infrastructure;
- Identify and screen critical risks and concerns for (i) aviation sector and airports, (ii) maritime sector and ports;

- Introduce maritime weather stations in ports to record trends of major parameters; and
- Improvement of Harbour Wave Climate (Government of Malta, 2021).

6.3.2.3 LAND USE AND BUILDINGS

(1) STATE OF PLAY

The most recent land use and land cover data is available through the Copernicus Land Monitoring Service Corine Land Cover data. Table 6.8 shows the distribution of land uses and percentage of area covered over the period 2000-2018.

Table 6.8. Land Cover Distribution for Malta 2000-2018. Compiled from the Copernicus Land Monitoring Service Corine Land Cover data[60].

Land Cover Type	2000		2006		2012		2018	
	km²	%	km²	%	km²	%	km²	%
Artificial surfaces	93.3	29.52	93.4	29.55	93.6	29.61	94.5	29.90
Arable land and permanent crops	7.3	2.31	7.3	2.31	7.3	2.31	7.3	2.31
Pastures and mosaic farmland	156.9	49.66	156.9	49.66	156.9	49.66	156.0	49.38
Forests and transitional woodland shrub	2.1	0.65	2.1	0.65	2.1	0.65	2.1	0.65
Natural grassland, heatland, schlerophylous vegetation	48.5	15.34	48.4	15.31	48.2	15.25	48.1	15.24
Open space with little or no vegetation	7.7	2.43	7.7	2.43	7.7	2.43	7.7	2.43
Wetlands	0.3	0.09	0.3	0.09	0.3	0.09	0.3	0.09

The fact that the Corine project scale is 1:100.000 and the minimum mapping unit is 25ha makes the spatial resolutions of the source satellite images good enough for a European scale project. However, for a Maltese map with a larger scale (around 1:10.000) and smaller minimum mapping unit (around 0.5ha.), a more detailed spatial resolution would be required.

The last detailed report on land use in Malta was published by the National Statistics Office in 2006 (Table 6.9). This data however, does not take into account the 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), building heights and changes to the rural development guidelines, all having the potential to contribute to changes in land use in the islands.

Agriculture still accounts for almost half of Malta's land area whilst natural vegetation areas account for just over 20% of the land cover. The urban area, including industrial parks, airport and port areas has increased to now cover an area equivalent to 30% 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. However, the current

[60] https://www.eea.europa.eu/themes/landuse/land-cover-country-fact-sheets

planning system lacks a holistic strategy and is largely based on *ad hoc* decisions on single developments, taking its toll on the land, with further substantial losses being reported (Mallia, et al. 2002). Furthermore, the still outdated Local Plans, last approved in 2006, provide opportunity for further uncoordinated and unplanned development to occur.

The pressures of the different activities on the land are very evident and the challenges for planners 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 6.9. Land use in Malta (2006) (NSO 2011).

Description	Km²	% 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.

A revision of the SPED was announced in 2020[61] however this process is still ongoing amidst pressure from various stakeholders to uphold and implement the revision process as quickly as possible.

In addition to issues of land use, Malta's waste is managed through a network of private waste management facilities and public facilities, operated by WasteServ, a government-owned company set up for the purpose of promoting and facilitating the management of primarily municipal waste. The infrastructure includes an engineered landfill for non-hazardous waste, a mechanical-biological waste treatment plant, a rudimentary sorting line for recyclable waste, and a thermal treatment facility for limited quantities of certain non-hazardous and hazardous wastes, over 400 bring-in sites (not operated by WasteServ but by private recycling scheme operators) and five civic amenity centres, as well as a door-to-door collection system for recyclables, organic, and residual municipal waste. Having said so, Malta is heavily reliant on exports for final treatment of its waste.

In 2017, concerns over the capacity of the landfill as well as the reliance on landfilling were raised. This has resulted in a number of projects to increase the landfill void space in Malta, as well the quality of separately collected waste and its sorting, with the aim to reduce the dependence on landfilling by increasing the proportion of waste recycling, or otherwise recovered. Malta has published a Long-Term Waste Management Plan (2021 – 2030) with short-, medium-, and long-term measures aimed at improving waste management within the Maltese Islands, with a view to reflecting the national and Union's view to move to a true circular economy.

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.

[61] https://www.gov.mt/en/Government/DOI/Press%20Releases/Pages/2020/July/08/pr201301en.aspx

(2) VULNERABILITY TO CLIMATE CHANGE AND ITS IMPACTS ON LAND USE AND BUILDINGS

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 several 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 6.10.

Table 6.10. 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 cm.
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). No updates to these studies were conducted despite the increasing density along the coast brought about by the replacement of single household units with multiple (apartment) unit buildings over the past decade or so.

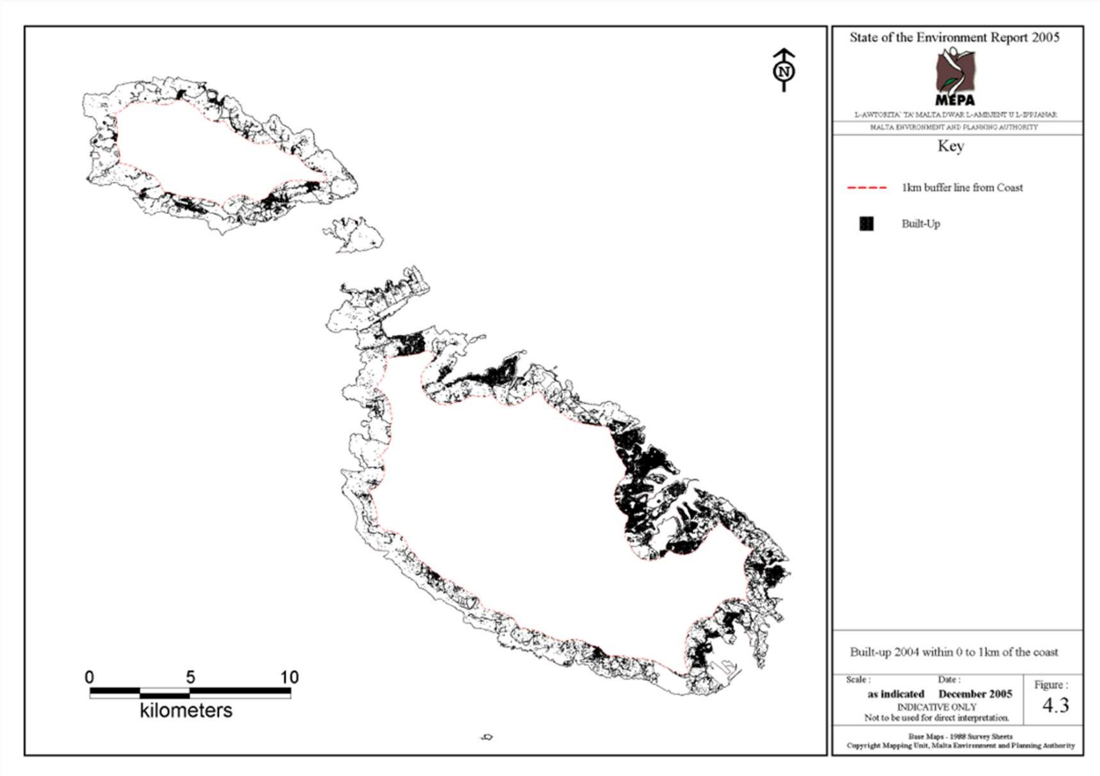


Figure 6-13. Built-up areas within 0 to 1 km of the coast (2004) (MEPA 2006).

Climate change has also the potential of impacting 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.

The VRA has also identified hazards which will affect this sector's assets, which are the following: heat, coastal flood, coastal erosion, severe windstorms, landslides, heavy precipitation. Further detail will be elaborated upon in further continuation of this study relating to the interplay of these hazards with the different impacts they will cause.

(3) ADDRESSING VULNERABILITY OF THE LAND USE AND BUILDINGS

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. The 2021 Low Carbon Development Strategy identifies a list of measures with respect to this sector:

- Joint initiatives between Transport Malta, the Planning Authority, Infrastructure Malta and the Marine, Storm Water and Valley Management Unit in coordinating operations, especially design of new developments;

- Identify high risk/vulnerability areas in Malta and apply appropriate treatment;
- Integrated policy framework for coastal zones and beaches;
- Raise awareness to reduce trampling and compaction of land;
- Research examining the climate status of public buildings;
- Study on green buildings in Malta;
- Update building regulations and codes to ensure climate proof buildings;
- Create incentives to incorporate green features and measures in buildings;
- Quality Seal (Considerate Construction Scheme) for building contractors; and
- Land use management to be adapted to the changing climate.

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.

Malta follows the requirements of the Floods Directive (2007/60/EC) and an updated Preliminary Flood Risk Assessment Report was published in 2019 as the initial step in the development of the 2nd Flood Risk Management Plan (FRMP)[62]. These plans and adjoining maps guide the development of measures for risk aversion within Malta's 2nd FRMP

The Planning Authority and the Environment and Resources 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.

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.

6.3.2.4 Natural ecosystems, agriculture and fisheries

(1) STATE OF PLAY

(A) *TERRESTRIAL AND MARINE ECOSYSTEMS*

Despite its size, Malta has a rich biodiversity, including in terms of indigenous species (of which a number are endemic to the archipelago) and a wide diversity of natural habitats. Climate change is also considerably affecting biodiversity. A changing climate means changing ecosystems, threatening vulnerable species. Due to the inter-connected nature of ecosystems, the loss of species can have knock-on effects upon a range of ecosystem functions and their services. Biodiversity, through the ecosystem services it supports, makes an important contribution to both climate change mitigation and adaptation. Scientific evidence suggests that climate change will impact terrestrial ecosystems through impacts such as shifts in species distribution, habitat loss, changes in species composition, reduction of groundwater quantity and quality, increased desertification, drought and fires, and a potential fertilizing effect. All terrestrial flora and fauna groups may be vulnerable to these impacts.

[62] https://www.energywateragency.gov.mt/water-framework-directive/

On the other hand, the impacts on marine ecosystems include changes in marine species diversity, spread of non-indigenous species, epidemiological outbreaks, changes in hydrodynamics, coastal erosion and habitat loss. Close to 100 non-indigenous marine species have been recorded from Maltese waters to date, across different taxa, including fish, molluscs, crustaceans, macrophytes (algae and seagrasses), sponges and corals. One of the most important habitats in the Mediterranean Sea, seagrass meadows, are particularly vulnerable to a number of 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 may affect the natural vegetation negatively. Malta's ecosystems may be categorised as follows:

(i) *Terrestrial Ecosystems:* Schembri et al. (1999[63]) grouped Malta's terrestrial habitats into three categories, each of which hosts different biological communities[64]:
- Mediterranean-type communities, including xeric grassland and steppic communities, garrigues and phrygana, maquis and Mediterranean sclerophyllous woodland;
- Coastal communities, including marshlands, coastal wetlands, sand dunes, and habitats typical of the rocky coastal fringe;
- Communities of disturbed grounds and afforested areas.

(ii) *Freshwater Ecosystems:* Malta is naturally dry with limited natural freshwater sources. All watercourses are supplied by rainfall from valleys' catchments during the wet season, with some also fed by small springs overflowing from perched aquifers. Hence all streams are small and for the most part temporary in nature, in that they generally only carry water during the wet season. Freshwater habitats are therefore few and only support extremely localised rare and specialized (and occasionally endemic) biota. These vary from very rare riparian communities to small temporary rock pools in karst, the latter being totally dependent on rain water

(iii) *Marine Ecosystems:* These range from those found in the littoral zone (those part of the rocky or sandy shore that are regularly covered and uncovered by sea water) through those in the sub-littoral zone (permanently submerged shore and shelf) and down to the deep-sea ecosystems at depths of 1km or more. Such marine habitats include seagrass meadows, mostly typified by *Posidonia oceanica* or *Cymodocea nodosa*, which generally occur at a depth of 5 to 45m, as well as various biogenic and geogenic reefs and submerged caves. Other important marine habitats, usually found at greater depths, include maerl beds and cold-water coral reefs. These habitats support marine biodiversity and are key elements in marine ecosystems.

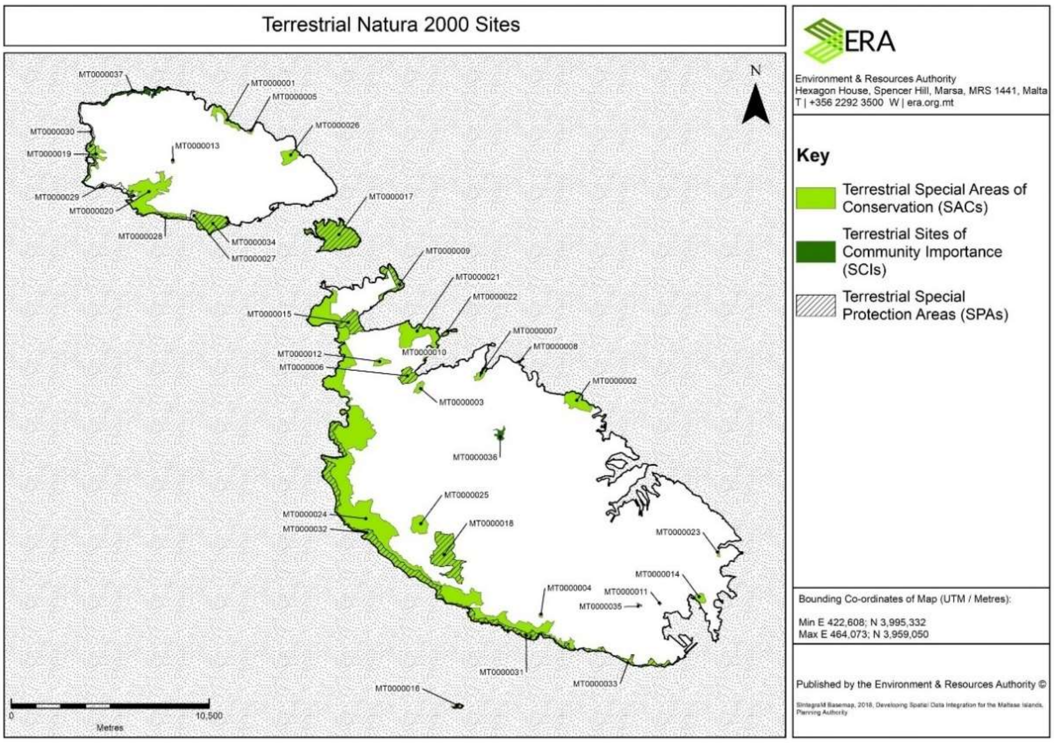
Many species have already been identified as under threat or are in decline. This is due mostly to development, construction and related infrastructure areas, the introduction of alien and problematic species, natural process (excluding catastrophes and processes induced by human activity or climate change), 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, anchoring coupled with the intrusion by a non-indigenous species have already been documented.

As discussed above the competition between land-use for anthropogenic needs and the

[63] 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.

[64] Further information available in Malta's reports to the CBD (Convention on Biological Diversity);
Sixth national report available at: https://chm.cbd.int/database/record?documentID=252696 .

conservation of natural habitats in such a small country has left an indelible mark on the Maltese natural landscape and ecosystems. The agricultural and fisheries sectors have shaped the terrestrial and marine environment. In 2016, the Environment and Resources Authority has published 22 site management plans and conservation orders for Natura 2000 terrestrial sites (Table 6.11 and Figure 6-14)[65], and these are currently under review[66]. Moreover, the conservation measures for the marine Natura 2000 sites (Figure 6-15) were published for public consultation in 2021[67]. Such measures developed for terrestrial, coastal and marine sites, aim to foster collaboration among the different sectors that can impact ecosystems, including fisheries, transport and tourism.



[65] Management Plans of Terrestrial Natura 2000 sites: https://era.org.mt/topic/natura-2000-management-planning-for-terrestrial-sites-in-malta-gozo/;
National Reports on the Implementation of the EU Habitats Directive: http://cdr.eionet.europa.eu/mt/eu/art17/.
[66] Public consultation for the Intent and Objectives of Conservation Objectives and Measures for Malta's Terrestrial Natura 2000 sites: https://era.org.mt/intent-and-objectives-conservation-objectives-and-measures-for-maltas-terrestrial-natura-2000-sites/
[67] Public consultation for the Conservation Measures and Objectives for Malta's Marine Natura 2000 sites https://meae.gov.mt/en/Public_Consultations/MECP/Pages/Consultations/ConservationMeasuresandObjectivesforMaltasMarineNatura2000sites.aspx
Marine Protected Areas: https://era.org.mt/topic/marine-protected-areas-2/
Coastal, Transitional and Inland surface water: 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.

Figure 6-14. Terrestrial Natura 2000 Sites in the Maltese Islands[68].

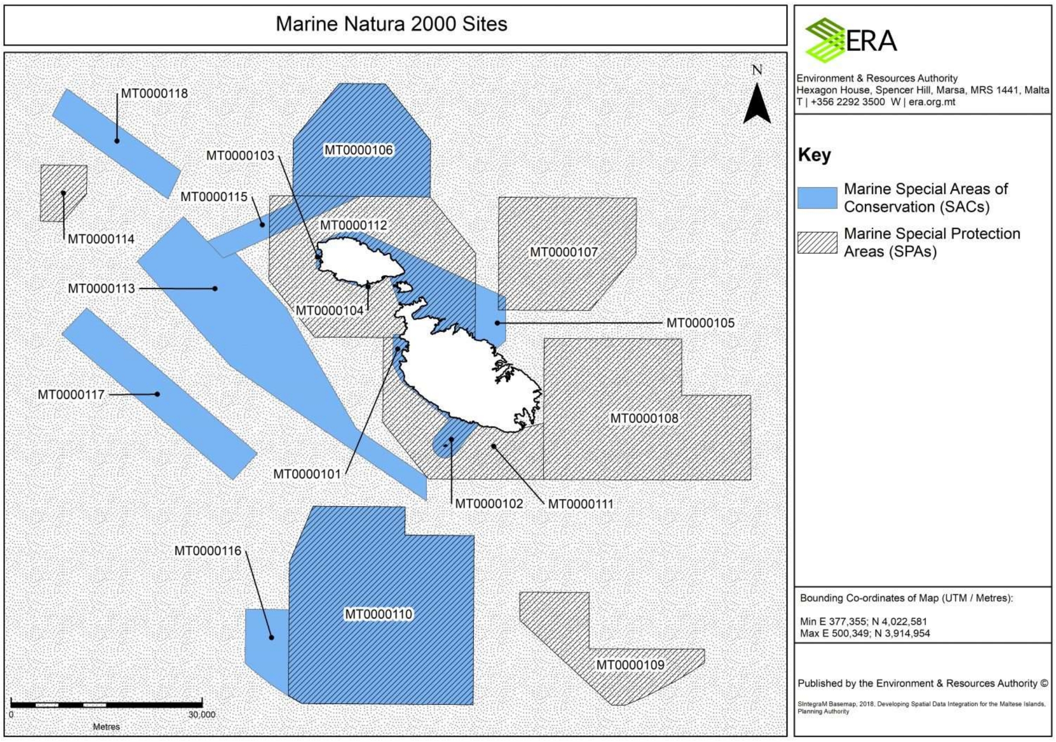


Figure 6-15. Marine Natura 2000 Sites in the Maltese Islands[69].

Table 6.11. Terrestrial Natura 2000 Sites in Malta[70].

Site	Description
L-Inħawi ta' Għajn Barrani	Conservation Order
Il-Maqluba (limiti tal-Qrendi)	Conservation Order
L-Għadira s-Safra	Conservation Order
Ix-Xagħra tal-Kortin	Conservation Order
Għar Dalam (limiti ta' Birżebbuġa)	Conservation Order
Iċ-Ċittadella	Conservation Order
Filfla u l-Gżejjer ta' Madwarha	Conservation Order
Il-Gżejjer ta' San Pawl (Selmunett)	Conservation Order
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

[68] Environment and Resources Authority: https://era.org.mt/topic/natura-2000-datasheets-maps/ ttps://era.org.mt/topic/natura-2000-management-planning-for-terrestrial-sites-in-malta-gozo/
[69] Environment and Resources Authority: https://era.org.mt/topic/marine-protected-areas-2/
[70] Environment and Resources Authority: https://era.org.mt/en/Pages/Natura-2000-Management-Planning.aspx

Site	Description
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' Bengħisa	Management Plan
Rdumijiet u L-Inħawi ta' Ta' Ċenċ	Management Plan
Wied il-Miżieb	Management Plan

(B) *FISHERIES AND AQUACULTURE*

Maltese fisheries are considered multi-species and multi-gear fisheries, whereby fishers alter between fishing gears throughout the year depending on the commercial species being targeted. The Maltese fishing fleet is known to land a variety of species of fish and shellfish, with the majority of this commercial stock being shared across the Mediterranean region.

Fisheries depend on a number of environmental factors governing the supply of young stock, feeding and predation conditions, as well as natural processes such as migrations of fish populations. Malta's fisheries sector is small and contributes very little to the economy, including a small working population (1.0%) which depends on fishing and aquaculture for their livelihood. Particular fish species 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 6.12, that landings from marine capture fisheries in Malta are dominated by mackerel, swordfish, lampuki (dolphin fish) and tuna. 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.

Table 6.12. Top 75% of species landed by the Maltese fishing fleet in 2015-2017[71].

Species Name	Average Landings (tonnes) 2015-2017	% Contribution to GSA 15 Landings
Scomber japonicus	573	24.49
Xiphias gladius	428	18.30
Coryphaena hippurus	272	11.60
Thunnus thynnus	178	7.62
Scomber scombrus	126	5.40
Lepidopus caudatus	125	5.35
Boops boops	53	2.25

(ii) *Aquaculture:* The aquaculture industry has operated in the islands since the late 1980s, 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 6.13 shows the Aquaculture Annual Production for the years 2009-2014.

Table 6.13 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

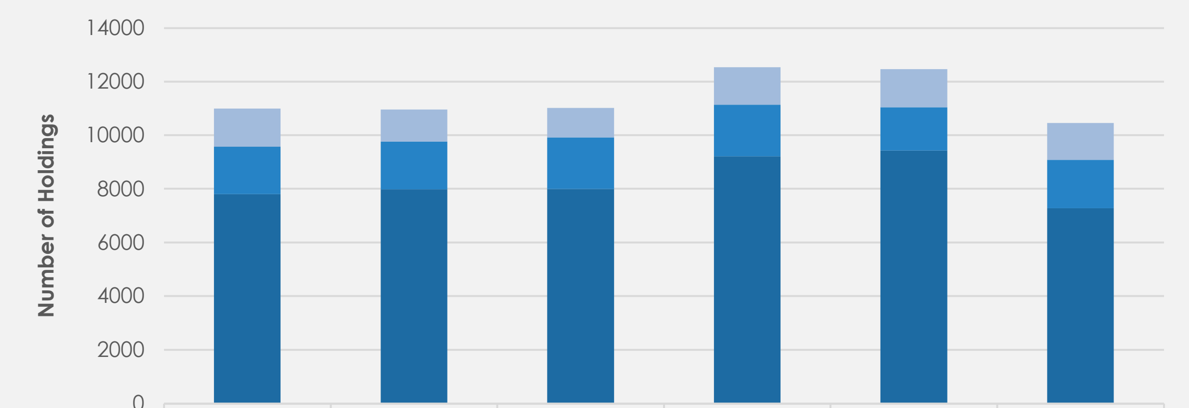
(C) *AGRICULTURE*

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 agricultural holdings in 2020 dropped from 12,466 in 2013 to 10,449, with a total of 10,730 hectares of Utilised Agricultural Area (NSO 2020) The losses were experienced in the number of holdings of smaller and larger unit (Figure 6-16). Figure 6-17 shows the distribution of land dedicated to different crops which changes from year to year.

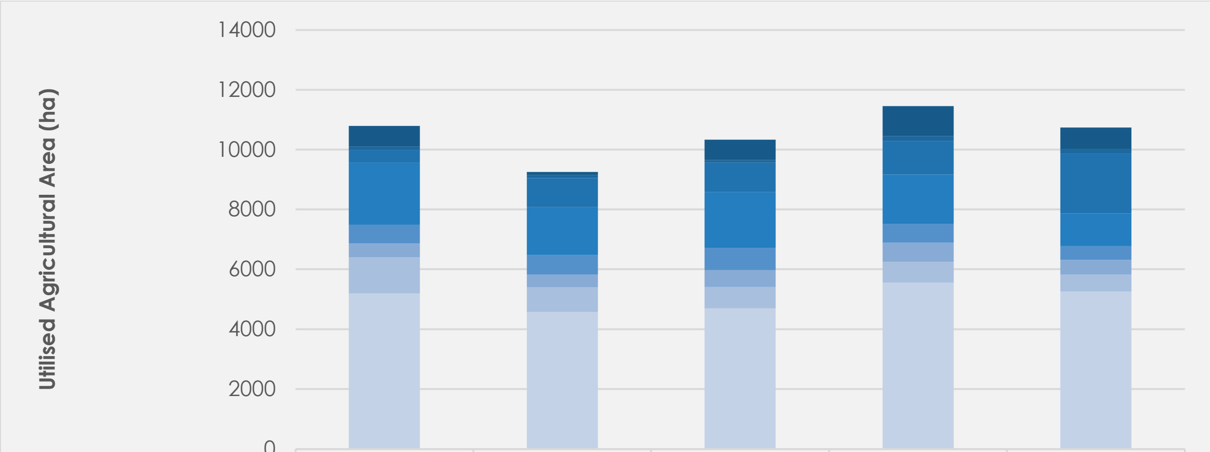
In 2020 the number of managers employed in farming holdings was 10,449. This sector was dominated by men (89%) and with over 40% growing produce for own consumption (NSO 2020). Previous Communications reported urban sprawl as the major threat to agricultural land, as well as other issues such as abandonment 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, drought, salinisation of groundwater sources, flooding and sea level rise. A detailed assessment of climate change impacts needs to take into account the extent of impact and the socio-economic impacts on the sector.

[71] Environmental and Resources Authority: https://era.org.mt/wp-content/uploads/2020/06/MSFD-Art.-17-Update-Malta_FINAL.pdf



	2003	2005	2007	2010	2013	2020
≥ 2 ha	1418	1197	1105	1395	1,431	1374
1 -< 2 ha	1767	1782	1923	1931	1,607	1795
0 -< 1 ha	7802	7982	7990	9208	9427	7280

Figure 6-16. Number of agricultural holdings by size for 2003 to 2013 (NSO 2016, NSO 2020).



	2003	2005	2007	2010	2020
Fallow Land	696	115	676	1007	725
Other Areas	107	93	89	157	146
Kitchen Gardens	423	968	987	1123	1995
Market Gardening	2083	1594	1851	1661	1090
Vineyards	615	661	751	614	456
Permanent Cropping	465	429	570	637	497
Potatoes	1207	820	712	701	570
Forage	5197	4574	4690	5553	5251

Figure 6-17. Size of utilizable agricultural area by type of crop for 2003 to 2013 (NSO 2016, NSO 2020).

(2) VULNERABILITY OF NATURAL ECOSYSTEMS, AGRICULTURE AND FISHERIES

(A) NATURAL ECOSYSTEMS

The major threat to Malta's biodiversity lies in the fact that many species are threatened, under stress or in decline. This is also recognised in Malta's Low Carbon Development Strategy published in 2021. 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).

Apart from the impacts identified in the Low Carbon Development Strategy (listed in Table 6.6), impacts were also summarized in 2010 (Table 6.14). These are still relevant today.

Table 6.14. Climate change impacts and vulnerability for terrestrial and marine ecosystems. (adapted from (MRRA 2010)).

Terrestrial Ecosystems	**Loss of biodiversity and increased risk of extinction** - 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). - Species populations in Malta are already small which could push many taxa to extinction. - All terrestrial flora and fauna are considered vulnerable to climate change. **Shift in the distribution of species** - Changes in temperature, precipitation and sea level will affect ecosystem boundaries. - Climate change might also affect habitat. - All terrestrial flora and fauna will be affected by distributional shifts. **Sea level rise** - 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. - Coastal areas are most vulnerable habitats, including some already protected sites such as Natura 2000 sites, Special Areas of Conservation and Specially Protected Areas[72]. A full list of vulnerable habitats was produced for the Second Communication. **Temperature increase** - Temperature increases will favour species with a higher affinity to subtropical climates. - Warming and drying is most likely to induce species-range shifts, with migration rates exceeding the capacity of many endemic species to do so. - 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. - Warming will impact phenology (timing of seasonal activities). - Water availability will change as temperatures rise and increasing the demand for water. - Desertification and fires will severely impact terrestrial ecosystems. **Decrease in precipitation** - Water availability will reduce due to a decrease in rainfall, leading to a loss of hydrophilic species and increase in soil salinity. - Droughts will occur. - Potential sea water contamination of the groundwater from over abstraction, affecting also the populations of migratory birds residing in inland wetlands. **Effects of CO_2 emissions** - A fertilization effect causing greening of the Mediterranean.
Marine Ecosystems	**Temperature increase**

[72] Currently a total of 190 sites are protected in Malta covering an area of over 13,500hectares **Invalid source specified.**.

	- Temperature anomalies can dramatically change faunal diversity in the Mediterranean. - Higher sea temperatures also facilitate the spread of alien species. This might dislocate species and possibly affect the food web. - Warming has already led to the shift in Mediterranean species (Perez 2008). - Climate change might also favour epidemiological outbreaks as pathogens are temperature sensitive. - A number of consequences have already been documented as a result of increasing sea temperatures in the Mediterranean. **Changes in coastal hydrodynamics** - Any changes to coastal currents will impact littoral and sub-littoral communities and *Posidonia oceanica* meadows. **Changes in deep water circulation** - This may strongly reduce spring phytoplankton blooms and export production to the deep layers. - Low oxygen areas (hypoxia or anoxia) in bottom waters might affect bays and inlets. **Increase in sea level** - Changes will affect the distribution of benthic and pelagic organisms. - Inundation will affect the zonation patterns on rocky shores in an upward shift. - Sea level rise may affect seagrass meadows by exposing them to more wave action and swell leading to erosion and loss of habitat. **Increase in the intensity of rainfall events** - Increase in sea water turbidity and decrease in salinity. - *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. **Increase in CO_2** - Acidification will result from the increase in the concentration of dissolved carbon dioxide. - Organisms such as corals, most molluscs and sea urchins will face greater prospects of erosion. - 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 (such as windstorms and coastal floods – as confirmed by the VRA) 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.
- Increased water temperature (confirmed by the VRA)

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 6.15 reports on the impacts expected on important components within agriculture in the islands, still very much relevant today.

Table 6.15. 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. 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. 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. Accelerated ripening due to increasingly warmer temperatures, has serious consequences for precocious varieties. Malta's vineyards will suffer particularly during drought periods.

Impact on Livestock	Increases in air temperature may affect behavioural or physiological functions of livestock. Most of Malta's farms are not equipped with cooling devices and a reduction in produce, brought about by warmer temperatures is possible. 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. Rate of absorption of rainfall will decrease as heavy storms will fill reservoirs and wells fast but not for long. 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. Whilst milder winters might increase the incidence of pest outbreaks, higher temperatures and longer periods of warm weather will allow proliferation of insect pests. Use of pesticides to control pests in itself can harm agriculture.

