The Third, Fourth, Fifth and Sixth National Communication of Malta

under the
United Nations
Framework Convention
on Climate Change

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

The Third, Fourth, Fifth and Sixth National Communication of Malta to the United National Framework Convention on Climate Change

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Introduction

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

Emission reduction or limitation commitments applicable to Malta

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

In fact, the two major point sources of greenhouse gas emissions in Malta, namely the two electricity generation plants were, as of 2005, and continue to be, subject to the EU Emissions Trading Scheme, whereby they are required to surrender allowances in respect of emissions of carbon dioxide. All other emissions of greenhouse gases, except for some exceptions, are subject to an overall limit under the so-called Effort-Sharing Decision. Under this decision, Malta must limit such greenhouse gases to not more than 5% over emission levels in 2005, by 2020.

With the adoption of amendments to the Kyoto Protocol (the Doha Amendments), an overall quantified emission reduction target of 20% compared to 1990 levels has been inscribed for Malta for the second commitment period of the Protocol. However, as a member state of the European Union, Malta will be jointly fulfilling the second commitment period with the other Union member states; therefore, emissions from the afore-mentioned power plants remain subject to compliance with EU Emissions Trading Scheme provisions, while the Effort-Sharing Decision target is the principal emissions mitigation obligation that the country has until 2020, for all other greenhouse gas emissions.

Greenhouse gas emissions

(Refer to Chapter 2 for more detailed information.)

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

The estimation of emissions and removals is a process currently in the hands of a small team of inventory compilation experts within the Malta Resources Authority. Efforts continue in order to build capacity and systems to ensure that this requirement, so fundamental to informed and effective greenhouse gas mitigation policy, is met to the highest possible levels of reliability and quality.

Inventory results for the time-series 1990 to 2011 (the latter being the most recent year for which inventory data submission to the UNFCCC is available) are presented in Table 0-1 (by gas) and Table 0-2 (by sector) and Figure 0-1 (by gas) and Figure 0-2 (by sector). Total net emissions in 2011 were 2962 Gg CO_2 equivalent, an almost 52% growth in emissions over 1990 levels, when net emissions are estimated to have been 1950 Gg CO_2 equivalent (gross emissions in 1990 were 2007 Gg CO_2 equivalent and in 2011, 3021 Gg CO_2 equivalent, an overall increase of around 51%).

Carbon dioxide dominates as the greenhouse gas with the highest level of emissions in Malta. Indeed, emissions of carbon dioxide from all sources, taking also into account removals by sinks, account for 88% of total national net emissions (for 2011). Methane and hydro fluorocarbons are a distant second and third in level of emissions.

The sector Energy, which includes emissions from electricity generation and transport, is by far the largest contributor to national emissions. This sector accounts for 89% of total national greenhouse gas emissions (for 2011). Indeed, emissions of carbon dioxide from electricity generation and transport also account for the bulk of total national emissions. Emission sources electricity generation and transport warrant particular mention, and policy attention, as they represent the most important source categories in terms of greenhouse gas emissions.

Table 0-1 Overview of national greenhouse gas emissions and removals (Gg CO_2 equivalent), by gas.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO_2 (Net)	1,809.0	1,984.5	2,088.9	2,084.9	2,196.3	2,156.5	2,208.7	2,198.7	2,202.1	2,292.2	2,289.3
CO_2 (Gross)	1,865.5	2,041.0	2,145.5	2,141.4	2,252.9	2,213.0	2,265.2	2,255.3	2,258.6	2,348.1	2,345.2
CH_4	91.1	91.4	94.4	98.1	100.9	104.7	107.0	110.4	112.2	113.8	125.0
N_2O	49.9	50.4	51.7	52.8	54.3	59.2	54.9	55.4	61.2	56.5	61.0
HFCs	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	73.9	73.9	73.9	8.3
PFCs	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	0.0
SF_6	0.0	0.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Total Net Emissions	**1,950.0**	**2,126.3**	**2,236.5**	**2,237.3**	**2,353.0**	**2,321.8**	**2,372.1**	**2,439.9**	**2,450.9**	**2,537.9**	**2,485.1**
Total Gross Emissions	**2,006.6**	**2,182.8**	**2,293.0**	**2,293.9**	**2,409.5**	**2,378.4**	**2,428.6**	**2,496.5**	**2,507.4**	**2,593.8**	**2,541.0**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
CO_2 (Net)	2,408.9	2,428.9	2,606.7	2,560.4	2,647.0	2,612.1	2,698.0	2,656.8	2,569.6	2,580.9	2,603.4
CO_2 (Gross)	2,464.8	2,484.8	2,663.7	2,618.6	2,704.0	2,671.0	2,756.9	2,715.6	2,628.5	2,640.6	2,663.1
CH_4	125.5	126.9	126.8	132.8	139.9	148.7	158.8	158.0	167.2	175.4	167.4
N_2O	58.7	58.2	55.5	56.5	58.5	59.9	59.3	55.7	54.3	51.9	50.4
HFCs	15.3	28.7	40.1	60.4	64.5	87.5	106.2	116.7	120.3	121.6	132.2
PFCs	0.0	0.0	0.0	27.9	23.4	23.3	22.8	12.9	7.0	6.6	3.3
SF_6	1.6	1.6	2.2	1.6	1.6	1.7	1.7	1.8	1.6	1.8	4.8
Total Net Emissions	**2,610.0**	**2,644.3**	**2,831.1**	**2,839.7**	**2,934.9**	**2,933.2**	**3,046.7**	**3,002.0**	**2,920.1**	**2,938.2**	**2,961.5**
Total Gross Emissions	**2,665.9**	**2,700.2**	**2,888.1**	**2,897.8**	**2,992.0**	**2,992.0**	**3,105.6**	**3,060.8**	**2,979.0**	**2,997.9**	**3,021.2**

