STATE OF THE ENVIRONMENT REPORT 2018

Chapter 3: Climate Change

Reporting status from 2009 to 2015

KEY MESSAGES

Policy context:

- Climate policy action in Malta is driven by policy action at an international level, particularly through policy and legislative actions taken by the European Union to implement the Union's commitments under the United Nations Framework Convention on Climate Change, the Kyoto Protocol and the recently adopted Paris Agreement.
- Malta contributes its share of mitigation effort towards the overall European Union goals, as established primarily by the current 2020 Climate and Energy Package: all local public electricity generation plants participate in the EU Emissions Trading Scheme in respect of carbon dioxide emissions, while other emissions are covered by the +5 %, compared to 2005 emission levels, target for 2020 under the Effort-sharing Decision. The 2020 vision also binds Member States to renewable energy, and energy efficiency targets.
- The European Union 2030 emission reduction objectives represent an even greater level of effort for Malta particularly under the Effort-sharing regime, with the target for 2030 being even more onerous than the 2020 target, with emissions having to be reduced by at least 19 % compared to 2005 levels. This means that the significant reductions seen in the electricity generation sector in recent years need to be complemented by further action in activities such as transport, use of F-gases, agriculture and waste. Land use and changes in land-use will also be required to contribute.
- The adoption of the Climate Action Act in 2015 is an important milestone in climate policy in Malta, providing a solid legislative basis for action by all concerned 'to protect the climate and to assist in the taking of preventive and remedial measures to protect the climate'.

The state of Malta's climate:

- The local climate shows an annual mean temperature of 18.6°C, a mean maximum temperature of 22.3°C and a mean minimum temperature of 14.9°C. Such a temperature regime coupled with a total annual precipitation of 553.1 mm and 2,954 hours of bright sunshine corresponds to a hot and dry archipelago.
- Malta's mean air temperature profile for the period 1981-2015 shows a local warming trend of +0.22°C per decade. A stronger warming trend of +0.38°C per decade is observed for the annual mean minimum temperature, indicating that the incidence of warmer nights is becoming increasingly common. A lower rate of increase is seen by the annual mean maximum air temperature for the period 1981-2015. A recent study that considers a much longer observation time-period (1967-2013) shows a local warming trend of +0.09°C per year, significant at the 99 % confidence level. The anomaly trend for the annual mean maximum temperature shows a definitive departure from the climate norm. The analysis of a longer time series (1951-2010) shows a statistically significant anomaly trend of +1.2°C for the entire period.
- Over the period 1981-2015, the total yearly precipitation showed a negative trend with a rate of decline of -6.3 mm per decade. However, this trend was found to be not statistically

significant at 95 % confidence level, and this could be attributed to the analysis of a relatively short time series of observations.

- Local oceanographic observations over the relatively short climatic period of 1992-2006 show that sea level fell by an average rate of 0.50 ± 0.15 cm per annum.
- The surface temperatures of the Mediterranean Sea are increasing at +0.35°C per decade, which is especially marked in the Levantine basin. Local studies on changes in sea surface temperature within Maltese waters are still ongoing.

National emissions of GHGs:

- After a long period of generally sustained increase in total national greenhouse gas emissions, recent years have seen an important reversal, with 2015 GHG emissions (2228.32 Gg CO_2 eq., with LULUCF) being second lowest since 1990 levels (2105.03 Gg CO_2 eq.). Emissions peaked in 2012 (3224.29 Gg CO_2 eq.).
- Carbon dioxide emissions account for the biggest share of total national greenhouse gas emissions (79.1 % in 2015). HFCs have seen a rapid increase in their share, reaching 11.0 % in 2015.
- The Energy sector contributed 79.3 % of total national greenhouse gas emissions in 2015, its share seeing a decrease in recent years, coinciding with rapid reductions in emissions from electricity generation due to recent investments in the sector. On the other hand, the IPPU sector has seen its contribution to total national GHG emissions increasing, with its share in 2015 being 11.1 %, driven largely by increases in estimated emissions of hydrofluorocarbons.
- Malta's per capita greenhouse gas emissions show a similar trend to that of absolute emissions, including a reduction in per capita emissions over the most recent years coinciding with the decrease seen in total national emissions. The emissions intensity of Malta's economy maintains the trend of continued improvement, with fewer emissions generated per unit GDP: decoupling of emissions trends from economic growth.
- Projections of total national emissions point towards continued improvement in the shorter term followed by slacking impact of existing measures in place. This highlights the need for new actions to be taken to improve the outlook particularly in activities contributing to emissions covered by binding targets set out in the EU's Effort-sharing Decision.

Local pressures on the environment:

- Ambient temperature increase may have resulted in shifts in local terrestrial and marine species composition and changes in their life cycles. An increased water temperature leads to a reduction of dissolved oxygen and changes in water circulation.
- Sea level rise can have detrimental consequences to our natural and socio-economic amenities situated along low-lying part of the Maltese coastline.
- The presence of alien marine species identified in local waters has been mainly attributed to the general warming trend of Mediterranean waters, increased marine traffic and aquaculture activities.

- In 2015 it was reported how a new invasive species of seaweed was discovered in 2013 following its observation in seagrass meadows. Warmer marine conditions are providing the right ambient conditions for such species to flourish in local waters.
- Increased drought conditions will also bring about changes in land-use and crop production that will further intensify the pressures on freshwater systems. The limited availability of local data and information on climate change impacts on this sector represents one of the major hurdles to freshwater management. The management of the local water sector is extremely important and urgent, and the First Water Catchment Management Plan issued during this reporting period (2000-2015) is seen as crucial for the sustainability of this sector.

Adaptation:

- In 2009, Malta's National Strategy for Policy and Abatement Measures relating to the Reduction of Greenhouse Gas Emissions was published and adopted.
- In 2012, Malta adopted a new Climate Adaptation Strategy recommending the necessary adaptation measures deemed relevant to sectors that are vulnerable to a changing climate through a set of 72 actions which addresses the following areas: agriculture, biodiversity, fresh water resources and coastal zones, land degradation, fisheries and migration. It also addresses issues related to financial impacts and sustainability.
- The enactment of adaptation-related actions is being implemented by various Ministries and departments. The progress made at the Ministerial level is reported to an Inter-Ministerial Committee.
- In 2013 the European Commission adopted an EU strategy on adaptation to climate change with the scope of making Member States more resilient to climate change.

3.1 INTRODUCTION

The climate system is an interactive, multi-component system that consists of the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere. These components are influenced by various external (i.e. by astronomical events, including variations in solar radiation) and internal (i.e. by terrestrial events, including volcanic eruptions, ice cover, vegetation and by human activities) forcing factors. Life on earth for example, has been responsible for altering the composition of the terrestrial atmosphere some 2.4 billion years ago. Cyanobacteria managed to change the composition of the atmosphere by producing oxygen and hence ozone, and together with the later evolution of plant life, photosynthetically produced most of the oxygen currently found in the atmosphere. Incidentally, this natural change eventually led to the extinction of many life forms that were unable to thrive or adapt to an atmosphere that had become so rich in oxygen.

Apart from being capable of changing the gaseous composition of the atmosphere, internal factors can influence the atmospheric energy balance. For example, the trace levels of Greenhouse Gases (GHGs, such as CO_2, CH_4, short-lived tropospheric ozone, nitrous oxide, fluorocarbons (Chlorofluorocarbons (CFCs), Hydrofluorocarbons (HFCs), and Perfluorocarbons (PFCs)), sulphur hexafluoride (SF_6), etc.) emitted to the atmosphere by both *natural* and *anthropogenic* processes, are capable of trapping part of the heat that is emitted by the Earth as a result of its temperature. Higher concentrations of anthropogenic GHGs mean an increase in the amount of energy being trapped in the climate system. Indeed, without this natural 'greenhouse effect' the global surface temperature would plunge by some 35°C (NASA, 2014),[1] creating difficulties for life on Earth.

Continuous monitoring of atmospheric GHGs by leading climatological agencies has shown that the current global concentration of CO_2, at 408.39 ppm,[2] has far exceeded the natural cyclical variation of 180 and 280 parts per million (ppm) by volume over the past 800,000 years.[3] The true nature of the problem lies in the speed at which its level is changing, of which half of this observed increase occurred since 1970. Calculations using climate models show that there would have been little warming, or even a slight cooling over the 20th century if only natural factors were influencing the climate system. Only when numerical models include human influences on the composition of the atmosphere are the resulting temperature changes consistent with observed changes. While climate sceptics invoke the role of natural forcing behind such a rapid change, an overwhelming majority of scientists rule out any natural changes in external forcing by the sun, volcanic activity, or variations such as El Niño-Southern Oscillation (ENSO) as being the main culprit of the present change in the climate.

> *Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history*.
>
> *Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are*

[1] NASA 2017a.
[2] ESRL Team 2017; monthly mean carbon dioxide globally averaged over marine surface sites.
[3] Tripati et al. 2009.

extremely likely *to have been the dominant cause of the observed warming since the mid-20th century*.

Source: *IPCC*[4]

The atmospheric CO_2 concentration that has already accumulated in the atmosphere will continue changing the Earth's radiation budget in centuries to come. So far, the global temperature anomaly of 0.87°C since 1880 is considered to be quite significant. In certain parts of the world however, such as the central Mediterranean, the rate of increase has been shown to be higher during the past recent years.[5] Such global warming is affecting the normal behaviour of the climate system – warmer oceans, rise in sea level, strong decline in Arctic sea ice, changes in precipitation patterns and amounts, intensity of storms, occurrence of heatwaves, etc. Long-term climate change over many decades will depend mainly on the total amount of CO_2 and other GHGs emitted by human activities. Such an ongoing increase of GHGs in the atmosphere, coupled with the relatively slow response of the climate system to the energy being trapped by these gases, imply that further increase in global temperature is inevitable during this century. Therefore, urgent mitigation is required to reduce GHG emissions in order to limit the extent of adverse and dangerous impacts on climate change at least during the second half of this century. In its 5th Assessment Report, the IPCC strongly emphasizes those mitigation pathways that are likely to limit global average warming to below 2°C relative to pre-industrial levels would require substantial emissions reduction over the next few decades and near zero emissions of CO_2 and other long-lived greenhouse gases by the end of the century.[6]

This chapter focuses on scientific evidence for local climate change as well as mitigation and adaptation measures that took place in Malta during the reporting period 2008-2015. Its format follows the one included in the former State of the Environment Report (SoER) and is written in a language that is accessible by all so that it can be of benefit to both the non-specialist and the serious researcher.

3.2 Policy Context

3.2.1 Climate action at international level

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) is considered by many to be the principal policy instrument governing international climate action. It sets an 'ultimate objective' of stabilizing 'greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'.[7] The objective does not specify what these concentrations should be, stating only that they be at a level that is not dangerous. The UNFCCC entered into force on March 21, 1994, and since then a total of 197 countries have ratified this Convention, thus becoming Parties to the Convention.

[4] IPCC 2015.
[5] Galdies 2011b.
[6] IPCC 2015.
[7] UNFCCC 2017a.

In 1997, the Parties to the UNFCCC adopted the Kyoto Protocol. The Protocol builds on the principles of the Convention by adding new commitments, particularly quantified emission limitation or reduction commitments for developed country Parties listed in Annex I to the UNFCCC (thus often referred to as Annex I Parties). The Kyoto Protocol commits these Parties to reducing their collective emissions by at least 5 %, compared to 1990 levels, by the commitment period 2008-2012. The then European Community's collective reduction target was set at 8 % below 1990 levels.

The Doha Amendments to the Kyoto Protocol, agreed in 2012, extends the Protocol to a second commitment period 2013-2020. The EU's collective commitment inscribed in the Doha Amendment is a reduction in GHG emissions of at least 20 % compared to 1990 levels, by 2020, with a conditional offer to move to a 30 % reduction by 2020 provided that other developed countries commit themselves to comparable emission reductions and developing countries contribute adequately according to their responsibilities and respective capabilities. The European Union and its Member States are committed to reach the 20 % reduction target within the set timeframe, notwithstanding the fact that the Doha Amendment presently not yet being in force due to an insufficient number of Parties to the Kyoto Protocol having ratified the Amendment.

The most recent major climate policy development at international level is the adoption in 2015 of the Paris Agreement. This agreement has, as its primary goal, that of keeping the increase in global average temperature to well below 2°C above pre-industrial levels with the aim to limit any increase to not more than 1.5°C. The Paris Agreement requires all Parties to put forward their best efforts through nationally determined contributions (NDCs). The Agreement entered into force in November 2016 and presently counts 176[8] Parties to the Convention as having ratified it. In its intended nationally determined contribution towards the Paris Agreement, the EU and its Member States committed to a binding target of an at least 40 % domestic reduction in greenhouse gas emissions by 2030 compared to 1990, to be fulfilled jointly.

3.2.2 Policy action at European Union level

The course of European Union climate policy action is closely linked to the international process and is based on the commitments that the bloc has taken in respect of the Kyoto Protocol, the Doha Amendment to the Protocol, and the Paris Agreement, as already discussed previously.

[8] Status of ratification as at 31 May 2018.

One may differentiate EU policy action in the field of climate action in four policy streams, namely:

- Strategic political direction on EU climate policy action, usually at European Council level on the basis of proposals by the European Commission and input from the European Parliament;
- Economy-wide policy instruments;
- Sector-specific policy action; and
- Monitoring of greenhouse gas emissions and reporting thereof.

Stemming from its commitments towards the first commitment period of the Kyoto Protocol, the European Community had established the EU Emissions Trading Scheme (EU ETS) through Directive 2003/87/EC.[9] Originally covering large land-based stationary installations, and later expanded to also cover aviation activities,[10] the EU ETS provides for a market-based approach to the limitation of CO_2 emissions from participating entities, based on defined rules for monitoring, reporting and verification of emissions, the allocation of allowances to emit to participating entities, the accounting of emissions by surrendering allowances, and the possibility to trade in allowances.

To ensure that it meets its commitments towards the Kyoto Protocol's second commitment period, the EU then set out climate and energy targets under the 2020 Climate and Energy Package, which included:

- The reduction of overall EU GHG emissions by 20 % compared to 1990 levels;
- Saving 20 % of energy consumption by means of increased energy efficiency;
- Meeting 20 % of EU energy needs coming from renewable sources.

The 2020 Climate and Energy Package, reflecting the EU's vision towards 2020, is implemented via a number of important legislative actions:

- Amendments to the EU ETS Directive,[11] so as to improve the greenhouse gas emissions trading scheme, including by the annual reduction of the overall cap of allowances by 1.74 % per annum, as of 2013, by the use of auctioning as a means to allocate allowances to participating installations, the application of harmonized EU-wide rules on free allocation of allowances to eligible entities and the utilisation of revenue generated from monetization of a quantity of allowances set aside for the purpose to support low-carbon demonstration projects in renewable energy technology development and carbon capture and storage;
- Setting binding targets for Member States, through the so-called Effort-sharing Decision,[12] for emissions not covered by the EU ETS, covering sectors such as buildings, transport, agriculture and waste;
- Setting binding national targets for Member States for the share of renewables in their energy consumption by 2020, under the Renewable Energy Directive;[13]

[9] Directive 2003/87/EC.
[10] Directive 2008/101/EC.
[11] Directive 2009/29/EC.
[12] Decision 406/2009/EC.
[13] Directive 2009/28/EC.

- The Energy Efficiency Directive of 2012[14] establishing a set of binding measures to help the EU reach an overall level of 20 % energy efficiency by 2020 with individual EU countries setting their own indicative national energy efficiency targets contributing to the overall 20 % target.

The EU's contribution towards global climate mitigation efforts up to 2030 is implemented via the 2030 Climate and Energy Framework, providing also the basis for longer-term objectives. This implements the commitment agreed upon by EU leaders at the European Council of October 2014 for an at least 40 % domestic reduction in overall EU greenhouse gas emissions by 2030 compared to 1990. This framework of policy actions includes, among others:

- A revision of the EU ETS Directive,[15] with greater emphasis on cost-effective reductions in emissions by industry and support to low-carbon investments. The revisions include a bigger rate of reduction of the overall cap of allowances (2.2 % per annum as of 2021, compared to the previous 1.74 % annual decrease), better alignment of the level of free allocation with actual production levels, better targeted rules to address the risk of carbon leakage, and funding towards demonstration of innovative technologies and breakthrough innovation in industry and to support investments in modernising the power sector and wider energy systems, boosting energy efficiency, and facilitating a just transition in carbon-dependent regions;
- The continuation of the Effort-sharing approach towards limiting and reducing emissions from activities not covered by the EU ETS, albeit now in the form of a regulation[16] rather than a decision, retaining the approach of targets for respective Member States (for 2030, no Member States are allowed to increase emissions to a level above 2005 levels) and retaining existing flexibility mechanisms but also adding new flexible compliance approaches to ensure cost-effective achievement of set goals;
- A new regulation[17] that, for the first time ever, provides for a contribution by land use, land use change and forestry towards the EU's overall GHG emission reduction effort, setting a binding commitment for each Member State to ensure that accounted emissions from land use are entirely compensated by an equivalent removal of CO_2 from the atmosphere through action in the sector, known as the 'no debit' rule.

The October 2014 European Council also agreed two other important key targets, namely the EU-wide target of at least 27 % share for renewable energy and at least 27 % improvement in energy efficiency.

The economy-wide approaches discussed above are furthermore complemented by sector-specific policy and legislative actions that directly or indirectly limit the emissions of GHGs. Such actions range from emission performance standards on vehicles placed on the market, to specific legislation related to geological carbon storage, regulation on fluorinated gases which are particularly used in

[14] Directive 2012/27/EU.
[15] Directive (EU) 2018/410.
[16] Regulation (EU) 2018/… of the European Parliament and of the Council of … 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 (still to be published in the Official Journal).
[17] Regulation (EU) 2018/… of the European Parliament and of the Council of … 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 (still to be published in the Official Journal).

refrigeration and air-conditioning systems, requirements for reporting on carbon dioxide emissions by ships entering EU ports, among others.

So far, the discussion has focussed mainly on mitigation of the problem by controlling the cause, i.e. the limitation or reduction of anthropogenic greenhouse gas emissions. But it is also acknowledged that adaptive action is and will remain important, especially if mitigation pathways are not to the level required to limit the increase in average global temperature to not more than 2°C above pre-industrial temperatures. Adaptation refers to action that is taken to prevent or minimise the adverse effects of climate change may cause, or even taking advantage of any opportunities that may arise.

Adaptation is an important element in the UNFCCC: 'All Parties […] shall […] [c]ooperate in preparing for adaptation to the impacts of climate change'. Its importance is reaffirmed in the Paris Agreement requiring that all Parties do their utmost to promote resilience to climate change whilst, in instances where impacts are beyond the limitations of adaptation, find ways to address 'loss and damage'.

In 2013, the European Commission adopted an EU Adaptation Strategy[18] that focuses on three main objectives:

- Promoting action by Member States of the EU, including with regards to adopting national adaptation strategies;
- Promoting better informed decision-making, especially by addressing gaps in existing knowledge; and
- Promoting adaptation in key vulnerable areas.

Finally, policy action must be based on a clear understanding of the status of the system targeted by that action, on effective monitoring of the changes brought about by that action and effective assessment of potential effect of the action being taken in order to adapt such action to future needs. Reliable monitoring and reporting is indeed another crucial element found in the UNFCCC and the Kyoto Protocol. In response, the EU's own specific Monitoring Mechanism established through Regulation (EU) No 525/2013[19] indeed provides for, among others, reporting on the historic trends of GHG emissions, the assessment of the impact of policy action on future emission trends, adaptation and other relevant information.

The Monitoring Mechanism provides, among others, for:

- The establishment of national GHG inventory systems to estimate anthropogenic GHG emissions by sources and removals by sinks, and annual reporting thereof;
- The establishment of national systems for reporting on policies and measures and for reporting on projections of anthropogenic GHG emissions by sources and removals by sinks, and reporting thereof;
- Regular reporting on national adaptation planning and strategies;

[18] EC 2018.
[19] Regulation (EU) 525/2013.

- The assessment of progress made by the EU and its Member States to meet climate action commitments under the UNFCCC, the Kyoto Protocol and EU policy decisions and legislation.

3.2.2 The national context

As an EU Member State, Malta's climate action is primarily driven by EU climate policy, being also obliged to abide by relevant EU legislative instruments. Malta became an Annex I Party to the UNFCCC[20] in 2010 and is included in the joint target of the EU under the Doha Amendment.[21] [22] Its membership of the EU and its Annex I status mean that Malta has had to step up climate action, both in terms of monitoring and reporting, and in terms of quantified emission limitation and reduction commitments towards EU and global mitigation efforts.

The EU ETS is fully implemented in Malta, where the local electricity generation plants at Marsa and Delimara fall within its scope, as do a number of locally based airlines, including the national airline. It is worth noting that Malta is also committed to start implementing, immediately upon its start, a global market-based mechanism adopted by the International Civil Aviation Organisation (ICAO) for international aviation activities: this mechanism (the Carbon Offsetting and Reduction Scheme for International Aviation, or CORSIA) is a major achievement in the area of climate action by the aviation sector.

With regards to GHG emissions not covered by the emissions trading scheme, the Effort-sharing Decision requires Malta to limit such emissions to a level not greater than 5 % above 2005 emission levels, by 2020, including interim annual targets. Malta's contribution to EU climate mitigation action in the longer-term is even more stringent, with Malta's target for 2030 being a reduction of 19 % compared to 2005 levels. To this should be added the additional effort required to meet the 'no debit rule' under the new LULUCF Regulation, considering that the LULUCF sector is estimated to account for net positive emissions.