There have however been preliminary findings from the VRA which indicate that the main hazards which will affect agricultural assets are those of: heat, precipitation, aridity, agricultural and ecological drought, rainfall and flooding, sea level rise, or a combination of these.

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

Adaptation measures addressing and conserving natural ecosystems, such as nature-based solutions may be challenging to devise. The vulnerability of biodiversity and the various negative impacts which human activities have upon natural ecosystems will only be further exacerbated as a result of climate change. Unfortunately, however 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[73].

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

[73] National Strategy for the Environment: https://era.org.mt/era-topic-categories/national-strategy-for-the-environment/;
Malta's National Biodiversity Strategy & Action Plan 2012 – 2020: https://era.org.mt/maltas-national-biodiversity-strategy-action-plan-2012-2020/;
Marine Programme of Measures: https://era.org.mt/topic/msfd-programme-of-measures/;
Water Catchment Management Plan: https://era.org.mt/topic/water-catchment-management-plan-2/
[74] See (COM(2006) 232) Proposal for a Directive of the European Parliament and of Council establishing a framework for the protection of soil.

health laws, fisheries and agriculture related laws to assist this sector to adapt to climate change.

The new Common Agricultural Policy (CAP) Strategic Plan 2023-2027 is currently being finalised following a public consultation period in late 2021. The three general objectives and nine specific objectives following the European Commission Recommendations and complement several other national policies and plans. Table 6.16 lists these objectives.

Table 6.16. General and specific objectives of the CAP Strategic Plan 2023-2027 (Government of Malta 2021).

General Objective 1 - Foster a smart, competitive, resilient and diversified agricultural sector ensuring long-term food security Specific Objective 1 - Support viable farm income and resilience of the agricultural sector across the Union in order to enhance long-term food security and agricultural diversity as well as to ensure the economic sustainability of agricultural production in the Union Specific Objective 2 - Enhance market orientation and increase farm competitiveness both in the short and long term, including greater focus on research, technology and digitalisation Specific Objective 3 - Improve the farmers' position in the value chain
General Objective 2 - Support and strengthen environmental protection, including biodiversity, and climate action and to contribute to achieving the environmental and climate-related objectives of the Union, including its commitments under the Paris Agreement Specific Objective 4 - Contribute to climate change mitigation and adaptation, including by reducing greenhouse gas emissions and enhancing carbon sequestration, as well as to promote sustainable energy Specific Objective 5 - Foster sustainable development and efficient management of natural resources such as water, soil and air, including by reducing chemical dependency Specific Objective 6 - Contribute to halting and reversing biodiversity loss, enhance ecosystem services and preserve habitats and landscapes
General Objective 3 - Strengthen the socio-economic fabric of rural areas Specific Objective 7 - Attract and sustain young farmers and new farmers and facilitate sustainable business development in rural areas Specific Objective 8 - Promote employment, growth, gender equality, including the participation of women in farming, social inclusion and local development in rural areas, including the circular bio-economy and sustainable forestry Specific Objective 9 - Improve the response of Union agriculture to societal demands on food and health, including high-quality, safe and nutritious food produced in a sustainable way, to reduce food waste, as well as to improve animal welfare and to combat antimicrobial resistance

In addition to the above, the cross-cutting objective aimed at modernising the sector through fostering knowledge sharing, innovation and digitalisation in agricultural practices and rural areas will also aim at strengthening the resilience and sustainability of the sector (Government of Malta, 2021).

Adaptation measures under this sector should 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.

6.3.2.5 HEALTH AND CIVIL PROTECTION.

(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, illegal and unregulated migration from third states, which Malta is constantly subjected to, is already sometimes caused by food and water security issues in States already afflicted by drought and conflict over access to natural resources. The situation is most likely to exacerbate as a result of climate change.

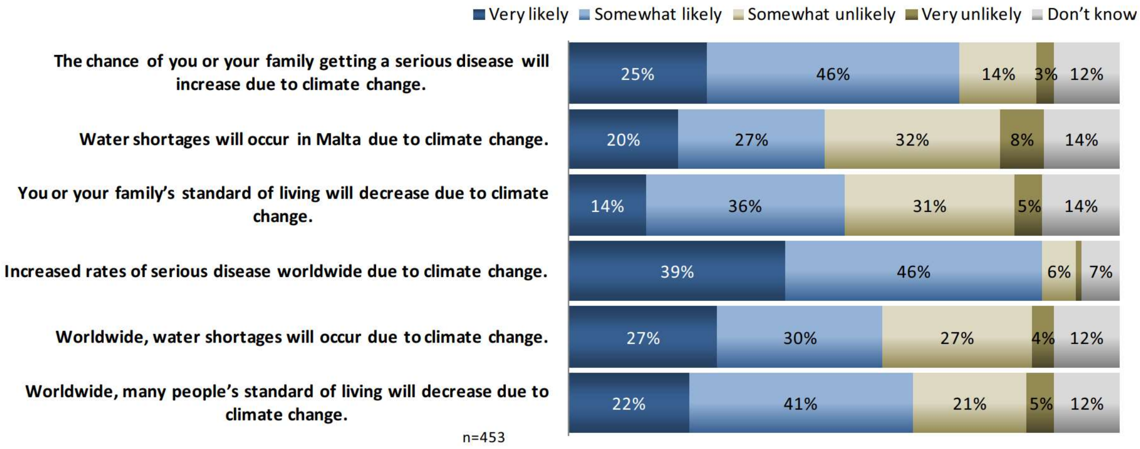
Many climate change concerns are linked to human health and the state of our environment has a direct impact on human wellbeing. The gradual warming of the planet, as well as increased heavy storms and longer period of droughts will affect many aspects of human health such as air quality, water and food 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 2021). In most cases the most vulnerable are the elderly, disabled, children, ethnic communities and people on low income.

The study (Akerlof, et al. 2010) included amongst others the Maltese perception of impacts of climate change on health (Figure 6-18). 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. The results of this study are still very much relevant today.

Diseases of the circulatory system and neoplasms accounted for the vast majority of deaths, accounting for 33.5% and 28.6% respectively in 2018 (Figure 6-19). Ischaemic heart disease, other heart diseases (including heart failure) and cerebrovascular diseases were the leading causes of death. There were 1234 deaths due to diseases of the circulatory system, a decrease of 14 deaths from the year 2017. Diseases of the circulatory system were the leading cause of death (DHIR 2018).

Causes of death vary with age and gender, with external causes of morbidity and mortality accounting for a large proportion of deaths in the younger age groups, cancers dominating the middle-aged groups, and circulatory diseases increasing in importance with increasing age. Conditions such as dementia, pneumonia and diabetes mellitus are emerging as significant causes of death in the older age groups.

The year 2021 was the deadliest over the past five years with a steep rise in mortality recorded during the second year of the COVID-19 pandemic. Further information still needs to be compiled and published to fully understand the impact of the COVID-19 pandemic in Malta.



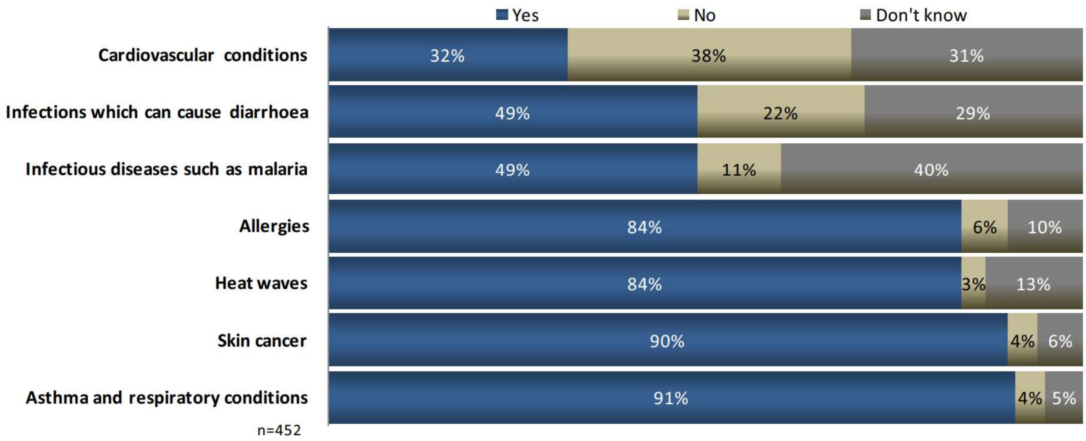


Figure 6-18. Maltese perceptions of likelihood of health risks resulting from climate change (Akerlof, et al. 2010).

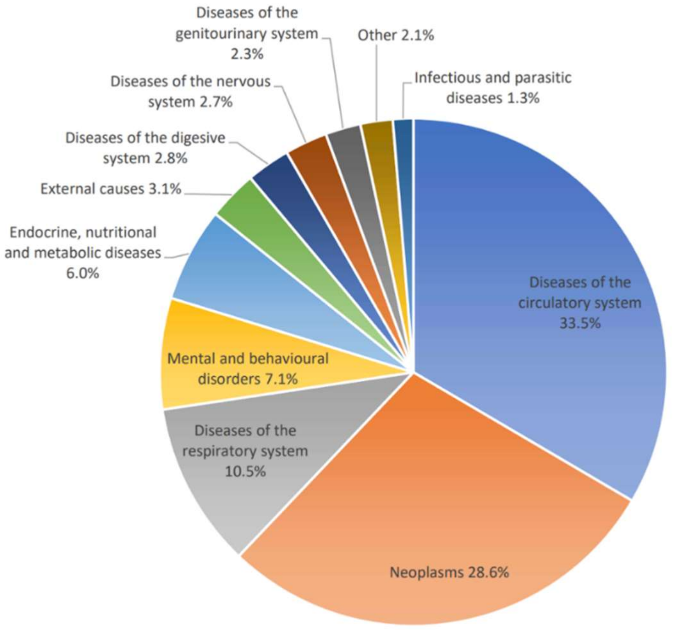


Figure 6-19. Most common causes of death using broad categories (DHIR 2018).

(2) VULNERABILITY ON 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 6-20). The revision of the population projections are expected following the release of the full 2021 Census of Population and Housing. Given the increase in the population (estimated at 100,000 since 2010) and the increase in a younger foreign population changes to the projections are expecte. However, a resident ageing population is still envisaged and is still expected to become vulnerable to climate changes with higher exposure to system collapse particularly the stress of increased cases for beds in the current health care system. This was evident also throughout the two years of the COVID-19 pandemic.

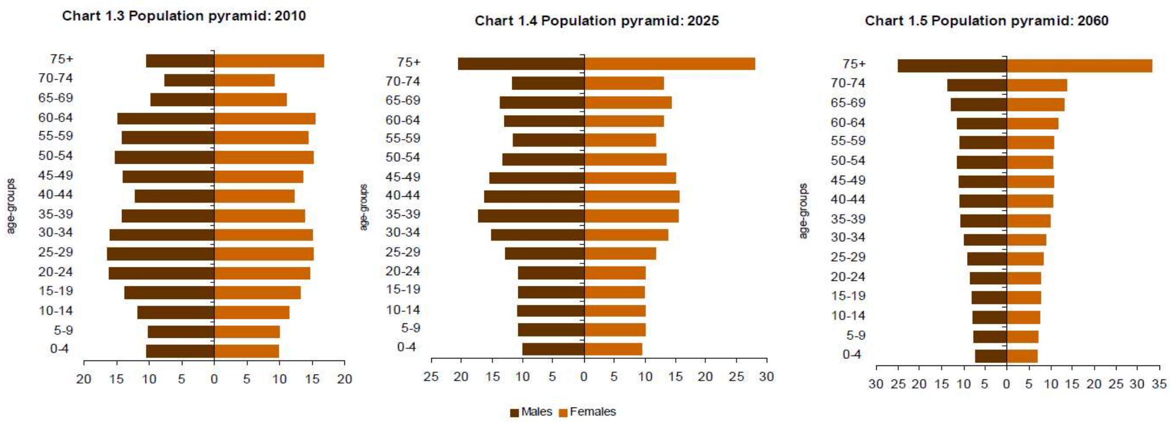


Figure 6-20. Population projections for Malta 2010-2060. (NSO 2012)

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 effect 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). Whilst a study by Gerada et al. (2015) indicated a rise in severity of rhinitis and a reduction in severity of wheezing and eczema in Maltese 12- to 15- year old children over the period 1995-2013. Further investigation into the causes and the possible impact from climate changes would be required to assess the vulnerability of these young children.

Malta has also some challenges with respect to migration primarily because of 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.

It is also important to note that the VRA is indicating the following hazards as being the ones contributing to climate impacts on this sector's assets: all climate parameters, air pollution weather, aridity, extreme heat, cold spell, hydrological drought, heavy precipitation and fluvial flooding and coastal flooding.

(3) ADDRESSING VULNERABILITY OF PUBLIC HEALTH AND CIVIL PROTECTION

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. Authorities are still undertaking 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.

6.3.2.6 Tourism

(1) STATE OF PLAY

Tourism is Malta's main economic driver. Rising record tourist numbers have been the norm with pre-pandemic totals reaching 2.8 million inbound tourists in 2018. These figures went down to 658,567 in 2020 and 968,136 in 2021amidst COVID-19 travel restrictions, closure of airports and national boundaries and special travel requirements.

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 in 2019 Were primarily frm the European Union (83%) and primarily visiting fr holidays (88%). British, Italian and French tourists dominate the tourist population in the islands with tourists from Germany also arriving in high numbers. Cruise liner passengers also registered an increase with 765,696 arriving in 2019, an incrase of 21% over 2018. Over 64.2% of the cruise liner passengers came from EU Member States.

The direct contribution of Travel and Tourism to GDP in Malta stood at 12.8% of the total GDP in 2018 (OECD 2020).

(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. Few university dissertations have tried to look at the theme (Palmieri 2014). 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. All of the results of the VRA will be applicable to this sector (hence further detail will be obtained).

(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 tourism transport modes including walking and cycling are supported through various policies. They have also been subject to pilot measures and awards funded through the CIVITAS HORIZON project DESTINATIONS[76] (2016-2021).

The 2021-2030 Tourism Strategy for Malta identifies post-pandemic and climate change realities as important for the long-term re-evaluation and repositioning of tourism in the islands. It recognizes the relevance and increasing importance to sustainability principles and climate impacts, in particular the threats from sea level rise and coastal erosion. The Tourism Strategy refers to the need of mitigation measures to safeguard the cost, alongside efforts to declare Marine Protected Areas. It identifies other impacts which will affect tourism including extreme weather events, desertification, availability of water and climate refugees.

A number of Strategic Objectives on Environment, Climate and Tourist Product are relevant here.

Strategy 10 - to prioritise the establishment of Malta as a Climate Friendly Travel Destination through the dual actions of understanding and mitigating the impacts of Climate Change on the local territory and its tourism infrastructure and to concurrently take a leading international role in championing Climate Friendly Travel with the travel industry, academia and other stakeholders as a response to the existential threat of global warming.

Strategy 11 to introduce a set of measurable climate and sustainability indicators to properly measure tourism impacts on the environment to ensure that future tourism development embraces sustainable parameters within the widest possible range of measurable variables (Government of Malta 2021).

Amongst the goals there is a lot of emphasis on the need to investigate the potential climate change impacts on the sector, as well as the creation of a Climate Change Tourism Risk Index. The Strategy is consisent in the inclusion of climate change risks in its various goals.

In 2016, Malta also 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.

[75] http://www.mta.com.mt/eco-certification
[76] https://civitas.eu/projects/destinations

7 FINANCIAL, TECHNOLOGICAL & CAPACITY-BUILDING SUPPORT

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 2013 and 2020. 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[77]) 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.

A Programme of Scholarships in Climate Action was launched in 2016 in collaboration between the Maltese Government and University of Malta. This programme is intended to bring students from third world countries to study in Malta. Throughout the years there were a total of six scholarships awarded with students coming from various countries such as Palau, Botswana, Grenada, and Zambia. No calls were issued during Covid-19 restrictions. The programme is to be relaunched in 2023.

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.

In 2017 public financial support was provided for two projects. The Ministry for Energy, the Environment and Enterprise, 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). The second project involved the construction of a borehole to provide access to safe water to the inhabitants of Bouar, Central African Republic, through the St. Jeanne Antide Foundation. From 2018 till2020, €100,000 per annum were contributed towards the Green Climate Fund, a fund set up by the UNFCCC in 2010 and dedicated towards helping developing countries reduce their greenhouse gas emissions and enhance their ability to respond to climate change A summary of projects sponsored

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

through grants given by Malta from 2017 to 2020 is given from Table 7.9 to 7.11. Subsequent sections provide more detailed information on the individual project.

Table 7.1 Provision of public financial support: summary information in 2017

Allocation channels	Year 2017									
	European - EUR					National currency				
		Climate-specific					Climate-specific			
	Core/ general	Mitigation	Adaptation	Cross-cutting	Other	Core/ general	Mitigation	Adaptation	Cross-cutting	Other
Total contributions through multilateral channels:										
Multilateral climate change funds[e]	0.00	0.00	0.00	0.00	0.00					
Other multilateral climate change funds[f]		0.00	0.00	0.00	0.00					
Multilateral financial institutions, including regional development banks	0.00	0.00	0.00	0.00	0.00					
Specialized United Nations bodies	20,000.00	0.00	0.00	0.00	0.00					
Total contributions through bilateral, regional and other channels		0.00	9,265.20	60,000.00	0.00					
Total climate specific by funding type (total for mitigation, adaptation, crosscutting, other)		0.00	9,265.20	150,000.0	0.00					

Total climate specific by funding source (EUR)		Total climate specific by financial instrument (EUR)	
ODA	69,265.20	Grant	159,265.20
OOF	0.00	Concessional loan	0
Other	90,000.00	Non-concessional loan	0
		Equity	
		Other	

Table 7.2 Provision of public financial support: summary information in 2018

Allocation channels	Year 2018									
	European - EUR					National currency				
	Core/ general	Climate-specific				Core/ general	Climate-specific			
		Mitigation	Adaptation	Cross-cutting	Other		Mitigation	Adaptation	Cross-cutting	Other
Total contributions through multilateral channels:										
Multilateral climate change funds[e]	0.00	0.00	0.00	100,000	0.00					
Other multilateral climate change funds[f]		0.00	0.00	0.00	0.00					
Multilateral financial institutions, including regional development banks	0.00	0.00	0.00	0.00	0.00					
Specialized United Nations bodies	20,000.00	0.00	0.00	0.00	0.00					
Total contributions through bilateral, regional and other channels		0.00	0.00	0.00	0.00					
Total climate specific by funding type (total for mitigation, adaptation, crosscutting, other)		0.00	0.00	100,000	0.00					

Total climate specific by funding source (EUR)		Total climate specific by financial instrument (EUR)	
ODA		Grant	100,000
OOF		Concessional loan	0
Other	100,000	Non-concessional loan	0
		Equity	
		Other	

Table 7.3 Provision of public financial support: summary information in 2019

Allocation channels	Year 2019									
	European - EUR					National currency				
		Climate-specific					Climate-specific			
	Core/ general	Mitigation	Adaptation	Cross-cutting	Other	Core/ general	Mitigation	Adaptation	Cross-cutting	Other
Total contributions through multilateral channels:										
Multilateral climate change funds[e]	0.00	0.00	0.00	100,000	0.00					
Other multilateral climate change funds[f]		0.00	0.00	0.00	0.00					
Multilateral financial institutions, including regional development banks	0.00	0.00	0.00	0.00	0.00					
Specialized United Nations bodies	20,000.00	0.00	0.00	0.00	0.00					
Total contributions through bilateral, regional and other channels		0.00	0.00	0.00	0.00					
Total climate specific by funding type (total for mitigation, adaptation, crosscutting, other)		0.00	0.00	100,000	0.00					

Total climate specific by funding source (EUR)		**Total climate specific by financial instrument (EUR)**	
ODA		Grant	100,000
OOF		Concessional loan	0
Other	100,000	Non-concessional loan	0
		Equity	
		Other	

Table 7.4 Provision of public financial support: summary information in 2020

Allocation channels	Year 2020									
	European - EUR					National currency				
		Climate-specific					Climate-specific			
	Core/ general	Mitigation	Adaptation	Cross-cutting	Other	Core/ general	Mitigation	Adaptation	Cross-cutting	Other
Total contributions through multilateral channels:										
Multilateral climate change funds[e]	0.00	0.00	0.00	100,000	0.00					
Other multilateral climate change funds[f]		0.00	0.00	0.00	0.00					
Multilateral financial institutions, including regional development banks	0.00	0.00	0.00	0.00	0.00					
Specialized United Nations bodies	20,000.00	0.00	0.00	0.00	0.00					
Total contributions through bilateral, regional and other channels		0.00	0.00	0.00	0.00					
Total climate specific by funding type (total for mitigation, adaptation, crosscutting, other)		0.00	0.00	100,000	0.00					

Total climate specific by funding source (EUR)		Total climate specific by financial instrument (EUR)	
ODA		Grant	100,000
OOF		Concessional loan	0
Other	100,000	Non-concessional loan	0
		Equity	
		Other	

Table 7.5 Provision of public financial support: contribution through multilateral channels in 2017

Donor funding	*Total amount*				*Status: disbursed, committed*[c, 3]	*Funding source: ODA, OOF, Other*[4]	*Financial instrument: grant, concessional loan, non-concessional loan, equity, other*[5]	*Type of support: Mitigation, adaptation, crosscutting, other*[c,6]	*Sector*[d, 7]
	Core/general[a, 1]		*Climate-specific* [2]						
	European euro - EUR	*National currency*	*European euro - EUR*	*National currency*					
Multilateral climate change funds									
1. Global Environment Facility									
2. Least Developed Countries Fund									
3. Special Climate Change Fund									
4. Adaptation Fund									
5. Green Climate Fund			€90,000	Euro	Disbursed	Other	Grant	Crosscutting	Channel Parent Category 4700 and Chennel ID 41317 (DAC-CRS)
6. UNFCCC Trust Fund for Supplementary Activities									
7. Other multilateral climate change funds									
Multilateral financial institutions, including regional development banks									
1. World Bank									
2. International Finance Corporation									

3. African Development Bank									
4. Asian Development Bank									
5. European Bank for Reconstruction and Development									
6. Inter-American Development Bank									
7. Other									
Specialized United Nations bodies									
1. United Nations Development Programme	€20,000	Euro	0	n/a	Disbursed	ODA	Grant	Crosscutting	General Unspecified Code 998
2. United Nations Environment Programme									
3. Other - UNICEF									
Total contributions through multilateral channels	20,000.00	Euro	90,000.00	Euro					

Table 7.6 Provision of public financial support: contribution through multilateral channels in 2018

Donor funding	*Total amount*				*Status: disbursed, committed*[3]	*Funding source: ODA, OOF, Other*[4]	*Financial instrument: grant, concessional loan, non-concessional loan, equity, other*[5]	*Type of support: Mitigation, adaptation, crosscutting, other*[c,6]	*Sector*[d, 7]
	Core/general[a, 1]		*Climate-specific* [2]						
	European euro - EUR	*National currency*	*European euro - EUR*	*National currency*					
Multilateral climate change funds									
1. Global Environment Facility									
2. Least Developed Countries Fund									
3. Special Climate Change Fund									
4. Adaptation Fund									
5. Green Climate Fund			€100,000	Euro	Disbursed	Other	Grant	Crosscutting	Parent
6. UNFCCC Trust Fund for Supplementary Activities									
7. Other multilateral climate change funds									
Multilateral financial institutions, including regional development banks									
1. World Bank									
2. International Finance Corporation									
3. African Development Bank									
4. Asian Development Bank									

5. European Bank for Reconstruction and Development									
6. Inter-American Development Bank									
7. Other									
Specialized United Nations bodies									
1. United Nations Development Programme		Euro	0	n/a	Disbursed	ODA	Grant	Crosscutting	General Unspecified Code 998
2. United Nations Environment Programme									
3. Other - UNICEF									
Total contributions through multilateral channels		Euro	100,000.00	Euro					

Table 7.7 Provision of public financial support: contribution through multilateral channels in 2019

Donor funding	*Total amount*				*Status: disbursed, committed*[c, 3]	*Funding source: ODA, OOF, Other*[4]	*Financial instrument: grant, concessional loan, non-concessional loan, equity, other*[5]	*Type of support: Mitigation, adaptation, crosscutting, other*[c,6]	*Sector*[d, 7]
	Core/general[a, 1]		*Climate-specific* [2]						
	European euro - EUR	*National currency*	*European euro - EUR*	*National currency*					
Multilateral climate change funds									
1. Global Environment Facility									
2. Least Developed Countries Fund									
3. Special Climate Change Fund									
4. Adaptation Fund									
5. Green Climate Fund			€100,000	Euro	Disbursed	Other	Grant	Crosscutting	Parent
6. UNFCCC Trust Fund for Supplementary Activities									
7. Other multilateral climate change funds									
Multilateral financial institutions, including regional development banks									
1. World Bank									
2. International Finance Corporation									
3. African Development Bank									
4. Asian Development Bank									

5. European Bank for Reconstruction and Development									
6. Inter-American Development Bank									
7. Other									
Specialized United Nations bodies									
1. United Nations Development Programme		Euro	0	n/a	Disbursed	ODA	Grant	Crosscutting	General Unspecified Code 998
2. United Nations Environment Programme									
3. Other - UNICEF									
Total contributions through multilateral channels		Euro	100,000.00	Euro					

Table 7.8 Provision of public financial support: contribution through multilateral channels in 2020

Donor funding	*Total amount*				*Status: disbursed, committed[3]*	*Funding source: ODA, OOF, Other[4]*	*Financial instrument: grant, concessional loan, non-concessional loan, equity, other[5]*	*Type of support: Mitigation, adaptation, crosscutting, other[c,6]*	*Sector[d, 7]*
	Core/general[a, 1]		*Climate-specific [2]*						
	European euro - EUR	*National currency*	*European euro - EUR*	*National currency*					
Multilateral climate change funds									
1. Global Environment Facility									
2. Least Developed Countries Fund									
3. Special Climate Change Fund									
4. Adaptation Fund									
5. Green Climate Fund			€100,000	Euro	Disbursed	Other	Grant	Crosscutting	Parent
6. UNFCCC Trust Fund for Supplementary Activities									
7. Other multilateral climate change funds									
Multilateral financial institutions, including regional development banks									
1. World Bank									
2. International Finance Corporation									
3. African Development Bank									
4. Asian Development Bank									

5. European Bank for Reconstruction and Development									
6. Inter-American Development Bank									
7. Other									
Specialized United Nations bodies									
1. United Nations Development Programme		Euro	0	n/a	Disbursed	ODA	Grant	Crosscutting	General Unspecified Code 998
2. United Nations Environment Programme									
3. Other - UNICEF									
Total contributions through multilateral channels		Euro	100,000.00	Euro					

Table 7.9 Provision of public financial support: contribution through bilateral, regional and other channels in 2017.

Recipient country/ region/project/programme	Total amount		Status: disbursed, committed[3]	Funding source: ODA, OOF, Other	Financial instrument: grant, concessional loan, non-concessional loan, equity, other5	Type of support: Mitigation, adaptation, crosscutting, other[a, 6]	Sector[b, 7]	Additional information [c]
	Climate-specific[2]							
	European euro - EUR	national currency						
Scholarships in Climate Action Offered by the Government of Malta for Postgraduate Studies at the University of Malta	60,000	euro - EUR	Disbursed	Other	Grant	Crosscutting	Education (DAC 114, CRS 11420)	
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)								
Construction of a borehole in Bouar, Central African Republic'	9,265	euro - EUR	Disbursed	ODA	Grant	Adaptation	CRS 14020	
This project involved the construction of a bore hole to provide access to safe water to the inhabitants of Bouar, Central African Republic, through the St. Jeanne Antide Foundation								
Total contributions through bilateral, regional and other channels	69,265.20	euro - EUR						

Table 7.10 Provision of public financial support: contribution through bilateral, regional and other channels in 2018

Recipient country/ region/project/programme	Total amount		Status: disbursed, committed[3]	Funding source: ODA, OOF, Other	Financial instrument: grant, concessional loan, non-concessional loan, equity, other[5]	Type of support: Mitigation, adaptation, crosscutting, other[a 6]	Sector[b,7]	Additional information [c]
	Climate-specific[2]							
	European euro - EUR	national currency						
Total contributions through bilateral, regional and other channels	**0.00**	**euro - EUR**						

Table 7.11 Provision of public financial support: contribution through bilateral, regional and other channels in 2019

Recipient country/ region/project/programme	Total amount		Status: disbursed, committed[3]	Funding source: ODA, OOF, Other	Financial instrument: grant, concessional loan, non-concessional loan, equity, other[5]	Type of support: Mitigation, adaptation, crosscutting, other[a 6]	Sector[b,7]	Additional information [c]
	Climate-specific[2]							
	European euro - EUR	national currency						
Total contributions through bilateral, regional and other channels	**0.00**	**euro - EUR**						

Table 7.12 Provision of public financial support: contribution through bilateral, regional and other channels in 2020

Recipient country/ region/project/programme	Total amount		Status: disbursed, committed[3]	Funding source: ODA, OOF, Other	Financial instrument: grant, concessional loan, non-concessional loan, equity, other[5]	Type of support: Mitigation, adaptation, crosscutting, other[a 6]	Sector[b,7]	Additional information [c]
	Climate-specific[2]							
	European euro - EUR	national currency						
Total contributions through bilateral, regional and other channels	**0.00**	**euro - EUR**						

8 RESEARCH & SYSTEMATIC OBSERVATION

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.

The National Research and Innovation Strategy 2020[78] approved by Cabinet in 2014 looked at building critical mass and capacity in select areas, giving the country a competitive edge. The Mission of this strategy was 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 Smart Specialisation Strategy[79] published by the MCST as a follow up Research and Innovation Strategy post 2020 identified 6 smart specialisation areas for the period 2021-2027 which included *Sustainable Use of Resources for Climate Change Mitigation and Adaptation*. This focuses on *net-zero carbon buildings, renewable energy generation and energy storage solutions, resource efficiency in industry*, and *turning waste into a resource*.

Currently, there is no policy or funding for systematic observation in most areas of climate change data and information. The 2021 Low Carbon Development Strategy itself identifies the lack of local data and information. And whilst the policy for climate research falls under the MCST Smart Specialisation Strategy, there is no policy or specific funding allocated for systematic observation yet. The lack of institutional set up (at the University of Malta (UM) or elsewhere), the lack of direct funding for systematic observation, and the lack of a repository for climate change data and information are main barriers to free and open international exchange of data and information. Much of the limited information generated locally results from local, but more often international research funding. In this context, there is no effort undertaken to cooperate in scientific and technical research to promote the maintenance and the development of systematic observation systems, and the development of data archives, and no set up is being planned.