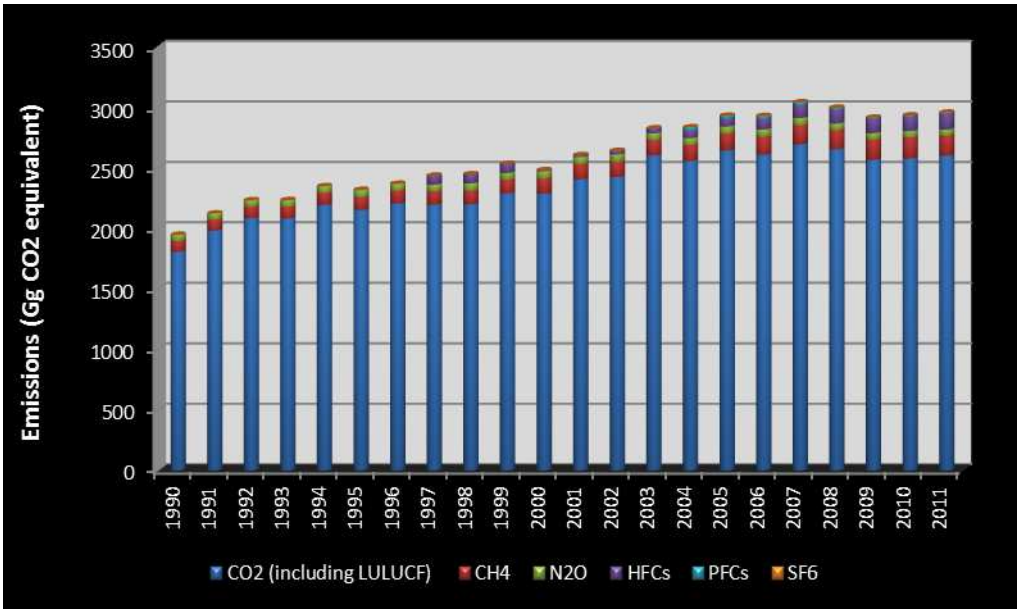


Figure 0-1 Trends in emissions of greenhouse gases (net emissions for CO_2), by gas.

Table 0-2 Overview of national greenhouse gas emissions and removals (Gg CO_2 equivalent), by sector.

	1990	1991	1992	1993	1994	1995	1996	1997
1. Energy	1,878.10	2,054.36	2,159.82	2,156.12	2,267.74	2,226.04	2,278.68	2,268.69
2. Industrial Processes	0.33	0.53	1.65	1.69	1.99	3.21	3.04	77.11
3. Solvents and Other Product Use	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48
4. Agriculture	87.81	85.53	86.96	87.53	86.80	93.83	90.93	92.85
5. LULUCF	-56.54	-56.54	-56.54	-56.54	-56.54	-56.54	-56.54	-56.54
6. Waste	37.84	39.88	42.08	46.04	50.51	52.81	53.49	55.34
Total (net emissions)	**1,950.02**	**2,126.25**	**2,236.45**	**2,237.32**	**2,352.98**	**2,321.85**	**2,372.09**	**2,439.93**

	1998	1999	2000	2001	2002	2003	2004	2005
1. Energy	2,272.74	2,363.35	2,360.56	2,480.70	2,500.77	2,680.35	2,634.63	2,722.43
2. Industrial Processes	76.54	75.80	10.11	17.27	30.61	42.43	90.34	89.92
3. Solvents and Other Product Use	2.48	2.72	3.01	2.33	2.56	2.38	2.37	2.26
4. Agriculture	95.39	91.27	102.95	98.77	97.94	91.10	95.65	93.58
5. LULUCF	-56.54	-55.91	-55.91	-55.91	-55.91	-57.00	-58.17	-57.08
6. Waste	60.25	60.62	64.40	66.84	68.29	71.88	74.86	83.76
Total (net emissions)	**2,450.86**	**2,537.86**	**2,485.12**	**2,610.00**	**2,644.26**	**2,831.14**	**2,839.68**	**2,934.88**