The Renewable Energy Directive (Directive 2009/28/EC) sets Malta target for raising the share of renewable energy sources in gross final consumption of energy to 10 % by 2020, complemented by a 10 % target for the share of renewable energy sources in all transport in 2020.

On a strategic level, Malta has in place national mitigation[23] and adaptation[24] strategies. The National Environment Policy[25] published in 2012 also dedicates ample space to the issue of climate change. But what one may consider as a major policy achievement for Malta is the adoption, with unanimous bipartisan support, of an Act of Parliament specifically addressing climate action: the Climate Action Act of 2015. The Act states that '[i]t shall be the duty of every person together with the Government to protect the climate and to assist in the taking of preventive and remedial measures to protect the

[20] UNFCCC 2009.
[21] Malta ratified the UNFCCC in 1994 and the Kyoto Protocol in 2001.
[22] The Doha Amendment inscribes a commitment for Malta to decrease its emissions by 20% compared to 1990 levels, by 2020, representing the overall EU commitment, with the understanding that the EU and its Member States will achieve such a target jointly.
[23] MRRA 2009.
[24] MRRA 2012.
[25] MTEC 2012.

climate', and '[i]t shall be the duty of the Government to protect the climate for the present and future generations', further elaborating actions that Government should take in respect of climate action and setting guiding principles for climate action. Furthermore, the Climate Action Act (Cap. 543) provides for the regular review of national low carbon development strategies and national adaptation strategies,[26] the establishment of a Climate Action Board to, among others, oversee the implementation of the Act, and the setting up of a Climate Action Fund to support the implementation of the Act and the good fulfilment of Malta's obligations and commitments at international and EU level.

3.3 The state of Malta's climate

3.3.1 Climatological profile

Malta's climate and related trends are detailed in the National Statistics Office publication *The Climate of Malta*.[27] The local climate (as based on the WMO official 30-year period of 1961-1990) shows an annual mean temperature of 18.6°C, a mean maximum temperature of 22.3°C and a mean minimum temperature of 14.9°C. Such a temperature regime coupled with a total annual precipitation of 553.1 mm and 2,954 hours of bright sunshine corresponds to a hot and dry archipelago. Monthly values of a number of climatic parameters are provided in Table 3.1 below.

[26] Incidentally, the Government is currently undertaking a review of the existing national mitigation and adaptation strategies with the aim of revising these in the form of a low-carbon development strategy to replace the existing mitigation strategy and an updated national adaptation strategy.
[27] Galdies 2011b.

Table 3.1: Climate summary for the Maltese Islands based on 1961-1990 Malta's climate norm

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average temperature (°C)	12.2	12.4	13.4	15.5	19.1	23.0	25.9	26.3	24.1	20.7	17.0	13.8
Average maximum temperature (°C)	15.2	15.5	16.7	19.1	23.3	27.5	30.7	30.7	28.0	24.2	20.1	16.7
Average minimum temperature (°C)	9.2	9.3	10.1	11.9	14.9	18.4	21.0	21.8	20.1	17.1	13.9	11.0
Sunshine hours (hrs)	159	171	224	247	300	328	365	338	260	221	185	156
Rainfall (mm)	89	61	41	23	7	3	0	7	40	90	80	112
Average wind speed (knots)	10.2	10.3	10.2	10.3	9.1	8.2	7.0	6.9	7.2	7.5	8.8	9.8
Most frequent direction	300	300	300	300	300	310	300	300	300	290	300	310

Source: *Galdies 2011a (adopted)*

3.3.2 Climatological trends (1981-2015)

The locally observed rate of ambient temperature warming has varied from year to year, decade to decade. Short-term variations can easily be explained on the basis of a good understanding of the physical nature of the climate system. However, what is most relevant to this chapter is the consideration of the longest climatological trends possible over a particular location, so that these inter-annual variations are averaged out and long-term climatic variation can be clearly discerned. A number of long-term local climatological indices can be studied, the most common being temperature and rainfall.

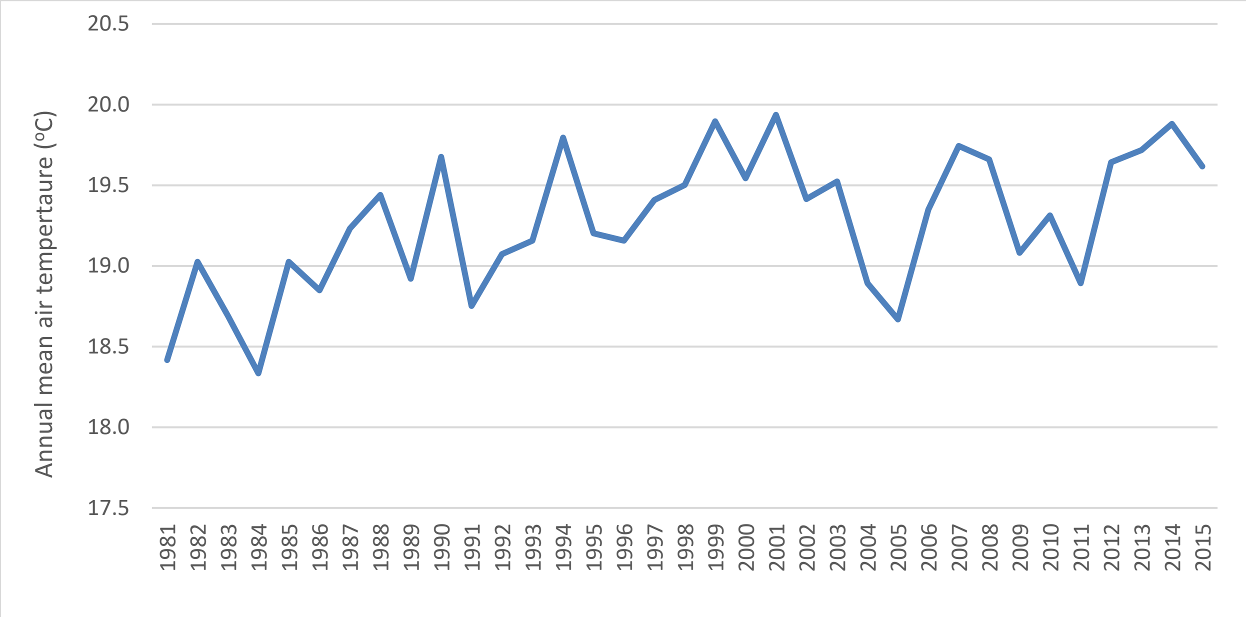
3.3.2.1 Time-series analysis of some atmospheric indices

The following sections summarise the recent climate trends over the period 1981-2015 (unless stated otherwise) which covers the reporting period of this SoER.

(i) Air temperature:

An analysis of the mean air temperature profile observed during the period 1981-2015 from Malta's climate station situated at Luqa Airport shows a local warming trend of +0.22°C per decade (Figure 3.1 refers), significant at the 95 % confidence level.

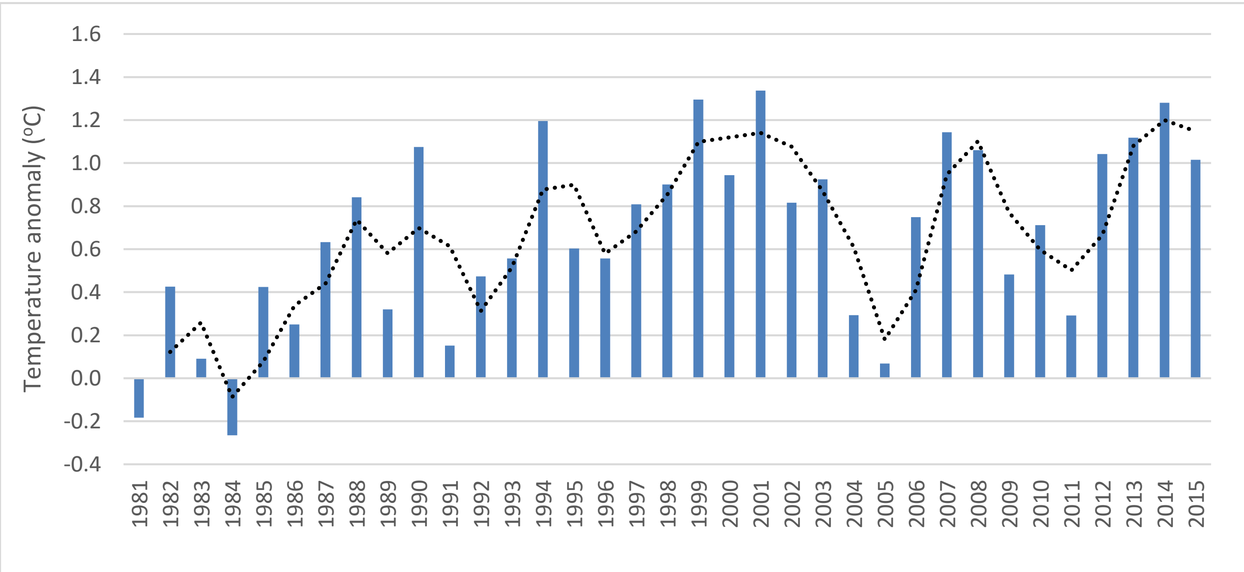
Figure 3.1: **Trend of the annual mean air temperature over the Maltese Islands observed during the period 1981-2015**



Source: *Maltairport MetOffice*

Figure 3.2 below shows the annual mean air temperature anomaly registered in Malta compared to its climate norm for the period 1961–1990. The positive trend observed is significant at the 95 % confidence level.

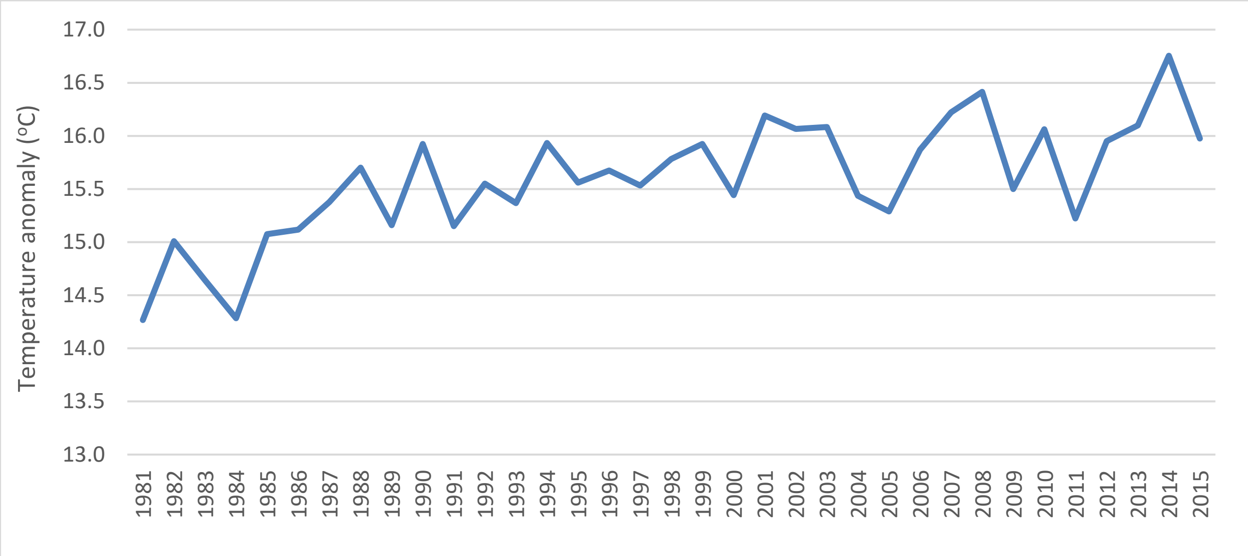
Figure 3.2: **Annual mean air temperature anomalies for the period 1981-2015. Three-year running average shown in black. Anomaly is based on Malta's 30-year climatology of the annual mean air temperature observed during the climate norm 1961-1990**



Source: *Maltairport MetOffice*

Throughout this 35-year period of observation, a stronger warming trend of +0.38°C per decade is observed for the annual mean minimum temperature (Figure 3.3 refers), significant at the 95 % confidence level. This indicates that the incidence of warmer nights is becoming increasingly common.

Figure 3.3: Trend of the annual mean minimum air temperature over the Maltese Islands observed during the period 1981-2015

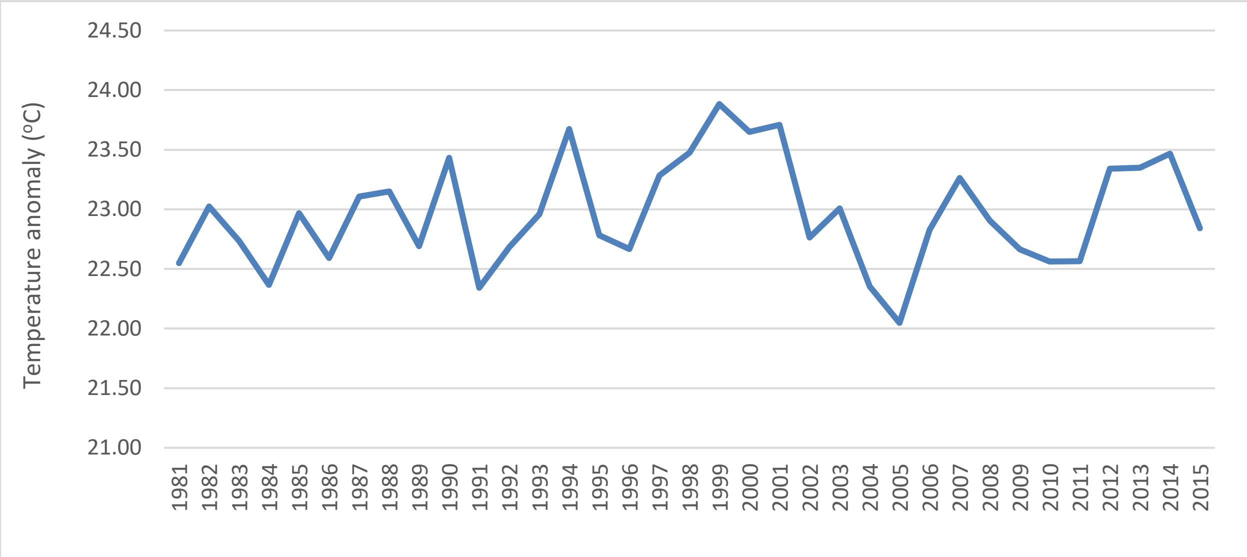


Source: *Maltairport MetOffice*

Unlike for the previous index, a lower rate of increase is seen by the annual mean maximum air temperature for the period 1981-2015 (Figure 3.4 refers), but is not statistically significant at the 95 % confidence level. However, a recent study that considers a much longer observation time-period (1967-2013) shows a local warming trend of +0.09°C per year, significant at the 99 % confidence level.[28]

[28] Galdies et al. 2016.

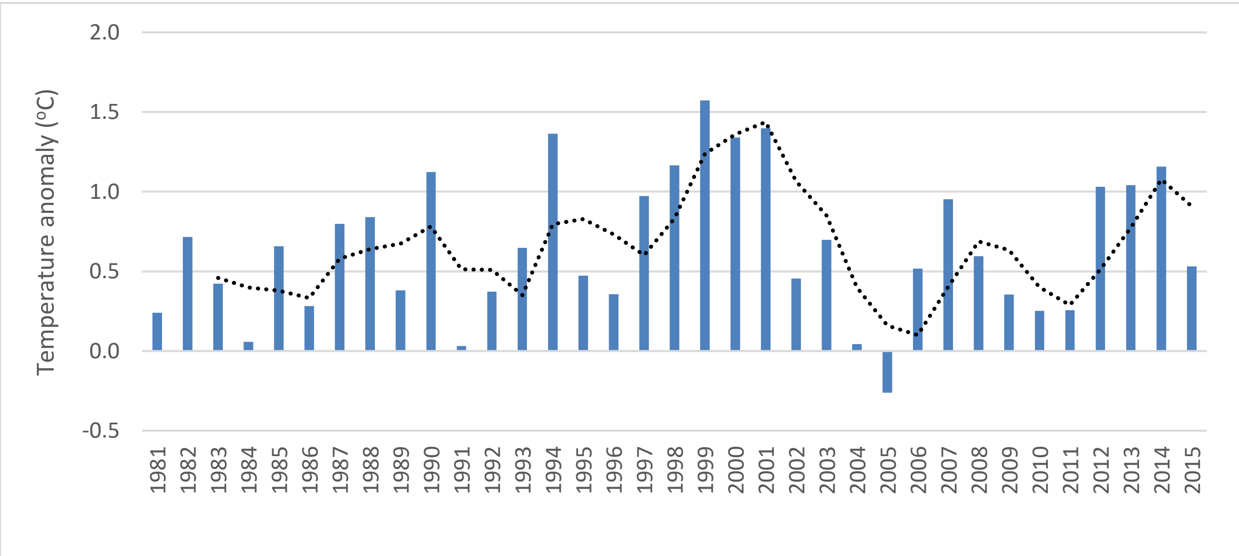
Figure 3.4: Trend of the annual mean maximum air temperature over the Maltese Islands observed during the period 1981-2015



***Source:** Maltairport MetOffice*

The anomaly trend for the annual mean maximum temperature from the climate norm of 1961-1990 (Figure 3.5 refers) shows a definitive departure from the climate norm; however, this positive anomaly for the period 1981-2015 was not found to be statistically significant. The analysis of a longer time series (1951-2010) shows a statistically significant anomaly trend of +1.2°C for the entire period.[29]

Figure 3.5: Annual mean maximum air temperature anomalies for the period 1981-2015. Three-year running average shown in black. Anomaly is based on Malta's 30-year climatology of the annual mean air temperature observed during the climate norm 1961-1990



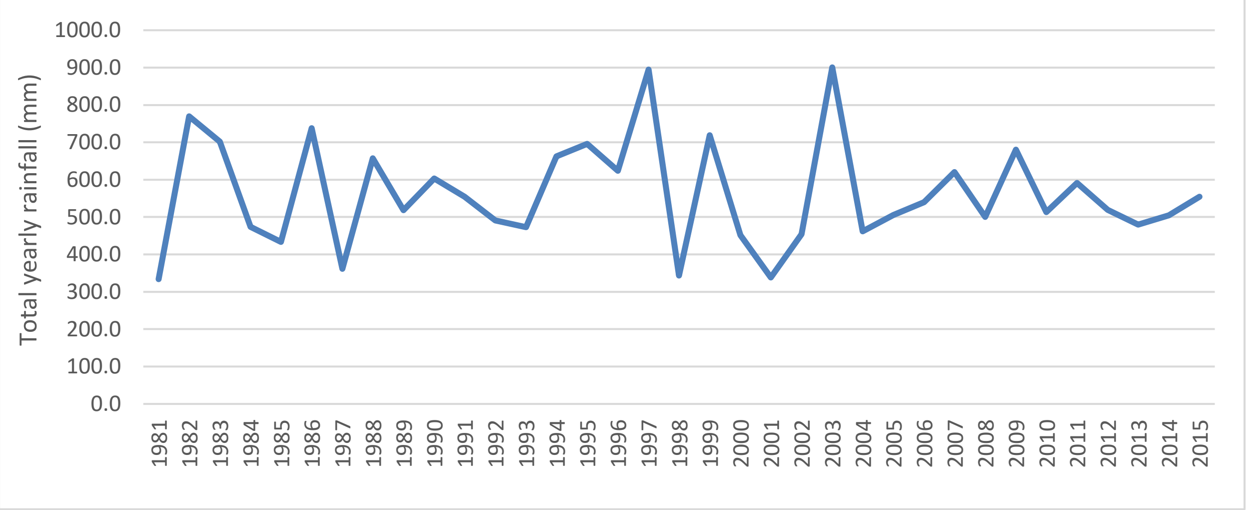
***Source:** Maltairport MetOffice*

(ii) Rainfall:

[29] Galdies 2011b.

As to local trends in liquid precipitation, the number of consecutive dry days for the period 1967-2013 indicate a statistically significant climatic trend in terms of increased drought conditions.[30] The time series for the total yearly precipitation for the period 1981-2015 show a negative trend with a rate of change of -6.3 mm per decade (Figure 3.6 refers). However, this trend was found to be not statistically significant at 95 % confidence level, and this could be attributed to the statistical analysis of a relatively short time series of observations.

Figure 3.6: Trend of the annual total precipitation registered in the Maltese Islands during the period 1981-2015



Source: *Maltairport MetOffice*

3.3.2.2 Oceanographic indices

(i) Sea level:

Records of global sea level are now being derived from both tide gauges and satellite altimeter measurements. The observations collected from these two independent systems are giving further evidence for the rise in sea level. On December 2015, the global sea height variation as measured by remote sensing since 1993, reached already +86 mm.[31]

The interpretation of sea level variation within the Mediterranean region is not straightforward. Observations show decelerations for the 20th century, possibly caused by an increase in the density of the deep waters and changes in air pressure changes. Local oceanographic observations over the relatively short climatic period of 1992-2006 show that sea level fell by an average rate of 0.50 ± 0.15 cm per annum.[32] Local authorities decided to follow a cautious approach by taking into account a future increase in mean sea level around the Maltese Islands over the long-term in view of the latest official projections.[33]

[30] Galdies et al. 2016.
[31] NASA 2017b.
[32] MEPA 2010a.
[33] MRA 2014.