In 2020 the Energy and Water Agency issues a National Strategy for Research and Innovation in Energy and Water[80]. This strategy is dedicated to Research and Innovation (R&I) in the fields of water and energy. Malta as a semi-arid Mediterranean country with few resources of energy considered to be technically and economically viable and limited availability of natural sources of fresh water, and sustainable use of resources is a priority. This strategy serves 3 policy priorities;

[78] http://mcst.gov.mt/policy-strategy/national-research-innovation-strategy/
[79] https://mcst.gov.mt/wp-content/uploads/2022/01/RIS3-Strategy-2020-2027.pdf
[80] National-Strategy-for-Research-and-Innovation-in-Energy-and-Water-2021-2030-EWA-web.pdf (gov.mt)

1. Contributing to Malta's transition to sustainability and decarbonization in an effective justly and timely manner
2. Strengthening competitiveness, growth and commercial attractiveness while ensuring a high level of environment protection and climate change resilience
3. Increasing the level of domestic support for R&I in Malta.

With the implementation of this strategy the Government of Malta will encourage and guide the direction of domestic R&I in the fields of energy and water management.

The evaluation of the National Strategy for Research and Innovation in Energy and Water (2021-2030) is envisaged, at the time of writing, to take place at the mid-point in its implementation period. This will coincide with the evaluation of the NECP, as mandated under the Regulation of the Governance of the Energy Union, and the early stages of the development of the fourth River Basin Management Plan. Thus, continued alignment between these three interrelated policy documents will be maintained. Should it be determined that a revision of the Strategy is required, this will be guided by the updated policy documents and the evidence-based evaluation assessing the progress made towards achieving the Strategy's objectives.

8.1.2 Actions to support research

The previous Malta Government Scholarship Schemes (2006-2013) were replaced by the Endeavour Scholarship scheme [81] (2014 to date) in support of Masters and PhD scholarships.

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 in 2017 and 2018 were 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 provided 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 six scholarships in post graduate studies were offered for students seeking to enroll in post-graduate studies at the University of Malta in 2017 and 2018. Each scholarship focused on one of the three key areas recognized as essential pathways for ensuring effective climate action on a national level.

These pathways were:

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

- 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 offered 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 Government of Malta served 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 were distributed to students following the following programmes in 2017: MSc in Sustainable Energy, MSc in Built Environment, MSc Sustainable Development, and in 2018: MSc Biology and MA Islands and Small States Studies.

The funding by the Government of Malta covered, wholly or partially, various expenses that would be presented to the awardee. These include, payment of the University of Malta tuition and enrolment fees, health insurance, reimbursement for visa expenses, and one return journey to the home country. The scholarship also provided a monthly subsistence allowance to be used towards accommodation, living, transport and academic expenses, and any other expenses.

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.

The academics of the UM have played a vital role in guiding the government of Malta to adopt the necessary measures for climate action. The UM 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.

8.2 RESEARCH AND SYSTEMATIC OBSERVATION ACTIVITIES

The interest in Climate Research and its effects has been steadily increasing throughout the years. Numerous research groups within the University of Malta have led this development together with other institutions such as the Met Office and the Malta College of Arts, Science and Technology (MCAST) and government entities such as the National Statistics Office (NSO). While many institutions conduct research, a number also contribute to Systematic Observation of climate-related parameters. A summary of the research institutions and the nature of their contribution can be found in Table 8.1, while those that engage in Systematic Observation are included in Table 8.2.

At a local level, Malta contributes at an 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 Space Programme Committee - Copernicus Configuration (SPC-CC) and the Space Programme Committee - Copernicus User Forum, (SPC-CUF);
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 Environment Resources Authority;
3. Malta also forms part of the Copernicus Academy. The Oceanography Malta Research Group (OMRG, previously known as the Physical Oceanography Research Group) at the University of Malta contributes towards the use of Copernicus Marine Environment Monitoring Service (CMEMS) and the update of CMEMCS data by local users. The OMRG also forms part of the Copernicus Academy. The data products are used in courses that we offer at undergraduate and post-graduate levels, as well as in dedicated short courses that are organized regularly;
4. As part of the EIONET Group Land Systems - Thematic group "support to Copernicus land monitoring", Malta, through the Planning Authority, contributes towards the Copernicus Land Monitoring Systems (CLMS).

Table 8.1 Overview of Maltese Institutions that contribute to research efforts in (a) Climate process and climate system studies, including paleoclimate studies; (b) Modelling and prediction, including general circulation models; (c) Research on the impacts of climate change; (d) Socio-economic analysis, including analysis of both the impacts of climate change and response options; and (e) Research and development on mitigation and adaptation technologies.

Institution	Research Efforts
UNIVERSITY OF MALTA	
Department of Geosciences - *Faculty of Science*	(a), (c), (e)
Department of Geography - *Faculty of Arts*	(c), (d), (e)
Department of Economics - *Faculty of Economics, Management and Accountancy*	(d)
Faculty of the Built Environment	(e)
Environmental and Resources Law Department - *Faculty of Laws*	(d)
Forum on Legal Issues for Adaptation to Climate Change	(d)
Centre for Environmental Education and Research	(d), (e)
Institute for Climate Change and Sustainable Development	(d), (e)
Institute of Earth Systems	(a), (b), (c), (d)
Islands and Small States Institute	(d)
Institute for Sustainable Energy	(e)
Institute for European Studies	(e)
THE MALTA COLLEGE OF ARTS, SCIENCE AND TECHNOLOGY (MCAST)	(a), (c), (e)

Table 8.2 Overview of Maltese Institutions that contribute to Systematic Observation activities in (a) Atmospheric climate observing systems, including those measuring atmospheric constituents; (b) Ocean climate observing systems; (c) Terrestrial climate observing systems; and (d) Support for developing countries to establish and maintain observing systems, and related data and monitoring systems. Note that no local institution currently contributes to activity (d).

Institution	Obs. Activity
University of Malta	
Department of Geosciences - *Faculty of Science*	
Atmospheric Pollution Research Group	(a)
Oceanography Malta Research Group	(b)
Department of Biology - *Faculty of Science*	
Marine Ecology Research Group	(b)
Met Office	(a), (c)

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 main objectives of the Climate Change Platform (CCP) are to facilitate collaboration between UM entities and individual UM academics interested in climate change issues, to promote research and teaching initiatives relating to climate change, and to foster cooperation with the private sector, industry, associations and civil society organisations, relating to climate change. The platform provides various facilities to encourage such collaboration and promotion of research.

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.

8.3.1 Department of Geosciences - Faculty of Science

The Department of Geosciences is largely an applied research institution in the earth-related sciences, founded on a strong base of interdisciplinary science, with a focus on operational oceanography, seismology and geophysics, marine geology, and atmosphere and climate research. The Atmospheric Pollution and Oceanography Malta Research Groups focus on systematic observation within the Department. Regrettably, the University could not provide funding to maintain the Climate Research Group within the

[82] www.um.edu.mt/iccsd
[83] https://www.um.edu.mt/islands/climate

Department, which now, no longer includes in-house expertise on climate modelling and thus, is no-longer equipped to conduct Climate Modelling research and projections.

The Seismic Monitoring Research Group, within the Department, is currently working on a groundwater monitoring system, using ambient seismic noise and correlation with meteorological parameters.

The Department is also involved in a project called C-COVER[84] (Coastal-Climate Overall Vulnerability and Exposure Risk – protection strategy for the Maltese Islands). The project seeks:

- to develop a national integrative instrument that will: identify the full range of policy priorities in order to reduce coastal pressures, while protecting and preserving the shoreline mostly exposed to coastal dynamics;
- to assess coastal risks and identify sustainable, suitable, and effective protective solutions, that take into account the impacts of climate change, the integrated management of water and land-side resources, and land-sea interactions; and
- to promote national harmonization among the various ministries and key stakeholders, to implement of coastal protection solutions for the Maltese Islands, by establishing a consistent and holistic strategic framework at national level.

The project is a Technical Support Instrument funded by DG-REFORM, and requested by the Public Works Department[85] (Ministry of Infrastructure and Projects) and Malta Tourism Authority. It seeks to provide a national strategy for coastal management. This project is being implemented by the Coastal & Marine Union (EUCC) and its core team of experts: the Environmental Hydraulics Institute of the University of Cantabria (IHCantabria), AKTIS Hydraulics, the University of Malta, supported by international experts.

The Department is also working on using satellite data (as well as geophysics and ground-truthing) for the monitoring of sediments at pocket beach sites. Another one uses a similar method to evaluate cliff failures. The projects in question are SIPOBED and Coastal-SAGE[86].

Ray Zammit and his colleagues (Cardiff, Utrecht, Haifa, Geneva, Malta) have used lithological and geochemical records from Malta, to demonstrate that the North African and central Mediterranean climate shifted from a cool-arid to a humid regime during the early Miocene (around 19.0 Ma). Such a transition may have been a consequence of water flow restriction through the Mesopotamian Seaway (Eastern Mediterranean connection to the Indian Ocean). They are also investigating the oceanographic response of the central Mediterranean to sea-level fall and temperature drop during the Middle Miocene (around 14 Ma) global cooling.

8.3.2 Department of Geography - Faculty of Arts

The Department of Geography is involved in research in a number of broad areas related to physical and human geography. Of particular interest to climate change is the research concerning Coastal Zone Management, Coastal Geomorphology, Geosites and impacts of Sea Level Rise[87]. In addition to this, over the past year the Department has been engaged in research together with the Public Works Department, within the Ministry for Public Works and Planning, supporting the C-COVER project looking into the

[84] https://publicworksdepartment.gov.mt/en/Pages/Research-and-Planning.aspx
[85] https://publicworksdepartment.gov.mt/en/Pages/default.aspx
[86] https://www.um.edu.mt/projects/coastal-sage/
[87] http://www.um.edu.mt/arts/geography

Vulnerability and Exposure Risk of Coastal areas. This collaboration extends beyond the Department of Geography and includes also the Department of Geosciences at the University of Malta.

8.3.3 Department of Economics – Faculty of Economics, Management and Accountancy

The Department of Economics placed a strong emphasis on environmental issues in its MSc Economics programme. This is a highly technical unit aimed at bridging theory and practice on the evaluation of projects or activities with environmental impacts. The unit is serviced by four academics who all have experience in evaluating environmental impacts of projects and activities. Departmental staff have, in fact, been involved in a Horizon 2020 programme on the circular economy and in 2020, two members drew up the 2020 Productivity Report for MCESD where the link between productivity/investment and the European Green Deal featured very prominently. The recommendations are being followed up by MCESD and Government entities.

8.3.4 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 have hosted a Developing World Student following funding from the Scholarships in Climate Action offered by the Government of Malta. Her research focused on Building Resilience for Water Resources in 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 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.

In addition, the Department of Architecture and Urban Design has 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 has continued working on waste materials in the construction industry, and on the life cycle of buildings, with a view to reducing waste. Research by the department members focus primarily on life cycle assessment, materials and durability and energy efficiency and lifetime engineering.

The faculty is still engaged a major ERDF funded project with the objective of building a prototype resource-efficient building on campus entitled the Sustainable Living Complex. This building will act as a live laboratory, and will provide the research infrastructure for topics, ranging from the 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. Once completed, the building will also act as a demonstration building for the industry, and for the public.

8.3.5 *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 undergraduate 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 focus 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.

The Department is also expanding its research with respect to the climate-ocean nexus with doctoral research, various publications as well as key note participation at academic and inter-governmental conferences.

8.3.6 *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

[88] http://www.um.edu.mt/laws/env-resources.

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 Prof. Simone Borg (University of Malta; Ambassador to Malta on Climate Change) and Prof Dr Kurt Deketelaere (University of Leuven) 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.

8.3.7 *Centre for Environmental Education and Research*

The University of Malta officially established the Centre for Environmental Education and Research[89] (CEER) in 2004, in preparation for the launch of the UN Decade of Education for Sustainable Development (2005-2014). CEER offers opportunities for Education for Sustainable Development (ESD) to empower citizens to actively participate in environmental decision-making fora and in initiatives that promote a good quality of life for all. CEER provides a focal point for coordinating ESD initiatives, increasing the opportunity for ESD research, making scientific and technological research results more accessible and facilitating resource transfer and capacity building in Malta and the Euro-Med region. CEER is involved in policy formulation with government entities on areas that feature climate change and also spearheads a number of initiatives in education, both in formal settings, like schools, and within the community.

CEER spearheads a Master degree in Education for Sustainable Development. This master is focused on creating sustainability champions or change agents within the community. The Centre also delivers study units on sustainability to other centres, institutes and faculties within the University of Malta and beyond. The Centre is also launching a new Certificate in Environmental Interpretation and Education in 2022 which will focus on the people-environment nexus with particular emphasis on sustainability issues.

Through its staff CEER is also involved in outreach activities and training courses in the community that link livelihoods and sustainability issues including climate change with various sectors of the community including fisherfolk, farmers and youth. Staff members of CEER support schools in the running of ESD programs such as Eco-Schools and GLOBE (Global Learning and Observations to Benefit the Environment).

CEER cooperates with other international entities to develop innovative teaching materials, and pedagogical processes to offer embedded learning experience to its various students. Such projects include:

[89] http://www.um.edu.mt/ceer.

- Raising Awareness for Development Cooperation (RADC) - development of an online teaching module on climate change.
- Global Action Schools - a project 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.
- EduChange - addresses climate change through innovative place-based education and blended learning;
- PEERMENT - aims to promote peer mentoring among educators on pedagogical issues related to ESD and climate change.
- Teacher Education for Sustainability (TEDS) - focuses on producing pedagogical material and techniques that focus on sustainability issues including climate change
- BlueSchoolsMed - aims to increase the awareness of the community towards ocean challenges including links to climate change.

8.3.8 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. The Institute offers programmes leading to Masters by Research in Sustainable Development and Ph.D. in Climate Change or Sustainable Mobility.

The research spans various fields related to the fields of urban transport, mobility 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].

8.3.9 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. It is currently made up of two divisions: the Division of Environmental Management and Planning and the Division of Rural Sciences and Food Systems.

The IES conducts research on climate and related trends at both local and regional levels. Subthemes include the understanding of regional past and current climate, and the impacts of climate change on biodiversity, health, and infrastructure. Within the IES, Prof. Charles Galdies focuses his research on recent local climatic trends and their impact on social and agri-systems and had developed small-scale weather and ocean forecasting in the central Mediterranean region using novel remote sensing. The IES also carried out past climate reconstruction using models based on palynology studies, with an emphasis on late glacial and early Holocene, led by Dr Belinda Gambin. Furthermore, the ongoing FAST project investigates the vectors and colonization patterns of Invasive Alien Species, partially known to be inflicted by climate change.

---

[90] Information on the programmes, research and outreach are available at www.um.edu.mt/iccsd

[91] http://www.um.edu.mt/ies

This year, the IES will be coordinating a Marie Skłodowska-Curie Postdoctoral Fellowship focusing on high-resolution climate modelling of the Circum-Sicilian Islands (which include Malta) with Prof. David Mifsud as the Principal Investigator, and Dr James Ciarlo` as the Marie Curie Fellow. The project (PALEOSIM) aims to run multiple 2-3 km resolution climate simulations spanning from paleoclimate scenarios of the Last Glacial Maximum (21,000 years ago) to future scenarios used in the IPCC's Sixth Assessment Report[92] to study the long-term impacts of climate change on arthropod habitats in small-island systems.

The IES has built a knowledge base to assist students to perform studies on weather and climate change and its impacts on many sectors, including studies[93] commissioned by the National Statistics Office on the state of Maltese climate. 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 projections 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 sedimentary palynological records;
- Long-term monitoring of phenological shifts on selected plant species in relation to climate change.

8.3.10 Islands and Small States Institute

The Islands and Small States Institute (ISSI)[94] 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. The former Director of the ISSI, Prof. Lino Briguglio, was involved in the work of the Intergovernmental Panel on Climate Change in Working Group II, as a lead author for the chapter on Small Islands in the Third, Fourth and Fifth assessment reports. Dr Stefano Moncada, current Director of the ISSI, was involved as an official reviewer of the Sixth assessment report for the chapter on Small Islands, and some of his papers cited in the chapter itself.

The ISSI hosts the CCP[95] of the University of Malta, which is coordinated by Dr Moncada. The CCP facilitated the dissemination of climate change research produced by the University of Malta, and provided government authorities with feedback to ongoing and proposed legislation in the area of climate change, energy and decarbonisation. The social media accounts of the CCP (Facebook and Twitter) are constantly updated, and are used to disseminate information about climate change, including new research initiatives, undertaken both at the University of Malta and abroad.

The ISSI has developed specific climate change research projects, such as the Situated Understanding of Resilience in Island Societies and Environments (SUNRISE), in cooperation

[92] Lee JY, et al. (2021) Future Global Climate: Scenario-Based Projections and Near-Term Information. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte V, et al. (eds)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 553–672, doi:10.1017/9781009157896.006.
[93] Galdies C (2011). The Climate of Malta: statistics, trends and analysis 1951-2010. National Statistics Office, Valletta; NSO, Galdies C (2022). The State of the Climate 2022: A Multidecadal Report and Assessment of Malta's Climate. National Statistics Office, Valletta.
[94] http://www.um.edu.mt/islands
[95] https://www.um.edu.mt/r/platforms/climatechange

with the lead partner Birkbeck College University of London, University of Mauritius, the University of Sunshine Coast, and the University of West Indies. Another project, entitled 'Heritage Ecologies: culture, resilience and development in Island States (ECO-HERITAGES)' links climate and human resilience in small island states, and the project 'Beyond Pandemics: Improving climate resilience and health systems in small island states', which identifies existing climate and public health risks and resilience-building measures in Small Island States.

The ISSI is an official World Health Organisation (WHO) research Collaborating Centre on health systems and policies of small countries, coordinated by Dr Stefano Moncada and Prof. Neville Calleja, and climate change research is an integral part of the work conducted in this context, especially costs and preparedness of health systems to the negative impacts of climate change.

8.3.11 Institute for Sustainable Energy

The Institute for Sustainable Energy[96] (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, offshore energy, energy storage, energy in buildings, geothermal energy, energy economics and policy.

8.3.12 Institute for European Studies

The Institute for European Studies[97] is a multi-disciplinary teaching and research institute which was awarded the Jean Monnet Centre of Excellence in 2004. Since the previous National Communication, the institute has maintained research activities. 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

[96] http://www.um.edu.mt/iet
[97] http://www.um.edu.mt/europeanstudies

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).

8.3.13 The Malta College of Arts, Science and Technology (MCAST)

MCAST is home to a number of applied research groups that focus on a wide array of topics, including climate change and its impacts. The Applied Environmental Sciences Research Group (which worked 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), and the Energy Research Group (which specialised in global and regional solutions by innovative devices in emerging technologies, systems level integration to policy engagement for better community) are examples of such research groups that have since concluded their objectives. The current MCAST research groups that are linked to climate change and its impacts include:

- The **Water Research and Training Centre** focuses on water enterprise, as it aims to embody the application of creative ideas and innovations to practical situations in the water field, as well as solving the challenges that are encountered locally. The Centre focuses on areas such as Water Efficiency, Water Quality, Water Meter Research & Apparent Water Losses, and Water Treatment;
- The **MED-WET** (*Improving MEDiterranean irrigation and Water supply for smallholder farmers by providing Efficient, low-cost and nature-based Technologies and practices*) Consortium addresses the significant water scarcity of the Mediterranean region by improving upon sustainable water irrigation methods. The project is funded by the Malta Council for Science and Technology through the PRIMA initiative of Member States, Associated Countries and Participating Countries'. The PRIMA Programme is supported by the European Union;
- **SPIDEM** (*Studying Pollutants in Different Environmental Matrices*) studies pollutants in different environmental settings, in order to obtain a proper understanding of concepts such as: understanding the effects of anthropogenic activity on a particular environmental system, pollutant transfer between different systems, and others.

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)[98].

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[99].

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.

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.

Giordan Lighthouse is located in the Malta – Sicily channel and is ideally situated to study the primary sources of atmospheric pollution. A total of 12 years data has been accumulated from the reactive gas and greenhouse gas detectors as well as the aerosol analysers found at this station. The data has been evaluated with trends in shipping emissions coming to the fore. The other source of emissions originates from Mount Etna located on Sicily and represents the highest active volcano in Europe.

The model used to evaluate shipping emissions was the Ship Traffic Emission Assessment Model (STEAM) developed at the Finnish Meteorological Institute. From trace gas measurements a slowly decreasing trend in Sulphur Dioxide and Nitrogen Oxide emissions was noted. To better understand the results obtained the STEAM model was fed, as input, an Automatic Identification System (AIS) dataset to describe the vessel activity in the area concerned. The COVID – 19 influence was also studied using SENTINEL data. The work was published last year in Journal of Marine Science and Engineering 2021,9.762.

[98] 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.
[99] www.wmo.int

Oceanography Malta Research Group, Department of Geosciences – Faculty of Science

The Oceanography Malta (OM) Research Group within the Department of Geosciences aims to promote the field of oceanography through its applied research and teaching activities, making it the quintessential oceanography research group in the Maltese Islands. The OM group in fact integrates multifarious expertise through the background of its academic staff, such that it can address a diverse array of sub-disciplines linked with the field of oceanography. These sub-disciplines include physical oceanography, biological and chemical oceanography, geological oceanography and marine meteorology.

The OM group's collaborative portfolio is extensive, given that the research group is currently representing the University of Malta within a substantial number of externally-funded projects within the ambit of numerous EU and national funding programmes, including the Interreg MED, Interreg Italia-Malta 2014-2020, JPI Oceans, Erasmus+ and MCST Space Fund ones, even coordinating a number of the same projects, including CORALLO and CALYPSO. As a result, the research group delivers a substantial research output each year in the form of peer-reviewed publications and manages to expose the numerous post-graduate research students (PhD, MSc) it supervises to the deliverables of the same projects.

The OM group also coordinates the Master of Science in Applied Oceanography, which is offered on a full-time, taught basis and which combines both theoretical and applicative aspects of oceanography, such that students can partake of overseas research visits, work placements and numerous instrument field deployments opportunities at sea. In addition, the OM group actively participates in the Bachelor of Science undergraduate course offered by the Department of Geosciences and services a substantial number of alternative University of Malta Departments and Institutes through regular lecturing, include the Institute for Earth Systems, the Institute for Renewable Energy, the Faculty of Laws and MEDAC. The OM research group also manages, on behalf of the University of Malta, a long-standing fruitful relationship with the International Ocean Institute (IOI), with Prof. Alan Deidun (Malta's Ocean Ambassador and CIESM national delegate for Malta) directing the IOI's Malta Training Centre which delivers an annual, accredited, international course on ocean governance.

The OM group also coordinates a total of three national citizen science campaign, as follows:

- Spot the Jellyfish, running since June 2010,
- Spot the Alien Fish, running since January 2016,
- Spot the Alien, running since January 2018,

These make the research group Malta's foremost entity for the conduction of marine-oriented citizen science campaigns. The three campaigns are supported by the IOI, the Malta Tourism Authority (MTA) as well as the Environment and Resources Authority (ERA). Through these campaigns, the OM research group regularly liaises with a broad array of marine and maritime stakeholders, promoting good ocean literacy practice, consistent with the targets of the UN's Ocean Sciences Decade (2021-2030).

The OM Research Group is involved in various research activities and also provides various scientific services. The group undertakes oceanographic research, in a holistic perspective, including operational observations and forecasts, specialised data management analysis and participation in international cooperative ventures. The overarching research themes cover coastal meteorology, hydrography and physical oceanography with a main emphasis on the experimental study of the hydrodynamics of the sea in the vicinity of the Maltese Islands. The main endeavour is to promote activities in operational oceanography by the installation and maintenance of permanent sea monitoring systems, and the provision of meteo/marine forecasts.

The OM act as a national oceanographic data centre and promote the IOC/IODE (IOC Committee on the International Oceanographic Data and Information Exchange) products and oceanographic data management activities in Malta (IODE National Report). They provide support to local entities involved in marine research and monitoring, to collect and maintain oceanographic data according to international standards.

The group also plays the role of keeping track of ocean observations made in the vicinity of the Maltese Islands. Data collected by individual scientists, local agencies and governmental departments is primarily kept under the respective sources, and under different, often incompatible formats. The aim is to identify these data holdings and to bring the data under one database with standardised formats.

Marine Ecology Research Group, Department of Biology – Faculty of Science

The Marine Ecology Research Group (MERG) is actively involved in research on ecological aspects of the Central Mediterranean coastal and offshore environments, including studies on the species, assemblages and habitats that contribute to the marine biodiversity in this region and on assessment of human impact on the natural environment in this area. Within the context of climate change, the MERG carries out research on the effects of climate-induced warming on local marine biodiversity, with particular focus on the extent of 'tropicalisation' of the central Mediterranean. 'Tropicalisation' refers to the increasing presence and abundance of species having warm-water affinities or which can tolerate warming waters. Such species are both those not native to the Mediterranean, whose occurrence has been linked to a changing marine environment as a consequence of climate change, as well as others, including native species and Atlantic species entering from the Strait of Gibraltar, that are expanding their distributional range as the sea warms up.

Climate change plays a role by facilitating the spread of these non-indigenous[100] and range-expanding [101] species, and by increasing their chances of survival and of establishing breeding populations. The research undertaken by the MERG focuses on the detection and monitoring of such non-indigenous and range-expanding species in Maltese waters, including analysis of their mode of entry in order to evaluate the extent of

[100] Species occurring outside of their historically known distribution range (geographical area occupied naturally) and beyond their natural dispersal potential as a result of deliberate or accidental introduction by humans. In the Mediterranean marine environment, these are mainly introduced accidentally via shipping or as a result of the opening of the Suez Canal.
[101] 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. This includes Eastern Atlantic species that are expanding their range into the Mediterranean.

climate-induced distributional changes. Additionally, the MERG also studies newly arrived species that have become established in the Maltese Islands in order to assess their effects on native communities.

Key outputs of this research include:

- An inventory of non-indigenous and range-expanding species reported from Maltese waters that is periodically updated to reflect the current status and assess temporal trends[102]
- Contributions to new findings of non-indigenous and other newcomer species in Maltese waters[103]
- Monitoring changes in the distribution and abundance of newly established non-indigenous species, especially ones having the potential to become invasive[104]
- Assessment of the dynamics of warm-water species, including the role of climate warming as a driver for such changes[105]

The MERG is led by Dr Julian Evans, in collaboration with Prof. Joseph A. Borg and Prof. Patrick J. Schembri as senior members of the research team, and includes several undergraduate and postgraduate students undertaking research linked to the effects of climate change on Maltese marine biodiversity. Amongst others, the MERG has also hosted students following research degrees through the 'Scholarships in Climate Action' scheme offered by the Government of Malta for postgraduate studies at the University of Malta.

8.4.2 MET OFFICE

Since 1922 the Met Office has 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 more complete and comprehensive data 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 currently operates eight stations across the Maltese islands, with plans to increase these to ten in the near future. The data collected from these stations includes the following parameters: wind speed and direction; temperature; humidity; precipitation; atmospheric pressure; global solar irradiance.

The Met Office participates in the Global Climate Observing System (GCOS) through the GCOS Surface Network (GSN), under station 16597 - LUQA, as the observations are primarily related to the surface. Here, CLIMAT messages (round-ups of every month prepared and coded by the Met Office) are collected and forwarded through a fixed network. They also contribute with SYNOP messages (encoded communications sent

[102] Evans J., Barbara J. and 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.
[103] E.g. Evans J., Borg J.A. and Schembri P.J. (2020). First record of *Paranthias cf. furcifer* (Actinopterygii: Perciformes: Serranidae) from the central Mediterranean, with notes on the identification of marine species from imagery. Acta Ichthyologica et Piscatoria, 50 (4): 489–492.
[104] E.g. Cutajar M., Evans J., Borg J.A., Abela H. and Schembri P.J. (2020). Distribution, abundance and colony size of the invasive coral *Oculina patagonica* (Cnidaria, Scleractinia) in Malta. BioInvasions Records, 9(4): 737–744.
[105] E.g. Guastella R., Marchini A., Caruso A., Evans J., Cobianchi M., Cosentino C., Langone L., Lecci R. and Mancin N. (2021). Reconstructing bioinvasion dynamics through micropaleontologic analysis highlights the role of temperature change as a driver of alien Foraminifera invasion. Frontiers in Marine Science, 8: 675807.

every 3 hours with detailed weather variables that are inputted manually and checked thoroughly). This data also interjects in enhancing numerical weather prediction models used for forecasting, where super computers can identify patterns and localised weather phenomena, and improve itself by automatic verification.

The Met Office also compiles a number of statistical data for internal research and also shares this research with various local and international entities. The Met Office is also participating with EUMETNET in the storm naming for central Mediterranean.

8.4.3 THE ENVIRONMENT AND RESOURCES AUTHORITY

The Environment and Resources Authority (ERA) presently runs five automated near real time measuring stations across Malta, situated at fixed sites: two traffic sites in Msida (within the agglomeration) and St Paul's Bay (outside of the agglomeration), an urban background site in Żejtun, an urban site in Attard and a rural background site in Għarb, Gozo. The near real time air monitoring stations can determine concentrations of most air pollutants every 15 minutes. The pollutants monitored in near real time are ozone, sulphur dioxide, nitrogen oxides, carbon monoxide, volatile organic compounds, gaseous mercury, particulate matter (PM10 and PM2.5) and meteorological variables.

9 EDUCATION, TRAINING & PUBLIC AWARENESS

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*" [106] . Consequently, Education for Sustainable Development (ESD) 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; and
- experiences that empower learners to transform themselves and society[107].

This chapter explores the ESD initiatives related to climate change that follow the dimensions listed above, albeit the initiatives addressing all the dimensions are still noticeably limited in number. The chapter provides a follow-up to the initiatives reported in the NC7, keeping UNESCO's five Priority Action Areas (PAAs) as a backdrop. The following PAAs were identified in an effort to advance the ESD agenda by enabling a strategic focus and foster stakeholder commitment:

1. Mainstreaming ESD into both education and sustainable development policies, to bring about systemic change.
2. Adopting a whole institution approach by integrating sustainability principles into education and training settings.
3. Ensuring that educators and trainers receive the appropriate training to deliver ESD more effectively.
4. Empowering and mobilizing youth.
5. Scaling up community-based ESD programmes and multi-stakeholder ESD networks[108].

Although this National Communication was not subjected to a formal process of public review prior to submission, its preparation involved contributions from a number of organizations representing a wide range of expertise. This provides a comprehensive overview of the status of climate action in Malta at different levels and across various relevant sectors.

It is also to note that Malta's Low Carbon Development Strategy, which is extensively referred to with regards to national policy for the mitigation of national greenhouse gas emissions, underwent an extensive process of public consultation and stakeholder engagement, as discussed in detail in the Strategy document published in 2021.

---

[106] 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 (p.5).

[107] 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

[108] UNESCO (2020). Education for sustainable development: a roadmap. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000374802.locale=en

9.1 EXAMPLES OF GOOD PRACTICE

From the last report, there has been a further consolidation of efforts aimed at providing ESD 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, initiatives in the latter two sectors are still rather sporadic and not part of a well-thought and coordinated educational strategy with clear intended learning outcomes and monitoring and evaluation mechanisms. Progress is inevitably slow and limited to aspects that, although being culturally popular at a given point, might not have a high priority when it comes to effective climate action.

9.1.1 FORMAL EDUCATION

The formal education sector is characterised by structures and trained personnel that facilitate the development of educational programmes and consequently this sector has once again proved to be the most creative in climate change education.