	2006	2007	2008	2009	2010	2011
1. Energy	2,689.09	2,775.93	2,734.83	2,647.29	2,659.62	2,681.65
2. Industrial Processes	112.80	130.90	131.66	129.17	130.24	140.57
3. Solvents and Other Product Use	2.03	2.71	2.10	1.60	1.29	1.31
4. Agriculture	93.36	95.23	86.45	83.26	78.04	70.90
5. LULUCF	-58.87	-58.86	-58.86	-58.87	-59.67	-59.67
6. Waste	94.76	100.78	105.77	117.64	128.73	126.76
Total (net emissions)	**2,933.18**	**3,046.69**	**3,001.96**	**2,920.09**	**2,938.24**	**2,961.52**

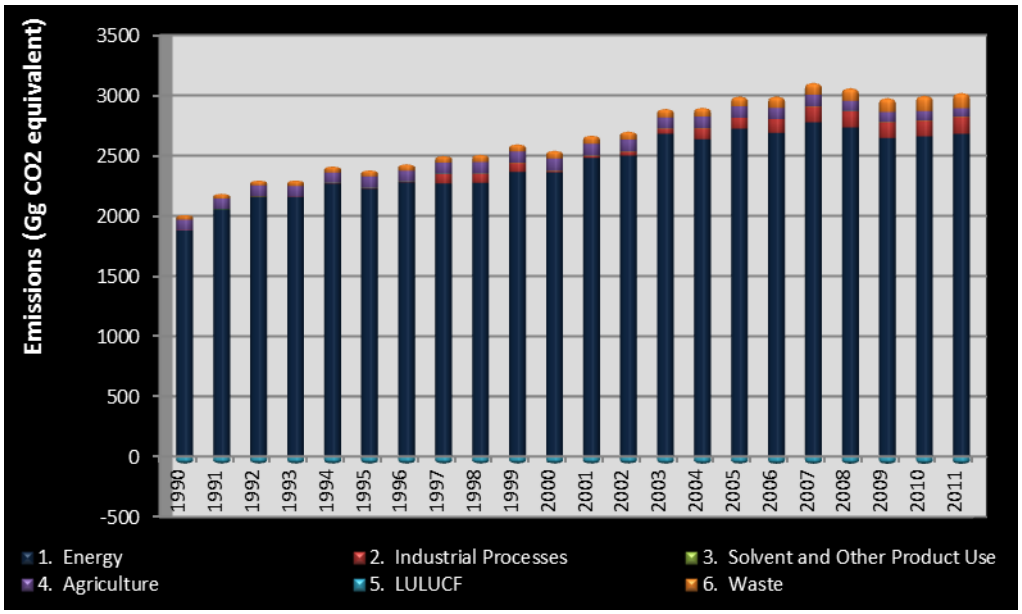


Figure 0-2 Trends in emissions by sources and removals by sinks of greenhouse gases, by sector.

GHG mitigation policies and measures and their aggregate effect

(Refer to Chapters 3 and 4 for more detailed information.)

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

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

Table 0-3 Summary of policy approach in respect of greenhouse gases.

Sector	Mitigation action focus
Energy	Conventional energy generation; Energy end-use efficiency; Energy-related cross sectoral; Transport (particularly road transport.
Industrial processes and other product use	Fluorinated greenhouse gases.
Agriculture	Rural development; Nitrates action programme.
Land use, land-use change and forestry	Afforestation.
Waste	Solid waste management; Waste water treatment.

The combined effect of the policies and measures discussed and presented in this Communication is represented in the projected emission profiles by sector (Figure 0-3) and by gas (Figure 0-4). Table 0-4 gives a quantified summary of projected emissions. These represent a policy scenario with existing measures, that is, including measures that are being implemented or for which a firm decision to adopt has been taken (end of 2012 as the cut-off date).

The strong effect that policies and measures in the energy generation sector have on overall future emission profiles is obvious. Considering that these actions will directly or indirectly affect emissions from the only two locally operating conventional power plants, it is pertinent to also keep in mind the relevance that progress in limiting and reducing emissions related to electricity generation has on the compliance costs related to the EU Emissions Trading Scheme for the two plants.

Figure 0-5 shows the projected aggregate effect of policies and measures when comparing the no policy ('without measures') scenario, the 'with existing measures' scenario and the 'with additional measures' scenario.