(ii) Sea surface temperature:

According to recent studies, the Mediterranean Sea surface temperature is significantly warming by +0.35°C per decade,[34] and this is especially marked in the easternmost part of the Mediterranean Sea (about twice the rate as that of the global oceans during the period 1996-2012).[35] Local studies on changes in sea surface temperature within Maltese waters are still ongoing.

3.3.2.3 Projected climatological trends

Climate modelling studies provide essential information on the direction and likely impacts of climate change for Malta. The main findings from local studies have already been published by the Government of Malta as part of its National Communications to UNFCCC.

3.4 NATIONAL EMISSIONS OF GREENHOUSE GASES

Knowing from where you started from, where you are at present, and what the situation looks likely to be in future is crucial in assessing policy needs. The monitoring and reporting regime (Regulation (EU) 525/2013) referred to in section 3.2 is not simply a means of determining and setting out facts: rather, it is underpinned by the need to inform policy-makers so that they can adopt and implement the right set of actions to address the problem of climate change.

As an Annex I Party of the UNFCCC, and a Member State of the European Union, Malta is required to report, on an annual basis, on historic trends of GHG emissions from anthropogenic activities taking place within the Maltese territory (national emissions), and, on a biennial basis, on the impact of policies and measures on future GHG emission trends, and to project, to the extent possible, such future trends. The information being provided is based on the most recent reports submitted by Malta to the European Commission under Regulation (EU) 525/2013 namely its 2018 submission of the national GHG inventory of emissions from sources and removals by sinks,[36] and the 2017 submission of its report on policies and measures and projections of emissions and removals[37] under the same Regulation.

The discussion in this chapter relates to estimates[38] of the so-called Kyoto Protocol greenhouse gases, namely carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs, actually a collection of different gaseous chemical species), perfluorocarbons (PFCs, also a group of different gases) and sulphur hexafluoride (SF_6). The level of emissions, or where applicable, removals, of each, both in terms of total national levels and within different sources or sinks, varies widely, as will be seen. The impact of different gases on climatic conditions also varies, not only in terms of how much of a type of gas is emitted, but also the characteristics of each emitted chemical species. The latter is

[34] Shaltout & Omstedt 2014.
[35] Samuel-Rhoads et al. 2013.
[36] MRA 2018.
[37] MRA 2017.
[38] National GHG inventories present estimates of historic emissions and removals, using methodologies adopted by the InterGovernmental Panel on Climate Change. National GHG inventories are also subject to annual reviews; in the case of EU Member States, GHG inventories undergo twice-yearly expert peer reviews, as they are reviewed both by the European Commission and by the UNFCCC Secretariat.

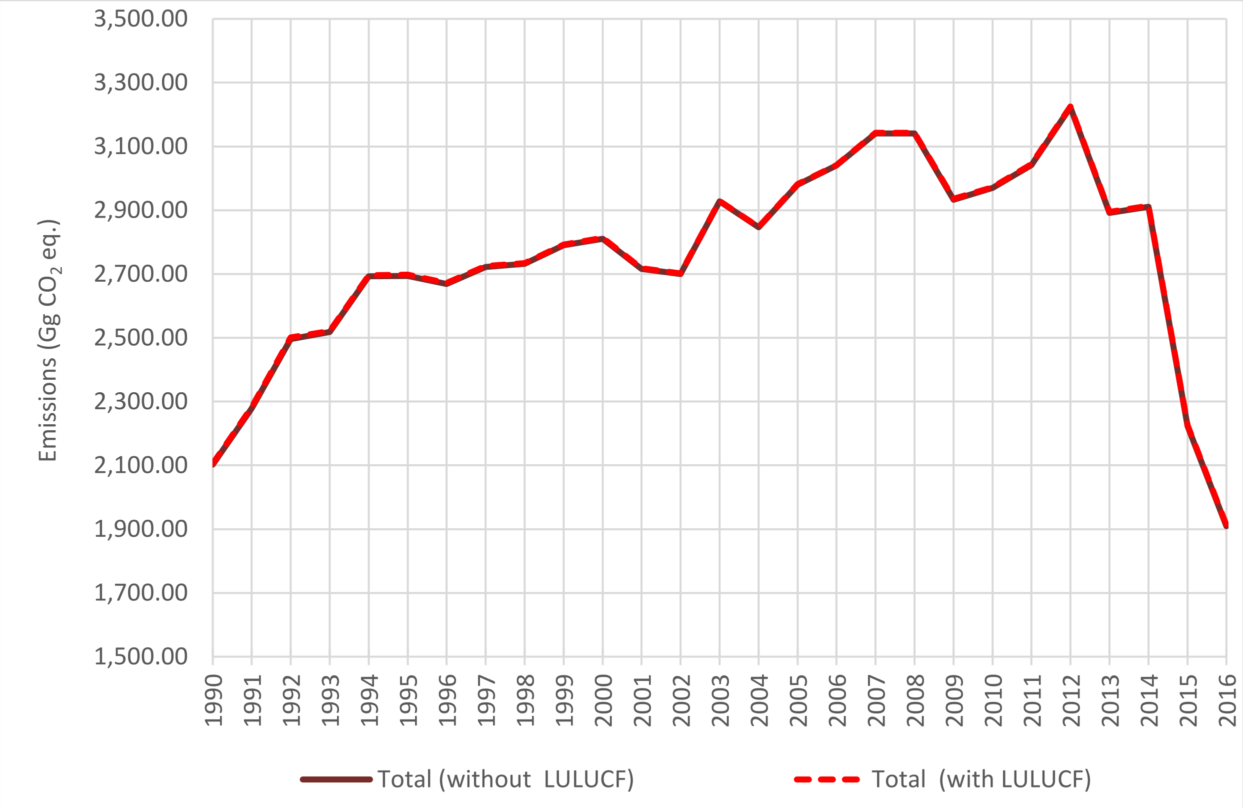
often represented by the specific global warming potential (GWP) of the gas, which compares the relative effect of different gases to each other. Thus, in this discussion, the quantities of greenhouse gases quoted are presented in terms of CO_2 equivalents (CO_2 eq.), where estimated absolute quantities of gases emitted (or removed) are multiplied by the GWP of the respective gas, giving a quantity in CO_2 equivalents, which makes it easier to compare like-with-like.

Anthropogenic activities for which GHG emissions are estimated and reported in national greenhouse gas inventories are usually grouped into five main sectors, namely Energy (includes emissions from public electricity and heat production, transport and fossil fuel use in the industrial, commercial, institutional and residential sectors and in other specific activities), Industrial Processes and Product Use (IPPU; includes, among others, emissions from industrial processes and the use of products such as fluorinated gases (F-gases) in air-conditioning and refrigeration, in foam blowing and fire extinguishing systems), Agriculture (emissions relating to animal husbandry and agricultural soils), Land Use, Land-use Change and Forestry (LULUCF; covers emissions and, or, removals from certain types of land categories, such as forest land, cropland, grassland, wetlands and settlements and from changes between such land categories) and Waste (emissions from solid waste disposal and treatment, incineration and wastewater treatment and discharge).

3.4.1 Malta's national greenhouse gas emissions and removals

The historic profile of total national greenhouse gas emissions is shown in Figure 3.7[39] (numerical data is presented in Table 3.2).

Figure 3.7: Total national greenhouse gas emissions: 1990-2015



What immediately becomes apparent are two main trends: a general increase in emissions in the period up to 2012, the year when total emissions reached their highest level since the 1990[40] base year, followed by a rapid decrease in emissions after 2012, reaching a level of total emissions in 2015 that is second lowest since 1990 levels.[41] 2015 emissions were 5.8 % higher than 1990 emissions, compared to 2012 when emissions were 53.3 % higher than base year. Between 2012 and 2015, the overall decrease in total national emissions was more than 31.0 %.

It is also worth noting that the largest year-to-year change in total emissions occurred in 2015, representing a 23.6 % reduction over 2014 emissions. The highest year-to-year increase occurred between 1991 and 1992, when total national GHG emissions increased by 9.6 %.

[39] For the purposes of good reporting, total greenhouse gas emissions are reported as 'without LULUCF', which do not take into account emissions or removals from the LULUCF sector, and as 'with LULUCF', which take into account emissions or removals from LULUCF. For Malta, LULUCF accounts for a very small amount of emissions; thus, the difference between 'without LULUCF' and 'with LULUCF' is marginal and pictorially these appear to be almost the same.

[40] 1990 is the internationally recognized 'base year' when discussing GHG emissions trends, unless otherwise formally declared by countries for specified gases.

[41] It is to note that estimates available for 2016 show that the downward trend after 2012 has been sustained at least up to 2016.

Table 3.2: **Total (without and with LULUCF) national greenhouse gas emissions: 1990-2015 (data for period covered by this report is shown in bold)**

	Total emissions without LULUCF	Total emissions with LULUCF
	Gg CO_2 eq.	
1990	2102.06	2105.03
1991	2277.86	2282.61
1992	2496.40	2500.75
1993	2517.93	2521.20
1994	2692.53	2696.21
1995	2694.34	2697.41
1996	2668.89	2671.90
1997	2721.91	2724.84
1998	2731.73	2734.28
1999	2790.27	2792.19
2000	2810.52	2813.68
2001	2715.55	2717.65
2002	2700.36	2701.63
2003	2927.55	2928.94
2004	2844.79	2846.33
2005	2978.52	2980.22
2006	3037.61	3039.49
2007	3138.54	3140.55
2008	3138.54	3140.65
2009	**2931.20**	**2933.45**
2010	**2967.77**	**2696.77**
2011	**3040.61**	**3042.84**
2012	**3221.82**	**3224.29**
2013	**2890.86**	**2893.56**
2014	**2908.66**	**2911.60**
2015	**2225.14**	**2228.32**

Disaggregating total national emission into the respective contributions by the different Kyoto Protocol greenhouse gases, it becomes evident that CO_2 by far accounts for the biggest share of national emission of greenhouse gases. Indeed, the contribution of emissions of carbon dioxide is so substantial, that the profile of total national emissions follows very closely that of carbon dioxide emissions, as can be seen in Figure 3.8 (numerical data is presented in Table 3.3). The other greenhouse gases account for significantly smaller contributions towards total national emissions.

Figure 3.8: Greenhouse gas emissions trends by gas: 1990-2015

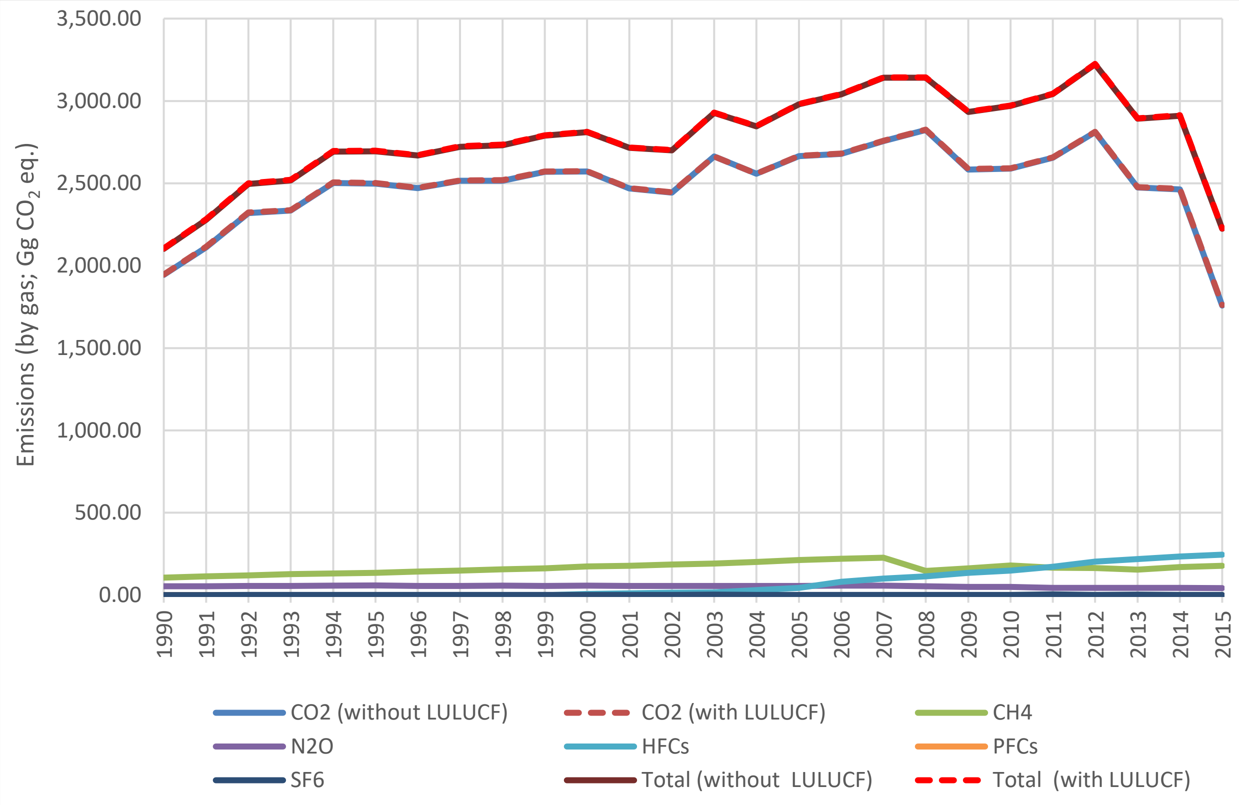


Table 3.3: Greenhouse gas emissions by gas: 1990-2015 (data for period covered by this report is shown in bold)[42]

	CO_2 (without LULUCF)	CO_2 (with LULUCF)	CH_4	N_2O	HFCs	PFCs	SF_6	Total - without LULUCF	Total - with LULUCF
	Gg CO_2 eq.								
1990	1943.32	1946.28	105.92	52.81	NO, NE, NA	NO, NA	0.01	2102.06	2105.03
1991	2110.58	2115.33	113.24	54.04	NO, NE, NA	NO, NA	0.01	2277.86	2282.61
1992	2319.45	2323.81	120.18	55.33	NO, NE, NA	NO, NA	1.43	2496.40	2500.75
1993	2333.91	2337.19	126.45	56.13	NO, NE, NA	NO, NA	1.43	2517.93	2521.20
1994	2502.53	2506.21	131.61	56.96	0.00	NO, NA	1.43	2692.53	2696.21
1995	2498.30	2501.37	135.91	58.69	0.00	NO, NA	1.44	2694.34	2697.41
1996	2469.97	2472.97	142.45	55.03	0.00	NO, NA	1.45	2668.89	2671.90
1997	2515.05	2517.98	149.32	56.09	0.00	NO, NA	1.45	2721.91	2724.84
1998	2516.05	2518.60	155.92	58.28	0.01	NO, NA	1.47	2731.73	2734.28
1999	2570.29	2572.21	162.72	55.79	0.01	NO, NA	1.47	2790.27	2792.19
2000	2570.87	2574.02	173.53	57.96	6.70	NO, NA	1.47	2810.52	2813.68
2001	2468.11	2470.22	178.36	56.32	11.26	NO, NA	1.49	2715.55	2717.65
2002	2443.92	2445.18	184.73	55.24	14.99	NO, NA	1.50	2700.36	2701.63
2003	2662.36	2663.74	191.69	54.98	16.45	NO, NA	2.06	2927.55	2928.94
2004	2557.28	2558.81	201.19	55.31	29.48	NO, NA	1.54	2844.79	2846.33
2005	2666.02	2667.73	212.95	56.20	41.78	NO, NA	1.56	2978.52	2980.22
2006	2679.44	2681.32	220.71	57.02	78.86	NO, NA	1.57	3037.61	3039.49
2007	2756.05	2758.06	226.88	57.29	96.74	0.00	1.58	3138.54	3140.55
2008	2823.74	2825.85	146.48	54.19	112.37	0.00	1.75	3138.54	3140.65
2009	**2584.32**	**2586.57**	**161.51**	**50.74**	**133.13**	**0.00**	**1.50**	**2931.20**	**2933.45**
2010	**2590.22**	**2592.22**	**179.72**	**50.64**	**145.49**	**0.00**	**1.69**	**2967.77**	**2696.77**
2011	**2655.27**	**2657.50**	**167.53**	**44.19**	**169.02**	**0.00**	**4.59**	**3040.61**	**3042.84**
2012	**2810.52**	**2812.99**	**165.55**	**44.28**	**201.03**	**0.00**	**0.45**	**3221.82**	**3224.29**
2013	**2473.93**	**2476.64**	**154.95**	**42.98**	**216.32**	**0.00**	**2.68**	**2890.86**	**2893.56**
2014	**2463.00**	**2465.94**	**171.21**	**43.10**	**230.77**	**0.00**	**0.58**	**2908.66**	**2911.60**
2015	**1757.75**	**1760.93**	**178.36**	**42.47**	**246.37**	**0.00**	**0.19**	**2225.14**	**2228.32**

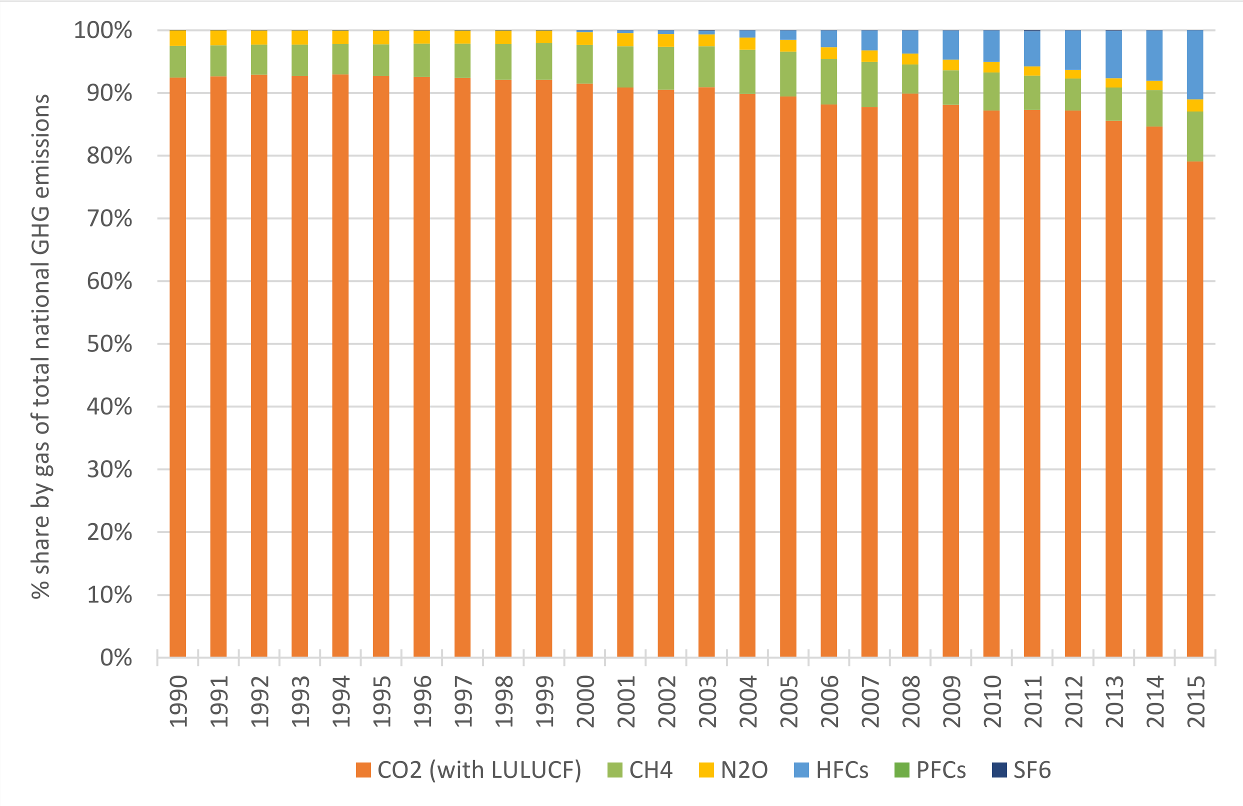
It is however interesting to note how the percentage contribution of different gases towards total national GHG emissions has changed over the course of the time series up to 2015, and in particular the more substantial changes seen over the period covered specifically by this report (Figure 3.9

[42] Values denoted as '0.00' indicate that emissions have been estimated but the value is so small that it cannot be represented at two decimal places. In a number of instances, standard notation keys are used to represent the status of emissions: 'NO'= emissions Not Occurring; 'NE'= emissions Not Estimated (when emissions of a gas for particular category or sub-category could not be estimated for one or more reasons, e.g. no activity data is available); 'NA'= emissions are Not Applicable (meaning that a particular gas cannot be emitted by one or more activity covered by the GHG inventory). For the sake of accurate reporting, the Table retains these notation keys where applicable.

refers). Until 2003, CO_2 always accounted for more than 90 % of total national emissions (2003: 2663.74 Gg CO_2 eq.; 90.9 % share of CO_2 in total 'with LULUCF' emissions). That share has, in general, decreased since then, at first slowly (2009: 2586.57 Gg CO_2 eq.; 88.1 % share of total), but subsequently at a rather more rapid rate, as may be observed especially for 2013 (2476.64 Gg CO_2 eq.; 85.6 % share of total), 2014 (2465.94 Gg CO_2 eq.; 84.6 % share of total) and 2015 (1760.93 Gg CO_2 eq.; 79.1 % share of total).