Topics related to climate change have continued to feature in various educational programmes – from pre-school right through tertiary education and in diverse subject areas. However, the predominant perspective nurtured is that climate change is essentially an environmental issue that could be remedied through the right technological and legal fixes. Therefore, the nature of the topics is still predominantly scientific/technological closely followed by economic and legal aspects of the phenomenon. There has been a significant increase in themes related to climate justice and social issues following the UN's launch of the SDGs. Still the impact of climate change on health is still marginally addressed.

Local and international research and innovation projects related to climate change have continued to increase significantly at the University of Malta (UM) and the Malta College of Arts, Science & Technology (MCAST). These projects, mainly scientific and technological in nature, are mainly related to climate modelling, energy efficiency, water conservation and transport. Chaired by, Malta's Ambassador for Climate Change, the UM's Climate Change Platform (CCP) was specifically set up to coordinate, facilitate and promote collaboration between UM entities and academics about climate change research and teaching.

The Institute for Climate Change and Sustainable Development (ICCSD) and the Centre for Environmental Education and Research (CEER) are academic entities within the University of Malta of 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 UM and in the community. CEER was specifically set up to promote ESD, based on the dimensions outlined earlier, in different educational sectors and with different audiences. Through its educational programmes, CEER is providing a cohort of individual specialised in ESD who are a valuable resource for the provision of education, training and public awareness on climate issues. One of CEER's main engagements in the community is the co-ordination of ESD programmes in schools, i.e., EkoSkola and GLOBE (see below).

Sustainability is one of the main themes in the UM Strategic Plan 2020-2025 with one of its main commitments being to "*deliver training and research on sustainability*"[109]. In September 2018, Rector set up the Committee for Sustainability at the UM (C-SUM) tasked with fostering a culture of sustainability in line with the SDGs and improving sustainability on the UM's campuses and educational programmes. However, initial attempts by C-SUM to encourage academic entities to relate their respective educational programmes to the SDGs were met with suspicion and resistance.

Till 2018, the Government of Malta offered Scholarships in Climate Action for postgraduate studies at the UM to students from developing states. This was 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 National Curriculum Framework (2012)[110] recognised ESD as an important dimension in a learner's entitlement and proposed it as a cross curricular theme with the aim of creating curriculum space for it. This was followed by the listing of the general intended learning outcomes for ESD. However, to date, specific guidelines about the integration of ESD within the early years and in the various curriculum areas are still missing. Consequently, ESD is still lacking its due space in the curriculum. Any space given to ESD depends on the goodwill of dedicated educators that either integrate ESD in their teaching and/or engage in extracurricular programmes offered by NGOs.

In the meantime, the Eco-Schools programme[111] (known locally as EkoSkola) continued to develop into the largest ESD network on the island, with more than 84% of the total student population (from kindergarten to post-secondary schools) participating in the programme. 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 NC7, climate change continued to feature as a recurrent theme in the activities addressed by EkoSkola, nationally and in the individual schools/communities. The activities mainly consisted in:

- Lessons (in various curriculum subject areas) and information meetings to the community focusing on diverse aspects of climate change.
- Growing and eventual planting of trees to reduce CO_2 content.
- Audits of community resources during which students review the sustainability of community spaces and make recommendations for their improvement. These audits provide students with an opportunity to practice their environmental auditing skills (developed during EkoSkola) by facing real-life sustainability issues/dilemmas that challenge the 'textbook' approach to sustainable development. During the audit students look at ways how to reduce the carbon footprint by the installation and proper use of technologies/appliances and behaviour change. Following each audit, students develop an action plan aimed at helping the organisation visited to improve its practices. Students revisit the organisation after a year to monitor its progress along the action plan. During the timeframe covered by NC8, students carried out an audit of the Offices of the

[109] https://www.um.edu.mt/about/strategy/strategicgoals7sustainability/

[110] 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

[111] Acknowledged by UNESCO as the largest global ESD network, Eco-Schools is an international programme involving more than 20 million students from 72 different countries. In Malta, it is run by Nature Trust – FEE Malta (an NGO) and supported by CEER.

Ministry of Education (2019,) an audit of a 4 Star Hotel (2019) and the Offices of the Prime Minister (2021).

- The FEE Fest is a 3-day event with different exhibition stalls and scheduled information sessions targeting students, teachers, and parents. Participants are free to attend on any day and plan their stay according to their particular interests and needs. It is an opportunity to learn about the various FEE[112] programmes, explore issues related to sustainable development, develop ideas for cross-curricular work, and get information about initiatives organised by organisations and entities that work on issues related to sustainability (including climate change). Three editions of the FEE Fest were organised during the timeframe covered by NC8.
- Young People's Summits are organised annually in line with Nature Trust – FEE Malta's policy of promoting the voice of young people in decision making fora. The Summits provide students with an opportunity to discuss at length their concerns and propose solutions about specific sustainability issues of local, national, and global relevance with experts and policy makers. Each summit ends with the formulation of a declaration (collated from the student inputs) that is approved by the attendees and presented to the local MPs during the following parliamentary session (see below). Three editions of the FEE fest were organised during the timeframe covered by NC8:
- In 2019, the Summit was organised in collaboration with the Malta-EU Steering and Action Committee (MEUSAC) and focused on the following themes: (i) the impact of heavy traffic on air quality, health and climate change; (ii) marine plastic waste; and (iii) the lack of green open spaces because of too many buildings.

In 2021, the Summit was held virtually (due to COVID 19 restrictions). The themes discussed were: (i) marine pollution and loss of biodiversity; (ii) urbanism; (iii) sustainable food consumption; and (iv) carbon neutrality & carbon sequestration.

  - In 2022, as a follow-up to the COP26 meeting in Glasgow, a series of six online mini summits, each exploring a different aspect of climate change, were organised in collaboration with the British High Commission. The themes discussed were: (i) climate change & transport; (ii) climate change & life on land; (iii) climate change & life under water; (iv) climate change & energy and water; and (v) climate change & production/consumption patterns. The sixth summit involved an online meeting with schools from the UK during which students exchanged climate actions they carried out in their respective communities. The students' recommendations were collated into a publication[113] that was distributed among MPs. link.

- The EkoSkola Parliament Session is an annual event that brings together students and the country's official policy makers in a positive parliamentary debate about ways of improving the quality of life in our country. Way back in 2008, during an EkoSkola Parliament session, students had requested that climate change becomes a national concern and that the two political parties should collaborate on the issue. This was 7 years BEFORE the enactment of the Climate Change Action Act (in 2015) and 11 years before Parliament declared a climate emergency (in 2019). Three

[112] The Foundation for Environmental Education (FEE) is the largest global network involving 81 countries. Its programmes represent the absolute cutting edge in ESD: **Eco-Schools**, **Learning About Forests** (LEAF) and **Young Reporters for the Environment** (YRE) programmes target young people, **Green Key** and **Blue Flag** promote sustainable business practices and the protection of natural resources. See also: https://www.fee.global/

[113] Publication available here: https://ekoskola.org.mt/resource/we-care-about-our-present-and-our-future/

editions of the EkoSkola Parliament Session were organised during the timeframe covered by NC8. Issues related to climate action were discussed in all the sessions.

- In 2022, Nature Trust - FEE Malta launched the Green School Travel Plan in collaboration with Transport Malta and HSBC Bank. This initiative aimed at bringing together various climate actions related to sustainable mobility. During the year-long initiative students investigated current school modalities and took concrete action to improve mobility practices in their respective schools and communities. These included bike days, installation of new bike racks, involvement in the MOVE campaign to cycle or walk for trees and data collection on air quality through the GLOBE programme (see below). Since schools promoted community-based actions, students were asked to nominate community stakeholders which were key to achieving more sustainability. In fact, the Community Police Team from Gozo as well as Kirkop Local Council were awarded for their important contribution. Four educators as well as two students were also honoured as Sustainable Mobility Champions due to their outstanding contributions in promoting the use of bicycles and assisting with a walking bus initiative.

Following EkoSkola's success story in seamlessly infusing ESD in schools through a bottom-up whole-school approach, three other international programmes were introduced:

- Learning about Forests (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. Currently, a total of 62 schools are registered in the programme.
- Young Reporters for the Environment (YRE): aims to empower young people to take a stand on local sustainable development issues (such as climate change) they feel strongly about by giving them a platform to articulate these issues through the media of writing, photography, or video. Over 300 contributions were submitted in 2022.
- Global Learning and Observations to Benefit the Environment (GLOBE): provides students with opportunities to conduct and share scientific investigations of environmental parameters. A large part of these investigations focuses on data concerning climate change (for example investigating the heat island effect in urban and rural areas). Currently 44 schools are registered in the programme.

9.1.2 NON-FORMAL AND INFORMAL EDUCATION

Initiatives in this sector have been relatively low except for some occasional action taken up by Ministries, 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 Energy and Water Agency (EWA) offers a number of activities for students at Ċentru Għajn. This centre offers a variety of interactive games aimed at raising awareness and to promote water conservation and energy efficiency. EWA has also published original books in Maltese to continue raising awareness about the efficiency and sustainability of natural resources. They also developed 'Green Home Explained', an educational toolkit for teachers to promote renewable energy and its efficiency.

In May 2022, the Ministry for the Environment, Energy and Enterprise launched the second edition of the #ClimateOn campaign. The campaign is a platform that focuses on awareness raising for companies, businesses, families and young people climate friendly practices in relation to sustainable energy use, sustainable mobility, and sustainable financing. In June, 2022, the same ministry launched the second edition of SeedGreen, as part of the #ClimateOn campaign. SeedGreen is an entrepreneurial programme that incentivises young entrepreneurs who have solutions and start-up ideas aimed at protecting the environment and target climate change. SeedGreen provides participants with the tools they require to develop start-ups offering solutions and sustainable services to the current market. The programme has been put together by the Ministry, Malta Enterprise, the Junior Chamber International Malta (JCI Malta), and the EIT Climate-KIC Malta Hub at MCAST.

The EIT Climate-KIC Malta Hub, forms part of the EU's EIT Climate-KIC flagship initiative and was set up in 2016 with the aim of accelerating the transition to a zero-carbon and resilient world by enabling systems transformation. The Hub works closely with key stakeholders, including the Ministry responsible for Environment and Climate Change, AquaBioTech Group and the Energy and Water Agency to achieve national environmental and climate targets and boost Malta's capacity to take on innovative projects whilst creating links among local entities working towards similar climate goals. The target beneficiaries of the EIT Climate-KIC concept may come from a wide range of interests, including business accelerators and incubators, start-ups and scale-ups, SMEs, and institutions involved in education and research. MCAST is the current Hub Coordinator.

The EIT Climate-KIC engages in, and supports, various initiatives, including events, published material, public awareness and engagement with communities. The following programmes provide examples of key events held during the timeframe covered by NC8, where Malta was actively involved:

a. Pioneers into Practice: equips participants with practical tools needed to lead the transition to a zero carbon, climate-resilient society. The programme connects professionals across Europe and provides a transformative learning experience through a mix of e-learning, workshops, group projects, and optional placements. The programme is structured around local climate mitigation and adaptation needs, allowing participants to work on relevant challenges in their locations while connecting to a broader, European community of changemakers. The program was run in 2017, 2018, 2019 and 2020.

b. Climate Leadership Journey Summer School: is an extracurricular challenge-based programme that prepares master students, post-graduates, and young professionals to lead the transformation that society needs. The programme runs on yearly cycles from April to December and empowers future professionals to become a force in creating a net-zero and climate-resilient world by developing future-oriented skills and capabilities in participants. Seventy summer schools were hosted across Europe, generating over 400 projects and business ideas, and building a strong global network of over 3,000 peers. In 2018, Malta hosted the final leg of Journey Summer School and in 2021, MCAST hosted a theme specific Journey on Blue Economy.

c. Young Innovators Malta: the programme offers students the tools and skills they need to become changemakers and lead systemic innovation. Educators use challenge-led learning to empower teenagers to strive for a zero-carbon economy. The programme aims to challenge current paradigms in the education system, mainstream climate change education and embed systems thinking and challenge-based learning into curricula. The program was run in 2021 and 2020.

d. Climathon: is an international movement that engages cities and citizens in climate action. It lays the foundations for tangible projects, impact-driven start-ups and longlasting conversations with decision-makers around city plans and policies. Policymakers, entrepreneurs, youth, business leaders, hackers, academics, students and professionals are invited to participate. Climathon was run in 2017, 2018, 2019, 2020, 2021.

e. ClimAccelerator: is a global programme giving start-ups access to innovate, catalyse, and scale the potential of their climate solutions. The programme goes beyond European borders, building providing a powerful platform where global industry experts and systems can connect and scale towards true industry transformation to break new ground in carbon reduction. The programme was run in 2017, 2018, 2019, 2021 and 2022.

The Interdiocesan Environment Commission was set up to promote values that are conducive to sustainable lifestyles. It has been active in issuing opinion papers about sustainability issues (including climate change); conducting training sessions in the community; and providing consultancy and support to parishes wishing to reduce their carbon footprint.

The Office of the Commissioner for Children (OCC) forms part of the European Network of Ombudspersons for Children (ENOC). The theme adopted by the members of ENOC for 2022 was Climate Justice and the Impact of Climate Change on Children's Rights. ENOC will be publishing a position statement at the end of September consisting of recommendations based on data collected from the different members of ENOC as well as through the proposals made by young people from 17 different countries/regions. Malta's OCC organised a two-day seminar during which young people discussed climate change and energy sources and proposed recommendations for climate actions. These recommendations will be presented to ENOC. OCC will also be advocating for the implementation of the young people's recommendations on a national level.

HSBC Malta Foundation organised a webinar on Environmental Social Governance (ESG) that explored the value of ESG for businesses, organizations, and schools. The webinar stressed the need to move towards a whole institution (school) approach to achieve sustainability and effective climate action in particular.

9.2 HURDLES TO EDUCATION TARGETING CLIMATE CHANGE

As outlined in NC7, 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 ESD'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 capable of providing effective educational programmes irrespective of the fact that s/he has not been trained in ESD 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;
- although there has been a significant shift towards targeting youths, educational campaigns are mostly conceived with children in mind. Adult education programmes are noticeably lacking;
- 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 general reluctance (resistance) to change outdated approaches in education, training, and public awareness;
- a top-down approach to education characterised by the transmission of other people's priorities, knowledge, values and thinking to passive learners;
- curriculum structures that are built around the diktat of the discipline rather than the learners' needs. Consequently, educational programmes are too crammed to allow the elbow-space required to accommodate ESD (and climate education); and
- a preference to short-term goals that tend to generate actions that are more akin to greenwashing rather than significant behavioural changes.

What is needed are enabling and transformative pedagogies that identify the learners' needs and actively engage them in their learning. Learners (of all ages) 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 ESD professionals in acknowledged and tapped.

9.3 Looking forward

Furthermore, NC7 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.

Phase 2 would entail further discussions with the interest groups to compile an NSESD Action 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.

However, the development of Phase 2 of the strategy has grounded to a standstill, mainly because providing a coordinated front for ESD provision is still not seen as a priority.

REFERENCES

Akerlof, K., Debono, R., Berry, P., Leiserowitz, A., Roser-Renouf, C., Clarke, K., . . . Maibach, W. (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, 7*.

Anon. (2010). Frontex attributes substantial drop in illegal migrants to Europe this year to economic ills. *Times of Malta*(7 October 2010).

Aquilina, N., Attard, M., Borg, S., Ciarlo`, J., Fenech, S., Kemp, L., . . . Vassallo, S. (2014). *The Third, Fourth, Fifth and Sixth National Communication of Malta: under the United Nations Framework Convention on Climate Change*. 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), 141-152.

Attard, M., Von Brockdorff, P., & Bezzina, F. (2015). *The External Costs of Passenger and Commercial Vehicle Use in Malta*. University of Malta - European Commission Representation in Malta.

Ban, N, C Caillaud, E Coppola, E Pichelli, S Sobolowski, M Adinolfi, B Ahrens, et al. 2021. "The first multi-model ensemble of regional climate simulations at kilometer-scale resolution, part I: evaluation of precipitation." *Clim Dyn* 57: 275–302.

Birch Hill GeoSolutions. (2006). *Climate Change Adaptation for Land Use Planners.* Birch Hill GeoSolutions.

Borg, S. (2009). *Malta's Initiative on Climate Change*. 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.* University of Malta.

Coenen, P., Jozwicka, M., Pulles, T., Grebot, B., Lee, J., Goodwin, J., . . . Weis, P. (2012). *Development of GHG projection guidelines - CLIMA.A.3/SER/2010/0004.* TNO.

Copernicus. (2017). *Copernicus: Land Monitoring Service*. Retrieved from http://land.copernicus.eu/

de Haas, H. (2011). Mediterranean migration futures: Patterns, drivers and scenarios. *Global Environmental Change, 21*(1).

DHIR. 2018. *Annual Mortality Report.* Malta National Mortality Registry.

DHIR. (2013). *Annual Mortality Report, 2012*. Directorate for Health Information and Research.

DHIR. (2015). *Annual Mortality Report. National Mortality Registry. Malta.* Retrieved from 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.* European Environment Agency.

EEA. (2013). *Annual European Union greenhouse gas inventory 1990-2011 and inventory reprt 2013 - Technical report No 8/2013.* European Environment Agency.

EEA. (2013). *Municipal Waste in Malta,* EEA-ETC SPC Study, 2/2013 European Environment Agency, Copenhagen, Denmark.

EEA. (2017). *Climate change, impacts and vulnerability in Europe 2016: An indicator-based report.* European Environment Agency.

Energy and Water Agency. 2017. "Allocation of Water Resources, Case Study – Malta." Murcia, Spain: Presentation at the 5+5 Technical Workshop on Water Allocation.

ERA. 2016. *The 2nd Water Catchment Management Plan for the Malta Water Catchment District 2015 - 2021.* Marsa: Sustainable Energy and Water Conservation Unit, ERA.

EU Open Data Portal. (2017). *Digital Elevation Model over Europe (EU-DEM)*. Retrieved from https://data.europa.eu/euodp/data/dataset/data_eu-dem

European Commission. (2013). *Annual Tourism Report, Malta*. Retrieved from file:///Users/mariaattard/Downloads/annual%20tourism%20report%202013%20-%20Malta.pdf

European Commission. (2014). *Scandinavian – Mediterranean Corridor – Malta Core and Comprehensive Network, TENtec*. Retrieved from http://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/site/index_en.htm

EUROSTAT. (2021). *Economy and Finance Database*. Retrieved August 10, 2021, from https://ec.europa.eu/eurostat/web/main/data/database

European Commission, Directorate-General for Mobility and Transport. 2020. *Handbook on the external costs of transport : version 2019 – 1.1.* Publications Office.

Eyring, V, S Bony, GA Meehl, CA Senior, B Stevens, RJ Stouffer, and KE Taylor. 2016. "Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization." *Geosci. Model Dev.* 9: 1937–1958.

Fenech, S. (2013). *Evaluating the different schemes for studying wind fields with WRF-LES, BSc(Hons) dissertation.* University of Malta.

Fonseca, M. (2001). The geography of recent immigration to Potugal. In R. King, *The Geography, Environment and Development in the Mediterranean*. Sussex Academic Press.

Frontex . (2010). *FRAN Quarterly Update, Issue 1, January-March.* FRONTEX.

Fsadni, P., Ellul, P., Montefort, M., Caruana, S., Agius Muscat, H., & Montefort, S. (2012). ISAAC Malta: Changes in geographical distribution of wheezing children in Malta between 1994 and 2002. *Journal of Asthma and Allergy, 5*.

Galdies, C. (2011). *The Climate of Malta: statistics, trends and analysis 1951-2010.* National Statistics Office - Malta.

Gatt, A. (2009). *Infectious Disease Prevention and Control.* National Seminar on Health Effects of Climate Change, Malta.

Gerada, E, H Agius Muscat, L Camilleri, and S Montefort. 2015. "An increase in the severity of rhinitis and a reduction in severity of wheezing and eczema in 12- to 15- year old Maltese children over two decades (ISAAC-Malta)." *European Respiratory Journal* 46 (59): OA1977.

Giorgi, F., Coppola, E., Solmon, F., Mariotti, L., Sylla, M., Bi, X., . . . Brankovic, C. (2012). RegCM4: model description and preliminary tests. *Climate Research*(7-29), 52.

Government of Malta. 2021. *Malta Low Carbon Development Strategy: Public Consultation Document (June 2021).* Malta: Ministry for the Environment, Climate Change and Planning.

Government of Malta. 2021. *Malta's Tourism Strategy for the years 2021 - 2030.* Malta: Ministry for Tourism and Consumer Protection.

Government of Malta. 2021. *Public Consultation Document: CAP Strategic Plan 2023-2027.* Parliamentary Secretariat for European Funds.

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*. Environment Protection Department, Ministry of the Environment.

MBB. (2012). *EU LIFE+ Investing in Water Project - Project Portfolio.* Malta Business Bureau.

MEPA. (2006). *State of the Environment Report, 2005.* Malta Environment and Planning Authority.

MEPA website. (n.d.). *Protected Areas - National.* Retrieved from Malta Environment and Planning Authority: www.mepa.org.mt/impnatareas-pas-nat

Ministry for Gozo. (2012). Naqqas u Ffranka: Eco-Gozo home consultancy visits. *Let's Gozo: it's all about Gozo*(6).

Ministry for Tourism. (2015). *National Tourism Policy (Draft). Malta*. Retrieved from http://mhra.org.mt/wp-content/uploads/2015/08/TOURISM-POLICY-2015-2020.pdf

MRA. (2010). *Malta's National Renewable Energy Action Plan* . Malta Resources Authority.

MRA. (2013). *National Greenhouse Gas Emissions Inventory for Malta 2013 - Report 4/2013.* Malta Resources Authority.

MRA. (2013). *Preliminary Flood Risk Assessment Final Report May 2013.* . Retrieved from http://www.preventionweb.net/files/33946_33946preliminaryfloodriskassessment.pdf

MRA. (2017). *Malta's Report on Policies and Measures and Projections - May 2017.* 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.* The Malta Resources Authority on behalf of the Ministry for Sustainable Development, the Environment and Climate Change.

MRRA. (2010). *National Climate Change Adaptation Strategy.* Ministry for Resources and Rural Affairs.

MRRA. (2010). *The Second Communication of Malta to the United Nations Framework Convention on Climate Change.* Ministry for Resources and Rural Affairs.

NSO. (1995). *Census of Population and Housing 1995, Volume 6: Dwellings.* National Statitics Office - Malta. Retrieved November 9, 2013, from National Statistics Office: www.nso.gov.mt

NSO. (2007). *Census of Population and Housing, 2005, Volume 2: Dwellings.* National Statistics Office - Malta.

NSO. (2011). *Demographic Review - 2010.*

NSO. (2011). *Malta in Figures, 2011.* National Statistics Office - Malta.

NSO. (2012). *Agriculture and Fisheries, 2010.* National Statistics Office - Malta.

NSO. (2012). *Agriculture and Fisheries, 2011.* National Statistics Office - Malta.

NSO. (2012). *Census of Population and Housing, 2011 - Preliminary Report.* National Statistics Office - Malta.

NSO. (2013). *Malta in Figures.*

NSO. (2013a). *Solid Waste Management in Malta, 2004-2011*. National Statistics Office - Malta.

NSO. (2013b). *Energy Consumption in Malta: 2003-2012*. National Statistics Office.

NSO. (2014). *Agriculture and Fisheries.* National Statistics Office - Malta.

NSO. (2014). *Malta in Figures, 2014.* National Statistics Office - Malta.

NSO. (2016). *Agriculture and Fisheries 2014.* Valletta.

NSO. (2016). *Demographic Review - 2014.* National Statistics Office - Malta.

NSO. (2017). *Electricity Generation: 2007-2016.* National Statistics Office - Malta.

NSO. (2017). *Electricity Generation: 2007-2016.* National Statistics Office - Malta.

NSO. (2017). *Trends in Malta, 2016.* National Statistics Office - Malta.

NSO. (2020). Inbound Tourism, 2020. National Statistics Office - Malta.

NSO. (2021). *Malta in Figures, 2021.* National Statistics Office - Malta.

NSO. (2021). *Regional Statistics Malta - 2021 Edition.* National Statistics Office - Malta.

NSO. (2021). Transport Statistics 2021. Reference Year 2020. National Statistics Office - Malta.

NSO. (n.d.). *Census 1995, Volume 6: Dwellings.* Retrieved from National Statistics Office: www.nso.gov.mt

NSO StatDB. (n.d.). *StatDB*. Retrieved November 9, 2013, from National Statistics Office: 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).

OECD. 2020. *OECD Tourism Trends and Policies 2020.* Paris: OECD Publishing.

Palmieri, P. 2014. *Climate Change: Impacts on the Maltese tourism and hospitality industry: reflections, responses and repercussions.* University of Malta: Dissertation.

Perez, T. (2008). *Impact of climate change on biodiversity in the Mediterranean Sea.* United Nations Environment Programme - MAP - RAC/SPA.

Pichelli, E, E Coppola, S Sobolowski, N Ban, F Giorgi, P Stocchi, A Alias, et al. 2021. "The first multi-model ensemble of regional climate simulations at kilometer-scale resolution part 2: historical and future simulations of precipitation." *Clim Dyn* 56: 3581–3602.

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., Qin, D., Plattner, G., Tignor, M., Allen, S., Boschung, J., . . . Midgley, P. (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.* Cambridge University Press.

Thomas, C., Cameron, A., Green, R., Bakkenes, M., Beaumont , L., Collingham, Y., . . . Williams, S. (2004). Extinction risk from climate change. *Nature*(427).

TINA Vienna. (2002). *Transport Infrastructure Needs Assessment for Malta.* TINA Vienna.

Ulman, A., Ferrario, J., Occhpinti-Ambrogi, A., Arvanitidis, C., Bandi, A., Bertolino, M., . . . Marchini, A. (2017). A massive update of non-indigenous species records in Mediterranean marinas. *PeerJ, 5*(e3954). doi:https://doi.org/10.7717/peerj.3954

UNHCR. (2017). *Malta Asylum Trends*. Retrieved from 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), 213-223.

WHO. 2021. *Climate change and health.* https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health.

WHO website. (n.d.). *Climate Change and Human Health - Global Environmental Change*. Retrieved from World Health Organization: www.who.int/globalchange/environment/en/

World Bank. (2021). *CO2 emissions (kg per 2015 US$ of GDP)*. Retrieved August 10, 2021, from https://data.worldbank.org/indicator/EN.ATM.CO2E.KD.GD

World Bank. (2021). *Energy intensity level of primary energy (MJ/$2011 PPP GDP)*. Retrieved August 10, 2021, from https://data.worldbank.org/indicator/EG.EGY.PRIM.PP.KD

World Bank 2022 https://data.worldbank.org/indicator/EN.ATM.CO2E.PP.GD

World Travel and Tourism Council. (2017). *Travel and Tourism Economic Impact 2017 Malta*. Retrieved from https://www.wttc.org/-/media/files/reports/economic%20impact%20research/countries%202017/malta2017.pdf

WSC. (2012). *Annual Report, 2011.* Water Services Corporation.

10 ANNEX 1: CRF TABLES

10.1 SUMMARY REPORTS

Table 10.1 Summary Report for CO_2 Equivalent Emissions in 1990.