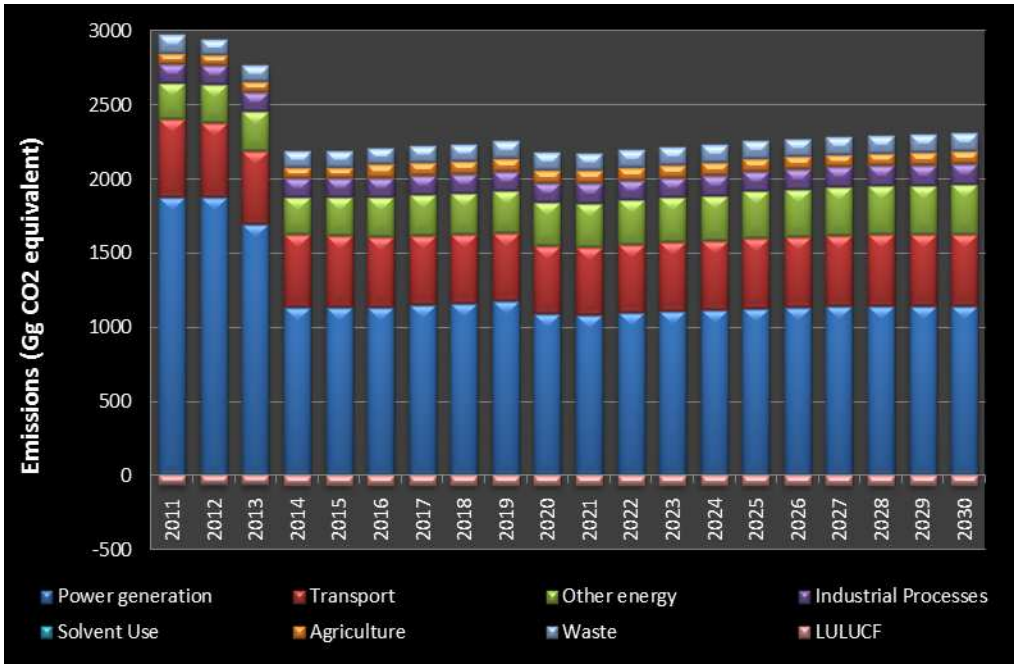


Figure 0-3 Projections (with existing measures) of total emissions differentiated by sector.

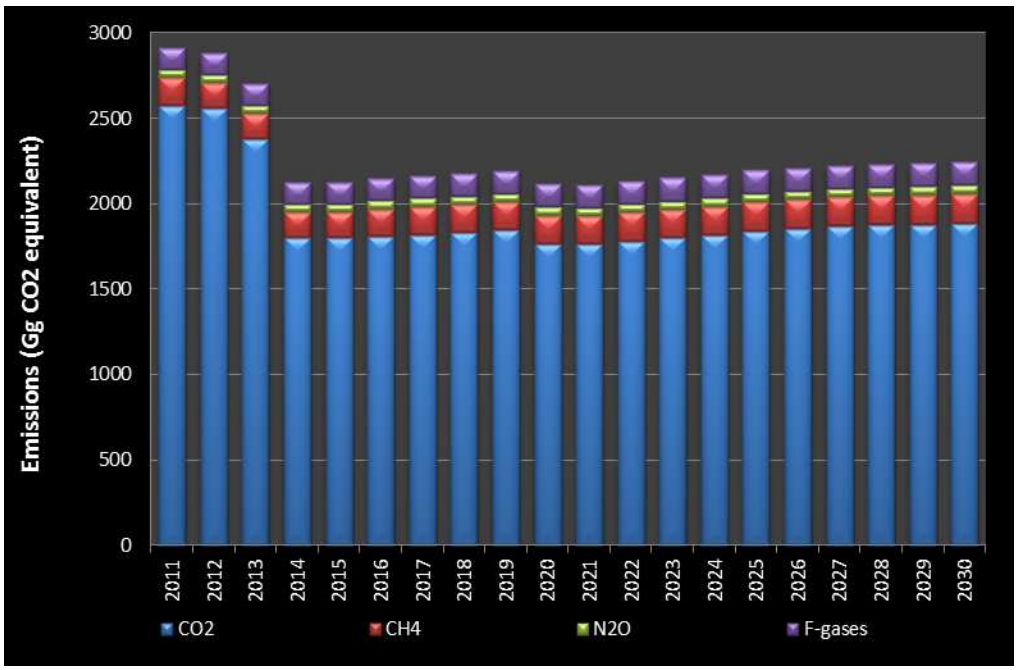


Figure 0-4 Projections (with existing measures) of total emissions differentiated by gas.