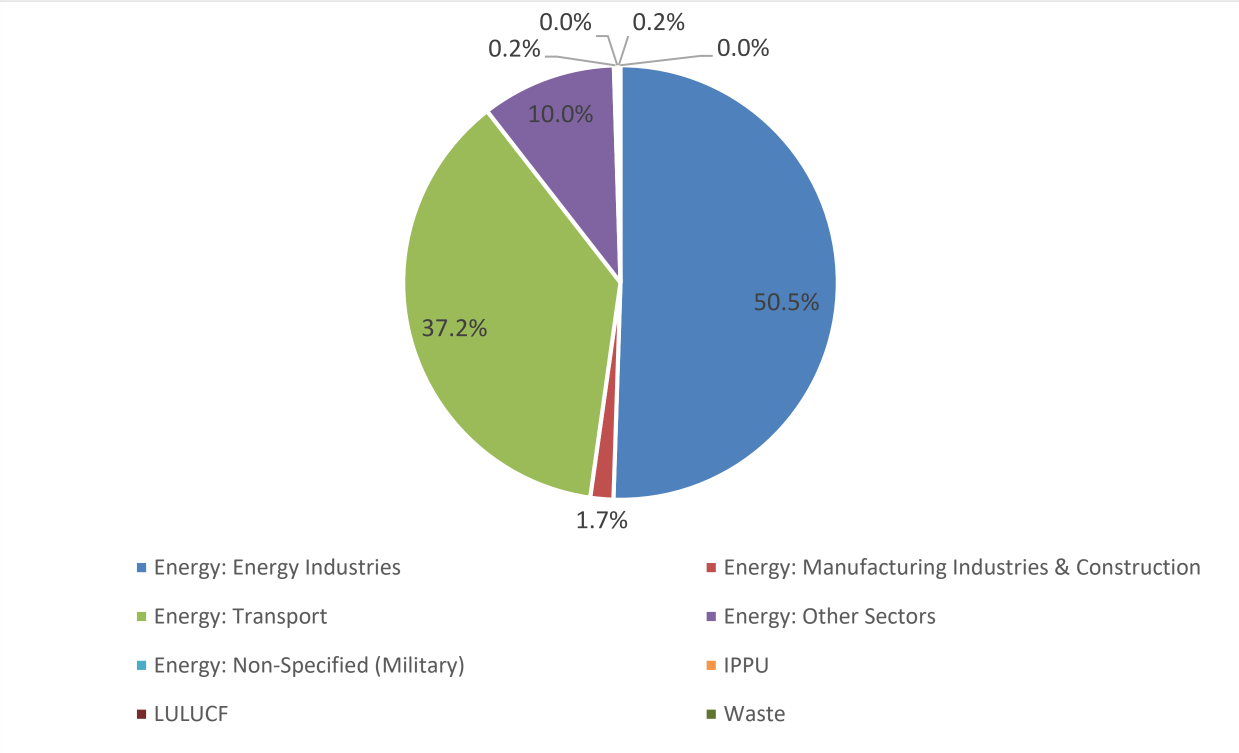
The decreasing relative contribution of CO_2 in total GHG emissions coincides with a counter trend in emissions of HFCs. Thus, while in 2003, HFCs accounted for just 0.6 % (16.45 Gg CO_2 eq.) of total national GHG emissions, in 2009 they represented a 4.6 % share (133.13 Gg CO_2 eq.), growing to 11.0 % (246.37 Gg CO_2 eq.) in 2015. The reasons for these trends will become evident later, when the sectoral trends are discussed.

Figure 3.9: Percentage share of total greenhouse gas emissions by gas: 1990-2015



By far the biggest bulk of CO_2 emissions reported by Malta are emitted by activities in the Energy sector (2015 share of total CO_2 emissions: 99.6 %) with emissions from the category Energy Industries (that includes the local power plants) and transport accounting between them for almost 70 % of total CO_2 emissions (Figure 3.10 refers). CO_2 being a main product of the combustion of fossil fuels, the observed contribution is not surprising, as these two activities account for the highest consumption of fossil fuels in Malta.

Figure 3.10: Share of sector/category (in the case of Energy) in total national CO_2 emissions for 2015



For methane, the Agriculture and Waste sectors are the main contributors to total national CH_4 emissions, with shares of 19.8 % and 78.2 % respectively in 2015 (Figure 3.11 refers). Over the period 1990-2015, the trend of methane emissions shows a general increase, though for the years 2009 to 2015 there have been a number of fluctuations that are evidently linked with similar fluctuations in methane emissions from the Waste sector (Figure 3.12 refers).

Figure 3.11: **Share of sector in total national CH_4 emissions for 2015**

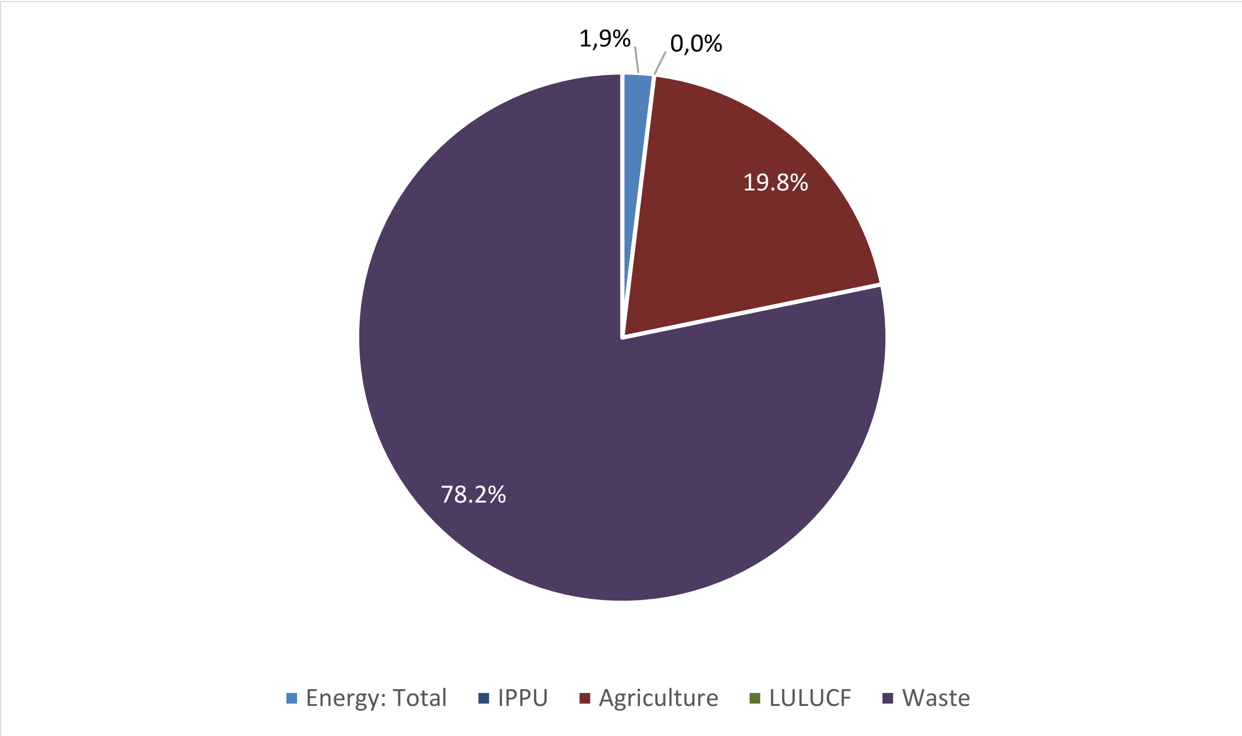
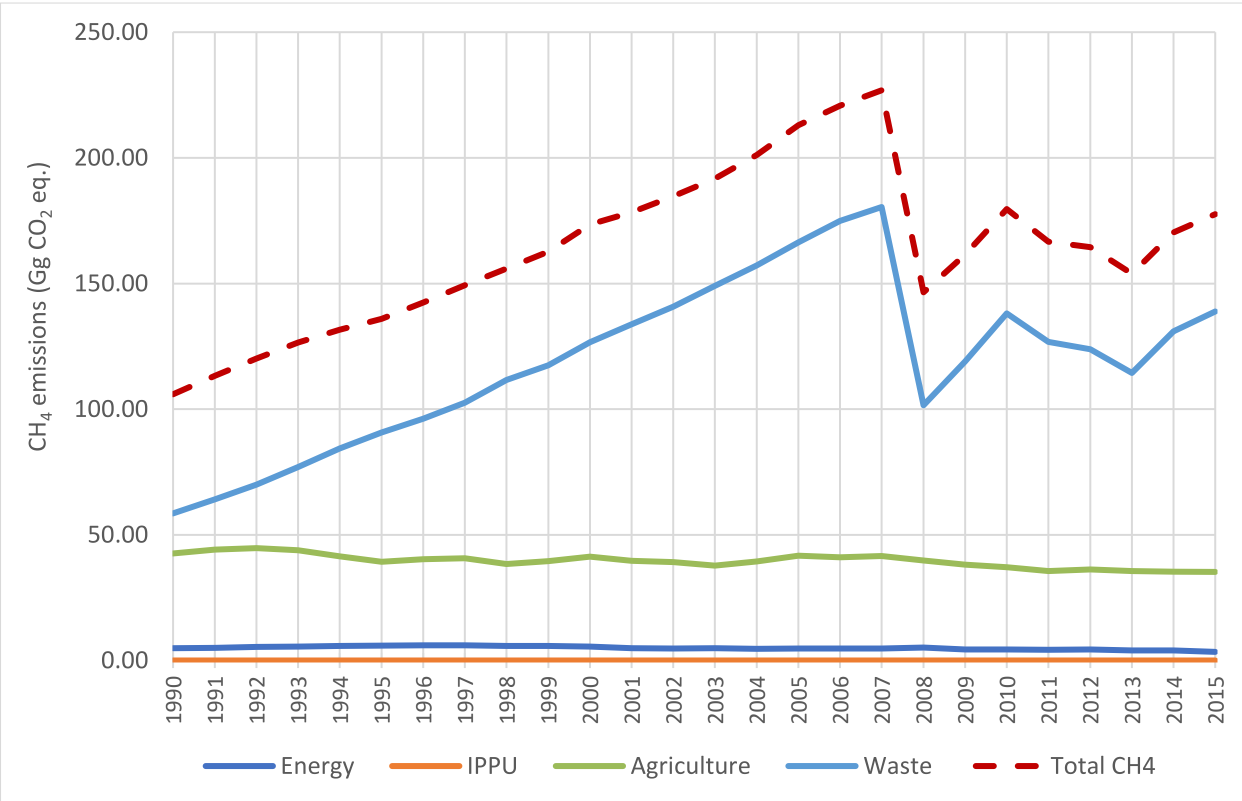
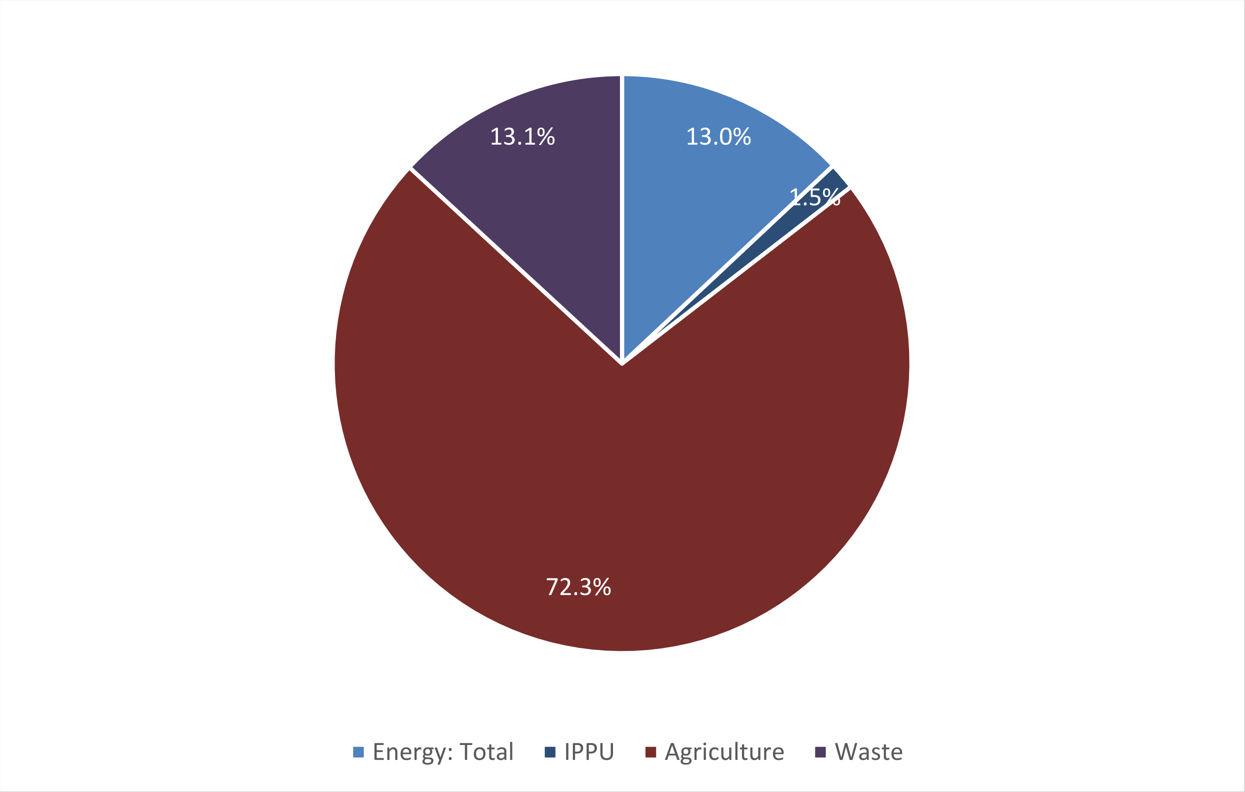


Figure 3.12: **Emission trends for CH_4, total and by sector: 1990-2015**



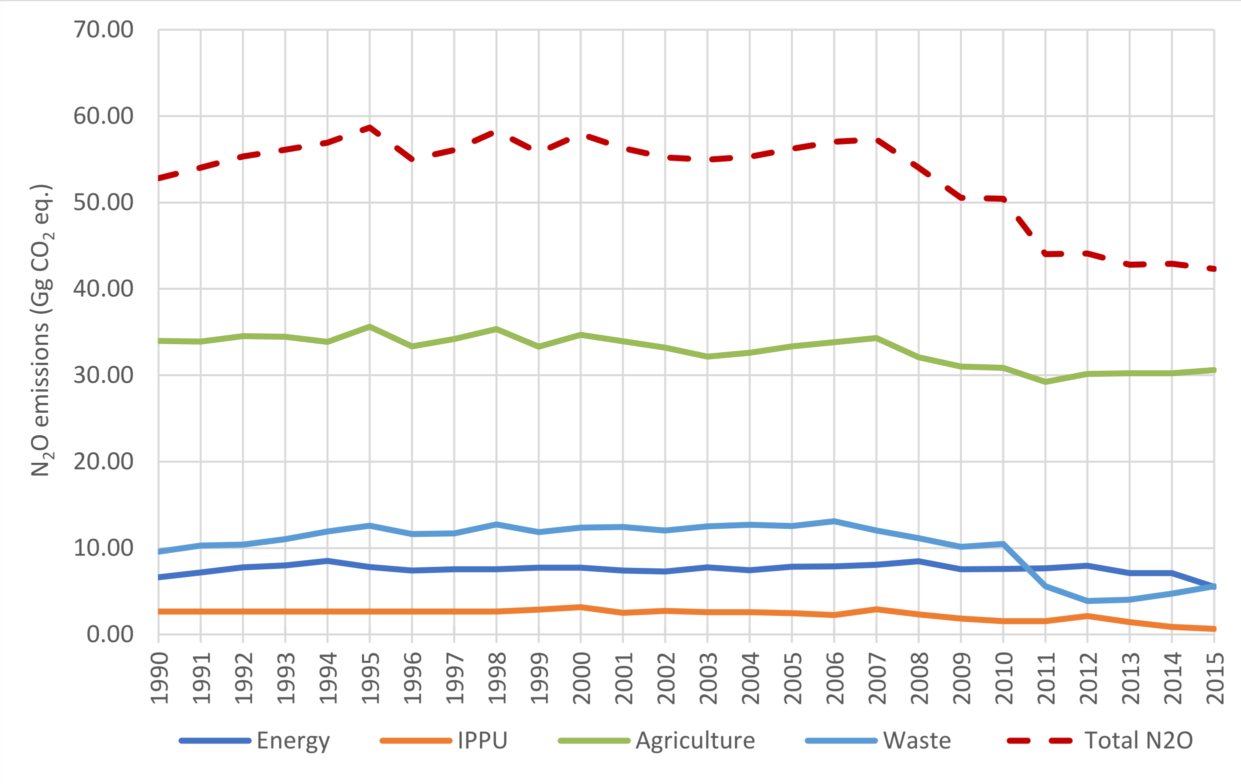
In the case of nitrous oxide, total national emissions are dominated by emissions from Agriculture[43] (72.3 % in 2015; Figure 3.13 refers), with smaller contributions by the Waste (13.1 %) and Energy (13.0 %) sectors and an even smaller contribution of the Industrial Processes and Product Use (1.5 %) sector. The overall trend over the 1990-2015 time series shows a general decrease in N_2O emissions which is also reflected in the similar trends of N_2O emissions by the respective sectors (Figure 3.14 refers).

Figure 3.13: Share of sector in total national N_2O emissions for 2015



[43] Emissions mainly originating from enteric fermentation (40.6%), manure management (36%) and from agricultural soils (23.4%) (MEAIM 2013.)

Figure 3.14: Emission trends for N_2O, total and by sector, 1990-2015



The predominance of the share of HFCs in total national emissions of F-gases (HFCs, PFCs and SF_6) cannot be disputed, as is obvious from Figure 3.15. Indeed, the level of emissions between these three classes of greenhouse gases differs widely, with, in 2015, 246.37 Gg CO_2 eq. for HFCs, a mere 0.19 Gg CO_2 eq. for SF_6 and a very minute quantity of PFCs (Table 3.3 refers). The rapid rate of increase in emissions of HFCs since the early 2000s is evident.

Figure 3.15: **Emission trends for HFCs, PFCs and SF_6: 1990-2015**

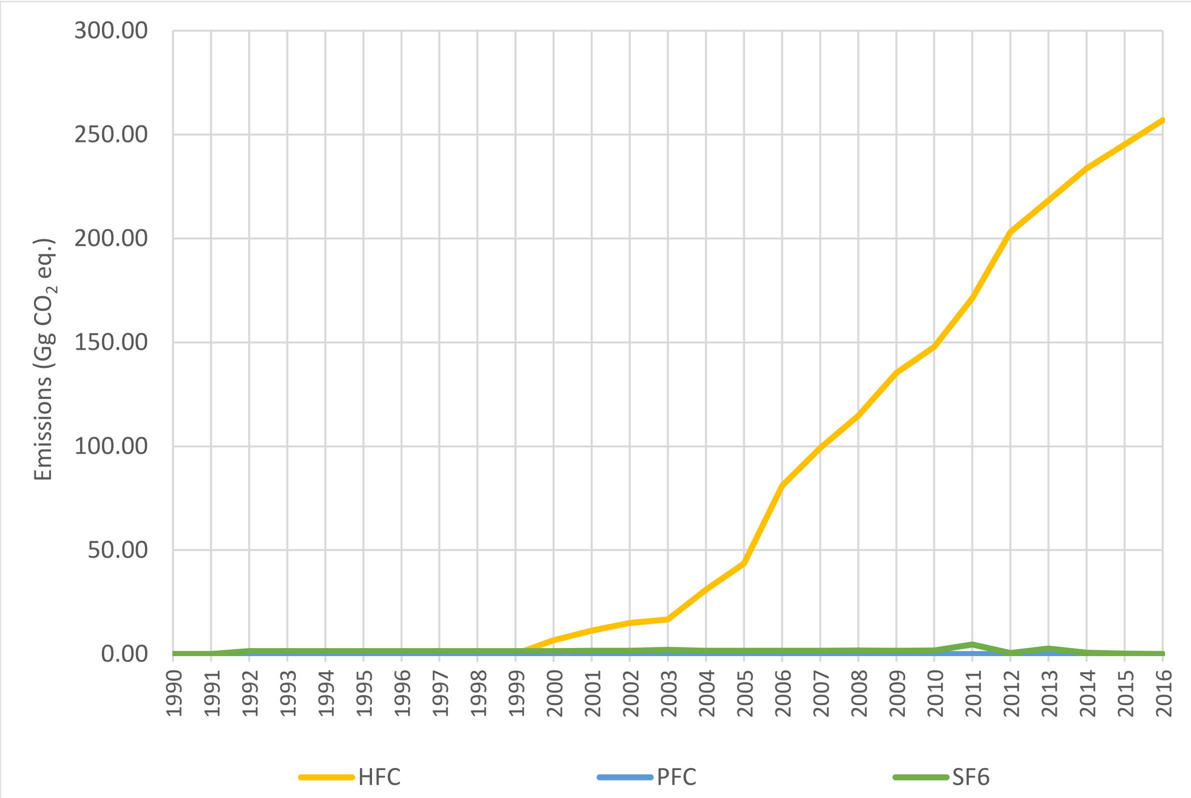
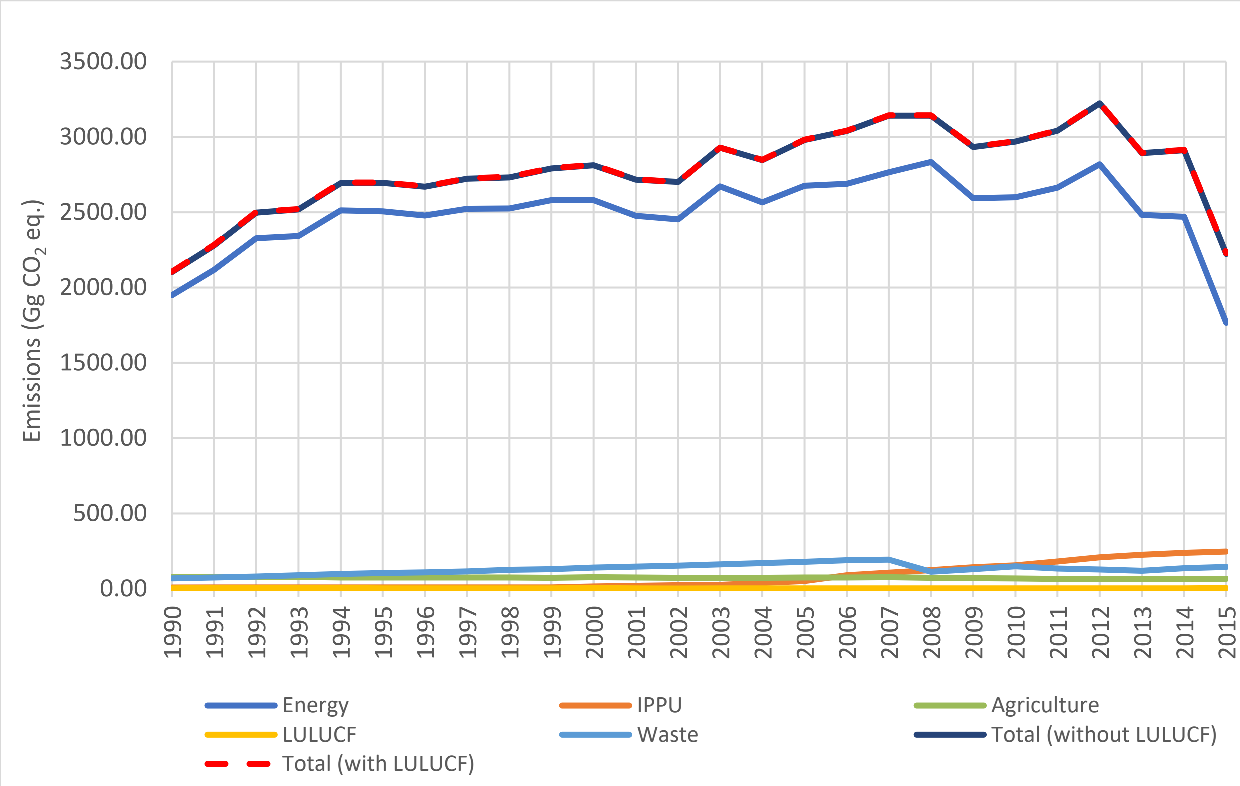


Table 3.4 gives an overview of emissions by sector for the years 1990 to 2015, pictorially presented in Figure 3.16.