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)	2385.86	125.21	80.04	NO,NE,NA	NO,NA	0.01	NA,NO	NA	2591.13
1. Energy	2388.70	5.24	9.20						2403.14
A. Fuel combustion (sectoral approach)	2388.70	5.24	9.20						2403.14
1. Energy industries	1758.52	1.21	5.78						1765.51
2. Manufacturing industries and construction	52.67	0.05	0.12						52.83
3. Transport	312.69	3.17	2.60						318.45
4. Other sectors	263.69	0.81	0.69						265.19
5. Other	1.14	0.00	0.01						1.16
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	2.64	NO,NE,NA	NO,NA	0.01	NA,NO	NA	7.78
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
D. Non-energy products from fuels and solvent use	3.52	NA	NA						3.52
E. Electronic Industry				NO		NO	NO		NO
F. Product uses as ODS substitutes				NO,NE	NO				NO,NE
G. Other product manufacture and use			2.64		NO	0.01			2.65
H. Other									
3. Agriculture	NE,NO	61.21	57.86						119.07
A. Enteric fermentation		52.30							52.30
B. Manure management		8.91	25.70						34.61
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	32.16						32.16
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-8.33	0.02	0.15						-8.15
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	-1.91	NO	0.02						-1.89
C. Grassland	-8.96	NO	NO						-8.96
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	2.05	NO	0.09						2.14
F. Other land	0.57	NO	0.05						0.62
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.37	58.74	10.19						69.30
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		17.20	10.17						27.37
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:(2)									
International bunkers	1152.96	2.72	7.40						1163.08
Aviation	196.96	0.69	0.49						198.14
Navigation	956.00	2.03	6.91						964.94
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			23.04						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2599.28
Total CO_2 equivalent emissions with land use, land-use change and forestry									2591.13
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 10.2 Summary Report for CO_2 Equivalent Emissions in 1991

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)]	2229.54	133.23	81.04	NO,NE,NA	NO,NA	0.01	NA,NO	NA	2443.82
1. Energy	2232.39	5.21	8.81						2246.41
A. Fuel combustion (sectoral approach)	2232.39	5.21	8.81						2246.41
1. Energy industries	1599.05	1.15	5.09						1605.29
2. Manufacturing industries and construction	54.61	0.05	0.12						54.78
3. Transport	332.20	3.26	2.93						338.39
4. Other sectors	245.44	0.75	0.65						246.84
5. Other	1.08	0.00	0.01						1.10
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	5.35	NO,NA	2.65	NO,NE,NA	NO,NA	0.01	NA,NO	NA	8.01
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
D. Non-energy products from fuels and solvent use	3.51	NA	NA						3.51
E. Electronic Industry				NO		NO	NO		NO
F. Product uses as ODS substitutes				NO,NE	NO				NO,NE
G. Other product manufacture and use			2.65		NO	0.01			2.66
H. Other									
3. Agriculture	NE,NO	63.66	58.51						122.17
A. Enteric fermentation		54.47							54.47
B. Manure management		9.19	26.65						35.84
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	31.86						31.86
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)]	-8.57	0.02	0.16						-8.38
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	-1.95	NO	0.02						-1.93
C. Grassland	-8.31	NO	NO						-8.31
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	1.26	NO	0.10						1.35
F. Other land	0.52	NO	0.05						0.57
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.37	64.34	10.92						75.62
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		17.30	10.90						28.20
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:[(2)]									
International bunkers	1148.54	2.84	7.91						1159.28
Aviation	186.11	0.65	0.47						187.22
Navigation	962.43	2.18	7.44						972.06
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			23.55						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2452.20
Total CO_2 equivalent emissions with land use, land-use change and forestry									2443.82
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	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)]	2286.75	140.89	82.97	NO,NE,NA	NO,NA	1.43	NA,NO	NA	2512.04
1. Energy	2286.77	5.52	9.21						2301.50
A. Fuel combustion (sectoral approach)	2286.77	5.52	9.21						2301.50
1. Energy industries	1536.25	1.15	4.72						1542.13
2. Manufacturing industries and construction	63.49	0.06	0.14						63.69
3. Transport	388.51	3.40	3.51						395.42
4. Other sectors	297.28	0.91	0.82						299.01
5. Other	1.23	0.00	0.01						1.25
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	4.94	NO,NA	2.65	NO,NE,NA	NO,NA	1.43	NA,NO	NA	9.02
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
D. Non-energy products from fuels and solvent use	3.50	NA	NA						3.50
E. Electronic Industry				NO		NO	NO		NO
F. Product uses as ODS substitutes				NO,NE	NO				NO,NE
G. Other product manufacture and use			2.65		NO	1.43			4.07
H. Other									
3. Agriculture	NE,NO	65.10	59.90						125.00
A. Enteric fermentation		55.67							55.67
B. Manure management		9.43	27.15						36.58
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	32.75						32.75
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)]	-5.33	0.02	0.17						-5.14
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	-1.98	NO	0.02						-1.97
C. Grassland	-5.11	NO	NO						-5.11
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	1.29	NO	0.10						1.39
F. Other land	0.56	NO	0.06						0.62
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.37	70.25	11.04						81.66
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		17.57	11.03						28.59
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:[(2)]									
International bunkers	1449.85	3.59	9.93						1463.38
Aviation	244.15	0.85	0.61						245.61
Navigation	1205.71	2.74	9.32						1217.77
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			24.01						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2517.18
Total CO_2 equivalent emissions with land use, land-use change and forestry									2512.04
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)]	2865.23	147.95	85.69	NO,NE,NA	NO,NA	1.43	NA,NO	NA	3100.29
1. Energy	2865.07	6.01	11.43						2882.52
A. Fuel combustion (sectoral approach)	2865.07	6.01	11.43						2882.52
1. Energy industries	2101.83	1.54	6.57						2109.94
2. Manufacturing industries and construction	65.16	0.06	0.15						65.37
3. Transport	395.87	3.48	3.87						403.23
4. Other sectors	300.88	0.93	0.82						302.63
5. Other	1.33	0.00	0.02						1.35
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	4.96	NO,NA	2.65	NO,NE,NA	NO,NA	1.43	NA,NO	NA	9.04
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
D. Non-energy products from fuels and solvent use	3.47	NA	NA						3.47
E. Electronic Industry				NO		NO	NO		NO
F. Product uses as ODS substitutes				NO,NE	NO				NO,NE
G. Other product manufacture and use			2.65		NO	1.43			4.08
H. Other									
3. Agriculture	NE,NO	64.67	59.74						124.41
A. Enteric fermentation		55.24							55.24
B. Manure management		9.43	27.01						36.44
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	32.73						32.73
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)]	-5.17	0.02	0.18						-4.97
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	-1.66	NO	0.01						-1.64
C. Grassland	-5.35	NO	NO						-5.35
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	1.32	NO	0.10						1.42
F. Other land	0.60	NO	0.06						0.67
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.37	77.24	11.68						89.29
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		17.78	10.96						28.74
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:[(2)]									
International bunkers	1716.95	4.21	11.97						1733.12
Aviation	250.28	0.88	0.63						251.78
Navigation	1466.67	3.33	11.34						1481.34
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			23.93						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3105.26
Total CO_2 equivalent emissions with land use, land-use change and forestry									3100.29
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	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)	2643.09	153.26	84.14	0.00	NO,NA	1.43	NA,NO	NA	2881.92
1. Energy	2642.32	6.04	10.80						2659.15
A. Fuel combustion (sectoral approach)	2642.32	6.04	10.80						2659.15
1. Energy industries	1809.12	1.41	5.35						1815.89
2. Manufacturing industries and construction	70.49	0.07	0.16						70.72
3. Transport	418.83	3.48	4.33						426.64
4. Other sectors	342.45	1.07	0.94						344.46
5. Other	1.43	0.00	0.02						1.45
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	5.24	NO,NA	2.65	0.00	NO,NA	1.43	NA,NO	NA	9.32
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
D. Non-energy products from fuels and solvent use	3.45	NA	NA						3.45
E. Electronic Industry				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									
3. Agriculture	NE,NO	62.55	57.93						120.49
A. Enteric fermentation		53.30							53.30
B. Manure management		9.26	26.03						35.29
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	31.90						31.90
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-4.84	0.02	0.18						-4.63
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	-1.16	NO	0.01						-1.15
C. Grassland	-5.59	NO	NO						-5.59
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	1.35	NO	0.11						1.46
F. Other land	0.65	NO	0.07						0.71
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.37	84.64	12.57						97.58
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		18.04	10.96						28.99
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:(2)									
International bunkers	1812.96	4.50	12.41						1829.87
Aviation	308.37	1.08	0.77						310.21
Navigation	1504.59	3.42	11.64						1519.65
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			23.12						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2886.54
Total CO_2 equivalent emissions with land use, land-use change and forestry									2881.92
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	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)]	2435.10	157.25	84.52	0.00	NO,NA	1.44	NA,NO	NA	2678.31
1. Energy	2433.86	5.92	9.78						2449.55
A. Fuel combustion (sectoral approach)	2433.86	5.92	9.78						2449.55
1. Energy industries	1590.47	1.46	3.98						1595.91
2. Manufacturing industries and construction	75.31	0.07	0.17						75.55
3. Transport	430.62	3.34	4.67						438.63
4. Other sectors	335.80	1.04	0.94						337.79
5. Other	1.65	0.00	0.02						1.67
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	5.19	NO,NA	2.65	0.00	NO,NA	1.44	NA,NO	NA	9.29
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
D. Non-energy products from fuels and solvent use	3.43	NA	NA						3.43
E. Electronic Industry				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									
3. Agriculture	NE,NO	60.39	58.66						119.04
A. Enteric fermentation		51.40							51.40
B. Manure management		8.99	25.03						34.03
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	33.62						33.62
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)]	-4.32	0.02	0.19						-4.10
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	-1.09	NO	0.01						-1.08
C. Grassland	-5.21	NO	NO						-5.21
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	1.38	NO	0.11						1.49
F. Other land	0.69	NO	0.07						0.76
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.37	90.92	13.24						104.53
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		18.19	11.59						29.77
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:[(2)]									
International bunkers	1858.02	4.63	12.66						1875.31
Aviation	329.72	1.15	0.82						331.69
Navigation	1528.31	3.47	11.83						1543.62
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			22.96						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2682.41
Total CO_2 equivalent emissions with land use, land-use change and forestry									2678.31
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	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)	2546.18	165.93	83.75	0.00	NO,NA	1.45	NA,NO	NA	2797.32
1. Energy	2545.18	6.14	10.10						2561.43
A. Fuel combustion (sectoral approach)	2545.18	6.14	10.10						2561.43
1. Energy industries	1646.98	1.60	3.82						1652.39
2. Manufacturing industries and construction	75.96	0.07	0.17						76.21
3. Transport	481.37	3.40	5.08						489.85
4. Other sectors	339.33	1.06	1.02						341.41
5. Other	1.55	0.00	0.02						1.57
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	4.98	NO,NA	2.66	0.00	NO,NA	1.45	NA,NO	NA	9.09
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
D. Non-energy products from fuels and solvent use	3.44	NA	NA						3.44
E. Electronic Industry				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									
3. Agriculture	NE,NO	63.35	58.65						122.00
A. Enteric fermentation		54.23							54.23
B. Manure management		9.12	26.06						35.18
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	32.59						32.59
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-4.35	0.02	0.19						-4.13
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	-0.91	NO	0.01						-0.91
C. Grassland	-5.45	NO	NO						-5.45
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	1.41	NO	0.12						1.52
F. Other land	0.69	NO	0.07						0.76
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.37	96.42	12.15						108.94
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		18.28	11.14						29.42
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:(2)									
International bunkers	1898.25	4.72	12.99						1915.96
Aviation	326.62	1.14	0.82						328.58
Navigation	1571.63	3.57	12.18						1587.38
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			23.38						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2801.45
Total CO_2 equivalent emissions with land use, land-use change and forestry									2797.32
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 10.8 Summary Report for CO_2 Equivalent Emissions in 1997

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)]	2552.15	173.00	84.98	0.00	NO,NA	1.45	NA,NO	NA	2811.58
1. Energy	2551.17	6.12	10.15						2567.44
A. Fuel combustion (sectoral approach)	2551.17	6.12	10.15						2567.44
1. Energy industries	1611.63	1.56	3.73						1616.92
2. Manufacturing industries and construction	78.30	0.08	0.18						78.56
3. Transport	476.81	3.27	5.09						485.17
4. Other sectors	382.71	1.21	1.13						385.04
5. Other	1.72	0.00	0.02						1.74
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	5.19	NO,NA	2.66	0.00	NO,NA	1.45	NA,NO	NA	9.30
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
D. Non-energy products from fuels and solvent use	3.43	NA	NA						3.43
E. Electronic Industry				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									
3. Agriculture	NE,NO	63.98	59.75						123.73
A. Enteric fermentation		54.76							54.76
B. Manure management		9.22	26.27						35.49
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	33.48						33.48
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)]	-4.58	0.02	0.19						-4.36
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	-0.92	NO	0.01						-0.91
C. Grassland	-5.64	NO	NO						-5.64
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	1.37	NO	0.11						1.48
F. Other land	0.69	NO	0.07						0.77
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.37	102.87	12.24						115.48
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		18.82	11.53						30.35
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:[(2)]									
International bunkers	2075.60	5.14	14.28						2095.03
Aviation	342.97	1.20	0.86						345.02
Navigation	1732.64	3.94	13.42						1750.00
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			23.69						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2815.94
Total CO_2 equivalent emissions with land use, land-use change and forestry									2811.58
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 10.9 Summary Report for CO_2 Equivalent Emissions in 1998

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)	2509.23	178.03	85.59	0.01	NO,NA	1.47	NA,NO	NA	2774.32
1. Energy	2508.64	5.77	10.04						2524.45
A. Fuel combustion (sectoral approach)	2508.64	5.77	10.04						2524.45
1. Energy industries	1636.41	1.59	3.79						1641.78
2. Manufacturing industries and construction	59.72	0.06	0.13						59.91
3. Transport	471.68	3.08	5.08						479.84
4. Other sectors	339.23	1.05	1.01						341.29
5. Other	1.60	0.00	0.02						1.62
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	4.60	NO,NA	2.66	0.01	NO,NA	1.47	NA,NO	NA	8.73
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
D. Non-energy products from fuels and solvent use	3.43	NA	NA						3.43
E. Electronic Industry				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									
3. Agriculture	NE,NO	60.35	59.43						119.79
A. Enteric fermentation		51.48							51.48
B. Manure management		8.88	24.85						33.73
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	34.58						34.58
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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	0.02	0.20						-4.13
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	-0.94	NO	0.01						-0.93
C. Grassland	-5.47	NO	NO						-5.47
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	1.40	NO	0.11						1.52
F. Other land	0.73	NO	0.08						0.81
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.35	111.88	13.26						125.48
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		18.62	11.60						30.22
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:(2)									
International bunkers	2184.27	5.37	15.20						2204.83
Aviation	329.56	1.15	0.82						331.54
Navigation	1854.70	4.22	14.37						1873.29
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			23.20						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2778.45
Total CO_2 equivalent emissions with land use, land-use change and forestry									2774.32
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 10.10 Summary Report for CO_2 Equivalent Emissions in 1999

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)	2586.69	185.90	84.77	0.01	NO,NA	1.47	NA,NO	NA	2858.84
1. Energy	2587.69	5.73	10.45						2603.87
A. Fuel combustion (sectoral approach)	2587.69	5.73	10.45						2603.87
1. Energy industries	1709.52	1.66	3.96						1715.14
2. Manufacturing industries and construction	63.46	0.06	0.14						63.67
3. Transport	510.12	3.07	5.36						518.55
4. Other sectors	302.99	0.93	0.97						304.90
5. Other	1.60	0.00	0.02						1.62
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	3.79	NO,NA	2.89	0.01	NO,NA	1.47	NA,NO	NA	8.15
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
D. Non-energy products from fuels and solvent use	3.37	NA	NA						3.37
E. Electronic Industry				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									
3. Agriculture	NE,NO	62.42	58.91						121.33
A. Enteric fermentation		53.28							53.28
B. Manure management		9.14	25.75						34.89
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	33.16						33.16
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-5.14	0.02	0.16						-4.96
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	-0.94	NO	0.01						-0.94
C. Grassland	-5.72	NO	NO						-5.72
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	0.87	NO	0.07						0.94
F. Other land	0.73	NO	0.08						0.82
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.35	117.73	12.37						130.44
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		17.83	11.40						29.23
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:(2)									
International bunkers	2367.00	5.80	16.57						2389.36
Aviation	338.17	1.18	0.85						340.20
Navigation	2028.83	4.62	15.72						2049.17
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	0.00								0.00
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			23.43						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2863.79
Total CO_2 equivalent emissions with land use, land-use change and forestry									2858.84
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)	2502.02	190.46	84.02	6.70	NO,NA	1.47	NA,NO	NA	2784.67
1. Energy	2503.26	5.50	10.36						2519.12
A. Fuel combustion (sectoral approach)	2503.26	5.50	10.36						2519.12
1. Energy industries	1602.33	1.56	3.73						1607.62
2. Manufacturing industries and construction	62.44	0.06	0.14						62.64
3. Transport	535.78	2.95	5.45						544.17
4. Other sectors	301.11	0.93	1.03						303.06
5. Other	1.61	0.00	0.02						1.63
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	3.65	NO,NA	3.17	6.70	NO,NA	1.47	NA,NO	NA	14.99
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
D. Non-energy products from fuels and solvent use	3.35	NA	NA						3.35
E. Electronic Industry				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									
3. Agriculture	NE,NO	58.04	57.37						115.41
A. Enteric fermentation		49.44							49.44
B. Manure management		8.60	24.38						32.98
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	32.98						32.98
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-5.23	0.02	0.17						-5.05
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	-0.88	NO	0.00						-0.87
C. Grassland	-5.96	NO	NO						-5.96
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	0.90	NO	0.07						0.97
F. Other land	0.78	NO	0.09						0.86
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.35	126.90	12.96						140.20
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		18.65	11.83						30.48
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:(2)									
International bunkers	2567.48	6.25	18.22						2591.95
Aviation	325.29	1.14	0.81						327.24
Navigation	2242.19	5.11	17.41						2264.70
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			22.57						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2789.72
Total CO_2 equivalent emissions with land use, land-use change and forestry									2784.67
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	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)]	2645.06	194.19	81.74	11.26	NO,NA	1.49	NA,NO	NA	2933.73
1. Energy	2643.53	5.14	10.21						2658.89
A. Fuel combustion (sectoral approach)	2643.53	5.14	10.21						2658.89
1. Energy industries	1943.92	1.89	4.51						1950.33
2. Manufacturing industries and construction	56.46	0.05	0.13						56.64
3. Transport	432.89	2.57	4.88						440.34
4. Other sectors	208.58	0.62	0.68						209.88
5. Other	1.68	0.00	0.02						1.70
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	3.84	NO,NA	2.51	11.26	NO,NA	1.49	NA,NO	NA	19.10
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
D. Non-energy products from fuels and solvent use	3.44	NA	NA						3.44
E. Electronic Industry				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									
3. Agriculture	NE,NO	55.39	55.98						111.37
A. Enteric fermentation		47.07							47.07
B. Manure management		8.32	23.81						32.13
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	32.17						32.17
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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	0.02	0.17						-2.47
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	-0.91	NO	0.00						-0.91
C. Grassland	-2.95	NO	NO,NE						-2.95
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	0.57	NO	0.07						0.65
F. Other land	0.71	NO	0.09						0.80
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.35	133.63	12.86						146.84
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		17.97	11.58						29.55
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:[(2)]									
International bunkers	2596.96	6.25	18.69						2621.90
Aviation	274.65	0.96	0.69						276.29
Navigation	2322.31	5.29	18.01						2345.61
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			22.15						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2936.20
Total CO_2 equivalent emissions with land use, land-use change and forestry									2933.73
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	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)	2708.83	200.95	81.04	14.98	NO,NA	1.50	NA,NO	NA	3007.30
1. Energy	2683.69	5.07	10.32						2699.08
A. Fuel combustion (sectoral approach)	2683.69	5.07	10.32						2699.08
1. Energy industries	1956.86	1.91	4.55						1963.32
2. Manufacturing industries and construction	59.59	0.06	0.13						59.78
3. Transport	464.08	2.52	4.90						471.50
4. Other sectors	201.56	0.59	0.71						202.86
5. Other	1.59	0.00	0.02						1.61
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	3.75	NO,NA	2.74	14.98	NO,NA	1.50	NA,NO	NA	22.97
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
D. Non-energy products from fuels and solvent use	3.38	NA	NA						3.38
E. Electronic Industry				NO		NO	NO		NO
F. Product uses as ODS substitutes				14.98	NO				14.98
G. Other product manufacture and use			2.74		NO	1.50			4.23
H. Other									
3. Agriculture	NE,NO	55.21	55.40						110.61
A. Enteric fermentation		46.97							46.97
B. Manure management		8.24	23.94						32.18
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	31.46						31.46
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	21.04	0.02	0.18						21.24
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	24.53	NO	0.02						24.55
C. Grassland	-4.69	NO	NO						-4.69
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	0.57	NO	0.07						0.65
F. Other land	0.71	NO	0.09						0.80
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.35	140.65	12.41						153.40
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		18.09	11.70						29.79
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:(2)									
International bunkers	3026.85	7.20	22.14						3056.19
Aviation	254.37	0.89	0.64						255.90
Navigation	2772.48	6.31	21.50						2800.29
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			22.30						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2986.06
Total CO_2 equivalent emissions with land use, land-use change and forestry									3007.30
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	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)	2981.55	207.36	79.29	16.46	NO,NA	2.06	NA,NO	NA	3286.73
1. Energy	2956.56	5.33	11.14						2973.04
A. Fuel combustion (sectoral approach)	2956.56	5.33	11.14						2973.04
1. Energy industries	2159.66	2.11	5.03						2166.80
2. Manufacturing industries and construction	64.04	0.06	0.14						64.24
3. Transport	523.94	2.55	5.15						531.63
4. Other sectors	207.39	0.61	0.80						208.79
5. Other	1.55	0.00	0.02						1.57
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	3.62	NO,NA	2.57	16.46	NO,NA	2.06	NA,NO	NA	24.72
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
D. Non-energy products from fuels and solvent use	3.40	NA	NA						3.40
E. Electronic Industry				0.15		NO	NO		0.15
F. Product uses as ODS substitutes				16.31	NO				16.31
G. Other product manufacture and use			2.57		NO	2.06			4.63
H. Other									
3. Agriculture	NE,NO	53.10	52.56						105.66
A. Enteric fermentation		45.36							45.36
B. Manure management		7.74	22.69						30.43
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	29.87						29.87
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	21.02	0.02	0.19						21.24
A. Forest land	-0.01	NO	NO						-0.01
B. Cropland	24.50	NO	0.03						24.53
C. Grassland	-4.69	NO	NO						-4.69
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	0.57	NO	0.07						0.65
F. Other land	0.72	NO	0.09						0.81
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.35	148.90	12.82						162.07
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		18.21	11.77						29.98
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:(2)									
International bunkers	3203.34	7.60	23.50						3234.44
Aviation	255.45	0.89	0.64						256.98
Navigation	2947.89	6.71	22.86						2977.45
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			21.08						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3265.49
Total CO_2 equivalent emissions with land use, land-use change and forestry									3286.73
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	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)	2819.38	217.58	80.23	24.79	NO,NA	1.54	NA,NO	NA	3143.53
1. Energy	2816.16	4.99	10.65						2831.80
A. Fuel combustion (sectoral approach)	2816.16	4.99	10.65						2831.80
1. Energy industries	2065.53	2.01	4.80						2072.34
2. Manufacturing industries and construction	64.18	0.06	0.15						64.39
3. Transport	471.73	2.29	4.89						478.91
4. Other sectors	213.04	0.63	0.79						214.46
5. Other	1.66	0.00	0.02						1.68
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	3.49	NO,NA	2.56	24.79	NO,NA	1.54	NA,NO	NA	32.39
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
D. Non-energy products from fuels and solvent use	3.15	NA	NA						3.15
E. Electronic Industry				0.43		NO	NO		0.43
F. Product uses as ODS substitutes				24.36	NO				24.36
G. Other product manufacture and use			2.56		NO	1.54			4.11
H. Other									
3. Agriculture	NE,NO	55.52	53.79						109.31
A. Enteric fermentation		47.69							47.69
B. Manure management		7.83	23.56						31.38
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	30.23						30.23
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-0.58	0.02	0.19						-0.36
A. Forest land	-0.07	NO	NO						-0.07
B. Cropland	-1.05	NO	0.03						-1.03
C. Grassland	-0.70	NO	NO						-0.70
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	0.57	NO	0.07						0.65
F. Other land	0.74	NO	0.09						0.83
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.32	157.05	13.04						170.40
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		18.33	11.92						30.25
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:(2)									
International bunkers	3414.24	8.10	25.13						3447.47
Aviation	260.97	0.91	0.65						262.53
Navigation	3153.28	7.19	24.48						3184.94
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			21.53						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3143.90
Total CO_2 equivalent emissions with land use, land-use change and forestry									3143.53
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	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)	2643.89	219.56	76.60	38.36	NO,NA	1.56	NA,NO	NA	2979.97
1. Energy	2640.70	4.85	11.49						2657.05
A. Fuel combustion (sectoral approach)	2640.70	4.85	11.49						2657.05
1. Energy industries	1973.48	1.92	4.57						1979.97
2. Manufacturing industries and construction	27.76	0.03	0.06						27.85
3. Transport	511.53	2.46	5.40						519.39
4. Other sectors	126.27	0.45	1.44						128.15
5. Other	1.67	0.00	0.02						1.69
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	3.65	NO,NA	2.46	38.36	NO,NA	1.56	NA,NO	NA	46.03
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
D. Non-energy products from fuels and solvent use	3.34	NA	NA						3.34
E. Electronic Industry				NO		NO	NO		NO
F. Product uses as ODS substitutes				38.36	NO				38.36
G. Other product manufacture and use			2.46		NO	1.56			4.02
H. Other									
3. Agriculture	NE,NO	49.52	49.59						99.11
A. Enteric fermentation		43.09							43.09
B. Manure management		6.43	21.38						27.81
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	28.22						28.22
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-0.78	0.02	0.19						-0.56
A. Forest land	-0.07	NO	NO						-0.07
B. Cropland	-1.19	NO	0.03						-1.16
C. Grassland	-0.78	NO	NO						-0.78
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	0.57	NO	0.07						0.65
F. Other land	0.75	NO	0.09						0.85
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.32	165.17	12.86						178.34
A. Solid waste disposal	NO,NA	145.12							145.12
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		18.44	11.71						30.15
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:(2)									
International bunkers	2379.09	4.88	18.59						2402.55
Aviation	266.45	0.05	2.16						268.66
Navigation	2112.64	4.82	16.43						2133.89
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			19.78						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2980.54
Total CO_2 equivalent emissions with land use, land-use change and forestry									2979.97
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 10.17 Summary Report for CO_2 Equivalent Emissions in 2006

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)	2659.69	225.44	76.81	75.85	NO,NA	1.67	NA,NO	NA	3039.45
1. Energy	2657.14	4.77	11.22						2673.13
A. Fuel combustion (sectoral approach)	2657.14	4.77	11.22						2673.13
1. Energy industries	1994.88	1.94	4.62						2001.44
2. Manufacturing industries and construction	30.66	0.03	0.06						30.75
3. Transport	521.19	2.41	5.45						529.05
4. Other sectors	108.59	0.40	1.06						110.05
5. Other	1.82	0.00	0.02						1.84
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	4.20	NO,NA	2.23	75.85	NO,NA	1.67	NA,NO	NA	83.95
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
D. Non-energy products from fuels and solvent use	3.93	NA	NA						3.93
E. Electronic Industry				NO		0.09	NO		0.09
F. Product uses as ODS substitutes				75.85	NO				75.85
G. Other product manufacture and use			2.23		NO	1.57			3.81
H. Other									
3. Agriculture	NE,NO	48.46	49.80						98.26
A. Enteric fermentation		42.04							42.04
B. Manure management		6.43	21.19						27.62
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	28.61						28.61
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-1.97	0.02	0.19						-1.76
A. Forest land	-0.07	NO	NO						-0.07
B. Cropland	1.69	NO	0.03						1.72
C. Grassland	-4.77	NO	NO						-4.77
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	0.55	NO	0.07						0.62
F. Other land	0.70	NO	0.09						0.79
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.32	172.17	13.37						185.86
A. Solid waste disposal	NO,NA	151.62							151.62
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		18.47	11.88						30.34
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:(2)									
International bunkers	2671.73	5.56	20.88						2698.17
Aviation	258.90	0.05	2.10						261.04
Navigation	2412.83	5.51	18.78						2437.12
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			19.84						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3041.21
Total CO_2 equivalent emissions with land use, land-use change and forestry									3039.45
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	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)	2729.57	230.04	77.30	93.42	0.00	1.67	NA,NO	NA	3132.00
1. Energy	2727.63	4.82	11.73						2744.17
A. Fuel combustion (sectoral approach)	2727.63	4.82	11.73						2744.17
1. Energy industries	2028.67	1.97	4.70						2035.34
2. Manufacturing industries and construction	36.86	0.03	0.07						36.96
3. Transport	542.73	2.39	5.56						550.68
4. Other sectors	117.33	0.42	1.37						119.13
5. Other	2.05	0.00	0.02						2.07
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	3.35	NO,NA	2.89	93.42	0.00	1.67	NA,NO	NA	101.34
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
D. Non-energy products from fuels and solvent use	3.19	NA	NA						3.19
E. Electronic Industry				NO		0.09	NO		0.09
F. Product uses as ODS substitutes				93.42	NO				93.42
G. Other product manufacture and use			2.89		0.00	1.58			4.48
H. Other									
3. Agriculture	NE,NO	48.78	50.11						98.89
A. Enteric fermentation		42.26							42.26
B. Manure management		6.52	21.52						28.03
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	28.60						28.60
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-1.73	0.02	0.19						-1.51
A. Forest land	-0.07	NO	NO						-0.07
B. Cropland	1.68	NO	0.04						1.72
C. Grassland	-4.51	NO	NO						-4.51
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	0.55	NO	0.07						0.62
F. Other land	0.70	NO	0.09						0.79
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.32	176.42	12.38						189.11
A. Solid waste disposal	NO,NA	157.85							157.85
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		18.57	12.38						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:(2)									
International bunkers	2978.56	6.22	23.24						3008.02
Aviation	274.97	0.05	2.23						277.25
Navigation	2703.58	6.17	21.01						2730.77
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			20.07						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3133.52
Total CO_2 equivalent emissions with land use, land-use change and forestry									3132.00
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 10.19 Summary Report for CO_2 Equivalent Emissions in 2008

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)]	2751.63	147.76	72.60	109.96	0.00	1.84	NA,NO	NA	3083.79
1. Energy	2735.96	5.10	12.38						2753.45
A. Fuel combustion (sectoral approach)	2735.96	5.10	12.38						2753.45
1. Energy industries	1985.75	1.94	4.61						1992.30
2. Manufacturing industries and construction	36.86	0.03	0.07						36.96
3. Transport	591.35	2.70	6.30						600.35
4. Other sectors	119.89	0.42	1.37						121.69
5. Other	2.11	0.00	0.02						2.14
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	3.58	NO,NA	2.31	109.96	0.00	1.84	NA,NO	NA	117.69
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
D. Non-energy products from fuels and solvent use	3.47	NA	NA						3.47
E. Electronic Industry				NO		0.09	NO		0.09
F. Product uses as ODS substitutes				109.96	NO				109.96
G. Other product manufacture and use			2.31		0.00	1.75			4.06
H. Other									
3. Agriculture	NE,NO	46.57	46.12						92.70
A. Enteric fermentation		40.39							40.39
B. Manure management		6.18	19.99						26.17
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	26.13						26.13
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)]	11.74	0.02	0.18						11.94
A. Forest land	-0.07	NO	NO						-0.07
B. Cropland	15.01	NO	0.04						15.05
C. Grassland	-4.32	NO	NO						-4.32
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	0.49	NO	0.06						0.56
F. Other land	0.69	NO	0.08						0.77
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.35	96.06	11.60						108.01
A. Solid waste disposal	NO,NA	78.60							78.60
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		17.46	11.44						28.90
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:[(2)]									
International bunkers	3207.12	6.74	25.06						3238.92
Aviation	282.67	0.05	2.29						285.01
Navigation	2924.45	6.68	22.77						2953.90
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			18.37						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3071.84
Total CO_2 equivalent emissions with land use, land-use change and forestry									3083.79
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 10.20 Summary Report for CO_2 Equivalent Emissions in 2009