Table 0-4 Emission projections (in Gg CO_2 equivalent) split by sector and by gas and total aggregated emissions projected for 2015, 2020, 2025 and 2030, for the 'with existing measures' scenario.

		2015	2020	2025	2030
Power generation	CO_2	1128.71	1093.12	1126.69	1138.95
	CH_4	0.93	0.90	0.93	0.94
	N_2O	2.75	2.65	2.74	2.77
		1132.38	1096.66	1130.36	1142.65
Transport	CO_2	474.24	444.43	461.90	477.70
	CH_4	2.61	2.50	2.53	2.58
	N_2O	7.55	7.33	7.58	7.82
		484.39	454.27	472.02	488.10
Other energy	CO_2	260.46	292.03	316.33	333.71
	CH_4	0.65	0.71	0.75	0.78
	N_2O	0.55	0.62	0.68	0.72
		261.66	293.36	317.77	335.21
Industrial Processes	CO_2	0.27	0.27	0.27	0.274253
	CH_4	0.00	0.00	0.00	0.00
	N_2O	0.00	0.00	0.00	0.00
	F-gases	129.07	133.23	136.25	138.6264
		129.34	133.50	136.53	138.90
Agriculture	CH_4	50.57	62.01	61.59	61.18
	N_2O	20.34	23.87	23.18	22.52
		70.91	85.87	84.78	83.71
Waste	CO_2	0.70	0.70	0.70	0.70
	CH_4	94.97	100.45	104.6578	107.87
	N_2O	13.75	13.84	13.91	13.87
		109.42	114.99	119.27	122.45
LULUCF	CO_2	-61.46	-63.53	-63.94	-63.94
TOTAL EMISSIONS BY GAS	CO_2	1802.92	1767.03	1841.96	1887.39
	CH_4	149.73	166.56	170.46	173.36
	N_2O	44.94	48.31	48.10	47.71
	F-gases	129.07	133.23	136.25	138.63
TOTAL EMISSIONS		2126.654	2115.133	2196.778	2247.088

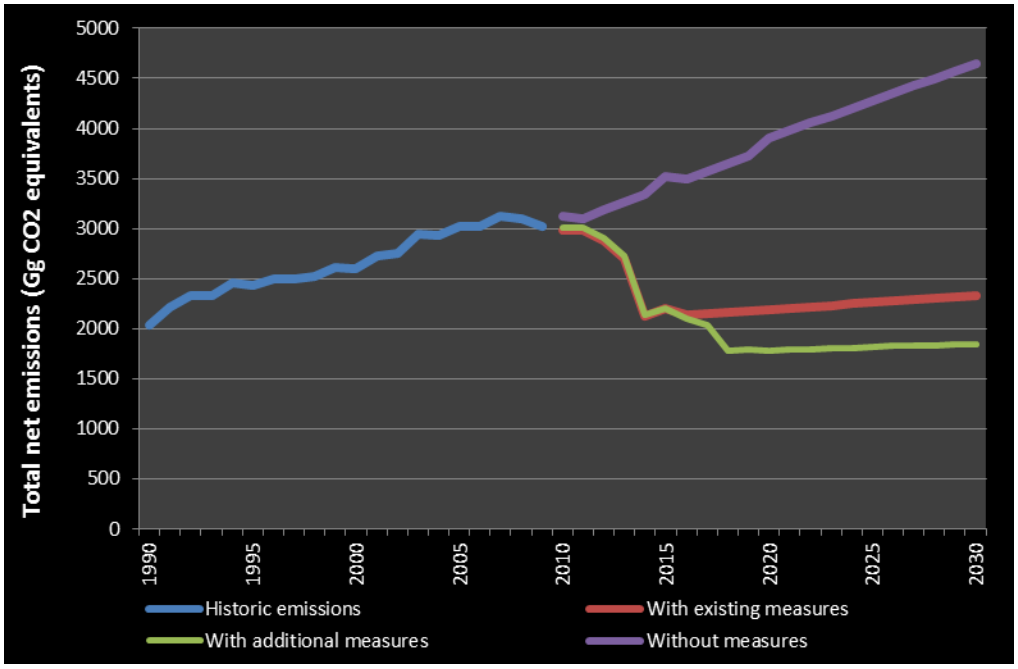


Figure 0-5 Projections of the aggregated effect of policies and measures for different scenarios.

Vulnerability assessment, climate change impacts and adaptation measures

(Refer to Chapter 5 for more detailed information.)

Table 0-5 presents an overview of the main findings of modelling of climate change impacts as had been presented in the Second National Communication of Malta. It is recognized that the system used at the time was subject to a number of limitations when it comes to modelling changes in parameters relating to changes in climatic conditions for a small area such as Malta. Work is currently ongoing at the University of Malta to adapt a new modelling system for the needs of the country with regards to projecting climate change impacts. An overview of detailed results from more recent modelling is presented in Table 0-6.