Table 3.4: Greenhouse gas emissions by sector: 1990-2015
(data for period covered by this report is shown in bold)

	Energy	IPPU	Agriculture	LULUCF	Waste	Total without LULUCF	Total With LULUCF
	Gg CO2 eq.						
1990	1949.12	7.93	76.52	2.96	68.49	2102.06	2105.03
1991	2116.90	8.16	78.03	4.75	74.77	2277.86	2282.61
1992	2327.21	9.17	79.22	4.36	80.79	2496.40	2500.75
1993	2341.96	9.20	78.35	3.27	88.40	2517.93	2521.20
1994	2511.06	9.50	75.26	3.68	96.71	2692.53	2696.21
1995	2506.22	9.47	74.93	3.07	103.73	2694.34	2697.41
1996	2477.86	9.25	73.60	3.00	108.91	2668.89	2671.90
1997	2522.90	9.46	74.85	2.93	114.70	2721.91	2724.84
1998	2524.32	8.88	73.79	2.55	124.74	2731.73	2734.28
1999	2579.40	8.35	72.81	1.92	129.71	2790.27	2792.19
2000	2579.94	15.20	76.05	3.15	139.35	2810.52	2813.68
2001	2476.12	19.22	73.66	2.11	146.54	2715.55	2717.65
2002	2451.70	23.13	72.36	1.26	153.18	2700.36	2701.63
2003	2670.94	24.84	69.87	1.39	161.90	2927.55	2928.94
2004	2565.48	37.11	72.00	1.54	170.20	2844.79	2846.33
2005	2674.70	49.48	75.07	1.71	179.27	2978.52	2980.22
2006	2687.52	86.89	74.88	1.88	188.31	3037.61	3039.49
2007	2765.22	104.59	75.95	2.01	192.78	3138.54	3140.55
2008	2833.44	120.03	71.88	2.11	113.19	3138.54	3140.65
2009	**2591.89**	**140.35**	**69.07**	**2.25**	**129.89**	**2931.20**	**2933.45**
2010	**2598.06**	**152.17**	**67.94**	**2.00**	**149.59**	**2967.77**	**2696.77**
2011	**2662.55**	**179.02**	**64.80**	**2.23**	**134.23**	**3040.61**	**3042.84**
2012	**2818.90**	**206.76**	**66.43**	**2.47**	**129.73**	**3221.82**	**3224.29**
2013	**2481.11**	**223.85**	**65.76**	**2.71**	**120.14**	**2890.86**	**2893.56**
2014	**2470.13**	**235.45**	**65.54**	**2.94**	**137.54**	**2908.66**	**2911.60**
2015	**1765.44**	**247.77**	**65.84**	**3.18**	**146.10**	**2225.14**	**2228.32**

Figure 3.16: **Greenhouse gas emission trends by sector: 1990-2015**



The contribution of the Energy sector to total national GHG emissions immediately becomes evident. As with the case of the influence of CO_2 emissions on the overall profile of total national emissions, it is clear to see how closely related the profile of total national emissions is to the profile of Energy sector emissions. This is no coincidence, considering the strong relationship between CO_2 emissions and the Energy sector: the absolute bulk of total national CO_2 emissions are generated by activities (fossil fuel combustion) in the Energy sector. The rapid decrease in emissions from the Energy sector since after 2012 can also be similarly correlated to the decrease already observed in total national GHG emissions post-2012.

A growing trend in emissions from IPPU (due to the increase in emissions of HFCs, all of which are reported under this sector) may also be observed, this trend also resulting in a gradual decrease in the overall share of the Energy sector in total national emissions (Figure 3.17 refers). Indeed, while in 1990, the Energy sector accounted for almost 92.6 % of total national GHG emissions, in 2009 this had gone down to 88.3 % in 2009 and to 79.3 % in 2015. On the other hand, the relative share of sector IPPU emissions in total national GHG emissions rose from less than 0.4 % in 1990 to 4.9 % in 2009 and 11.1 % in 2015. The trend in growth in emissions estimated for the IPPU sector is sustained throughout the period of time discussed here, as may be seen in the trend of the percentage change of respective sectoral emissions compared to 1990. The rate of growth in emissions for this sector by far surpasses the rate of change of emissions in the other sectors (Figure 3.18 refers).

The percentage annual change compared to 1990 for each sector is pictorially presented in Figure 3.17 showing in particular the evident correlation between the share trends for Energy and IPPU. The Waste sector may also be seen to have had, overall, a significant rise in its share of total national GHG emissions in 2015 (6.5 %) compared to 1990 (3.3 %), and even 2009 (3.6 %); however, there have been fluctuations in total emissions of this sector over the time series which do not necessarily point towards a consistent trend in the sector's relative contribution to total national emissions.

Figure 3.17: Percentage share by sector of total GHG emissions

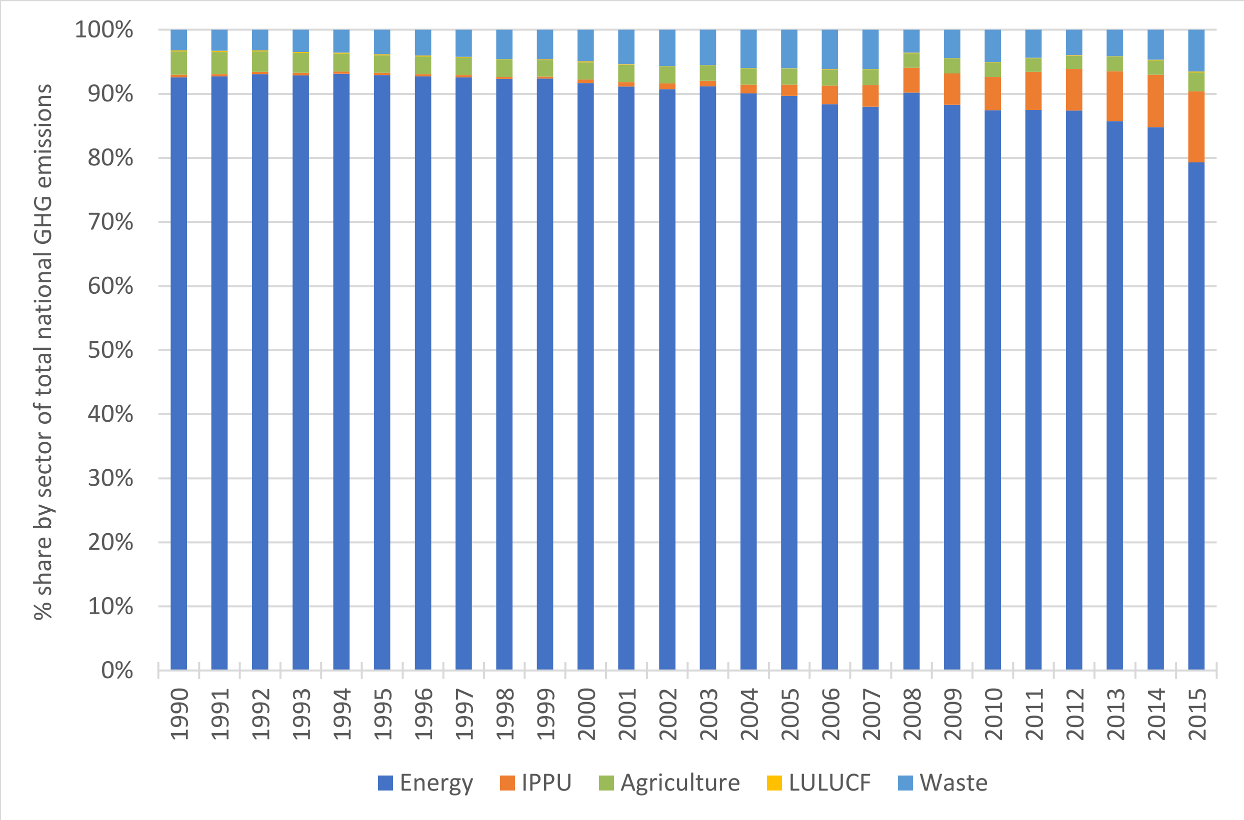
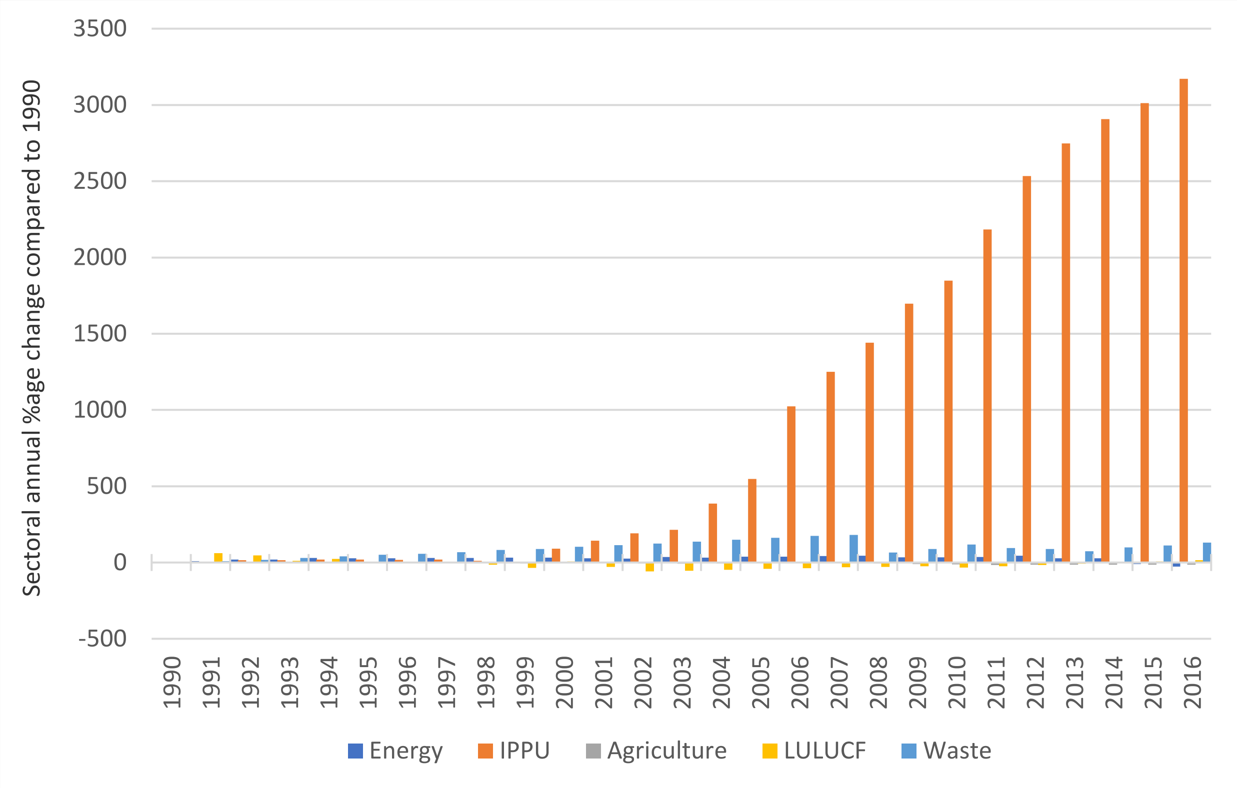


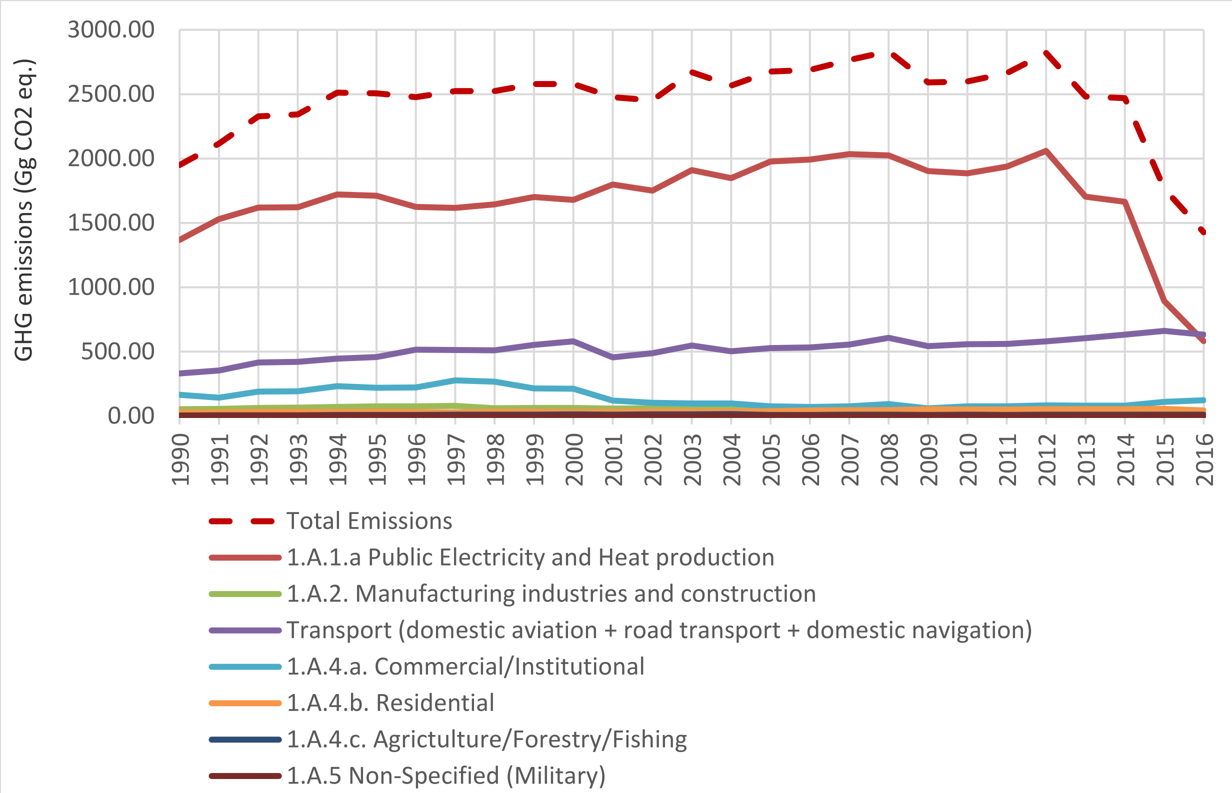
Figure 3.18: **Annual percentage change compared to 1990 by sector**



The trend profile for the Energy sector can be distinguished by two sub-trends, namely a general continued increase up to 2012, and a subsequent general decrease until 2015 (Figure 3.19 refers; compare to similar sub-trends in total national GHG emissions noted above). The first sub-trend reflects sustained increased demand for energy, primarily in electricity generation and transport; this is followed by very substantial, and relatively quick, efficiency gains in local electricity generation over the period 2013-2015, especially due to investment in new generation plants, complemented in particular by substantial imports of electricity from European sources through the interconnector in 2015, emissions of which would not be reported by Malta.[44] Meanwhile, transport related GHG emissions continue to increase with time, largely sustained by increase in emissions from road transport and domestic navigation activities.

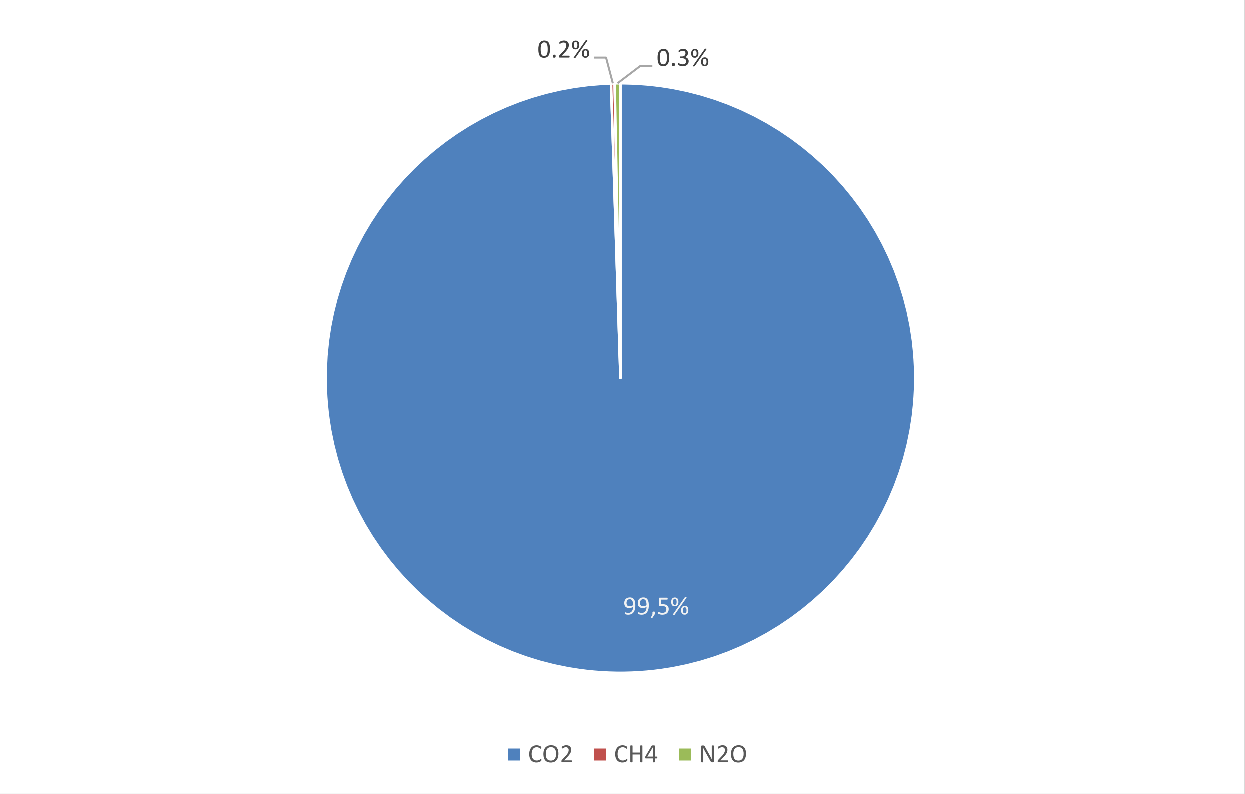
[44] Available information shows that this decrease in emissions from public electricity generation continues to 2016.