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)	2538.80	160.70	67.35	130.81	0.00	1.59	NA,NO	NA	2899.25
1. Energy	2523.23	4.43	10.84						2538.50
A. Fuel combustion (sectoral approach)	2523.23	4.43	10.84						2538.50
1. Energy industries	1864.55	1.82	4.33						1870.70
2. Manufacturing industries and construction	21.47	0.02	0.04						21.52
3. Transport	528.59	2.22	5.40						536.21
4. Other sectors	106.39	0.38	1.04						107.81
5. Other	2.23	0.00	0.02						2.26
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	1.83	130.81	0.00	1.59	NA,NO	NA	138.15
A. Mineral industry	0.11								0.11
B. Chemical industry	0.10	NO,NA	NO,NA	NO,NA	NA	NA	NA	NA	0.10
C. Metal industry	NO	NO				NO			NO
D. Non-energy products from fuels and solvent use	3.72	NA	NA						3.72
E. Electronic Industry				NO		0.09	NO		0.09
F. Product uses as ODS substitutes				130.81	NO				130.81
G. Other product manufacture and use			1.83		0.00	1.50			3.33
H. Other									
3. Agriculture	NE,NO	44.15	43.88						88.04
A. Enteric fermentation		38.19							38.19
B. Manure management		5.97	18.87						24.84
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	25.01						25.01
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	11.17	0.02	0.18						11.37
A. Forest land	-0.07	NO	NO						-0.07
B. Cropland	14.32	NO	0.04						14.36
C. Grassland	-4.13	NO	NO						-4.13
D. Wetlands	-0.07	0.02	NO						-0.05
E. Settlements	0.44	NO	0.05						0.49
F. Other land	0.68	NO	0.08						0.76
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.48	112.08	10.63						123.19
A. Solid waste disposal	NO,NA	96.59							96.59
B. Biological treatment of solid waste		NO	NO						NO
C. Incineration and open burning of waste	0.48	0.00	0.21						0.68
D. Waste water treatment and discharge		15.50	10.42						25.92
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:(2)									
International bunkers	3364.01	7.11	26.22						3397.34
Aviation	266.48	0.05	2.16						268.69
Navigation	3097.52	7.06	24.06						3128.65
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO								NO
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			17.31						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2887.88
Total CO_2 equivalent emissions with land use, land-use change and forestry									2899.25
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	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)	2600.14	147.76	65.35	141.07	0.00	1.79	NA,NO	NA	2956.11
1. Energy	2585.03	4.11	9.37						2598.51
A. Fuel combustion (sectoral approach)	2585.03	4.11	9.37						2598.51
1. Energy industries	1862.00	1.82	4.33						1868.14
2. Manufacturing industries and construction	30.75	0.03	0.06						30.84
3. Transport	559.43	1.58	3.51						564.52
4. Other sectors	130.41	0.68	1.45						132.54
5. Other	2.44	0.01	0.03						2.47
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	3.58	NO,NA	1.53	141.07	0.00	1.79	NA,NO	NA	147.96
A. Mineral industry	0.18								0.18
B. Chemical industry	0.10	NO,NA	NO,NA	NO,NA	NA	NA	NA	NA	0.10
C. Metal industry	NO	NO				NO			NO
D. Non-energy products from fuels and solvent use	3.30	NA	NA						3.30
E. Electronic Industry				NO		0.09	NO		0.09
F. Product uses as ODS substitutes				141.07	NO				141.07
G. Other product manufacture and use			1.53		0.00	1.69			3.22
H. Other									
3. Agriculture	NE,NO	42.84	43.37						86.21
A. Enteric fermentation		36.96							36.96
B. Manure management		5.88	18.21						24.09
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	25.16						25.16
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	11.01	NO	0.16						11.17
A. Forest land	-0.07	NO	NO						-0.07
B. Cropland	14.15	NO	0.04						14.20
C. Grassland	-4.02	NO	NO						-4.02
D. Wetlands	-0.02	NO	NO						-0.02
E. Settlements	0.34	NO	0.04						0.38
F. Other land	0.63	NO	0.07						0.70
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.52	100.81	10.92						112.26
A. Solid waste disposal	NO,NA	84.22							84.22
B. Biological treatment of solid waste		0.15	NO,NA						0.15
C. Incineration and open burning of waste	0.52	0.00	0.21						0.73
D. Waste water treatment and discharge		16.44	10.72						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:(2)									
International bunkers	4952.67	10.67	38.53						5001.88
Aviation	291.84	0.05	2.36						294.26
Navigation	4660.84	10.62	36.17						4707.62
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	5.11								5.11
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			16.87						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2944.94
Total CO_2 equivalent emissions with land use, land-use change and forestry									2956.11
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	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)	2575.04	146.07	58.30	163.86	0.00	4.69	NA,NO	NA	2947.95
1. Energy	2572.48	3.93	9.02						2585.43
A. Fuel combustion (sectoral approach)	2572.48	3.93	9.02						2585.43
1. Energy industries	1907.54	1.86	4.43						1913.82
2. Manufacturing industries and construction	15.27	0.01	0.03						15.31
3. Transport	550.20	1.47	3.47						555.15
4. Other sectors	96.27	0.58	1.06						97.92
5. Other	3.19	0.01	0.03						3.23
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	4.03	NO,NA	1.55	163.86	0.00	4.69	NA,NO	NA	174.13
A. Mineral industry	0.17								0.17
B. Chemical industry	0.13	NO,NA	NO,NA	NO,NA	NA	NA	NA	NA	0.13
C. Metal industry	NO	NO				NO			NO
D. Non-energy products from fuels and solvent use	3.73	NA	NA						3.73
E. Electronic Industry				NO		0.09	NO		0.09
F. Product uses as ODS substitutes				163.86	NO				163.86
G. Other product manufacture and use			1.55		0.00	4.59			6.15
H. Other									
3. Agriculture	NE,NO	41.38	41.71						83.08
A. Enteric fermentation		35.95							35.95
B. Manure management		5.43	17.44						22.87
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	24.26						24.26
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-2.15	NO	0.15						-2.00
A. Forest land	-0.07	NO	NO						-0.07
B. Cropland	0.79	NO	0.04						0.84
C. Grassland	-3.78	NO	NO						-3.78
D. Wetlands	-0.02	NO	NO						-0.02
E. Settlements	0.31	NO	0.04						0.35
F. Other land	0.62	NO	0.07						0.69
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.69	100.75	5.87						107.31
A. Solid waste disposal	NO,NA	95.50							95.50
B. Biological treatment of solid waste		0.88	NO,NA						0.88
C. Incineration and open burning of waste	0.69	0.00	0.18						0.87
D. Waste water treatment and discharge		4.37	5.68						10.06
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:(2)									
International bunkers	4595.40	9.83	35.75						4640.98
Aviation	302.88	0.05	2.45						305.39
Navigation	4292.53	9.78	33.30						4335.60
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	8.08								8.08
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			16.24						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2949.95
Total CO_2 equivalent emissions with land use, land-use change and forestry									2947.95
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	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)	2724.25	150.23	58.24	197.32	0.00	0.54	NA,NO	NA	3130.58
1. Energy	2720.41	4.11	9.04						2733.55
A. Fuel combustion (sectoral approach)	2720.41	4.11	9.04						2733.55
1. Energy industries	2018.99	1.97	4.69						2025.65
2. Manufacturing industries and construction	27.75	0.02	0.05						27.83
3. Transport	537.14	1.37	3.38						541.89
4. Other sectors	133.63	0.75	0.88						135.26
5. Other	2.90	0.01	0.03						2.93
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	5.19	NO,NA	2.13	197.32	0.00	0.54	NA,NO	NA	205.18
A. Mineral industry	0.90								0.90
B. Chemical industry	0.03	NO,NA	NO,NA	NO,NA	NA	NA	NA	NA	0.03
C. Metal industry	NO	NO				NO			NO
D. Non-energy products from fuels and solvent use	4.25	NA	NA						4.25
E. Electronic Industry				0.56		0.09	NO		0.65
F. Product uses as ODS substitutes				196.77	NO				196.77
G. Other product manufacture and use			2.13		0.00	0.45			2.58
H. Other									
3. Agriculture	NE,NO	42.24	42.80						85.04
A. Enteric fermentation		36.75							36.75
B. Manure management		5.49	17.75						23.24
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	25.05						25.05
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-1.96	NO	0.15						-1.81
A. Forest land	-0.07	NO	NO						-0.07
B. Cropland	0.78	NO	0.05						0.83
C. Grassland	-3.55	NO	NO						-3.55
D. Wetlands	-0.02	NO	NO						-0.02
E. Settlements	0.28	NO	0.03						0.32
F. Other land	0.61	NO	0.07						0.68
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.62	103.87	4.13						108.62
A. Solid waste disposal	NO,NA	102.83							102.83
B. Biological treatment of solid waste		1.04	NO,NA						1.04
C. Incineration and open burning of waste	0.62	0.00	0.17						0.78
D. Waste water treatment and discharge		NO,IE,NA	3.97						3.97
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:(2)									
International bunkers	4107.97	8.74	31.99						4148.71
Aviation	298.51	0.06	2.42						300.99
Navigation	3809.46	8.68	29.58						3847.72
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	14.97								14.97
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			16.64						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3132.39
Total CO_2 equivalent emissions with land use, land-use change and forestry									3130.58
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 10.24 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)	2377.42	147.80	56.08	209.46	0.00	2.77	NA,NO	NA	2793.53
1. Energy	2367.60	3.69	7.90						2379.19
A. Fuel combustion (sectoral approach)	2367.60	3.69	7.90						2379.19
1. Energy industries	1639.93	1.60	3.81						1645.33
2. Manufacturing industries and construction	53.48	0.05	0.12						53.65
3. Transport	537.01	1.28	3.35						541.64
4. Other sectors	133.90	0.75	0.59						135.25
5. Other	3.28	0.01	0.03						3.32
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	11.13	NO,NA	1.45	209.46	0.00	2.77	NA,NO	NA	224.81
A. Mineral industry	2.54								2.54
B. Chemical industry	0.03	NO,NA	NO,NA	NO,NA	NA	NA	NA	NA	0.03
C. Metal industry	NO	NO				NO			NO
D. Non-energy products from fuels and solvent use	8.56	NA	NA						8.56
E. Electronic Industry				1.33		0.09	NO		1.42
F. Product uses as ODS substitutes				208.13	NO				208.13
G. Other product manufacture and use			1.45		0.00	2.68			4.12
H. Other									
3. Agriculture	NE,NO	41.40	42.09						83.48
A. Enteric fermentation		35.96							35.96
B. Manure management		5.43	17.40						22.83
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	24.69						24.69
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-1.77	NO	0.14						-1.63
A. Forest land	-0.08	NO	NO						-0.08
B. Cropland	0.77	NO	0.05						0.82
C. Grassland	-3.31	NO	NO						-3.31
D. Wetlands	-0.02	NO	NO						-0.02
E. Settlements	0.26	NO	0.03						0.29
F. Other land	0.60	NO	0.06						0.66
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.46	102.71	4.50						107.68
A. Solid waste disposal	NO,NA	101.26							101.26
B. Biological treatment of solid waste		1.01	NO,NA						1.01
C. Incineration and open burning of waste	0.46	0.00	0.18						0.65
D. Waste water treatment and discharge		0.43	4.32						4.75
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:(2)									
International bunkers	4144.23	8.76	32.23						4185.22
Aviation	322.15	0.06	2.61						324.81
Navigation	3822.09	8.70	29.62						3860.41
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	21.13								21.13
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			16.30						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2795.16
Total CO_2 equivalent emissions with land use, land-use change and forestry									2793.53
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	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)]	2360.05	159.50	55.96	220.27	0.00	0.68	NA,NO	NA	2796.46
1. Energy	2352.79	3.72	7.96						2364.46
A. Fuel combustion (sectoral approach)	2352.79	3.72	7.96						2364.46
1. Energy industries	1599.32	1.56	3.71						1604.59
2. Manufacturing industries and construction	62.70	0.06	0.13						62.89
3. Transport	546.68	1.25	3.45						551.38
4. Other sectors	140.56	0.85	0.62						142.03
5. Other	3.54	0.01	0.03						3.58
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	10.95	NA,NO	0.88	220.27	0.00	0.68	NA,NO	NA	232.78
A. Mineral industry	2.48								2.48
B. Chemical industry	0.07	NO,NA	NO,NA	NA,NO	NA	NA	NA	NA	0.07
C. Metal industry	NO	NO							NO
D. Non-energy products from fuels and solvent use	8.41	NA	NA						8.41
E. Electronic Industry				0.34		0.09	NO		0.43
F. Product uses as ODS substitutes				219.93	NO				219.93
G. Other product manufacture and use			0.88		0.00	0.58			1.47
H. Other									
3. Agriculture	NE,NO	40.75	41.50						82.25
A. Enteric fermentation		35.37							35.37
B. Manure management		5.38	17.03						22.41
C. Rice cultivation		NA,NO							NA,NO
D. Agricultural soils		NA,NE	24.48						24.48
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)]	-4.33	NO	0.14						-4.20
A. Forest land	-0.08	NO	NO						-0.08
B. Cropland	-2.00	NO	0.05						-1.95
C. Grassland	-3.07	NO	NO						-3.07
D. Wetlands	-0.02	NO	NO						-0.02
E. Settlements	0.23	NO	0.03						0.26
F. Other land	0.59	NO	0.06						0.65
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.64	115.04	5.49						121.17
A. Solid waste disposal	NA,NO	111.95							111.95
B. Biological treatment of solid waste		0.91	NA,NO						0.91
C. Incineration and open burning of waste	0.64	0.00	0.17						0.82
D. Waste water treatment and discharge		2.18	5.31						7.49
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:[(2)]									
International bunkers	4278.86	9.03	33.29						4321.17
Aviation	340.42	0.06	2.76						343.24
Navigation	3938.44	8.96	30.53						3977.93
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	29.00								29.00
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			15.90						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2800.66
Total CO_2 equivalent emissions with land use, land-use change and forestry									2796.46
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	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)]	1661.32	171.09	55.64	230.78	0.00	0.28	NA,NO	NA	2119.11
1. Energy	1655.18	3.08	6.42						1664.68
A. Fuel combustion (sectoral approach)	1655.18	3.08	6.42						1664.68
1. Energy industries	850.11	0.83	1.97						852.91
2. Manufacturing industries and construction	59.70	0.06	0.13						59.89
3. Transport	580.57	1.26	3.62						585.46
4. Other sectors	160.94	0.93	0.66						162.53
5. Other	3.86	0.01	0.04						3.90
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	9.54	NA,NO	0.66	230.78	0.00	0.28	NA,NO	NA	241.26
A. Mineral industry	1.89								1.89
B. Chemical industry	0.07	NO,NA	NO,NA	NA,NO	NA	NA	NA	NA	0.07
C. Metal industry	NO	NO							NO
D. Non-energy products from fuels and solvent use	7.58	NA	NA						7.58
E. Electronic Industry				0.24		0.09	NO		0.33
F. Product uses as ODS substitutes				230.54	NO				230.54
G. Other product manufacture and use			0.66		0.00	0.19			0.85
H. Other									
3. Agriculture	NE,NO	40.15	41.80						81.95
A. Enteric fermentation		35.01							35.01
B. Manure management		5.14	17.07						22.21
C. Rice cultivation		NA,NO							NA,NO
D. Agricultural soils		NA,NE	24.73						24.73
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)]	-3.97	NO	0.13						-3.84
A. Forest land	-0.10	NO	NO						-0.10
B. Cropland	-1.81	NO	0.05						-1.76
C. Grassland	-2.83	NO	NO						-2.83
D. Wetlands	-0.02	NO	NO						-0.02
E. Settlements	0.21	NO	0.02						0.23
F. Other land	0.58	NO	0.06						0.64
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.57	127.86	6.62						135.05
A. Solid waste disposal	NA,NO	121.83							121.83
B. Biological treatment of solid waste		0.83	NA,NO						0.83
C. Incineration and open burning of waste	0.57	0.00	0.16						0.73
D. Waste water treatment and discharge		5.20	6.47						11.67
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:[(2)]									
International bunkers	5300.61	11.33	41.24						5353.18
Aviation	357.68	0.07	2.90						360.65
Navigation	4942.93	11.26	38.34						4992.54
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	27.57								27.57
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			16.14						
Indirect CO_2[(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2122.95
Total CO_2 equivalent emissions with land use, land-use change and forestry									2119.11
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 10.27 Summary Report for CO_2 Equivalent Emissions in 2016

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)]	1352.40	181.00	54.13	244.29	0.00	0.14	NO,NA	NA	1831.96
1. Energy	1348.42	2.69	5.73						1356.84
A. Fuel combustion (sectoral approach)	1348.42	2.69	5.73						1356.84
1. Energy industries	557.55	0.54	1.29						559.38
2. Manufacturing industries and construction	59.51	0.05	0.13						59.69
3. Transport	580.40	1.22	3.64						585.25
4. Other sectors	146.98	0.88	0.64						148.50
5. Other	3.97	0.01	0.04						4.02
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	7.41	NO,NA	2.00	244.29	0.00	0.14	NO,NA	NA	253.84
A. Mineral industry	1.13								1.13
B. Chemical industry	0.03	NO,NA	NO,NA	NO,NA	NA	NA	NA	NA	0.03
C. Metal industry	NO	NO							NO
D. Non-energy products from fuels and solvent use	6.25	NA	NA						6.25
E. Electronic Industry				0.10		0.09	NO		0.19
F. Product uses as ODS substitutes				244.19	NO				244.19
G. Other product manufacture and use			2.00		0.00	0.05			2.05
H. Other									
3. Agriculture	NO,NE	39.66	39.99						79.65
A. Enteric fermentation		34.69							34.69
B. Manure management		4.96	16.26						21.22
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	23.74						23.74
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)]	-3.95	NO	0.13						-3.82
A. Forest land	-0.10	NO	NO						-0.10
B. Cropland	-2.00	NO	0.05						-1.95
C. Grassland	-2.59	NO	NO						-2.59
D. Wetlands	-0.02	NO	NO						-0.02
E. Settlements	0.18	NO	0.02						0.20
F. Other land	0.57	NO	0.06						0.63
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.52	138.65	6.28						145.45
A. Solid waste disposal	NO,NA	132.51							132.51
B. Biological treatment of solid waste		2.04	NO,NA						2.04
C. Incineration and open burning of waste	0.52	0.00	0.14						0.67
D. Waste water treatment and discharge		4.09	6.13						10.23
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									
Memo items:[(2)]									
International bunkers	6032.10	12.91	46.89						6091.90
Aviation	392.30	0.07	3.18						395.54
Navigation	5639.80	12.84	43.71						5696.35
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	27.53								27.53
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			15.24						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									1835.78
Total CO_2 equivalent emissions with land use, land-use change and forestry									1831.96
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 10.28 Summary Report for CO_2 Equivalent Emissions in 2017

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)]	1528.88	177.88	52.65	255.77	0.00	0.99	NO,NA	NA	2016.17
1. Energy	1525.51	2.54	5.77						1533.82
A. Fuel combustion (sectoral approach)	1525.51	2.54	5.77						1533.82
1. Energy industries	717.61	0.41	0.68						718.71
2. Manufacturing industries and construction	53.50	0.05	0.11						53.66
3. Transport	601.15	1.20	3.79						606.15
4. Other sectors	149.15	0.87	1.14						151.16
5. Other	4.09	0.01	0.04						4.14
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	4.86	NO,NA	0.79	255.77	0.00	0.99	NO,NA	NA	262.41
A. Mineral industry	0.29								0.29
B. Chemical industry	0.04	NO,NA	NO,NA	NO,NA	NA	NA	NA	NA	0.04
C. Metal industry	NO	NO							NO
D. Non-energy products from fuels and solvent use	4.53	NA	NA						4.53
E. Electronic Industry				0.30		0.09	NO		0.39
F. Product uses as ODS substitutes				255.47	NO				255.47
G. Other product manufacture and use			0.79		0.00	0.90			1.69
H. Other									
3. Agriculture	NO,NE	38.39	39.72						78.12
A. Enteric fermentation		33.59							33.59
B. Manure management		4.81	15.95						20.75
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	23.78						23.78
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)]	-2.00	NO	0.12						-1.88
A. Forest land	-0.10	NO	NO						-0.10
B. Cropland	-0.25	NO	0.05						-0.20
C. Grassland	-2.35	NO	NO						-2.35
D. Wetlands	-0.02	NO	NO						-0.02
E. Settlements	0.15	NO	0.02						0.17
F. Other land	0.56	NO	0.05						0.61
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.51	136.95	6.24						143.70
A. Solid waste disposal	NO,NA	131.21							131.21
B. Biological treatment of solid waste		2.18	NO,NA						2.18
C. Incineration and open burning of waste	0.51	0.00	0.14						0.65
D. Waste water treatment and discharge		3.56	6.10						9.66
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									
Memo items:[(2)]									
International bunkers	7305.08	15.72	56.78						7377.58
Aviation	434.01	0.09	3.51						437.61
Navigation	6871.07	15.64	53.26						6939.97
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	30.88								30.88
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			15.18						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2018.05
Total CO_2 equivalent emissions with land use, land-use change and forestry									2016.17
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 10.29 Summary Report for CO_2 Equivalent Emissions in 2018

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)]	1545.69	184.95	52.65	245.29	0.00	0.30	NO,NA	NA	2028.87
1. Energy	1540.84	2.34	5.90						1549.09
A. Fuel combustion (sectoral approach)	1540.84	2.34	5.90						1549.09
1. Energy industries	697.33	0.32	0.40						698.06
2. Manufacturing industries and construction	43.21	0.04	0.08						43.33
3. Transport	665.98	1.17	4.24						671.39
4. Other sectors	130.66	0.80	1.14						132.61
5. Other	3.66	0.01	0.03						3.70
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	5.55	NO,NA	0.92	245.29	0.00	0.30	NO,NA	NA	252.06
A. Mineral industry	0.20								0.20
B. Chemical industry	0.04	NO,NA	NO,NA	NO,NA	NA	NA	NA	NA	0.04
C. Metal industry	NO	NO							NO
D. Non-energy products from fuels and solvent use	5.31	NA	NA						5.31
E. Electronic Industry				0.30		NO	NO		0.30
F. Product uses as ODS substitutes				244.99	NO				244.99
G. Other product manufacture and use			0.92		0.00	0.30			1.22
H. Other									
3. Agriculture	NO,NE	38.59	39.85						78.44
A. Enteric fermentation		33.72							33.72
B. Manure management		4.87	16.06						20.93
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	23.79						23.79
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)]	-1.26	NO	0.12						-1.14
A. Forest land	-0.10	NO	NO						-0.10
B. Cropland	0.29	NO	0.06						0.35
C. Grassland	-2.11	NO	NO						-2.11
D. Wetlands	-0.02	NO	NO						-0.02
E. Settlements	0.13	NO	0.01						0.14
F. Other land	0.55	NO	0.05						0.60
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.55	144.02	5.86						150.43
A. Solid waste disposal	NO,NA	138.82							138.82
B. Biological treatment of solid waste		2.40	NO,NA						2.40
C. Incineration and open burning of waste	0.55	0.00	0.13						0.69
D. Waste water treatment and discharge		2.80	5.72						8.52
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									
Memo items:[(2)]									
International bunkers	7580.29	16.27	58.95						7655.52
Aviation	478.92	0.10	3.88						482.89
Navigation	7101.38	16.17	55.08						7172.62
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	39.96								39.96
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			15.30						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2030.01
Total CO_2 equivalent emissions with land use, land-use change and forestry									2028.87
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 10.30 Summary Report for CO_2 Equivalent Emissions in 2019

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)	1647.70	192.11	55.49	234.77	0.00	0.33	NO,NA	NA	2130.39
1. Energy	1643.86	2.56	6.63						1653.05
A. Fuel combustion (sectoral approach)	1643.86	2.56	6.63						1653.05
1. Energy industries	739.17	0.35	0.46						739.98
2. Manufacturing industries and construction	47.12	0.04	0.09						47.25
3. Transport	708.63	1.21	4.54						714.37
4. Other sectors	145.32	0.95	1.51						147.78
5. Other	3.63	0.01	0.03						3.67
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	4.77	NO,NA	1.39	234.77	0.00	0.33	NO,NA	NA	241.25
A. Mineral industry	0.18								0.18
B. Chemical industry	0.03	NO,NA	NO,NA	NO,NA	NA	NA	NA	NA	0.03
C. Metal industry	NO	NO							NO
D. Non-energy products from fuels and solvent use	4.56	NA	NA						4.56
E. Electronic Industry				0.06		NO	NO		0.06
F. Product uses as ODS substitutes				234.70	NO				234.70
G. Other product manufacture and use			1.39		0.00	0.33			1.71
H. Other									
3. Agriculture	NO,NE	38.73	39.85						78.58
A. Enteric fermentation		33.87							33.87
B. Manure management		4.86	16.00						20.86
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	23.86						23.86
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)	-1.49	NO	0.12						-1.37
A. Forest land	-0.14	NO	NO						-0.14
B. Cropland	-0.11	NO	0.06						-0.05
C. Grassland	-1.87	NO	NO						-1.87
D. Wetlands	-0.02	NO	NO						-0.02
E. Settlements	0.10	NO	0.01						0.11
F. Other land	0.54	NO	0.05						0.59
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.55	150.81	7.50						158.87
A. Solid waste disposal	NO,NA	141.42							141.42
B. Biological treatment of solid waste		2.01	NO,NA						2.01
C. Incineration and open burning of waste	0.55	0.00	0.14						0.69
D. Waste water treatment and discharge		7.38	7.37						14.75
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									
Memo items:(2)									
International bunkers	7791.97	16.68	60.62						7869.27
Aviation	514.23	0.10	4.16						518.49
Navigation	7277.74	16.58	56.45						7350.77
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	44.40								44.40
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			15.23						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2131.76
Total CO_2 equivalent emissions with land use, land-use change and forestry									2130.39
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 10.31 Summary Report for CO_2 Equivalent Emissions in 2020

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)]	1597.28	193.81	55.58	272.34	0.00	0.40	NO,NA	NA	2119.41
1. Energy	1594.47	2.37	5.49						1602.33
A. Fuel combustion (sectoral approach)	1594.47	2.37	5.49						1602.33
1. Energy industries	809.85	0.41	0.58						810.83
2. Manufacturing industries and construction	56.74	0.05	0.12						56.91
3. Transport	565.89	0.97	3.73						570.59
4. Other sectors	157.61	0.93	1.03						159.57
5. Other	4.39	0.01	0.04						4.44
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	4.46	NO,NA	2.42	272.34	0.00	0.40	NO,NA	NA	279.62
A. Mineral industry	0.19								0.19
B. Chemical industry	0.00	NO,NA	NO,NA	NO,NA	NA	NA	NA	NA	0.00
C. Metal industry	NO	NO							NO
D. Non-energy products from fuels and solvent use	4.27	NA	NA						4.27
E. Electronic Industry				0.18		NO	NO		0.18
F. Product uses as ODS substitutes				272.16	NO				272.16
G. Other product manufacture and use			2.42		0.00	0.40			2.82
H. Other									
3. Agriculture	NO,NE	39.53	40.71						80.24
A. Enteric fermentation		34.52							34.52
B. Manure management		5.00	16.47						21.47
C. Rice cultivation		NO,NA							NO,NA
D. Agricultural soils		NA,NE	24.24						24.24
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
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)]	-2.29	NO	0.11						-2.18
A. Forest land	-0.29	NO	NO						-0.29
B. Cropland	-0.97	NO	0.06						-0.91
C. Grassland	-1.63	NO	NO						-1.63
D. Wetlands	-0.02	NO	NO						-0.02
E. Settlements	0.07	NO	0.01						0.08
F. Other land	0.53	NO	0.05						0.57
G. Harvested wood products	NO								NO
H. Other	NO	NO	NO						NO
5. Waste	0.65	151.92	6.84						159.41
A. Solid waste disposal	NO,NA	145.47							145.47
B. Biological treatment of solid waste		0.81	NO,NA						0.81
C. Incineration and open burning of waste	0.65	0.00	0.16						0.81
D. Waste water treatment and discharge		5.63	6.68						12.31
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									
Memo items:[(2)]									
International bunkers	7225.41	16.05	56.15						7297.61
Aviation	198.17	0.04	1.60						199.81
Navigation	7027.24	16.01	54.54						7097.80
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	53.36								53.36
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			15.69						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									2121.59
Total CO_2 equivalent emissions with land use, land-use change and forestry									2119.41
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

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 10.32 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	2394.19	2394.19	0.00
CO_2 emissions with net CO_2 from LULUCF	2385.86	2385.86	0.00
CH_4 emissions without CH_4 from LULUCF	125.19	125.19	0.00
CH_4 emissions with CH_4 from LULUCF	125.21	125.21	0.00
N_2O emissions without N_2O from LULUCF	79.89	79.89	0.00
N_2O emissions with N_2O from LULUCF	80.04	80.04	0.00
HFCs	NO,NE,NA	NO,NE,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	NA	0.00
Total (without LULUCF)	2599.28	2599.28	0.00
Total (with LULUCF)	2591.13	2591.13	0.00

Table 10.33 Emission Trends by Gas (in kt equivalent to CO2) for 1991.

GREENHOUSE GAS EMISSIONS	Base year(3)	1991	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2238.11	-6.52
CO_2 emissions with net CO_2 from LULUCF	2385.86	2229.54	-6.55
CH_4 emissions without CH_4 from LULUCF	125.19	133.21	6.40
CH_4 emissions with CH_4 from LULUCF	125.21	133.23	6.40
N_2O emissions without N_2O from LULUCF	79.89	80.88	1.24
N_2O emissions with N_2O from LULUCF	80.04	81.04	1.25
HFCs	NO,NE,NA	NO,NE,NA	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	0.01	-98.95
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2452.20	-5.66
Total (with LULUCF)	2591.13	2443.82	-5.69

Table 10.34 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	2394.19	2292.08	-4.27
CO_2 emissions with net CO_2 from LULUCF	2385.86	2286.75	-4.15
CH_4 emissions without CH_4 from LULUCF	125.19	140.87	12.53
CH_4 emissions with CH_4 from LULUCF	125.21	140.89	12.52
N_2O emissions without N_2O from LULUCF	79.89	82.80	3.65
N_2O emissions with N_2O from LULUCF	80.04	82.97	3.66
HFCs	NO,NE,NA	NO,NE,NA	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.43	-29.03
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2517.18	-3.16
Total (with LULUCF)	2591.13	2512.04	-3.05

Table 10.35 Emission Trends by Gas (in kt equivalent to CO2) for 1993.

GREENHOUSE GAS EMISSIONS	Base year(3)	1993	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2870.40	19.89
CO_2 emissions with net CO_2 from LULUCF	2385.86	2865.23	20.09
CH_4 emissions without CH_4 from LULUCF	125.19	147.92	18.16
CH_4 emissions with CH_4 from LULUCF	125.21	147.95	18.16
N_2O emissions without N_2O from LULUCF	79.89	85.51	7.04
N_2O emissions with N_2O from LULUCF	80.04	85.69	7.06
HFCs	NO,NE,NA	NO,NE,NA	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.43	-52.60

NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	3105.26	19.47
Total (with LULUCF)	2591.13	3100.29	19.65

Table 10.36 Emission Trends by Gas (in kt equivalent to CO2) for 1994.

GREENHOUSE GAS EMISSIONS	Base year(3)	1994	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2647.93	10.60
CO_2 emissions with net CO_2 from LULUCF	2385.86	2643.09	10.78
CH_4 emissions without CH_4 from LULUCF	125.19	153.23	22.40
CH_4 emissions with CH_4 from LULUCF	125.21	153.26	22.40
N_2O emissions without N_2O from LULUCF	79.89	83.95	5.09
N_2O emissions with N_2O from LULUCF	80.04	84.14	5.11
HFCs	NO,NE,NA	0.00	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.43	-64.31
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2886.54	11.05
Total (with LULUCF)	2591.13	2881.92	11.22

Table 10.37 Emission Trends by Gas (in kt equivalent to CO2) for 1995.

GREENHOUSE GAS EMISSIONS	Base year(3)	1995	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2439.42	1.89
CO_2 emissions with net CO_2 from LULUCF	2385.86	2435.10	2.06
CH_4 emissions without CH_4 from LULUCF	125.19	157.23	25.59
CH_4 emissions with CH_4 from LULUCF	125.21	157.25	25.59
N_2O emissions without N_2O from LULUCF	79.89	84.33	5.55
N_2O emissions with N_2O from LULUCF	80.04	84.52	5.59
HFCs	NO,NE,NA	0.00	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.44	-71.33
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2682.41	3.20
Total (with LULUCF)	2591.13	2678.31	3.36

Table 10.38 Emission Trends by Gas (in kt equivalent to CO2) for 1996.

GREENHOUSE GAS EMISSIONS	Base year(3)	1996	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2550.53	6.53
CO_2 emissions with net CO_2 from LULUCF	2385.86	2546.18	6.72
CH_4 emissions without CH_4 from LULUCF	125.19	165.91	32.53
CH_4 emissions with CH_4 from LULUCF	125.21	165.93	32.52
N_2O emissions without N_2O from LULUCF	79.89	83.56	4.60
N_2O emissions with N_2O from LULUCF	80.04	83.75	4.64
HFCs	NO,NE,NA	0.00	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.45	-75.92
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2801.45	7.78
Total (with LULUCF)	2591.13	2797.32	7.96

Table 10.39 Emission Trends by Gas (in kt equivalent to CO2) for 1997.