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

Table 0-5 Main model results generated using MAGICC/SCENGEN version 5.3 applicable to the region of the Maltese Islands for the years 2025, 2050, 2075 and 2100.

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

Table 0-6 Summary of modelled annual, seasonal and monthly changes in temperature (°C) and change in precipitation (%) (with respect to year 2005) for Malta.

Malta RCP2.6		**Year**	**Annual**	**DJF**	**MAM**	**JJA**	**SON**
HadGEM2	Change in Temperature (°C)	2025	1.24	-0.21	1.50	2.53	-2.17
		2050	1.63	0.78	2.09	2.38	1.51
		2075	1.08	0.29	0.81	1.47	1.97
		2099	1.51	0.52	1.59	2.24	1.92
	Change in Precipitation (%)	2025	0.61	0.73	-0.57	1.03	-0.41
		2050	0.39	1.06	-0.49	-0.71	-0.21
		2075	0.85	1.57	0.95	-0.22	-0.21
		2099	0.02	0.45	-0.18	-0.50	-0.53
Malta RCP4.5		**Year**	**Annual**	**DJF**	**MAM**	**JJA**	**SON**
HadGEM2	Change in Temperature (°C)	2025	0.70	0.40	1.28	1.23	-3.34
		2050	0.69	-0.59	0.81	1.84	0.93
		2075	2.30	0.80	3.09	2.91	2.62
		2099	2.27	2.20	2.38	2.44	2.28
	Change in Precipitation (%)	2025	0.52	0.80	0.21	-0.32	0.09
		2050	1.12	0.60	0.10	-0.47	1.21
		2075	0.16	-0.28	0.20	-0.23	0.13
		2099	0.43	-0.01	0.07	1.66	0.30
RegCM4	Change in Temperature (°C)	2025	0.80	0.12	1.99	2.14	-0.53
		2050	1.02	-0.76	1.46	3.52	0.01
		2075	2.66	0.55	4.50	4.10	1.41
		2099	2.88	1.93	3.16	3.76	2.28
Malta RCP8.5		**Year**	**Annual**	**DJF**	**MAM**	**JJA**	**SON**
HadGEM2	Change in Temperature (°C)	2025	0.81	0.52	0.66	1.45	-2.40
		2050	1.61	-0.18	1.79	2.32	2.75
		2075	3.59	2.75	3.23	4.03	4.58
		2099	4.00	2.80	4.29	4.26	4.88
	Change in Precipitation (%)	2025	0.82	0.33	0.88	-0.45	0.53
		2050	0.78	0.36	-0.58	-0.27	0.94
		2075	0.29	0.14	0.77	-0.58	-0.08
		2099	0.17	0.90	0.17	-0.46	-0.67
RegCM4	Change in Temperature (°C)	2025	0.86	0.15	1.15	2.64	-0.34
		2050	1.75	-0.36	3.13	3.14	1.31
		2075	3.86	2.26	4.47	5.54	3.32
		2099	5.03	2.93	5.30	6.11	3.94

Financial resources and transfer of technology

(Refer to Chapter 6 for more detailed information.)

Between 2011 and 2012 Malta contributed public funds amounting to €600,000 ($810,810) under the Fast Start Finance programme, financing projects in eight developing countries and contributing to the transfer of a wide array of technologies and practices that should assist in enhancing the resilience of the targeted vulnerable communities. Table 0-7 gives a summary of the projects funded through Malta's contributions.

Table 0-7 Overview of financial contributions to projects in 2011 and 2012.

Recipient country and project description	Total amount granted (€)	Total amount granted (US$)	Type of project	Sector
2011				
Ethiopia **Community managed environmental sanitation and biogas development**	32,570	44,025	Mitigation and adaptation	Water; Energy
Ethiopia **Integrated environmental intervention in Meki's rural area providing biogas, compost, soil and water conservation**	18,767	25,367	Mitigation and adaptation	Water; Agriculture; Energy
Ghana **Borehole project for the HopexChange Health Centre and neighbouring villages, including solar water heating project**	113,295	153,141	Mitigation and adaptation	Water; Energy
Tanzania **Construction of a biogas plant and delivery system at Makiungu Hospital**	25,000	33,793	Mitigation and adaptation	Energy
Uganda **Rainwater harvesting for natural resource management and sustainable development**	50,550	68,328	Adaptation	Water
Uganda **Installation of a mini-grid, as a means of establishing renewable energy sources in the Kids of Africa Orphanage in Garuga/Entebbe**	59,818	80,856	Mitigation	Energy
2012				
Ethiopia **Environmental education, model organic farming and water harvesting**	33,205	44,893	Mitigation	Agriculture; Energy; Water
Ghana **Biogas system for the production of gas for cooking in a hospital and hospital residences**	93,991	127,076	Mitigation and adaptation	Energy; Waste Management
India **Solar lighting for two educational institutions**	37,691	50,958	Mitigation and adaptation	Energy
Kenya **Construction of boreholes**	39,500	53,404	Adaptation	Water
Madagascar **Water harvesting project**	14,752	19,944	Mitigation and adaptation	Water; Sanitation
Philippines **Construction of water canals and access roads**	24,334	32,913	Mitigation and adaptation	Water (flooding)
Uganda **Water and food scarcity projects**	56,525	76,421	Adaptation	Water