Figure 3.19: Emission trends for the Energy sector, total and by category: 1990-2015



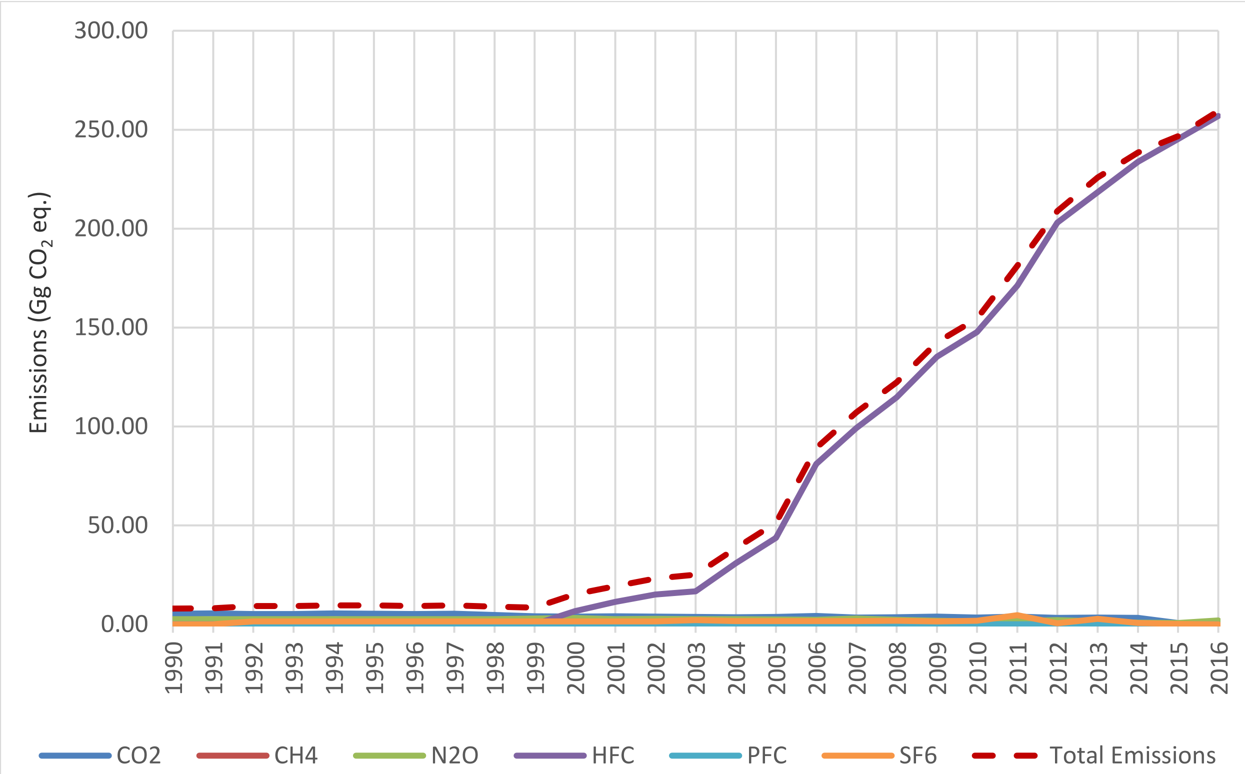
It was already noted earlier that the absolute majority of CO_2 emissions were generated by the Energy sector. Conversely, CO_2 emissions are predominant within this sector (Figure 3.20 refers), with methane and nitrous oxide emissions together accounting for just 0.5 % of total Energy greenhouse gas emissions in 2015. This state of affairs hasn't change in any substantive manner from 1990 and is indeed expected, since fossil fuel combustion results primarily in emissions of carbon dioxide rather than other greenhouse gases.

Figure 3.20: Share by gas in total Energy sector emissions in 2015



Ample reference has already been made to emissions of F-gases, particularly HFCs, and the trend in growth of these. This in turn underpins the growth trend in emissions for the IPPU sector, which, in the case of Malta, have been dominated by emissions of HFCs, at least since 2000, primarily from the use of such gases in air-conditioning and refrigeration systems, with much smaller contributions by other F-gases, and minimal emissions of other greenhouse gases. The overall profile of total IPPU emissions over the 1990-2015 period follows very closely that of emissions of HFCs (HFCs accounted for >99.0 % of total IPPU emissions in 2015).

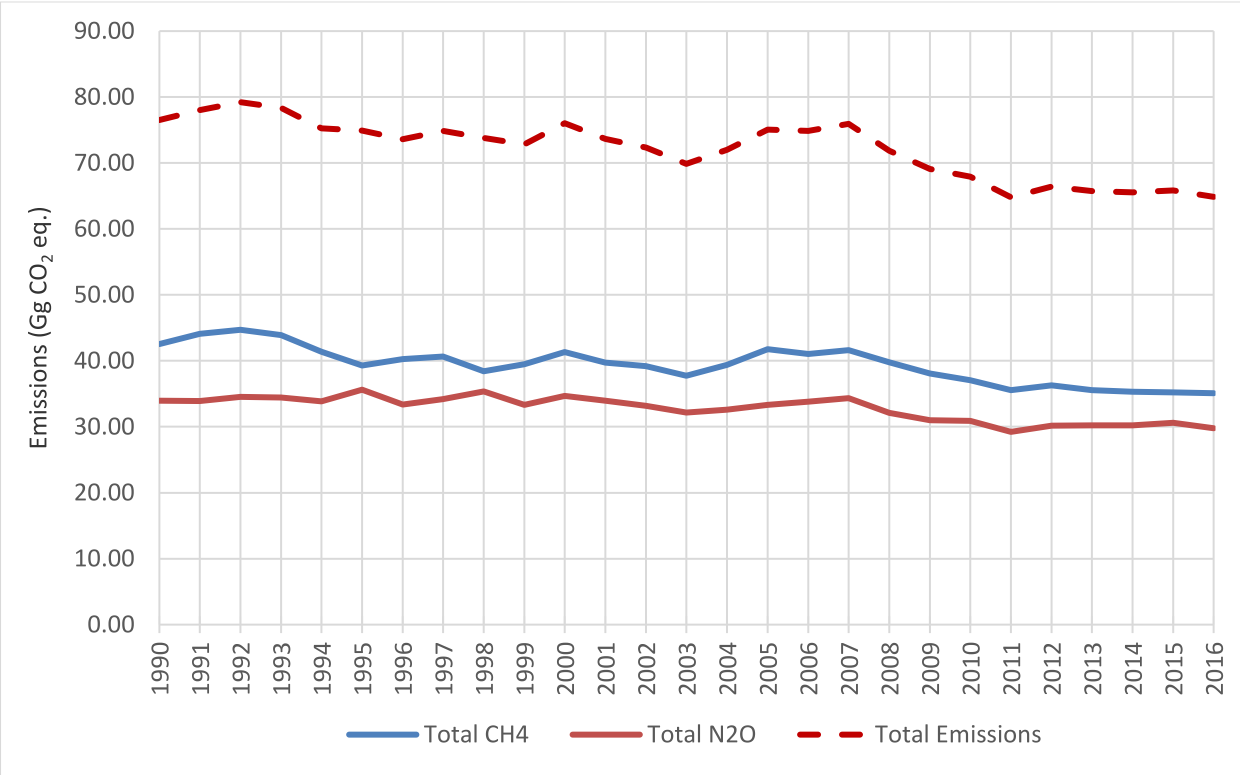
Figure 3.21: Emission trends for the IPPU sector, total and by gas: 1990-2015



In general, the Agriculture sector has seen a decrease in emissions over the 1990-2015 period (Figure 3.22 refers), with emissions in 2015 being around 14 % lower than 1990 emission levels. Methane and nitrous oxide emissions are important contributors, with a relatively small difference in their respective share of total Agriculture sector emissions, a situation that has been maintained over the course of the period 1990-2015, with CH_4 emissions always contributing the higher share (CH_4: 53.5 %; N_2O: 46.5 %; in 2015).

CH_4 emissions from enteric fermentation represent the highest share of total Agriculture GHG emissions (46.7 % in 2015). N_2O emissions from agricultural soils contribute a smaller, albeit significant share of sector emissions (29.7 % in 2015) with a slightly smaller aggregate share for CH_4 and N_2O emissions from manure management (23.6 % in 2015).

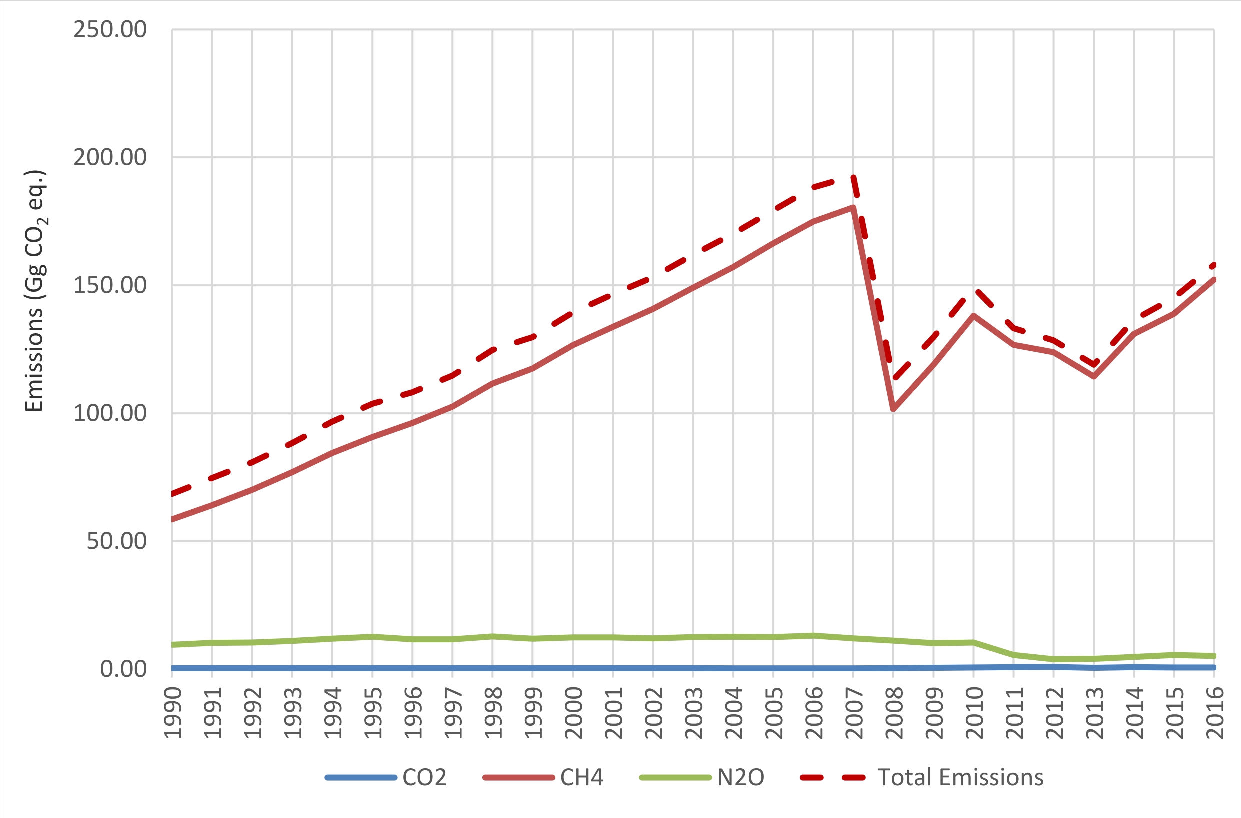
Figure 3.22: Emissions trends for the Agriculture sector, total and by gas: 1990-2015



LULUCF sector emissions have consistently accounted for the lowest share of total national GHG emissions throughout the time series (0.1 % in 1990; 0.1 % in 2016). Interestingly, in earlier stages of the development of Malta's GHG inventory process, this sector was considered to be a sink of greenhouse gases, that is, calculations carried out in the past showed an overall net removal effect of carbon dioxide. However, recent revisions of the manner of calculating emissions and removals from this sector have changed the status of this sector.

For some time during the 1990-2015 period, the Waste sector had the second highest share of total national GHG emissions in Malta, albeit a far second to the Energy sector. In recent years, Waste has been surpassed by IPPU in this respect. The distribution of Waste sector emissions between gases sees the predominance of CH_4 as the greenhouse gas with the largest share of sector emissions, surpassing in a substantive manner the contributions of N_2O and CO_2 (Figure 3.23 refers). Activity-wise, emissions from solid waste management account for the largest share of emissions in this sector. Indeed, the overall trend corresponds to a large extent to the profile of emissions from solid waste management activities, and reflects developments taking place in that respect in Malta, especially the shift from disposal of solid waste in unmanaged landfills to managed landfills, which largely accounts for the lower average emissions for the period after 2007, coupled with trends in total generated waste.

Figure 3.23: Emission trends for the Waste sector, total and by gas, 1990-2015



Per capita emissions for since 1990 are presented in Figure 3.24. Population has grown steadily over the years. As already observed for the trend in total emissions, GHG emissions per capita also show a general increasing trend from 1990 until 2012; this trend is then reversed after 2012, with GHG emissions per capita decreasing, even though population growth continued at a similar rate to previous years' growth. Emissions per capita reached their highest levels in 2007, at 7.7 tonnes CO_2 eq. per capita. The lowest rate of GHG emissions per capita is recorded for 2015 (4.9 tonnes CO_2 eq. per capita).

One can infer, for the latter years especially, an element of decoupling between GHG emission trends and population trends of the Maltese Islands, or, in other words, that population statistics alone cannot directly explain the changes in GHG emissions over the whole period under consideration. Indeed, one could consider that greater demand for major emitting activities in Malta, particularly energy (and therefore, energy generation) and mobility (i.e. road transport) as population grew, could explain the increasing emissions at least until 2012, as these activities have been major contributors to overall emissions in absolute terms. However, targeted measures even in one sector or category could have a major impact on overall emissions, despite continued population growth, even more so if that one sector or category has a significant share of total national emissions. This is the case for the period after 2012, when very substantial emission reductions due to major technical developments in the electricity generation sector, have counteracted any increase that one may have expected to occur due to continued population growth.

Figure 3.24: Trend in emissions per capita compared to population growth trend

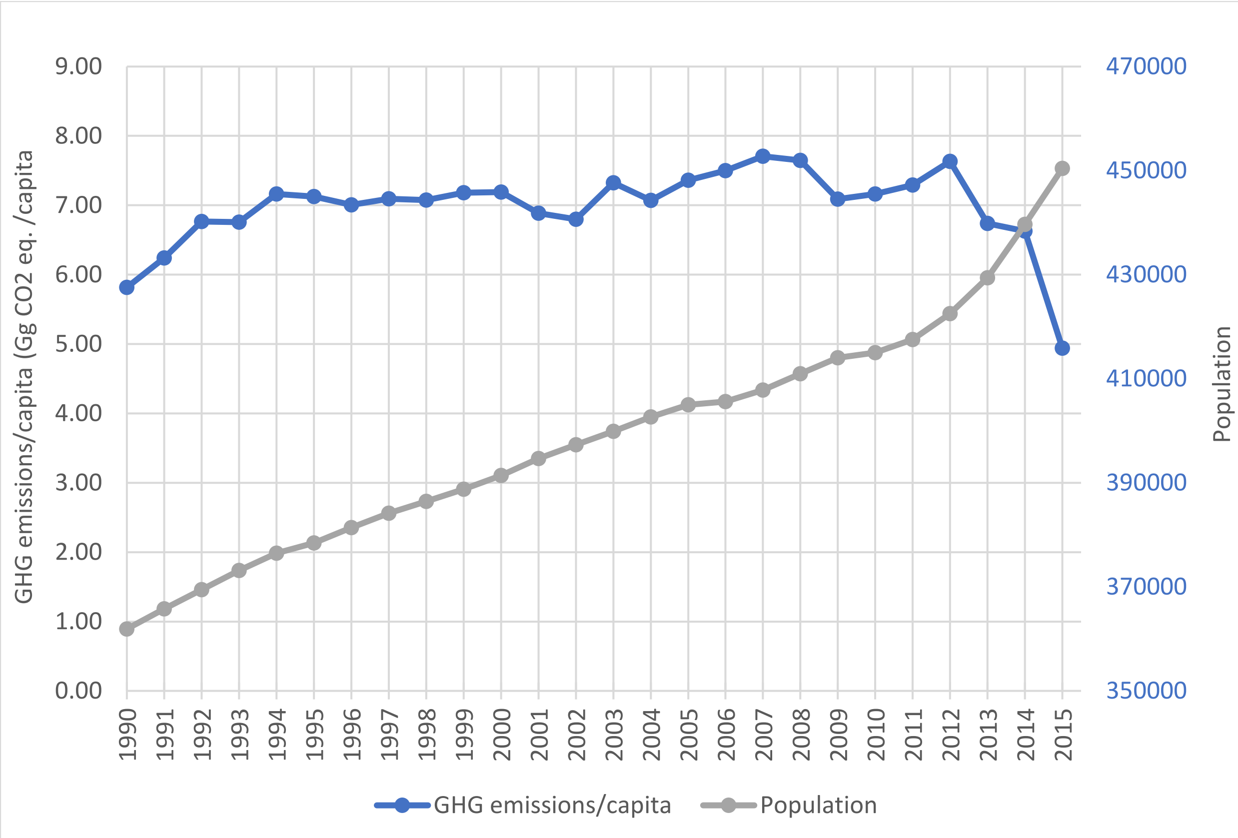


Figure 3.25: **Trend in the emissions intensity of Malta's economy in terms of GHG emissions per unit GDP: 1990-2015**

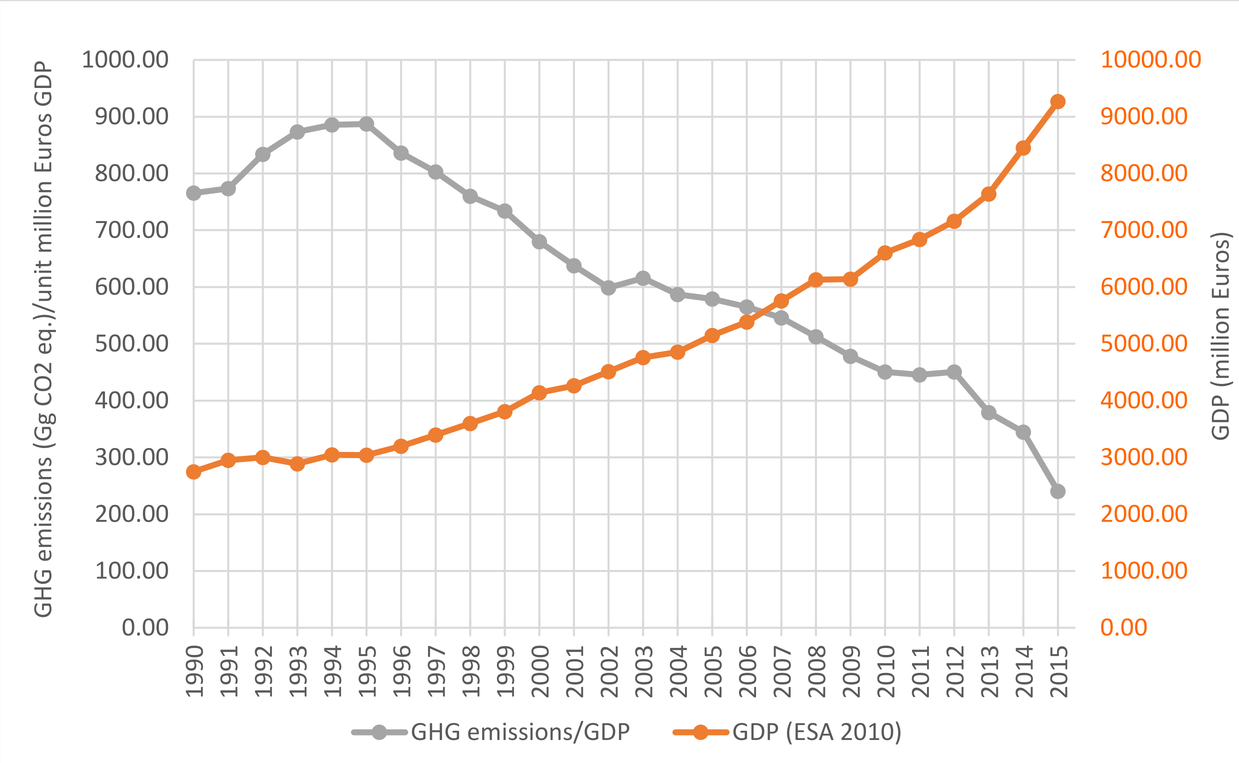


Figure 3.25 presents the trend in the 'emissions intensity' of the Maltese economy, in terms of GHG emissions per unit million Euros Gross Domestic Product (GDP), in comparison with the trend of GDP. GDP shows, throughout the 1990-2015 period, general sustained growth. Decoupling of the emissions intensity of the economy from economic trends is evident for most of the period, with, in recent years, a slight upturn in 2012, coinciding with years when total national GHG emissions peaked. The overall general downward trend of GHG emissions per GDP infers that economic growth is becoming increasingly more efficient, at least from the perspective of emissions.

3.4.2 Mitigation policy: looking towards the future

As seen above, the 2009-2015 presents a watershed in the trend of historic emissions in Malta, with a peak in total national emissions reached in 2012, followed by a rapid and largely sustained decrease in subsequent years. The policy process however does not stop there and actions remain to be taken to follow-up on the progress made so far and ensure that Malta is in a position to effectively contribute its fair share towards the overall EU and global greenhouse gas emissions mitigation efforts.

The Energy sector has been the main driver of GHG emissions trends since 1990, both in respect of the general increase seen up to 2012, and the rapid decrease seen afterwards. The fact that the Energy sector by far accounts for the biggest share of national total greenhouse gas emissions highlights the importance of this sector in the overall national GHG mitigation strategy. The developments taking place in the electricity generation sector since 2012 have had a major effect (Figure 3.19 refers). This in no way implies however that further action should not be taken in this area, to the extent that mitigation potential remains, especially in demand-side management and greater uptake of alternative sources of electricity.