GREENHOUSE GAS EMISSIONS	Base year(3)	1997	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2556.73	6.79
CO_2 emissions with net CO_2 from LULUCF	2385.86	2552.15	6.97
CH_4 emissions without CH_4 from LULUCF	125.19	172.97	38.17
CH_4 emissions with CH_4 from LULUCF	125.21	173.00	38.16
N_2O emissions without N_2O from LULUCF	79.89	84.79	6.14
N_2O emissions with N_2O from LULUCF	80.04	84.98	6.17
HFCs	NO,NE,NA	0.00	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.45	-79.36
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2815.94	8.34
Total (with LULUCF)	2591.13	2811.58	8.51

Table 10.40 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	2394.19	2513.58	4.99
CO_2 emissions with net CO_2 from LULUCF	2385.86	2509.23	5.17
CH_4 emissions without CH_4 from LULUCF	125.19	178.01	42.19
CH_4 emissions with CH_4 from LULUCF	125.21	178.03	42.18
N_2O emissions without N_2O from LULUCF	79.89	85.38	6.88
N_2O emissions with N_2O from LULUCF	80.04	85.59	6.92
HFCs	NO,NE,NA	0.01	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.47	-81.71
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2778.45	6.89
Total (with LULUCF)	2591.13	2774.32	7.07

Table 10.41 Emission Trends by Gas (in kt equivalent to CO2) for 1999.

GREENHOUSE GAS EMISSIONS	Base year(3)	1999	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2591.82	8.25
CO_2 emissions with net CO_2 from LULUCF	2385.86	2586.69	8.42
CH_4 emissions without CH_4 from LULUCF	125.19	185.88	48.48
CH_4 emissions with CH_4 from LULUCF	125.21	185.90	48.47
N_2O emissions without N_2O from LULUCF	79.89	84.62	5.92
N_2O emissions with N_2O from LULUCF	80.04	84.77	5.91
HFCs	NO,NE,NA	0.01	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.47	-83.74
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2863.79	10.18
Total (with LULUCF)	2591.13	2858.84	10.33

Table 10.42 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	2394.19	2507.26	4.72
CO_2 emissions with net CO_2 from LULUCF	2385.86	2502.02	4.87
CH_4 emissions without CH_4 from LULUCF	125.19	190.44	52.12
CH_4 emissions with CH_4 from LULUCF	125.21	190.46	52.11
N_2O emissions without N_2O from LULUCF	79.89	83.85	4.96
N_2O emissions with N_2O from LULUCF	80.04	84.02	4.96
HFCs	NO,NE,NA	6.70	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.47	-85.32
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2789.72	7.33
Total (with LULUCF)	2591.13	2784.67	7.47

Table 10.43 Emission Trends by Gas (in kt equivalent to CO2) for 2001.

GREENHOUSE GAS EMISSIONS	Base year(3)	2001	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2647.72	10.59
CO_2 emissions with net CO_2 from LULUCF	2385.86	2645.06	10.86
CH_4 emissions without CH_4 from LULUCF	125.19	194.16	55.10
CH_4 emissions with CH_4 from LULUCF	125.21	194.19	55.08
N_2O emissions without N_2O from LULUCF	79.89	81.57	2.10
N_2O emissions with N_2O from LULUCF	80.04	81.74	2.12
HFCs	NO,NE,NA	11.26	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.49	-86.47
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2936.20	12.96
Total (with LULUCF)	2591.13	2933.73	13.22

Table 10.44 Emission Trends by Gas (in kt equivalent to CO2) for 2002.

GREENHOUSE GAS EMISSIONS	Base year(3)	2002	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2687.78	12.26
CO_2 emissions with net CO_2 from LULUCF	2385.86	2708.83	13.54
CH_4 emissions without CH_4 from LULUCF	125.19	200.93	60.50
CH_4 emissions with CH_4 from LULUCF	125.21	200.95	60.49
N_2O emissions without N_2O from LULUCF	79.89	80.86	1.22
N_2O emissions with N_2O from LULUCF	80.04	81.04	1.25
HFCs	NO,NE,NA	14.98	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.50	-87.55
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2986.06	14.88
Total (with LULUCF)	2591.13	3007.30	16.06

Table 10.45 Emission Trends by Gas (in kt equivalent to CO2) for 2003.

GREENHOUSE GAS EMISSIONS	Base year(3)	2003	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2960.53	23.65
CO_2 emissions with net CO_2 from LULUCF	2385.86	2981.55	24.97
CH_4 emissions without CH_4 from LULUCF	125.19	207.33	65.61
CH_4 emissions with CH_4 from LULUCF	125.21	207.36	65.60
N_2O emissions without N_2O from LULUCF	79.89	79.10	-0.99
N_2O emissions with N_2O from LULUCF	80.04	79.29	-0.94
HFCs	NO,NE,NA	16.46	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	2.06	-84.15
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	3265.49	25.63
Total (with LULUCF)	2591.13	3286.73	26.85

Table 10.46 Emission Trends by Gas (in kt equivalent to CO2) for 2004.

GREENHOUSE GAS EMISSIONS	Base year(3)	2004	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2819.96	17.78
CO_2 emissions with net CO_2 from LULUCF	2385.86	2819.38	18.17
CH_4 emissions without CH_4 from LULUCF	125.19	217.56	73.78
CH_4 emissions with CH_4 from LULUCF	125.21	217.58	73.77
N_2O emissions without N_2O from LULUCF	79.89	80.04	0.19
N_2O emissions with N_2O from LULUCF	80.04	80.23	0.24
HFCs	NO,NE,NA	24.79	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.54	-88.98
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	3143.90	20.95
Total (with LULUCF)	2591.13	3143.53	21.32

Table 10.47 Emission Trends by Gas (in kt equivalent to CO2) for 2005.

GREENHOUSE GAS EMISSIONS	Base year(3)	2005	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2644.67	10.46
CO_2 emissions with net CO_2 from LULUCF	2385.86	2643.89	10.81
CH_4 emissions without CH_4 from LULUCF	125.19	219.54	75.36
CH_4 emissions with CH_4 from LULUCF	125.21	219.56	75.35
N_2O emissions without N_2O from LULUCF	79.89	76.40	-4.36
N_2O emissions with N_2O from LULUCF	80.04	76.60	-4.31
HFCs	NO,NE,NA	38.36	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.56	-89.58
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2980.54	14.67
Total (with LULUCF)	2591.13	2979.97	15.01

Table 10.48 Emission Trends by Gas (in kt equivalent to CO2) for 2006.

GREENHOUSE GAS EMISSIONS	Base year(3)	2006	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2661.66	11.17
CO_2 emissions with net CO_2 from LULUCF	2385.86	2659.69	11.48
CH_4 emissions without CH_4 from LULUCF	125.19	225.41	80.06
CH_4 emissions with CH_4 from LULUCF	125.21	225.44	80.04
N_2O emissions without N_2O from LULUCF	79.89	76.62	-4.09
N_2O emissions with N_2O from LULUCF	80.04	76.81	-4.04
HFCs	NO,NE,NA	75.85	NO,NE,NA
PFCs	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.67	-89.60
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	3041.21	17.00
Total (with LULUCF)	2591.13	3039.45	17.30

Table 10.49 Emission Trends by Gas (in kt equivalent to CO2) for 2007.

GREENHOUSE GAS EMISSIONS	Base year(3)	2007	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2731.30	14.08
CO_2 emissions with net CO_2 from LULUCF	2385.86	2729.57	14.41
CH_4 emissions without CH_4 from LULUCF	125.19	230.02	83.74
CH_4 emissions with CH_4 from LULUCF	125.21	230.04	83.72
N_2O emissions without N_2O from LULUCF	79.89	77.11	-3.48
N_2O emissions with N_2O from LULUCF	80.04	77.30	-3.43
HFCs	NO,NE,NA	93.42	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.67	-90.16
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	3133.52	20.55
Total (with LULUCF)	2591.13	3132.00	20.87

Table 10.50 Emission Trends by Gas (in kt equivalent to CO2) for 2008.

GREENHOUSE GAS EMISSIONS	Base year(3)	2008	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2739.89	14.44
CO_2 emissions with net CO_2 from LULUCF	2385.86	2751.63	15.33
CH_4 emissions without CH_4 from LULUCF	125.19	147.73	18.01
CH_4 emissions with CH_4 from LULUCF	125.21	147.76	18.01
N_2O emissions without N_2O from LULUCF	79.89	72.41	-9.36
N_2O emissions with N_2O from LULUCF	80.04	72.60	-9.30
HFCs	NO,NE,NA	109.96	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.84	-89.78
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	3071.84	18.18
Total (with LULUCF)	2591.13	3083.79	19.01

Table 10.51 Emission Trends by Gas (in kt equivalent to CO2) for 2009.

GREENHOUSE GAS EMISSIONS	Base year(3)	2009	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2527.63	5.57
CO_2 emissions with net CO_2 from LULUCF	2385.86	2538.80	6.41
CH_4 emissions without CH_4 from LULUCF	125.19	160.67	28.34
CH_4 emissions with CH_4 from LULUCF	125.21	160.70	28.34
N_2O emissions without N_2O from LULUCF	79.89	67.18	-15.91
N_2O emissions with N_2O from LULUCF	80.04	67.35	-15.86
HFCs	NO,NE,NA	130.81	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.59	-91.65
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2887.88	11.10
Total (with LULUCF)	2591.13	2899.25	11.89

Table 10.52 Emission Trends by Gas (in kt equivalent to CO2) for 2010.

GREENHOUSE GAS EMISSIONS	Base year(3)	2010	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2589.13	8.14
CO_2 emissions with net CO_2 from LULUCF	2385.86	2600.14	8.98
CH_4 emissions without CH_4 from LULUCF	125.19	147.76	18.03
CH_4 emissions with CH_4 from LULUCF	125.21	147.76	18.01
N_2O emissions without N_2O from LULUCF	79.89	65.20	-18.39
N_2O emissions with N_2O from LULUCF	80.04	65.35	-18.35
HFCs	NO,NE,NA	141.07	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	1.79	-91.07
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2944.94	13.30
Total (with LULUCF)	2591.13	2956.11	14.09

Table 10.53 Emission Trends by Gas (in kt equivalent to CO2) for 2011.

GREENHOUSE GAS EMISSIONS	Base year(3)	2011	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2577.20	7.64
CO_2 emissions with net CO_2 from LULUCF	2385.86	2575.04	7.93
CH_4 emissions without CH_4 from LULUCF	125.19	146.07	16.68
CH_4 emissions with CH_4 from LULUCF	125.21	146.07	16.65
N_2O emissions without N_2O from LULUCF	79.89	58.15	-27.22
N_2O emissions with N_2O from LULUCF	80.04	58.30	-27.17
HFCs	NO,NE,NA	163.86	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	4.69	-77.70
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2949.95	13.49
Total (with LULUCF)	2591.13	2947.95	13.77

Table 10.54 Emission Trends by Gas (in kt equivalent to CO2) for 2012.

GREENHOUSE GAS EMISSIONS	Base year(3)	2012	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2726.21	13.87
CO_2 emissions with net CO_2 from LULUCF	2385.86	2724.25	14.18
CH_4 emissions without CH_4 from LULUCF	125.19	150.23	20.00
CH_4 emissions with CH_4 from LULUCF	125.21	150.23	19.98
N_2O emissions without N_2O from LULUCF	79.89	58.09	-27.28
N_2O emissions with N_2O from LULUCF	80.04	58.24	-27.24
HFCs	NO,NE,NA	197.32	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	0.54	-97.53
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	3132.39	20.51
Total (with LULUCF)	2591.13	3130.58	20.82

Table 10.55 Emission Trends by Gas (in kt equivalent to CO2) for 2013.

GREENHOUSE GAS EMISSIONS	Base year(3)	2013	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2379.19	-0.63
CO_2 emissions with net CO_2 from LULUCF	2385.86	2377.42	-0.35
CH_4 emissions without CH_4 from LULUCF	125.19	147.80	18.06
CH_4 emissions with CH_4 from LULUCF	125.21	147.80	18.04
N_2O emissions without N_2O from LULUCF	79.89	55.94	-29.98
N_2O emissions with N_2O from LULUCF	80.04	56.08	-29.93
HFCs	NO,NE,NA	209.46	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	2.77	-87.97
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2795.16	7.54
Total (with LULUCF)	2591.13	2793.53	7.81

Table 10.56 Emission Trends by Gas (in kt equivalent to CO2) for 2014.

GREENHOUSE GAS EMISSIONS	Base year(3)	2014	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	2364.39	-1.25
CO_2 emissions with net CO_2 from LULUCF	2385.86	2360.05	-1.08
CH_4 emissions without CH_4 from LULUCF	125.19	159.50	27.41
CH_4 emissions with CH_4 from LULUCF	125.21	159.50	27.38
N_2O emissions without N_2O from LULUCF	79.89	55.83	-30.12
N_2O emissions with N_2O from LULUCF	80.04	55.96	-30.08
HFCs	NO,NE,NA	220.27	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	0.68	-97.19
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2800.66	7.75
Total (with LULUCF)	2591.13	2796.46	7.92

Table 10.57 Emission Trends by Gas (in kt equivalent to CO2) for 2015.

GREENHOUSE GAS EMISSIONS	Base year(3)	2015	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	1665.29	-30.44
CO_2 emissions with net CO_2 from LULUCF	2385.86	1661.32	-30.37
CH_4 emissions without CH_4 from LULUCF	125.19	171.09	36.66
CH_4 emissions with CH_4 from LULUCF	125.21	171.09	36.64
N_2O emissions without N_2O from LULUCF	79.89	55.51	-30.52
N_2O emissions with N_2O from LULUCF	80.04	55.64	-30.49
HFCs	NO,NE,NA	230.78	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NA,NO	NA,NO
SF_6	0.01	0.28	-98.88
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2122.95	-18.33
Total (with LULUCF)	2591.13	2119.11	-18.22

Table 10.58 Emission Trends by Gas (in kt equivalent to CO2) for 2016

GREENHOUSE GAS EMISSIONS	Base year(3)	2016	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	1356.35	-43.35
CO_2 emissions with net CO_2 from LULUCF	2385.86	1352.40	-43.32
CH_4 emissions without CH_4 from LULUCF	125.19	181.00	44.58
CH_4 emissions with CH_4 from LULUCF	125.21	181.00	44.55
N_2O emissions without N_2O from LULUCF	79.89	54.00	-32.40
N_2O emissions with N_2O from LULUCF	80.04	54.13	-32.38
HFCs	NO,NE,NA	244.29	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NO,NA	NA,NO
SF_6	0.01	0.14	-99.47
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	1835.78	-29.37
Total (with LULUCF)	2591.13	1831.96	-29.30

Table 10.59 Emission Trends by Gas (in kt equivalent to CO2) for 2017

GREENHOUSE GAS EMISSIONS	Base year(3)	2017	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	1530.88	-36.06
CO_2 emissions with net CO_2 from LULUCF	2385.86	1528.88	-35.92
CH_4 emissions without CH_4 from LULUCF	125.19	177.88	42.09
CH_4 emissions with CH_4 from LULUCF	125.21	177.88	42.06
N_2O emissions without N_2O from LULUCF	79.89	52.53	-34.25
N_2O emissions with N_2O from LULUCF	80.04	52.65	-34.22
HFCs	NO,NE,NA	255.77	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NO,NA	NA,NO
SF_6	0.01	0.99	-96.34
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2018.05	-22.36
Total (with LULUCF)	2591.13	2016.17	-22.19

Table 10.60 Emission Trends by Gas (in kt equivalent to CO2) for 2018

GREENHOUSE GAS EMISSIONS	Base year(3)	2018	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	1546.95	-35.39
CO_2 emissions with net CO_2 from LULUCF	2385.86	1545.69	-35.21
CH_4 emissions without CH_4 from LULUCF	125.19	184.95	47.74
CH_4 emissions with CH_4 from LULUCF	125.21	184.95	47.71
N_2O emissions without N_2O from LULUCF	79.89	52.53	-34.25
N_2O emissions with N_2O from LULUCF	80.04	52.65	-34.23
HFCs	NO,NE,NA	245.29	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NO,NA	NA,NO
SF_6	0.01	0.30	-98.93
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2030.01	-21.90
Total (with LULUCF)	2591.13	2028.87	-21.70

Table 10.61 Emission Trends by Gas (in kt equivalent to CO2) for 2019

GREENHOUSE GAS EMISSIONS	Base year(3)	2019	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	1649.19	-31.12
CO_2 emissions with net CO_2 from LULUCF	2385.86	1647.70	-30.94
CH_4 emissions without CH_4 from LULUCF	125.19	192.11	53.45
CH_4 emissions with CH_4 from LULUCF	125.21	192.11	53.42
N_2O emissions without N_2O from LULUCF	79.89	55.37	-30.69
N_2O emissions with N_2O from LULUCF	80.04	55.49	-30.68
HFCs	NO,NE,NA	234.77	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NO,NA	NA,NO
SF_6	0.01	0.33	-98.87
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2131.76	-17.99
Total (with LULUCF)	2591.13	2130.39	-17.78

Table 10.62 Emission Trends by Gas (in kt equivalent to CO2) for 2020

GREENHOUSE GAS EMISSIONS	Base year(3)	2020	Change from base to previous year (%)
CO_2 emissions without net CO_2 from LULUCF	2394.19	1599.58	-33.19
CO_2 emissions with net CO_2 from LULUCF	2385.86	1597.28	-33.05
CH_4 emissions without CH_4 from LULUCF	125.19	193.81	54.81
CH_4 emissions with CH_4 from LULUCF	125.21	193.81	54.78
N_2O emissions without N_2O from LULUCF	79.89	55.47	-30.57
N_2O emissions with N_2O from LULUCF	80.04	55.58	-30.56
HFCs	NO,NE,NA	272.34	NO,NE,NA
PFCs	NO,NA	0.00	NO,NA
Unspecified mix of HFCs and PFCs	NA,NO	NO,NA	NA,NO
SF_6	0.01	0.40	-98.66
NF_3	NA	NA	NA
Total (without LULUCF)	2599.28	2121.59	-18.38
Total (with LULUCF)	2591.13	2119.41	-18.21

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 10.63 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	2403.14	2403.14	0
2. Industrial processes and product use	7.78	7.78	0
3. Agriculture	119.07	119.07	0
4. Land use, land-use change and forestry(5)	-8.15	-8.15	0
5. Waste	69.30	69.30	0
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2591.13	0

Table 10.64 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	2403.14	2246.41	6.98
2. Industrial processes and product use	7.78	8.01	-2.82
3. Agriculture	119.07	122.17	-2.54
4. Land use, land-use change and forestry(5)	-8.15	-8.38	-2.73
5. Waste	69.30	75.62	-8.36
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2443.82	6.07

Table 10.65 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	2403.14	2301.50	4.42
2. Industrial processes and product use	7.78	9.02	-13.73
3. Agriculture	119.07	125.00	-4.74
4. Land use, land-use change and forestry(5)	-8.15	-5.14	58.73
5. Waste	69.30	81.66	-15.14
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2512.04	3.23

Table 10.66 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	2403.14	2882.52	-16.63
2. Industrial processes and product use	7.78	9.04	-13.90
3. Agriculture	119.07	124.41	-4.30
4. Land use, land-use change and forestry(5)	-8.15	-4.97	64.15
5. Waste	69.30	89.29	-22.39
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	3100.29	-16.33

Table 10.67 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	2403.14	2659.15	-9.63
2. Industrial processes and product use	7.78	9.32	-16.55
3. Agriculture	119.07	120.49	-1.18
4. Land use, land-use change and forestry(5)	-8.15	-4.63	76.11
5. Waste	69.30	97.58	-28.99
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2881.92	-9.95

Table 10.68 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	2403.14	2449.55	-1.89
2. Industrial processes and product use	7.78	9.29	-16.21
3. Agriculture	119.07	119.04	0.02
4. Land use, land-use change and forestry(5)	-8.15	-4.10	98.69
5. Waste	69.30	104.53	-33.71
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2678.31	-3.07

Table 10.69 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	2403.14	2561.43	-6.18
2. Industrial processes and product use	7.78	9.09	-14.38
3. Agriculture	119.07	122.00	-2.40
4. Land use, land-use change and forestry(5)	-8.15	-4.13	97.27
5. Waste	69.30	108.94	-36.39
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2797.32	-7.16

Table 10.70 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	2403.14	2567.44	-6.40
2. Industrial processes and product use	7.78	9.30	-16.33
3. Agriculture	119.07	123.73	-3.76
4. Land use, land-use change and forestry(5)	-8.15	-4.36	86.85

5. Waste	69.30	115.48	-39.99
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2811.58	-7.59

Table 10.71 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	2403.14	2524.45	-4.81
2. Industrial processes and product use	7.78	8.73	-10.85
3. Agriculture	119.07	119.79	-0.60
4. Land use, land-use change and forestry(5)	-8.15	-4.13	97.27
5. Waste	69.30	125.48	-44.78
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2774.32	-6.31

Table 10.72 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	2403.14	2603.87	-7.71
2. Industrial processes and product use	7.78	8.15	-4.56
3. Agriculture	119.07	121.33	-1.86
4. Land use, land-use change and forestry(5)	-8.15	-4.96	64.48
5. Waste	69.30	130.44	-46.87
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2858.84	-9.05

Table 10.73 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	2403.14	2519.12	-4.60
2. Industrial processes and product use	7.78	14.99	-48.09
3. Agriculture	119.07	115.41	3.17
4. Land use, land-use change and forestry(5)	-8.15	-5.05	61.58
5. Waste	69.30	140.20	-50.57
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2784.67	-6.59

Table 10.74 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	2403.14	2658.89	-9.62
2. Industrial processes and product use	7.78	19.10	-59.27
3. Agriculture	119.07	111.37	6.91
4. Land use, land-use change and forestry(5)	-8.15	-2.47	229.91
5. Waste	69.30	146.84	-52.81
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2933.73	-11.30

Table 10.75 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	2403.14	2699.08	-10.96
2. Industrial processes and product use	7.78	22.97	-66.13
3. Agriculture	119.07	110.61	7.65
4. Land use, land-use change and forestry(5)	-8.15	21.24	-138.37
5. Waste	69.30	153.40	-54.83
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	3007.30	-13.44

Table 10.76 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	2403.14	2973.04	-19.17
2. Industrial processes and product use	7.78	24.72	-68.52
3. Agriculture	119.07	105.66	12.69
4. Land use, land-use change and forestry(5)	-8.15	21.24	-138.39
5. Waste	69.30	162.07	-57.24
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	3286.73	-20.77

Table 10.77 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	2403.14	2831.80	-15.14

2. Industrial processes and product use	7.78	32.39	-75.98
3. Agriculture	119.07	109.31	8.93
4. Land use, land-use change and forestry(5)	-8.15	-0.36	2137.79
5. Waste	69.30	170.40	-59.33
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	3143.53	-17.13

Table 10.78 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	2403.14	2657.05	-9.56
2. Industrial processes and product use	7.78	46.03	-83.10
3. Agriculture	119.07	99.11	20.13
4. Land use, land-use change and forestry(5)	-8.15	-0.56	1351.31
5. Waste	69.30	178.34	-61.14
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2979.97	-12.55

Table 10.79 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	2403.14	2673.13	-10.10
2. Industrial processes and product use	7.78	83.95	-90.73
3. Agriculture	119.07	98.26	21.17
4. Land use, land-use change and forestry(5)	-8.15	-1.76	363.94
5. Waste	69.30	185.86	-62.72
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	3039.45	-14.22

Table 10.80 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	2403.14	2744.17	-12.43
2. Industrial processes and product use	7.78	101.34	-92.32
3. Agriculture	119.07	98.89	20.40
4. Land use, land-use change and forestry(5)	-8.15	-1.51	438.43
5. Waste	69.30	189.11	-63.36
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	3132.00	-16.73

Table 10.81 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	2403.14	2753.45	-12.72
2. Industrial processes and product use	7.78	117.69	-93.39
3. Agriculture	119.07	92.70	28.45
4. Land use, land-use change and forestry(5)	-8.15	11.94	-168.25
5. Waste	69.30	108.01	-35.84
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	3083.79	-15.39

Table 10.82 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	2403.14	2538.50	-5.33
2. Industrial processes and product use	7.78	138.15	-94.37
3. Agriculture	119.07	88.04	35.25
4. Land use, land-use change and forestry(5)	-8.15	11.37	-171.70
5. Waste	69.30	123.19	-43.75
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2899.25	-9.97

Table 10.83 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	2403.14	2598.51	-7.52
2. Industrial processes and product use	7.78	147.96	-94.74
3. Agriculture	119.07	86.21	38.12
4. Land use, land-use change and forestry(5)	-8.15	11.17	-173.00
5. Waste	69.30	112.26	-38.27
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2956.11	-11.67

Table 10.84 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	2403.14	2585.43	-7.05
2. Industrial processes and product use	7.78	174.13	-95.53
3. Agriculture	119.07	83.08	43.31
4. Land use, land-use change and forestry(5)	-8.15	-2.00	307.30
5. Waste	69.30	107.31	-35.42
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2947.95	-11.39

Table 10.85 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	2403.14	2733.55	-12.09
2. Industrial processes and product use	7.78	205.18	-96.21
3. Agriculture	119.07	85.04	40.02
4. Land use, land-use change and forestry(5)	-8.15	-1.81	349.78
5. Waste	69.30	108.62	-36.20
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	3130.58	-16.53

Table 10.86 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	2403.14	2379.19	1.01
2. Industrial processes and product use	7.78	224.81	-96.54
3. Agriculture	119.07	83.48	42.62
4. Land use, land-use change and forestry(5)	-8.15	-1.63	399.89
5. Waste	69.30	107.68	-35.64
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2793.53	-6.42

Table 10.87 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	2403.14	2364.46	1.64
2. Industrial processes and product use	7.78	232.78	-96.66
3. Agriculture	119.07	82.25	44.76
4. Land use, land-use change and forestry(5)	-8.15	-4.20	94.14
5. Waste	69.30	121.17	-42.81
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2796.46	-6.48

Table 10.88 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	2403.14	1664.68	44.36
2. Industrial processes and product use	7.78	241.26	-96.78
3. Agriculture	119.07	81.95	45.29
4. Land use, land-use change and forestry(5)	-8.15	-3.84	112.45
5. Waste	69.30	135.05	-48.69
6. Other	NA	NA	NA
Total (including LULUCF)(5)	2591.13	2119.11	23.45

Table 10.89 Emission Trends by Sector (in kt equivalent to CO_2) for 2016

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year(4)	2016	Change from base to previous year (%)
1. Energy	2403.14	1356.84	77.11
2. Industrial processes and product use	7.78	253.84	-96.93
3. Agriculture	119.07	79.65	49.49
4. Land use, land-use change and forestry(5)	-8.15	-3.82	113.15
5. Waste	69.30	145.45	-52.36
6. Other	NA		NA
Total (including LULUCF)(5)	2591.13	1831.96	42.86

Table 10.90 Emission Trends by Sector (in kt equivalent to CO_2) for 2017

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year(4)	2017	Change from base to previous year (%)
1. Energy	2403.14	1533.82	56.68
2. Industrial processes and product use	7.78	262.41	-97.03
3. Agriculture	119.07	78.12	52.42
4. Land use, land-use change and forestry(5)	-8.15	-1.88	334.51
5. Waste	69.30	143.70	-51.78

6. Other	NA		NA
Total (including LULUCF)[5]	2591.13	2016.17	29.86

Table 10.91 Emission Trends by Sector (in kt equivalent to CO_2) for 2018

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[4]	2018	Change from base to previous year (%)
1. Energy	2403.14	1549.09	55.13
2. Industrial processes and product use	7.78	252.06	-96.91
3. Agriculture	119.07	78.44	51.80
4. Land use, land-use change and forestry[5]	-8.15	-1.14	615.63
5. Waste	69.30	150.43	-53.94
6. Other	NA		NA
Total (including LULUCF)[5]	2591.13	2028.87	29.09

Table 10.92 Emission Trends by Sector (in kt equivalent to CO_2) for 2019

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[4]	2019	Change from base to previous year (%)
1. Energy	2403.14	1653.05	45.38
2. Industrial processes and product use	7.78	241.25	-96.77
3. Agriculture	119.07	78.58	51.52
4. Land use, land-use change and forestry[5]	-8.15	-1.37	495.16
5. Waste	69.30	158.87	-56.38
6. Other	NA		NA
Total (including LULUCF)[5]	2591.13	2130.39	22.99

Table 10.93 Emission Trends by Sector (in kt equivalent to CO_2) for 2020

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[4]	2020	Change from base to previous year (%)
1. Energy	2403.14	1602.33	49.98
2. Industrial processes and product use	7.78	279.62	-97.22
3. Agriculture	119.07	80.24	48.40
4. Land use, land-use change and forestry[5]	-8.15	-2.18	274.07
5. Waste	69.30	159.41	-56.53
6. Other	NA		NA
Total (including LULUCF)[5]	2591.13	2119.41	23.67

11 ANNEX 2: INFORMATION PURSUANT TO ARTICLE 3, PARAGRAPH 3, AND ARTICLE 3, PARAGRAPH 4 OF THE KYOTO PROTOCOL

11.1 GENERAL INFORMATION

This chapter refers to information related to KP-LULUCF reporting. This reporting was introduced for the 2nd Commitment period (2013-2020) for Malta.

There are a number of policy tools that, inter alia, aim at aligning climate adaptation and mitigation action with biodiversity protection and sustainable resource use. In this respect, Malta has been working on:

1. National Strategy for the Environment (NSE);
2. National Biodiversity Strategy and Action Plan (NBSAP) to 2030;
3. measures pertaining to the improvement in both qualitative and quantitative status of ground water, good chemical and ecological status of inland surface waters and coastal waters detailed in Malta's Water Catchment Management Plan; and
4. measures geared towards the achievement of 'Good Environmental Status' in Malta's marine waters in line with the overall objective of the Marine Strategy Framework Directive.

The National Strategy for the Environment, which has recently undergone public consultation, lays down the strategic policy direction for Malta's environment until 2050 by setting out long-term Goals, while defining Strategic Objectives that outline how this is going to be done. It is underpinned by the recognition that the environment supports the existence of society, which in turn creates economic activity to sustain itself, and one cannot function successfully without the other. Furthermore, the National Biodiversity Strategy and Action Plan to 2030 is the principal instrument to implement the Convention on Biological Diversity (CBD) and the outcomes of its COP15, including the Kunming-Montreal Global Biodiversity Framework, at the national scale. The NBSAP has also undergone public consultation and is set to be adopted in the near future. This strategy and action plan falls within the scope of the National Strategy for the Environment and builds upon Malta's first NBSAP (2012-2020) and its final review of progress, in order to continue the Government's long-term efforts to manage and protect biodiversity. With regards to restoration of biodiversity, the NBSAP aims that by 2030, degraded ecosystems, in particular those with potential for climate change adaptation and mitigation, are under restoration or rehabilitation to ensure their integrity, structure, function, and connectivity.