Research and systematic observation

(Refer to Chapter 7 for more detailed information.)

The focal point for climate-related research in Malta is the University of Malta where academics from various faculties, institutes and centres within the University are contributing towards increasing knowledge on climate change issues from a variety of perspectives, including scientific and technological, legal and economic.

The University is also widening the perspective of the work being carried out by participating in a number of international initiatives. Two examples of such international collaboration are the Tropical Signals Programme which aims at detecting, monitoring and understanding the impacts of climate change on the marine biodiversity of the Mediterranean, and the international Forum on Legal Issues for Adaptation to Climate Change, gathering together experts working in the legal field from various academic institutions, and with a mandate to assist the European union Commission's Directorate General on Climate Action in its work on adaptation policy.

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

Education, training and public awareness

(Refer to Chapter 8 for more detailed information.)

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

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

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

1 INTRODUCTION AND NATIONAL CIRCUMSTANCES

1.1 The submission of a National Communication

The submission of a national communication by a Party to the United Nations Framework Convention on Climate Change[1] (UNFCCC) arises from the requirement for Parties to communicate information on the implementation of the objectives of the Convention[2]:

> "*1. In accordance with Article 4, paragraph 1* [of the UNFCCC], *each Party shall communicate to the Conference of the Parties, through the secretariat, the following elements of information:*
>
> *(a) A national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, to the extent its capacities permit, using comparable methodologies to be promoted and agreed upon by the Conference of the Parties;*
>
> *(b) A general description of steps taken or envisaged by the Party to implement the Convention; and*
>
> *(c) Any other information that the Party considers relevant to the achievement of the objective of the Convention and suitable for inclusion in its communication, including, if feasible, material relevant for calculations of global emission trends.*
>
> *2. Each developed country Party and each other Party included in Annex I shall incorporate in its communication the following elements of information:*
>
> *(a) A detailed description of the policies and measures that it has adopted to implement its commitment under Article 4, paragraphs 2 (a) and 2 (b)* [of the UNFCCC[3]]*; and*
>
> *(b) A specific estimate of the effects that the policies and measures referred to in subparagraph (a) immediately above will have on anthropogenic emissions by its sources and removals by its sinks of greenhouse gases during the period referred to in Article 4, paragraph 2 (a)* [of the UNFCCC]."

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

This National Communication is the third communication to be submitted by Malta, and the first to be submitted by Malta as an Annex I Party. Malta had previously submitted a First[7] and a

[1] United Nations Framework Convention on Climate Change, United Nations, 1992.
[2] UNFCCC: Article 12 'Communication of Information Related to Implementation'.
[3] Article 4, paragraphs 2(a) and 2(b) of the UNFCCC require "*developed country Parties and other Parties included in Annex I*" to "*adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs*" and to "*communicate,* [..] *periodically* [...] *detailed information on* [...] *policies and measures* [...] *as well as on its resulting projected anthropogenic emissions by sources and removals by sinks of greenhouse gases*", respectively.
[4] UNFCCC: Article 4 'Commitments', paragraph 3.
[5] UNFCCC: Article 4 'Commitments', paragraph 4.
[6] UNFCCC: Article 4 'Commitments': paragraph 5.
[7] *The First Communication of Malta to the United Nations Framework Convention on Climate Change*, Ministry for Rural Affairs and the Environment, 2004.

Second[8] Communication in 2004 and 2010 respectively, always as a non-Annex I Party to the Convention. To this effect, this Communication will actually serve as Malta's 3rd, 4th, 5th and 6th National Communication to the UNFCCC.

1.2 Introduction to this chapter

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

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

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

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

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

[8] *The Second Communication of Malta to the United Nations Framework Convention on Climate Change*, Ministry for Resources and Rural Affairs, 2010.

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

[10] Decision 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol; OJ L 49, 19.2.2004, pg. 1.

[11] Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC; OJ L 165, 18.6.2013, pg. 13.

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

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

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

It is pertinent to note that Malta is not an Annex II Party to the Convention.