Within the Energy sector, transport (road transport, domestic avtaion and navigation) emissions are becoming more and more important, in terms of their overall share of sector, and national, GHG emissions: in 1990, transport emissions acocunted for 15.7 % of total national (with LULUCF) GHG emissions, increasing to 29.7 % in 2015 . Road transport and domestic navigation[45] emissions gain an even greater importance policy-wise as they are responsible for the greater share of emissions that fall within the scope of the Effort-sharing Decision (49.4 % of 2015 total 'without LULUCF'[46] emissions falling within scope of emission targets under this Decision).

The other sectors with emissions covered by the Effort-sharing Decision, namely IPPU, Agriculture and Waste, all have their own respective contributions to make towards national goals of limiting and reducing greenhouse gas emissions, and, in the contect of the Effort-sharing Decision, contributing towards Malta meeting the set targets. In this respect, the growth in emissions of HFCs is an area warranting particular attention.

[45] Emissions from domestic civil aviation activities are not covered by the Effort-sharing Decision.
[46] Emissions or removals in the LULUCF sector are not covered by the Effort-sharing Decision. After 2020, LULUCF will be included in the overall EU GHG mitigation effort through separate legislation.

Table 3.5: Principal GHG mitigation policy approaches across sectors

Sector	Mitigation action focus
Energy	Efficient and sustainable sourcing of energy Greater uptake of renewable energy sources Supporting efficient use of transport systems Alternative modes of transport New mobility technologies and fuels
Industrial Processes and Product Use	Implementation of the F-gases Regulation[47]
Agriculture	Rural development[48] Nitrates action programme
Land use, land-use change and forestry	Afforestation
Waste	Solid waste management Waste water treatment

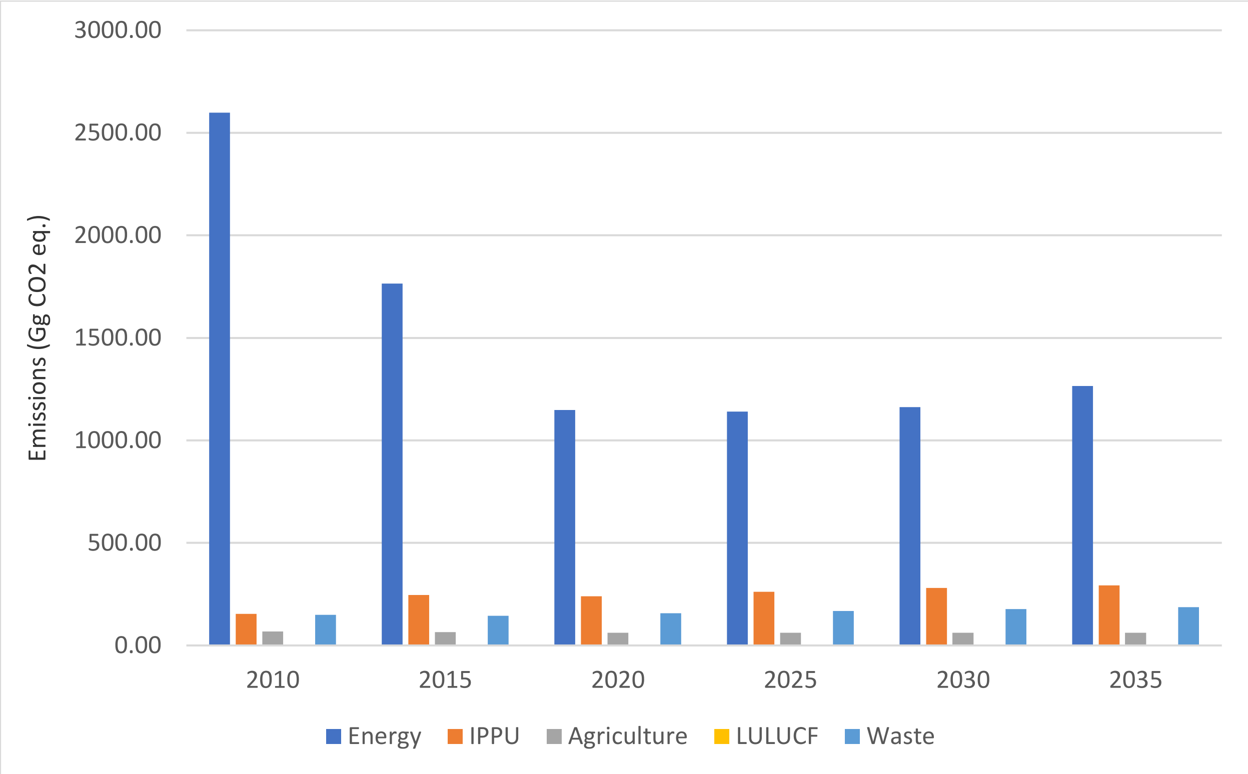
Emission projections provide a forecast of future emissions and are a valuable analytical tool to predict future trends of a country's emissions, taking into account different policy scenarios. Sectoral projections taking into account existing measures, that is, measures implemented or officially adopted by a defined reference point in time, here taken to be 2015, are presented in Figure 3.26.[49] The downward trend in emissions from the Energy sector is expected to be maintained over the short-term, with a limited subsequent upturn as the overall longer-term effect of existing measures is slightly reduced or counteracted by increased demand. Meanwhile, the growth in emissions from the IPPU sector is expected to continue with existing measures.

[47] Regulation (EU) No 517/2014; this regulation, among others, provides for limitations on the amount of F-gases that can be sold in the EU and phasing down of these gases, banning the use of such gases in new equipment where viable, less harmful alternatives exist, and preventing emissions from existing equipment.

[48] MEA 2017.

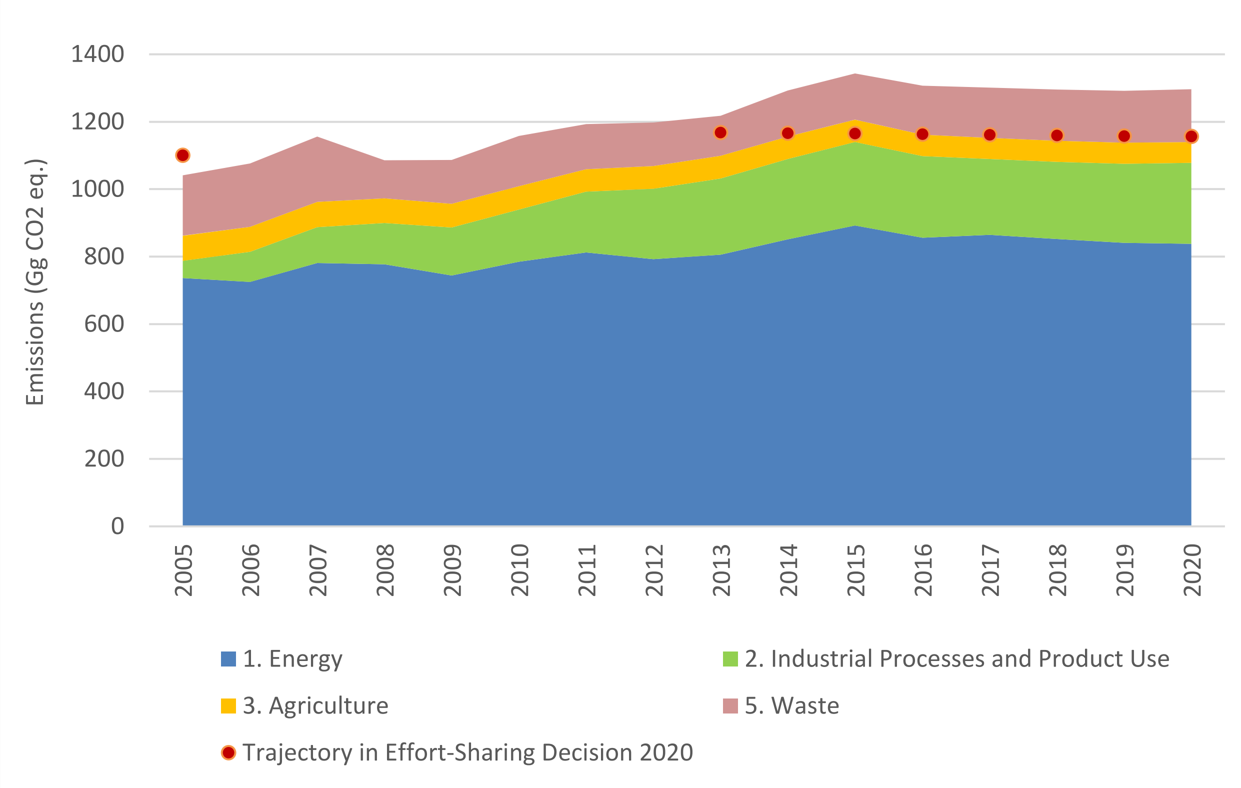
[49] The graph combines GHG inventory data for 2010 and 2015 as estimated in 2017 with projections for 2020, 2025, 2030 and 2035 produced in 2016; it is aimed at providing a general trend. Estimates of future emissions contain an element of uncertainty and furthermore, depend on the policies and measures implemented and adopted current to when the projections are carried out. Projections are thus updated on a regular basis to take into account the developing policy framework and more recent data on historic emissions, to which projections are also calibrated.

Figure 3.26: Trend of GHG emissions for 2010, 2015, 2020, 2025, 2030 and 2035 (GHG inventory estimates: 2010 and 2015; Projected estimates: 2020, 2025, 2030 and 2035)



Malta's commitments under the Effort-sharing Decision, and the status of meeting those commitments, highlight a situation that is worth considering in the context of Malta's particular circumstances, being, among others a small country that is undergoing the shift towards a strongly developed economy. As already seen, overall national GHG emissions have decreased in very significant amounts over the course of just a few years. This has been the result of concerted and targeted action taken in one particular economic sector, that is, electricity generation, that also involved substantial investment. However, emission mitigation effort in one sector, however large the reductions made, is not necessarily enough. This is particularly the case with those sectors and categories of activities (transport, use of F-gases, agriculture and waste management) that fall within the scope of the Effort-sharing Decision targets: despite the reductions in the electricity generation sector, Malta still needs to do much more across such sectors to be able to be able to meet those legal binding targets (Figure 3.27 refers). This is not to say that Malta will not comply with the obligations set out in the Effort-sharing Decision, as there are mechanisms that all Member States of the EU can utilise to ensure that they account for all emissions covered by that Decision, and which Malta is using and other Member States are expected to start using in the coming years as they also start facing the difficulty of meeting stringent emissions limitation and reduction commitments. However, its remains a given that greater efforts have to be undertaken *by all* to ensure that the worthy achievements made in one area can be also achieved across all economic activities that underpin the development of Malta.

Figure 3.27: **Projections of GHG emissions covered by the Effort-sharing Decision and projected situation compared to 2013-2020 targets under that Decision**



3.5 Local pressures on the environment due to a changing climate

A combination of associated disturbances to our local environment (such as increased incidence of droughts, coastal inundation, pests, soil erosion, heatwaves, etc.) coupled to 'external' harmful drivers (such as environmental pollution, unsustainable land-use change and rapid urbanisation) result in a reduction of the resilience of local ecosystems. In other words, these factors are leading to a reduced capacity of the local environment to withstand shocks and to be able to rebuild itself. Reduced resilience does not only come from harm to ecological factors but also from an increased fragility of social factors, such as lack of adaptive capacity building and lack of related technical and administrative knowledge. Below is a non-exhaustive list of some ongoing pressures on the environment arising from a changing climate.[50]

3.5.1 Sectoral environmental impacts

3.5.1.1 Climate

Readers can refer to section 3.3 above for a summary of the salient changes to our local climate during the reporting period. An interesting case in point is the spillover effect of ongoing pressure on our

[50] Direct reference to economic sectors has been excluded due to the narrow scope of this chapter.

local climate onto some of Malta's climate-dependent sectors, such as tourism[51] and agriculture.[52] A description of how climate change is impacting not only the latter two but other local economic sectors is beyond the scope of this chapter.

3.5.1.2 Coastal and marine resources

Ongoing changes in climate have added more pressures to coastal and marine resources, including a continued rise of the sea surface temperature. From a wider scope, the overall increase of sea surface temperature registered in the Mediterranean basin has been coupled to an overall increased heating of the region.[53] This regional warming of the sea will continue to modify our local climate due to its strong dependency on the physical characteristics of surrounding waters.[54]

This temperature increase may have resulted in shifts in local terrestrial and marine species composition and changes in their life cycles. An increased water temperature will also result in a reduction of dissolved oxygen mainly due to changes in both water stratification and thus water circulation, both of which can be additional stress factors on our local marine and coastal ecosystems.

Despite anomalous trends in sea levels in the Mediterranean, local observations show that between 1946 and 2007 the local mean sea level has risen by 19.5 cm.[55] This local change agrees with published IPCC global sea level patterns.[56] On the other hand, observations coming from many stations distributed within the Mediterranean basin show both decelerations and a decrease in sea level rise during the 20th century. This has been attributed to physical changes occurring in Mediterranean waters as well as to regional meteorological conditions (such as changes in air pressure) that could have favoured this trend. Longer time-series analysis and site specific studies are needed to determine the characteristics of such a pressure. Sea level rise can have detrimental consequences to our natural and socio-economic amenities situated along low-lying part of the Maltese coastline.

No studies have been conducted during the reporting period of this SoER to identify additional pressures arising from enhanced dissolution of CO_2 and heat absorption in local waters, nor regarding changes in the general circulation of local coastal waters, and on the disappearance, if any, of economically important species. However, monitoring of the pH of seawater[57] as part of a coastal water quality monitoring programme has been conducted as part of the EU Water Framework Directive baseline surveys undertaken in 26 stations during the period May-November 2012. No significant changes have been observed during this monitoring campaign. However, further interpretation of the data available is not possible at this stage due to the lack of continuous long term data. Such gaps could be addressed through the implementation of sustained monitoring programmes and further research is required urgently.

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[51] Galdies 2015.
[52] Galdies et al. 2016.
[53] Shaltout & Omstedt 2014.
[54] Galdies 2011b.
[55] MEPA 2008.
[56] IPCC 2014.
[57] MEPA 2015.

In 2012, the Department of Biology of the University of Malta updated its local list of alien marine species that have been recorded since 1990.[58] The presence of those identified in local waters has been mainly attributed to the general warming trend of Mediterranean waters, increased marine traffic and aquaculture activities. As of 2012, a total of 48 species, including nine dubious ones, have been included in the list. Of the accepted records, 64 % are established, of which 15.4 % were considered to be invasive, which included *Lophocladia lallemandii, Womersleyella setacea*, *Caulerpa racemosa* var. cylindracea, *Percnon gibbesi, Fistularia commersonii* and *Sphoeroides pachygaster*.

A related case concerns the current threat to legally protected *Posidonia oceanica* meadows, which are considered to be breeding grounds for a wide variety of species, and therefore are an important link in the overall sustainability of marine biodiversity. In 2015 it was reported how a new species of *Caulerpa* was discovered in 2013 following its observation adjacent to *P. oceanica* (L.) Delile stands.[59] The authors of this study maintain that its source originated from Sicily and transported to Maltese waters by means of recreational and/or commercial shipping. Warmer marine conditions are providing the right ambient conditions for such species to flourish in local waters.

3.5.1.3 Freshwater resources

Water resources are highly vulnerable to changing climatic conditions, especially for small islands situated in sub-tropical region. The expected increased drought conditions and more extreme shifts in precipitation patterns could bring about variations in both water flow patterns in vulnerable valley systems and recharge of the aquifer, with detrimental effects on valley ecosystems.

Increased drought conditions will also bring about changes in land-use and crop production[60] that will further intensify the pressures on freshwater systems. It is well known that local freshwater sources are already significantly stressed by their poor management, thus making this sector even more susceptible to a changing climate. Unfortunately, the limited availability of local data and information on climate change impacts on this sector represents one of the major hurdles to freshwater management. The management of the local water sector is extremely important and urgent, and the Water Catchment Management Plan issued during this reporting period (2000-2015) is seen as crucial for the sustainability of this sector.

3.6 Adapting to a changing climate

Apart from the need to have measures in place for the mitigation of GHG emissions, society must also consider how to adapt to a changing climate. According to the UNFCCC Climate Change Adaptation refers ‘to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change’. This need to adjust arises from the fact that certain climate change impacts are now unavoidable, and that

[58] Sciberras & Schembri 2007.
[59] Schembri et al. 2015.
[60] Galdies et al. 2016.

inaction could ultimately translate itself into higher costs. The understanding of climate change impacts and related adaptation can also bring about the recognition of new opportunities to society.

In 2009, Malta's National Strategy for Policy and Abatement Measures relating to the Reduction of Greenhouse Gas Emissions was published and adopted. It aims at providing the necessary framework for the governance and infrastructure needed towards this objective. Subsequently the Maltese Government continued building on this Strategy and on Malta's Communications on Climate Change to the UNFCCC, by publishing and adopting in 2012 a new Climate Adaptation Strategy with the objective of recommending the necessary adaptation measures deemed relevant to sectors[61] that are vulnerable to a changing climate. It also addresses issues related to financial impacts and sustainability.

The Implementation of this Strategy requires an appropriate working framework at Ministerial level. For this purpose, the enactment of adaptation-related actions identified in this Strategy is being implemented by various Ministries and departments. The progress made at the Ministerial level is reported to an Inter-Ministerial Committee.

In April 2013 the European Commission adopted an EU strategy on adaptation to climate change with the scope of making Europe more resilient to climate change. This strategy focuses on three key objectives: (i) promoting action by Member States through capacity building, (ii) 'Climate-proofing' action of various sectors at the EU level, and (iii) improving decision-making by addressing gaps in related knowledge. These knowledge gaps are being addressed through research and by means of channelling related actions through the European climate adaptation platform (Climate-ADAPT)[62] that was launched in March 2012. In this regard, an adaptation fiche for Malta[63] has been developed and a summary of this fiche can be found online.[64]

3.6.1 Adaptation-related activities

Adaptation-related activities generally encompass three main thematic areas, namely: observation, assessment of climate impacts and vulnerability; planning, and implementation, monitoring and evaluation of adaptation actions.[65] What follows is a summary of the progress made based on the information available from various official sources, such as from the European Climate Adaptation Platform,[66] that is relevant to the reporting period of this SOER.

i) Observations, assessment of climate impacts and vulnerability

- Ongoing collection of climatological observations WMO's climatological station of the Malta International Airport (MIA) Meteorological Services Office. The Office maintains a continuous observation and forecasting service.

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[61] These sectors are: Risks, financial impacts, Legal Framework, Sustainability, Water, Agriculture, Human Health, Tourism, Communication and Education.
[62] EC 2017a.
[63] EC 2018.
[64] EEA 2017a.
[65] UNFCCC 2017b.
[66] EEA 2017a.

- Research results generated at the University of Malta by i) the Climate Research Group (Department of Physics), ii) the Institute of Earth Systems (climate monitoring and related impacts on various sectors), and iii) the Institute for Climate Change and Sustainable Development. University research related to climate change is being promoted by the University's Climate Change Platform, which was setup in 2012. Further information concerning this type of research can be obtained for the Platform's website.[67]
- The University of Malta spearheaded research focusing on Education for Sustainable Development.
- The publication of the *National Climate Change Adaptation Strategy* (NAS; May, 2012) considered all potential impacts likely to affect Malta.[68]
- The Third, Fourth, Fifth and Sixth *National Communication of Malta to the UNFCCC* published in 2014 highlighted the major sectors that require adaptation measures due to their vulnerability to a changing climate.

ii) Planning

- The Ministry of Sustainable Development, the Environment and Climate Change (MSDEC) continued supporting both the coordination of Malta's Climate Action Policy and functions of the Inter-Ministerial Committee on Climate Change (IMCCC) setup in 2009 to ensure synergies between the various sectors. This Committee maintained its role as a forum through which overarching policies can be discussed and formulated even within climate change adaptation context.
- Malta's *National Environment Policy* was published in 2012, with a primary objective to monitor the strategies recommended by the NAS as well as to synergise the various sectors to achieve the recommended adaptation measures.
- Ongoing policy changes within the Maltese public services leading to the establishment of an Environment and Resources Authority (ERA) to regulate and monitor activities affecting the environment and climate. This Authority will take over the regulatory and technical support functions presently fulfilled by the Malta's Resources Authority's climate change unit. This reorganization will also positively impact the implementation of adaption measures by addressing the Nation's capacity and resources in support of climate action.
- A new *National Research and Innovation Strategy 2020* was published in June 2014. It aims at building critical mass and capacity building in areas related to climate change adaptation.
- Setting up of funding schemes in support of postgraduate studies. These included the Malta Government Scholarship Scheme (2006-2014) and Master it! (2013-2014) and the *Endeavour Scheme* (2014 - to date) which is the latest Government scholarship scheme.

iii) Implementation, monitoring and evaluation of actions

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[67] UoM 2017a.

[68] The NAS expresses the difficulties of implementing the necessary counter measures to a changing climate, which are mainly due to (i) current limitations in technology to predict the future state of our climate in view of the small size of the Maltese Islands, (ii) relative infancy of knowledge and understanding on the adoption of climate change adaptation measures, and (iii) limited research capability of the main local research institutions.