Moreover, climate proof action plans and comprehensive national policy frameworks with tailored measures to maintain or improve the conservation status of the habitats and species, are set to be established in the coming years as called for in the NBSAP. Such policies shall focus on the following areas, amongst others:

- the protection and enhancement of soil and its biodiversity;
- the decline on pollinators;
- forestation;
- landscapes and their characteristics;
- desertification, land degradation and drought;
- the capture, killing, and exploitation of wild species.

11.2 ELECTED ACTIVITIES UNDER ARTICLE 3, PARAGRAPH 4 OF THE KYOTO PROTOCOL

Malta confirms 'Forest Management' as the only activity elected under Article 3, paragraph 4 of the Kyoto Protocol for inclusion in the accounting for the 2nd Commitment Period of the Kyoto Protocol (period 2013-2020).

11.2.1 DESCRIPTION OF HOW THE DEFINITIONS OF EACH ACTIVITY UNDER ARTICLE 3, PARAGRAPH 3 OF THE KYOTO PROTOCOL AND EACH MANDATORY AND ELECTED ACTIVITY UNDER ARTICLE 3, PARAGRAPH 4 OF THE KYOTO PROTOCOL HAVE BEEN IMPLEMENTED AND APPLIED CONSISTENTLY OVER TIME

Definitions for the KP-LULUCF reporting chapter are consistent with those used in the UNFCCC inventory. Units of land subject to Article 3, paragraph 3 Afforestation and Reforestation are reported jointly, and are defined as units of land that did not comply with the forest definition on 1st January 1990 but do so some time thereafter. Afforestation/Reforestation category is equivalent to category 4.A.2 (Land converted to Forest land). Forest Management activity under Article 3, paragraph 4 is equivalent to category 4.A.1.2 (Forest land remaining Forest land/managed). Units of land subject to Article 3, paragraph 3 Deforestation are defined as units of land that did comply with the forest definition on or after 1st January 1990 but ceased to comply later on. According to Decision 16/CMP.1 Annex A.1.(d) of the Kyoto Protocol Deforestation is referred to as "the direct human-induced conversion of forested land to non-forested land". Deforestation does not occur in Malta, thus will not be taken into consideration for the reporting purposes. Further details indicating deforestation as not occurring is presented in the Forest Land chapter. It is to note that other treed lands that may meet the forest definition have been excluded from the reporting because those lands are predominantly urban use.

11.2.2 DESCRIPTION OF PRECEDENCE CONDITIONS AND/OR HIERARCHY AMONG ARTICLE 3, PARAGRAPH 4 ACTIVITIES, AND HOW THEY HAVE BEEN CONSISTENTLY APPLIED IN DETERMINING HOW LAND WAS CLASSIFIED

As described in the '2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol', Article 3.3 activities and Forest Management (FM) are mandatory and take precedence over elected 3.4 activities. The overall hierarchy among mandatory and elected activities is established as follows:

- Deforestation (D) activities take precedence in the reporting hierarchy over Afforestation (AR) activities. Therefore, land that was reported under D, on which subsequent regrowth of forests occurs continues to be reported under Article 3.3 (D) and it is good practice to report it as a subcategory to indicate that this previously deforested land can be acting as a carbon sink.

- AR and D activities take precedence in the reporting hierarchy over FM activities.

- AR, D and FM activities take precedence in the reporting hierarchy over any other elected Article 3.4 activity.

- Parties establish the reporting hierarchy among elected activities of Cropland Management (CM), Grassland Management (GM) and Revegetation (RV).

- Since Wetland Drainage (WDR) is limited to lands that are not accounted for under any other activity, lands not already reported under any of the above activities in a given year, on which drainage and rewetting of organic soils take place are reported under WDR, if elected by the Party.

Since Forest Management activity is only elected under Article 3, paragraph 4, the same hierarchy is followed for the Forest Land category, meaning that the same area and similar woodlands classifications are considered, thus, to be consistently applied throughout the whole reporting system.

11.3 ARTICLE 3, PARAGRAPH 3 OF THE KYOTO PROTOCOL

11.3.1 INFORMATION THAT DEMONSTRATES THAT ACTIVITIES UNDER ARTICLE 3.3 BEGAN ON OR AFTER 1 JANUARY 1990 AND BEFORE 31 DECEMBER 2012 AND ARE DIRECT HUMAN-INDUCED

Activities under Article 3.3 pertain to Afforestation and Deforestation. For afforestation, the plantings in the sites are a result of direct human induced activities. Thus, for the Afforestation activity it is considered that for plantings which began on or after 1 January 1990 and before 31 December 2012 all lands converted to Forest Land are human-induced. It is to note that no Deforestation occurs.

11.3.2 INFORMATION ON HOW HARVESTING OR FOREST DISTURBANCE THAT IS FOLLOWED BY THE RE-ESTABLISHMENT OF FOREST IS DISTINGUISHED FROM DEFORESTATION

Harvest or forest disturbances followed by re-establishment of forest do not occur.

11.3.3 INFORMATION ON THE SIZE AND GEOGRAPHICAL LOCATION OF FOREST AREAS THAT HAVE LOST FOREST COVER BUT WHICH ARE NOT YET CLASSIFIED AS DEFORESTED

Deforestation does not occur.

11.3.4 INFORMATION RELATED TO THE NATURAL DISTURBANCES PROVISION UNDER ARTICLE 3.3

Malta will not be applying the provisions related to Natural Disturbances.

11.3.5 INFORMATION ON HARVESTED WOOD PRODUCTS UNDER ARTICLE 3, PARAGRAPH 3

Malta does not produce any harvested wood products; therefore, this category does not occur in Malta.

11.4 ARTICLE 3, PARAGRAPH 4 OF THE KYOTO PROTOCOL

11.4.1 INFORMATION THAT DEMONSTRATES THAT ACTIVITIES UNDER ARTICLE 3.4 HAVE OCCURRED SINCE 1 JANUARY 1990 AND ARE HUMAN INDUCED

Activities under Article 3.4 pertain to Forest Management, Cropland Management, Grazing Land Management, Revegetation, and Wetland Drainage and Rewetting. Malta confirms ‘Forest Management’ as the only activity elected under Article 3, paragraph 4 of the Kyoto Protocol for inclusion in the accounting for the 2nd Commitment Period of the Kyoto Protocol (period 2013-2020).

The management that occurs in the forests is a result of direct human induced activity. Thus, for forest management on or after 1 January 1990 and before 31 December 2012, lands under Forest are considered managed.

11.4.2 Information relating to forest management

For the activity Forest Management under Article 3, paragraph 4, the activity follows the category of Forest Land were the same parameters are considered. The definition established and used for reporting the category of Forest Land is the following: Forest Land is defined as an area with minimum area of land of 1 hectare, tree crown-cover of more than 30% and tree minimum height of more than 5 meters. The woodland areas which are considered for Forest Land category, in line with the definition, are the Buskett, Mizieb and Wardija areas. Moreover, for the afforestation criteria the area pertaining to the Foresta 2000 reserve, Buskett, Gnien il-Mediterran, Mizieb, Wied Fulija and Benghajsa are taken into consideration, since afforestation occurred within these locations. The information related to the stratification and management of the forests is the same one as indicated in the forest description of the Forest Land category.

11.4.2.1 Conversion of natural forest to planted forest

The conversion of natural forests to planted forest do not occur. The few natural remnants of forests that remain are protected, managed and conserved for their status, therefore are not converted. Planted forests generally occur on bare or derelict land earmarked for afforestation, or as additional plantings to the existing natural woodlands.

11.4.2.2 Forest Reference Level (FRL)

The European Union report ‘Submission of information on forest management reference level by the European Union as requested by Decision 2/CMP6: The Cancun Agreements: Land use, Land Use Change and Forestry’ published in 2011 defined (paragraph 4) the FRL value for Malta at -0.049 Mt CO2 equivalent/year, indicating that this was derived through extrapolation of historic data on greenhouse removals related to forest management.

The FRL was updated in 2018/2019 which reflect the new FRL value established in the National Forestry Accounting Plan (NFAP) for the 1st Commitment Period until 2025, reflected in the ‘National Forestry Accounting Plan containing Malta’s Forest Reference Level’ (Said, 2019). The NFAP was submitted pursuant to Article 8(3) of Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU. The approach to, and structure of the NFAP follow the European Commission’s ‘Technical Guidance on developing and reporting the Forest Reference Levels in accordance with Regulation (EU) 2018/841’ (Forsell et. al., 2018) where a stepwise approach to prepare the NFAP and FRL is described.

The preparation of the NFAP and FRL considered the stratification of forest area, the assessment of forest management practices and the selection of an appropriate modelling framework. The stratification of forest area was documented by the use of documents and data provided by country managing authorities. The stratification of the Managed Forest Land (MFL) was based on the main criterion of distinguishing 'forest in equilibrium' and 'age dynamic forests'. The 'forest in equilibrium' stratum represents forests which reached an equilibrium between growth and decay, while 'age dynamic forests' represents forests which are still growing. Another stratification criterion considers the dominant tree species. In addition, age classes were created by documenting the age for forests planted less than 100 years before the Reference Period for considering their dynamic growth. Documentation on afforestation for the period 2000-2005 was gathered to include also the dynamic evolution of forest. Forest management practices were documented according to national laws and based on information gathered from the authorities managing the forest sites. A spreadsheet model was utilised to project gains and losses in the above-ground biomass pool in the 'age dynamic forests'. The model and methodologies are discussed in further detail in the corresponding sections.

11.4.2.3 TECHNICAL CORRECTION OF FRL

A description of how the present FRL was established in the NFAP is provided here. Since the national greenhouse gas inventory submission of 2011, Malta has changed the methodology for estimating emissions and removals for the sector LULUCF.

As stated in the previous section, the FRL was updated and corrected to reflect the FRL value established in the National Forestry Accounting Plan for the 1st Commitment Period from 2021- 2025.

The development of the carbon pools to establish the FRL was carried out on a model spreadsheet, produced to finally document the 5-year average of the projected FRL value for the period 2021-2025. An indicative estimate for the CP2 value is provided as tCO2/year based on the same methodology used for calculating the CP1 FRL. The model approach developed in the spreadsheet model considers the above-ground biomass pool including estimations in the 'age dynamic forest' pools for the forest sites which are less than 100 years. The model is based on the 'gains and losses' approach as indicated in the IPCC 2006 Guidance.

The estimations for the biomass pool are calculated based on the stratification classes of 'forest in equilibrium' and 'age dynamic forest', as well as considering the stratification of the dominant tree species for each stratification class, which are divided into conifer dominated and broad-leaved dominated, with tree species being younger than 100 years respectively, and also considering the afforestation criteria. The estimations include the calculations for dynamic growth for the 'age dynamic forests' and for the afforestation criteria. For the stratum of 'forests in equilibrium' no dynamic is included in the projection of the FRL. For these forests, it is assumed that an equilibrium has been reached between growth and decay of biomass and the carbon pool variation is zero.

The dynamic age structure module for the above-ground biomass pool is estimated for the strata belonging to the 'age dynamic forests', by assessing the classification of the area for the year 2009 in the age classes for the dominant tree species of each forest site. The simulation propagates to the end of the CP1 to provide the age structure for the period 2021-2025. Further detailed information can be retrieved from the report National Forestry Accounting Plan containing Malta's Forest Reference Level.

Considering the different stratification classes for the estimations of the MFL less than 100 years and the Afforestation criteria, the average sum of each stratification class is considered, then the sum of all the classes is the result of the final FRL for the CP1, i.e., 2021-2025. The final FRL value for CP1 is -0.0376 ktCO2.

11.4.2.4 Information related to natural disturbances provision under Article 3, paragraph 4

Malta will not be applying the provisions related to Natural Disturbances.

11.4.2.5 Information on harvested wood products under Article 3, paragraph 4

Malta does not produce any harvested wood products; therefore, this category does not occur in Malta.

11.4.3 Other information

11.4.3.1 Key Category Analysis for Article 3.3 Activities, Forest Management and any elected activities under Article 3.4

No key categories were identified within this category.

12 ANNEX 3: INFORMATION ON METHODS USED TO PROJECT THE WOM SCENARIO

12.1.1 MODEL DESCRIPTION OF THE WITHOUT MEASURES (WOM) SCENARIO

12.1.1.1 ENERGY MODEL

For the WOM projections of emissions derived from the Energy Sector, six models were used, two of which are non-transport models. All models were developed by the Energy and Water Agency (EWA) and Transport Malta (TM). Projections on power generation were generated through an electricity dispatch model, which is driven by Energy demand (model), electricity and gas price and affects Natural Gas, gasoil and electricity. For the Manufacturing industries subsector, commercial and Institutional services, Residential services and Agriculture, Forestry and Fisheries subsectors, non-transport fuel consumption models were used. These were driven by Gross Value Added (GVA), with the exception of the Residential Sector Model which was driven by population. A PV production model was also developed, which estimated the potential of residential and non-residential PVs using past trends, cost projections, feed-in tariffs and an independent study carried out by EWA on investigating PV technical potential.

With regards to transport, two road transport models were developed. Of which, one modelled the consumption of biofuels, driven by a substitution obligation of -14% to be reached by 2030. The second road transport model projected the consumption of diesel and petrol, using population and GVA as drivers. In conclusion, a model for inland navigation (excluding fishing vessels) was developed. Emissions resulting from gasoil, diesel and petrol used in national navigation were modelled based on GDP taking into consideration the changes due to fast ferry and Gozo tunnel being proposed.

The table below, summarizes the description of the models used for the Without Measures scenario projections for transport (note that domestic aviation is not included in the projections scenario.

Table 12.1 Transport Models (WOM Scenario)

Model name (abbreviation)	Road Transport Biofuels S/O	Road Transport Model	Inland Navigation Fuel Consumption Model
Full model name	Road transport Biofuels S/O Model	Road transport Model	Inland Navigation Fuel Consumption Model
Model version and status	V2 (final)	V2 (Under Revision)	V2 (Under Revision)
Latest date of revision	19/12/2021	19/12/2021	19/12/2021
URL to model description	N/A	N/A	N/A
Model type	Excel based	Excel based	Excel based
Summary	A Road transport model projecting the biofuel mix for transport fuels for the period 2018 - 2040. Fuel affected: Diesel and petrol Driver: Substitution obligation -14% by 2030	A transport model projecting the fuel and electricity consumption of the road transport sector for the period 2018 - 2040. Fuel affected: Diesel, Petrol, Electricity Driver: Population and GVA, CO2 emission standards for vehicles	An inland navigation fuel consumption model, projecting Gasoil, diesel and petrol consumption for the period 2018 - 2040. Fuel affected: Gasoil, Diesel & Petrol Driver: Macroeconomic projections (also takes into account fast ferry and gozo tunnel passenger rates).
Intended field of application	Road Transport	Road Transport	National Navigation
Description of main input data categories and data sources	Substitution obligation -14% by 2030;	Population and GVA, CO2 emission standards for vehicles	Macroeconomic projections (also takes into account fast ferry and gozo tunnel passenger rates).
Validation and evaluation	N/A	N/A	N/A
Output quantities	GWh and litres; EUR	GWh, vehicle-kilometers, vehicle stock	GWh and litres;
GHG covered	CO2, CH4, N2O	CO2, CH4, N2O	CO2, CH4, N2O
Sectoral coverage	Energy- Transport - Road Transport	Energy - Transport - Road Transport	Energy - Transport - Navigation
Geographical coverage	National	National	National
Temporal coverage (e.g. time steps, time span)	2018-2040	2018-2040	2018-2040
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	Road Transport Model	Electricity Dispatch Model (for EVs); Road Transport Biofuels Model	Road Transport Biofuels
Input from other models	Road Transport Model (total road transport fuel consumption)	N/A	N/A
References to the assessment and the technical reports that underpin the projections and the models used	N/A	N/A	N/A
Model structure (if diagram please attach to your submission in Reportnet)	N/A	N/A	N/A
Comments or other relevant information	N/A	N/A	N/A

It is to be noted that forecasts of macroeconomic indicators used in the energy models were developed by EPD in collaboration with Cambridge Econometric, using a short-term quarterly forecasting econometric model specifically for Malta (STEMM). This model is basically composed of six blocks, one of which is the value-added block disaggregated at sectoral level. The value-added sectors which are modelled in this block are mainly:

- Goods sectors:
    - Manufacture of Chemical and Chemical products, basic pharmaceutical products and pharmaceuticals operations (NACE 19-21) (CHEMPHAR)
    - Manufacture of Computer, Electronic and Optical Products, manufacture of Electrical Equipment and Manufacture of Machinery and Equipment n.e.c (NACE 26-28) (EM)
    - Construction sector and Real Estate Activities sector (NACE 41-43, 68)*. (RCONS) (F,L)
    - Other Goods sectors (all the A-F sectors not included in the previous/other domestic sectors) (OG)
    - Services sectors:
    - Government Sector; O-Q sectors (NACE 84-88) (PS) (O-Q)
    - Financial and Insurance Activities sector (NACE 64-66) (FIS) (K)
    - Other Business Services Sector (NACE 69-75) (OBS) (M)
    - Gaming Sector (NACE 92) (RG) (R)
    - Accommodation and food service activities (NACE 55-56) (TOUR) (G,H,I)
    - Wholesale and retail trade; repair of motor vehicles and motorcycles, transportation and storage sectors (NACE 45-54) (WRT) (G,H,I)
    - Other services sector (all the G-U sectors not includes above/other domestic sectors) (OS) (J)
    - Other Domestic Sectors (includes the A, B, D and N sectors) (OD)

12.1.1.2 INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU) MODEL

Over the year 2015, a model was developed to project GHG emissions from the industrial processes and product use sector. Since, in recent years, the emissions of HFCs from CRF category *2.F.1 Refrigeration and Air conditioning*, add up to almost the entirety of the GHG emissions from the IPPU sector, the said model is limited to project emissions from this category alone.

The model takes into consideration five different groups of activities, namely, residential (domestic), commercial, ships, transport and stationary. Based on historical data, including demand, imports, stock and emissions, the model estimates the stock and imports of a list of refrigerants (imported and used in the groups listed above) the emissions of which contribute to global warming.

The base year on which WOM projections are estimated is the year 2018, as submitted in Malta's National Inventory of Greenhouse Gas Emissions and Removals, 2020. An exception to this is the emissions from stationary air conditioning. In particular, a different set of data has been used in the estimation of the stock accumulated from F-gas in pre-charged equipment. It should also be pointed out that since emissions from categories other than CRF category *2.F.1* were not projected, the historical emissions for the year 2018 were not reported.

The current model used for projections estimates the emissions from the stock using the stock in the base year. This methodology is not congruent with the methodology used to estimate historic emissions. This results in emissions for the base year that are lower than historic emissions. It is the intention of the Inventory Agency to analyse this aspect of the current model further such that the emissions estimated in the projections model are more consistent with historic emissions.

A brief description of the equations underpinning the key factors making up the IPPU model is presented under the following sub-titles:

12.1.1.2.1 Forecasting stock

stock in base year × (1 - emission factor + reuse) + imports

The stock forecast depends on the stock in existence from previous year, the amount escaped through emissions and the amount reused. This is subsequently added to the amount imported.

12.1.1.2.2 Forecasting imports

stock in base year × (1 + activity growth) × exp(efficiency improvement) – (1 - emission factor + 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.

12.1.1.2.3 Forecasting activity growth

The forecast of activity growth depends on the activity indicators and its stock elasticity to the activity indicator.

Domestic sector: private consumption × elasticity of activity growth to household consumption

Commercial sector: GDP × elasticity of activity growth to GDP

In case of the domestic sector, the activity indicator used is disposable income, whilst GDP is used for the commercial sector.

12.1.1.3 AGRICULTURE MODEL

The model being used to produce the WOM projections reported in communication has been developed in 2018 and has been verified by experts from ICF and Aether as part of capacity-building projects undertaken by the Climate Change Unit at the Malta Resources Authority. The model, which covers projections of GHG emissions over a period spanning from 2016 – 2030, based on historic data from 1990 – 2015, has been quality controlled to ensure compliance with the IPCC's TCCAA principles. The 'Without Measures' (WOM) scenario presented in this communication takes into consideration the Mechanical Biological Treatment Plant, which treats 35,000T and 4,000T of cattle and poultry manure respectively. These values were introduced into equations calculating the nitrogen excretion rates of cattle and sheep, which ultimately affect the emissions emanating from the management of manure. The projections of cattle and poultry manure treated, and manure remaining were calculated based on the historical cattle and poultry populations and projected N excretion. The N excretion is calculated by multiplying the default N_{rate} (given in the 2006 IPCC guidelines) by the weight of the animal/1000 * 365 days. Since animal weight and N_{rate} remain constant throughout the time period, there is no projection of the value. The following process gives the method of how emissions are re-estimated integrating the measure of cattle and poultry manure treatment.

$$Cattle\ manure\ produced = \frac{BAU\ Nexcretion}{N\ content\ in\ manure}$$

The N content in cattle manure is taken as 0.0056, while 0.0207 is used for poultry as specified in the NAP schedule.

Cattle manure treated = 35,000,000 kg

Poultry manure treated = 4,000,000 kg

$$Manure\ remaining\ (kg) = Manure\ produced - Manure\ treated$$

$$Manure\ remaining\ (kgN) = Manure\ Remaining\ (kg) * N\ content$$

The percentage dairy cattle manure and other cattle manure is worked out from the total BAU cattle N excretion, to give DC manure % and OC manure %. The same is done for Layers and Broilers and Other Poultry.

$$MBT\ N\ excretion = Manure\ Remaining * Manure\ \%$$

Emissions are then worked out according to 2006 IPCC Guidelines

$$Nvol = \frac{MBT\ N\ excretion * FracGasMS}{100}$$

$Frac_{GasMS}$ DC = 30%, OC = 45%

$Frac_{GasMS}$ Layers = 55%, Broilers & Other Poultry = 40%

$$N\ lost\ as\ N_2O\ (kgN_2O) = cattle\ manure\ remaining * EF_3$$

EF_3 Cattle = 0.005 kgN20-N

EF_3 Poultry = 0.001 kgN20-N

$$MBT\ Direct\ N_2O\ emissions = \left(\frac{N\ lost\ as\ N_2O * \left(\frac{44}{28}\right)}{10^6}\right) * 298$$

$$MBT\ Indirect\ N_2O\ emissions = NvolTotal * EF4 * \frac{\frac{44}{28}}{10^6}$$

EF_4 Cattle = 0.01 kgN20-N

EF_4 Poultry = 0.01 kgN20-N

It should be noted that projections for the WOM scenario start from 2019, where thus the historic data is taken for 1990-2018.

The model and its projections for the agriculture sector have been developed in alignment with the national inventory system by integrating the model within the inventory's workbook itself. The values from the national inventory are taken into the model, processed and projections are then developed based on the base year chosen. The projections update whenever the historic data is updated, hence producing a more realistic projection with every submission which is based on actual historic data rather than past projections.

A number of quality assurance and quality control checks have been implemented in the worksheets and model of the Agriculture sector which tackle calculations for both the National GHG inventory Report and the PAMS and Projections Report. Such quality checks have been integrated through a full automation of the agricultural sector workbooks to reduce human error, data analysis checks, model performance checks to ensure that numbers projected are correct, and full transparency of the model calculations.

12.1.1.4 LAND USE, LAND-USE CHANGE AND FORESTRY

The LULUCF model was developed to construct projections related to the LULUCF sector to analyse the variations between the projected emissions within the sector, as well as development of related scenarios. The projections were developed based on the information available associated with land and forest related measures which are in place on a national scale that could affect the sequestration rates from the land-uses. The model illustrates a series of projections which were analysed based on the national information available. The historic data was acquired from the data presented in the LULUCF sector of the GHG Inventory report.

The growth in the level of sequestration of carbon in the LULUCF sector is not expected to be major, with minimum variations between the different projections presented. This is due to the fact that the national afforestation projects implemented do not cover a large tract of land, and when comparing the extent of the area of these plantations to the other categories in the LULUCF sector, the level of sequestration from these projects is as a result quite minimal.

The LULUCF sector projections model was developed through the assistance of an expert from the International Institute for Applied Systems Analysis (IIASA). The model works in a spreadsheet and aims to develop projections of LULUCF emissions and removals. The sheet also allows for the analysis and construction of various scenario-based projections. The model works by taking into account changes in activity rates or emission factors that the user specifies to develop projection estimates. All projections that are reported in the model are based on the general equation (1) for calculating emission projections as proposed in: *GHG Projection Guidelines. Part A: General Guidance. CLIMA.A.3/SER/2010/0004*. Emissions and removals are estimated by multiplying the activity rate with the associated emission factor, thereby assuming a linear relationship between the intensity of an activity and the resulting emission. Emission factors and activity rates can be changed over time in the model but only the linear relationship between activity and emission rates is currently implemented.

Moreover, a Forest Land category projections model was developed, to be attribute to the overall LULUCF sector projections model. This was done as a result of the National Forestry Accounting Plan (NFAP), where new data on Forest Land was acquired to compile the necessary calculations within this category to facilitate the compilation of the NFAP report. The Forest Land projections model was developed through the assistance provided from the ICF during the capacity building workshop on the NFAP. The Forest Land category model is largely based on the NFAP model (developed also on excel spreadsheet), since similar parameters and forest areas considered for the NFAP are being utilised for the Forest Land category. The Forest Land model was further updated and finalised, thus the projections from this category were included in the whole LULUCF sector.

The LULUCF models and projections are aligned with the national inventory system be means of the model incorporating data from the national inventory workbook into the projections model workbook. Values from the national inventory are utilised to develop projections based on the year of the projection.

QA/QC check in the LULUCF model were implemented within the model workbook. The quality checks were developed by means of equations and automated checks in the workbook, thus, to allow for the comparison of future activity rates with historical reporting, checking for internal consistency issues within a scenario, as well as to compare the outcome between scenarios.

12.1.1.5 WASTE MODEL

Projections of waste generation activity data have been compiled by the Ministry for the Environment, Climate Change and Planning, which also includes waste management policy under its portfolio.

The projection of waste generation is based on the relation between a relevant driver trend between 2013 and 2016, and the actual trend in waste generation 2013-2016. This relation is represented by a constant which is multiplied by the projected macroeconomic driver to result in a projected waste generation for that particular year. This exercise has been repeated for all waste streams as published in the National Statistics Office waste statistics, with each waste stream associated with a specific relevant driver.

Table 12.2 EWC-STAT driver association EWC-Stat code

	Description	Selected Driver
1.1	Spent solvents	Gross Domestic Product
1.3	Used oils	Gross Domestic Product
1.4, 2, 3.1	Chemical wastes	Gross Domestic Product
1.4, 2, 3.1	Chemical wastes	Gross Domestic Product
3.2	Industrial effluent sludges	Gross Domestic Product
3.2	Industrial effluent sludges	Gross Domestic Product
3.3	Sludges & liquid wastes from waste treatment*	Population
5	Health care and biological wastes	Population
5	Health care and biological wastes	Population
7.2	Paper and cardboard wastes	Disposable Income
7.3	Rubber wastes	Gross Domestic Product
7.4	Plastic wastes	Gross Domestic Product
7.5	Wood wastes	Gross Domestic Product
7.6	Textile wastes	Disposable Income
8 (excl. 8.1, 8.41)	Discarded equipment	Disposable Income
8 (excl. 8.1, 8.41)	Discarded equipment	Gross Domestic Product
8.1	Discarded vehicles	Disposable Income
8.41	Batteries and accumulators waste	Gross Domestic Product
8.41	Batteries and accumulators waste	Gross Domestic Product
9.1	Animal and mixed food waste	Population
9.2	Vegetal wastes	Population
9.3	Animal faeces, urine and manure	Gross Domestic Product
10.1	Household and similar wastes	Disposable Income
10.2	Mixed and undifferentiated materials	Population
10.2	Mixed and undifferentiated materials	Population
10.3	Sorting residues*	Gross Domestic Product
11	Common sludges	Gross Domestic Product
12.1	Mineral waste from construction & demolition	Gross Domestic Product
12.1	Mineral waste from construction & demolition	Gross Domestic Product
12.2, 12.3, 12.5	Other mineral wastes	Gross Domestic Product
12.2, 12.3, 12.5	Other mineral wastes	Gross Domestic Product

12.4	Combustion wastes	Gross Domestic Product
12.4	Combustion wastes	Gross Domestic Product
12.7	Dredging spoils	Gross Domestic Product
12.8, 13	Mineral waste from waste treatment & stabilised waste*	Gross Domestic Product
12.8, 13	Mineral waste from waste treatment & stabilised waste*	Gross Domestic Product

Following the completion of a waste generation scenario, each waste stream was portioned into the different waste treatment options based on the reference or policy scenario. In the reference scenario, the capacity of existing options is respected, with the remainder being directed to landfilling. In both scenarios, it is assumed that landfilling space will not run out at any moment and that capacity of present plants will be retained all along the period. This means that if any plant included in the reference ceases to operate in the timeframe of the projection, a similar plant in terms of technology and capacity will replace it immediately. The difference between the reference and policy scenarios, is due to shifting of waste streams from one option (e.g. landfilling) to another option higher in the waste hierarchy (e.g. waste to energy, biodigestion or recycling). To date, the model does not account for behavioural changes that induce quantitative waste generation changes, thus waste avoidance is not accounted for at this stage. This is mainly due to the low confidence and inability to model behavioural change induced by measures included both in the reference and policy scenario.

The waste sector will see a relevant decrease in the waste going to landfill, especially for municipal wastes which will be diverted to either biological treatment or incineration. The advent of the incineration of municipal waste will appear as a net increase in emissions for the year of application, with a gradual but constant decrease in emissions from landfilling becoming more accentuated in the later period. This trade off comes due to Malta’s obligation to address other targets in the waste sector, and land space issues caused by ever expanding landfill sites.

Following this distribution, the waste quantities were converted into emissions through inventory models based on the IPCC 2006 guidelines. The methodologies used for this conversion are the same as those discussed in detail in the 2020 annual National GHG inventory submissions.

13 ANNEX 4: SUMMARY OF REPORTING OF THE SUPPLEMENTARY INFORMATION IN ACCORDANCE WITH ARTICLE 7, PARAGRAPH 2, OF THE KYOTO PROTOCOL

INFORMATION TO BE REPORTED	RELEVANT SECTION IN THE 8TH NATIONAL COMMUNICATION
National GHG inventory system	Chapter 3, sections 3.2 & 3.7
National registry	Chapter 3, section 3.8
Supplementary information relating to mechanisms pursuant to Articles 6, 12 and 17	Chapter 4, sections 4.2, 4.3 & 4.5 Chapter 5, section 5.5
Policies and measures in accordance with Article 2	Chapter 4, section 4.4 Chapter 5
Minimization of adverse effects	Chapter 4, section 4.6
Domestic and regional programmes and/or legislative arrangements and enforcement and administrative procedures	Chapter 4, section 4.3.1
Information in accordance with Article 10:	/
Article 10a: data for national inventory of emissions and removals	Chapter 3, section 3.2
Article 10b: measures to mitigate climate change and to facilitate adaptation to climate change	Chapter 4, section 4.4 Chapter 6
Article 10c: technology transfer and capacity building, in particular to developing countries	Chapter 7 Chapter 8
Article 10d: research and systematic observation	Chapter 8
Article 10e: education and training programmes, public awareness and public access to information on climate change	Chapter 8 Chapter 9
Financial resources and capacity building	Chapter 7