- Enactment of the Climate Action Act, 2015 (Cap. 543).
- A more efficient administrative, policy and legal approach to adaptation, abatement and mitigation measures as of 2015 through the enactment of the new Climate Action Act, 2015 (Cap. 543).
- Setting up of the Directorate for the Environment and Climate Change within the Ministry for Sustainable Development, the Environment and Climate Change (in 2013). Its objectives are to design, implement and monitor environment and climate change policies, strategies and action plans.
- Setting up of a Climate Action Board (contained in the Climate Action Act, 2015 –Cap. 543: Coordination mechanism and involvement of stakeholders) to involve stakeholders of an inter-Ministerial nature. Its functions are to supervise the implementation of the Act so as to strengthen the collaboration across all relevant sectors.
- Catch the Drop Campaign by HSBC Malta (2013-2016), which was a 3-year national environmental and educational campaign for sustainable use of water in Malta. The campaign aims to reach over 50,000 school children, all the 67 local councils in Malta and Gozo, as well as the general public.
- Some of the recommended adaptation measures have been implemented as of 2012, while other measures have been superseded by other actions as part of other policies. Priority was given to those measures that promote the sustainability of the environment.
- Inclusion of themes related to climate change in school curricula (2002-). Inclusion of new study units related to the topic of climate and its change at the University of Malta[69] with an emphasis on the scientific and technological perspective, followed by themes related to the economic and legal dimension.
- Publication of the National Curriculum Framework in 2012 that includes Education for Sustainable Development as a cross curricular theme.
- Implementation of 34 school-community projects (funded by the School-Community Link Project Grant Scheme) and presented at the House of National Representatives in 2010 and 2011. These activities were organized by EkoSkola as part of its commitment towards education on climate change issues.
- Implementation in 2011 of an initiative called *Naqqas u Ffranka* (Save and Reduce) by the Ministry for Gozo in collaboration with the University of Malta. This targeted over 5,000 households and provided free advice about sustainable use of water and energy and on waste management.

3.7 Conclusion

Malta has long signified its commitment towards climate action. Being a small country presents important challenges, not least in terms of real mitigation potential and more adverse (geophysical, social and economic) vulnerability to the impacts of changing climatic conditions.

[69] UoM 2017b.

The progress achieved so far, as may be seen, for example, in the tangible progress in reducing national total emissions reported in this chapter and in the setting up of a legislative framework for national action through the adoption of the Climate Action Act, is a basis for further progress in future. It is important that policy action in the area of climate change should not only be seen as a means towards addressing a real existing problem of great concern, but rather, climate action should also be viewed as an opportunity to improve even more the social, economic and environmental status of Malta and an opportunity to benefit from the country's enhanced wellbeing deriving from a more sustainable use of resources.

REFERENCES

Climate Action Act 2015. Cap. 543. Laws of Malta. Available at: http://justiceservices.gov.mt/DownloadDocument.aspx?app=lom&itemid=12336&l=1 (Accessed 10 November 2017).

Commission Decision 2013/162/EU of 26 March 2013 on determining Member States' annual emission allocations for the period 2013 to 2020 pursuant to Decision No 406/2009/EC of the European Parliament and of the Council (notified under Document C(2013) 1708). Official Journal of the European Union L 90, 28.3.2013, pp. 106-110.

Commission Delegated Regulation (EU) No 666/2014 of 12 March 2014 establishing substantive requirements for a Union inventory system and taking into account changes in the global warming potentials and internationally agreed inventory guidelines pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council. Official Journal of the European Union L 179, 19.6.2014, pp. 26-30.

Commission Implementing Regulation (EU) No 749/2014 of 30 June 2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council. Official Journal of the European Union L 203, 11.7.2014, pp. 23-90.

Commission Regulation (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council. Official Journal of the European Union L 181, 12.7.2012, pp. 30-104.

Council Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006. Official Journal of the European Union L 140, 5.6.2009, pp. 114–135.

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. Official Journal of the European Union L 140, 5.6.2009, pp. 136-148. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009D0406&from=EN (Accessed 11 January 2017).

Directive (EU) 2015/1513 of the European Parliament and of the Council of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources. Official Journal of the European Union L 239, 15.9.2015, pp. 1-29.

Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for GHG emission allowance trading within the Community and amending Council Directive 96/61/EC Official Journal of the European Union L 275, 25.10.2003., pp. 1-32.

Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community Official Journal of the European Union L 8, 13.1.2009, pp. 3–21.

Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC Official Journal of the European Union L 140, 5.6.2009., pp. 39-85.

Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emissions allowance trading scheme of the Community. Official Journal of the European Union L 140, 5.6.2009, pp. 63–87.

Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. Official Journal of the European Union L 315, 14.11.2012, pp. 1–56.

Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814. Official Journal of the European Union L 76, 19.3.2018, pp. 3–27.

EC (European Commission) 2017a. EU Adaptation Strategy. Climate Action-European Commission. Available at: http://ec.europa.eu/clima/policies/adaptation/what_en (Accessed 11 January 2017).

EC (European Commission) 2017. 2020 Climate & Energy Package. Climate Action-European Commission. Available at: http://ec.europa.eu/clima/policies/strategies/2020_en (Accessed 11 January 2017).

EC (European Commission) 2017. 2030 Climate & Energy Framework. Climate Action-European Commission. Available at: http://ec.europa.eu/clima/policies/strategies/2030_en (Accessed 11 January 2017).

EC (European Commission) 2017. 2030 Energy Strategy. Energy-European Commission. Available at: http://ec.europa.eu/energy/en/topics/energy-strategy/2030-energy-strategy (Accessed 15 January 2017).

EC (European Commission). 2017. Carbon Capture and Geological Storage. Climate Action-European Commission. Available at: http://ec.europa.eu/clima/policies/lowcarbon/ccs_en#tab-0-1 (Accessed 11 January 2017).

EC (European Commission) 2017. Climate Action-European Commission. Available at: http://ec.europa.eu/clima/index_en (Accessed 11 January 2017).

EC (European Commission) 2017. Effort Sharing Decision. Climate Action-European Commission. Available at: http://ec.europa.eu/clima/policies/effort/index_en.htm (Accessed 11 January 2017).

EC (European Commission) 2017. Energy Efficiency Directive. Energy-European Commission. Available at: http://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive (Accessed 11 January 2017).

EC (European Commission) 2017. First European Climate Change Programme. Climate Action-European Commission. Available at: http://ec.europa.eu/clima/policies/eccp/first_en (Accessed 11 January 2017).

EC (European Commission) 2017. Paris Agreement. Climate Action-European Commission. Available at: https://ec.europa.eu/clima/policies/international/negotiations/paris_en (Accessed 11 January 2017).

EC (European Commission). 2017. The EU Emission Trading System (EU ETS). Climate Action-European Commission. Available at: http://ec.europa.eu/clima/policies/ets_en (Accessed 11 January 2017).

EC (European Commission) 2018. The EU Strategy on adaptation to climate change. Available at: https://ec.europa.eu/clima/sites/clima/files/docs/eu_strategy_en.pdf (Accessed 8 June 2018).

EEA (European Environment Agency) 2015. Trends and projections in Europe 2015. Tracking progress towards Europe's climate and energy targets. Available at: https://www.eea.europa.eu/publications/trends-and-projections-in-europe-2015 (Accessed 11 January 2017).

EEA (European Environment Agency) 2016. EEA Report No 15/2016-Annual European Union greenhouse gas inventory 1990–2014 and inventory report 2016. Submission to the UNFCCC Secretariat. Available at: https://www.eea.europa.eu/publications/annual-european-union-greenhouse-gas/at_download/file (Accessed 14 November 2017).

EEA (European Environment Agency) 2016. EEA Report No 4/2016-Renewable energy in Europe 2016. Recent growth and knock-on effects. Available at: https://www.eea.europa.eu/publications/renewable-energy-in-europe-2016 (Accessed 11 January 2017).

EEA (European Environment Agency) 2017a. European Climate Adaptation Platform: Malta. Available at: http://climate-adapt.eea.europa.eu/countries-regions/countries/malta (Accessed 11 January 2017).

EEA (European Environment Agency) 2017. Trends and projections in Europe 2016. Overall progress towards the European Union’s ’20-20-20’ climate energy targets. Available at: http://www.eea.europa.eu/themes/climate/trends-and-projections-in-europe/1-overall-progress-towards-the#tab-related-data (Accessed 11 January 2017).

Energy Efficiency and Cogeneration Regulations 2014, S.L. 545.16. Laws of Malta. Available at: http://justiceservices.gov.mt/DownloadDocument.aspx?app=lom&itemid=12364&l=1 (Accessed 10 November 2017).

ESRL Team 2017. ESRL Global Monitoring Division - Global Greenhouse Gas Reference Network. Available at: http://www.esrl.noaa.gov/gmd/ccgg/trends/global.html (Accessed 11 January 2017).

European Union Greenhouse Gas Emissions Trading Scheme for Stationary Installations Regulations 2013, S.L. 423.50. Laws of Malta. Available at: http://justiceservices.gov.mt/DownloadDocument.aspx?app=lom&itemid=12382&l=1 (Accessed 10 November 2017).

Galdies, C. 2011a. Malta’s climate anomaly trends and possible related socio-economic impacts. National Statistics Office, Malta. 45 p (Accessed 10 November 2017).

Galdies, C. 2011b. The Climate of Malta: statistics, trends and analysis 1951-2010. NSO (National Statistics Office, Malta). Available at: https://nso.gov.mt/en/publicatons/Publications_by_Unit/Documents/B3_Environment_Energy_Transport_Agriculture_Statistics/The_Climate_of_Malta.pdf (Accessed 11 January 2017).

Galdies, C. 2015. ‘Potential future climatic conditions on tourists: A case study focusing on Malta and Venice’. Xjenza Online 3 (2): 86-104. Available at:

https://www.um.edu.mt/library/oar/bitstream/handle/123456789/8288/Potential%20future%20climatic%20conditions%20on%20tourists.pdf?sequence=1&isAllowed=y (Accessed 14 November 2017).

Galdies, C. Said, A. Camilleri, L. and Caruana, M. 2016. 'Climate change trends in Malta and related beliefs, concerns and attitudes toward adaptation among Gozitan farmers'. European Journal of Agronomy 74 pp.18-28.

Geological Storage of Carbon Dioxide Regulations 2011, S.L. 549.68. Laws of Malta. Available at: http://justiceservices.gov.mt/DownloadDocument.aspx?app=lom&itemid=11753&l=1 (Accessed 10 November 2017).

IPCC (Intergovernmental Panel on Climate Change) 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Available at: https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter13_FINAL.pdf (Accessed 7 August 2017).

IPCC (Intergovernmental Panel on Climate Change) 2015. Climate Change 2014 – Synthesis Report – Summary for Policymakers. Available at: https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf (Accessed 6 June 2018).

Malta Airport MetOffice 2017. Data of the annual mean air temperature over the Maltese Islands: 1981-2015. Unpublished.

Malta Airport MetOffice 2017. Data of the annual mean maximum air temperature over the Maltese Islands: 1981-2015. Unpublished.

Malta Airport MetOffice 2017. Data of the annual mean minimum air temperature over the Maltese Islands: 1981-2015. Unpublished.

Malta Airport MetOffice 2017. Data of the annual total precipitation registered in the Maltese Islands: 1981-2015. Unpublished.

MEA (Ministry for European Affairs) 2017. Guidance Notes for Applications for Funding under Measure 10.1 – Payment for Agri-Environment-Climate Commitments. Available at: https://agriculture.gov.mt/en/arpa/Documents/2017/RuralDevelopmentMeasures/Measure%2010dot1%20-%20Version%202dot1.pdf (Accessed 8 June 2018).

MEAIM (Ministry for European Affairs and the Implementation of the Electoral Manifesto) 2013. Rural Development Programme for Malta 2007 -2013. Annual Progress Report 2013. Available at: https://eufunds.gov.mt/en/EU%20Funds%20Programmes/European%20Agricultural%20Fund/Documents/Downloads%20And%20Links/AIR/ARP%202013.pdf (Accessed 29 November 2017).

MEPA (Malta Environment and Planning Authority) 2006. State of the Environment report-Sub Report 3: Climate Change. Available at: https://era.org.mt/en/Documents/SOER%2005%20Sub%20Report%203%20-%20Climate%20Change.pdf.pdf (Accessed 14 November 2017).

MEPA (Malta Environment and Planning Authority) 2010a. Technical Document No: 3 Integrating climate change considerations in the Water Catchment Management Plan for the Maltese Islands. Available at: https://era.org.mt/en/Documents/Tech%20Doc3-Climate%20Check%20Water%20Catchment%20Mgt%20Plan.pdf (Accessed 11 January 2017).

MEPA (Malta Environment and Planning Authority) 2010b. State of the Environment report-Sub Report 6: Coastal and Marine Environment. Available at:

https://era.org.mt/en/Documents/Sub_report_Coastal%20and%20Marine%20Environment%202008.pdf (Accessed 14 November 2017).

MEPA (Malta Environment and Planning Authority) 2015. Initial Assessment Marine Acidification. Available at: https://era.org.mt/en/Documents/MFSD-InitialAssessment-MarineAcidification.pdf (Accessed 14 November 2017).

MRA (Malta Resources Authority) 2014. The First Biennial Report of Malta under the United Nations Framework Convention on Climate Change. Available at: https://unfccc.int/files/national_reports/biennial_reports_and_iar/submitted_biennial_reports/application/pdf/mlt_br1.pdf (Accessed 11 January 2017).

MRA (Malta Resources Authority) 2014. The First Biennial Report of Malta under the United Nations Framework Convention on Climate Change: common tabular format. Available at: http://unfccc.int/files/national_reports/biennial_reports_and_iar/submitted_biennial_reports/application/pdf/mlt_2014_v2.0.pdf (Accessed 11 January 2017).

MRA (Malta Resources Authority) 2014. The Third, Fourth, Fifth and Sixth National Communication of Malta to the United National Framework Convention on Climate Change. Available at: https://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/mlt_nc3,4,5,6.pdf (Accessed 11 January 2017).

MRA (Malta Resources Authority) 2016. National Greenhouse Gas Emissions and Removals Inventory for Malta-2016. Available at: http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/mlt-2016-nir-12oct16.zip (Accessed 14 November 2017).

MRA (Malta Resources Authority) 2016. The Second Biennial Report of Malta under the United Nations Framework Convention on Climate Change. Available at: http://unfccc.int/files/national_reports/biennial_reports_and_iar/submitted_biennial_reports/application/pdf/br2_malta.pdf (Accessed 11 January 2017).

MRA (Malta Resources Authority) 2016. The Second Biennial Report of Malta under the United Nations Framework Convention on Climate Change: common tabular format. Available at: http://unfccc.int/files/national_reports/biennial_reports_and_iar/submitted_biennial_reports/application/pdf/mlt_2016_v1_0_formatted.pdf (Accessed 11 January 2017).

MRA (Malta Resources Authority) 2017. Policies and Measures and Projections Report 2017. Available at: http://cdr.eionet.europa.eu/mt/eu/mmr/art04-13-14_lcds_pams_projections/colwkw8yg/envwkq0hw/ (Accessed 8 June 2018).

MRA (Malta Resources Authority) 2018. Malta's National Inventory of Greenhouse Gas Emissions and Removals, 2018. Available at: http://cdr.eionet.europa.eu/mt/eu/mmr/art07_inventory/ghg_inventory/envwp5tpg/ (Accessed 11 January 2017).

MRRA (Ministry for Resources and Rural Affairs) 2009. National Strategy for Policy and Abatement Measures Relating to the Reduction of Greenhouse Gas Emissions. Available at: https://www.gov.mt/en/Government/Publications/Documents/MSDEC/National%20Climate%20Change%20MITIGATION%20Strategy.pdf (Accessed 8 June 2018).

MRRA (Ministry for Resources and Rural Affairs) 2012. National Climate Change Adaptation Strategy. Available at:

https://msdec.gov.mt/en/Document%20Repository/Malta%20Climate%20Change%20Adaptation%20Strategy/National%20Adaptation%20Strategy.pdf (Accessed 8 June 2018).

MTEC (Ministry for Tourism, the Environment and Culture) 2012. National Environment Policy 2012. Available at: https://era.org.mt/en/Themes/Documents/National%20Environment%20Policy%20(Approved_Feb2012).PDF (Accessed 19 January 2017).

NASA (National Aeronautics and Space Administration) 2017a. Science Briefs: Taking the Measure of the Greenhouse Effect. NASA-GISS (Goddard Institute for Space Studies). Available at: http://www.giss.nasa.gov/research/briefs/schmidt_05/ (Accessed 11 January 2017).

NASA (National Aeronautics and Space Administration) 2017b. Global Climate Change Vital Signs of the Planet-Carbon Dioxide. Available from: http://climate.nasa.gov/vital-signs/carbon-dioxide/ (Accessed 11 January 2017).

NASA (National Aeronautics and Space Administration) 2017. Global Climate Change Vital Signs of the Planet-Sea Level. Available at: http://climate.nasa.gov/vital-signs/sea-level/ (Accessed 11 January 2017).

Regulation (EU) 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. Official Journal of the European Union L 165, 18.6.2013, pp. 13-40.

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. Official Journal of the European Union L 150, 20.5.2014, pp. 195–230.

Samuel-Rhoads, Y. Zodiatis, G. Hayes, D. Konnaris, G. and Georgiou, G. 2013. 'Climate change impacts on sea surface temperature in the eastern Mediterranean, Levantine Basin'.40th CIESM Congress Proceedings Volume 40. Available at: http://www.ciesm.org/online/archives/abstracts/pdf/40/Vol40_opt.pdf (Accessed 14 November 2017).

Schembri, P. Barbara, J. Deidun, A. Lanfranco, and E. Lanfranco, S. 2015. 'It was only a matter of time: occurrence of *Caulerpa taxifolia* (Vahl) C. Agardh var. *distichophylla* (Sonder) Verlaque, Huisman and Procaccini in the Maltese Islands (Chlorophyta, Ulvophyceae, Caulerpaceae)'. BioInvasions Records, 4 (1): 9–16. Available at: http://www.reabic.net/journals/bir/2015/1/BIR_2015_Schembri_etal.pdf (Accessed 16 November 2017).

Sciberras, M. and Schembri, P.J. 2007. 'A critical review of records of alien marine species from the Maltese Islands and surrounding waters (Central Mediterranean)'. Mediterranean Marine Science 8(1): 41-66. Available at: https://www.um.edu.mt/library/oar/bitstream/handle/123456789/21175/Sciberras%20&%20Schembri%20(2007)%20Medit%20Mar%20Sci%208(1)%20pp41-66.pdf?sequence=1&isAllowed=y (Accessed 14 November 2017).

SEWCU (Sustainable Energy and Water Conservation Unit) and ERA (Environment and Resources Authority) 2015. The Second Water Catchment Management Plan for the Malta Water Catchment District 2015 – 2021. Available at:

https://era.org.mt/en/Documents/2nd%20Water%20Catchment%20Management%20Plan%20-%20Malta%20Water%20in%20Maltese%20Islands.pdf (Accessed 10 November 2017).

Shaltout, M. and Omstedt, A. 2014. 'Recent sea surface temperature trends and future scenarios for the Mediterranean Sea'. Oceanologia. 56 (3):411–443.

Tripati, A., Roberts, C. and Eagle, R. 2009. 'Coupling of CO_2 and Ice Sheet Stability Over Major Climate Transitions of the Last 20 Million Years'. Science 326 (5958) pp. 1394-1397. Available at: http://science.sciencemag.org/content/326/5958/1394 (Accessed 11 January 2017).

UNFCCC (United Nations Framework Convention on Climate Change) 1997. Kyoto Protocol to the United Nations Framework Convention on Climate Change adopted at COP3 in Kyoto, Japan, on 11 December 1997. Available at: http://unfccc.int/resource/docs/convkp/kpeng.pdf (Accessed 11 January 2017).

UNFCCC (United Nations Framework Convention on Climate Change) 2009. FCCC/CP/2009/2 Conference of the Parties, Fifteenth session, Copenhagen, 7-18 December 2009. Proposal from Malta to amend Annex I to the Convention. Available at: http://unfccc.int/resource/docs/2009/cop15/eng/02.pdf (Accessed 13 November 2017).

UNFCCC (United Nations Framework Convention on Climate Change) 2016. Report of the technical review of the second biennial report of Malta-FCCC/TRR.2/MLT. Available at: http://unfccc.int/resource/docs/2016/trr/mlt.pdf (Accessed 14 November 2017).

UNFCCC (United Nations Framework Convention on Climate Change) 2017a. First steps to a safer future: Introducing The United Nations Framework Convention on Climate Change. Available at: http://unfccc.int/essential_background/convention/items/6036.php (Accessed 11 January 2017).

UNFCCC (United Nations Framework Convention on Climate Change) 2017b. Focus: Adaptation. Available at: http://unfccc.int/focus/adaptation/items/6999.php (Accessed 11 January 2017).

UoM (University of Malta) 2017a. Climate Change Platform. Available at: https://www.um.edu.mt/islands/climate/relevant_publications (Accessed 11 January 2017).

UoM (University of Malta) 2017b. Study Units featuring Climate Change at the University of Malta. Available at: https://www.um.edu.mt/__data/assets/pdf_file/0005/284441/StudyUnitsfeaturingClimateChangeattheUoM.pdf (Accessed 11 January 2017).

WMO-WDCGG (World Meteorological Organization – World Data Centre for Greenhouse Gases) 2017. CO_2 Giordan Lighthouse – Univ. Malta. Available from: http://ds.data.jma.go.jp/gmd/wdcgg/cgi-bin/wdcgg/download.cgi?index=GLH636N00-UMLT&param=201304220001&select=inventory (Accessed 11 January 2017).