1.4 Quantified economy-wide emission reduction target

The accession to Annex I status meant that Malta was inscribed in the list of parties to the Kyoto Protocol that intend to take on a quantified emission limitation or reduction commitment (QELRC) for the second commitment period of the Kyoto Protocol (CP2; 2013-2020). As such, the commitment for Malta as listed in the Doha Amendments to the Protocol[14] is of -20% by 2020, compared to 1990 levels. The ratification of these amendments by the EU and its Member States is still under discussion at the time of writing, but it is clearly the intention of the Union to jointly

[12] Directive 2003/87/EC Of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC; OJ L 275, 25.10.2003, pg. 32.

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

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

fulfil the commitments set out in the Doha Amendments[15]. Therefore, in practical terms, the target under the Effort-Sharing Decision remains the primary country-level quantified emission mitigation goal for Malta with respect to greenhouse gas emission mitigation, together with applicable compliance obligations for certain local activities under the EU ETS.

The two power generation plants operating in Malta to-date fall within the scope of the EU ETS, in respect of carbon dioxide emissions from the combustion of fossil fuels. From the start of the scheme in 2005 until 2013, the plants, which incidentally are operated by the same operator, were subject to allocation of free allowances in accordance with national allocation plans determined by the Maltese government in accordance with the rules stipulated in the EU ETS Directive. As of 2013, the plants are no longer eligible for any allocation of free allowances. International aviation activities by certain aircraft operators also fall within the scope of the EU ETS Directive. No domestic civil aviation activities in Malta fall under the EU ETS.

In the case of Malta, the Effort-Sharing Decision applies to all emissions from anthropogenic activities except for the carbon dioxide emissions from the power plants, aside from exceptions where these apply. Malta's binding target here is to limit such emissions, by 2020, to a level not greater than 5% over emission levels in 2005 with annual interim targets determined for the years 2013 to 2019.

1.5 Government structure

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

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

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

1.6 Geographic profile

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

The archipelago is situated in the central Mediterranean (Figure 1-1), approximately 90 kilometres from Sicily and 290 kilometres from the North African mainland. Towards, the East, the

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

Straits of Gibraltar are at a distance of almost 1,850 kilometres, while the Suez Canal is around 1,500 km towards the Southwest.

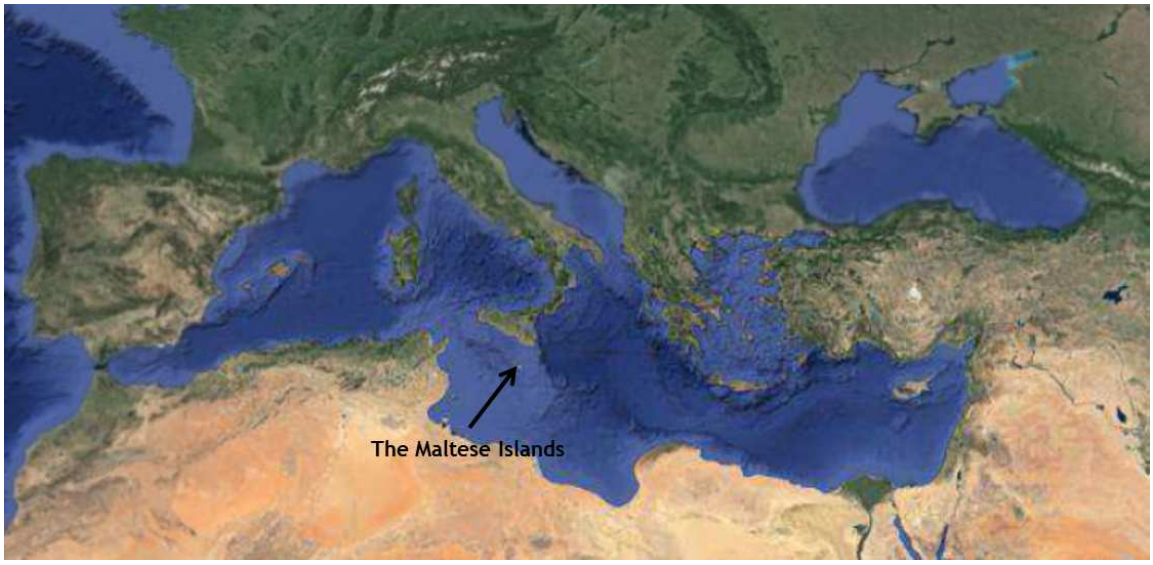


Figure 1-1 Map of the Mediterranean Sea showing the location of the Maltese Islands. (adapted from Google Maps)

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

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

Figure 1-2 Map of the Maltese Islands. Valletta, the capital city, is marked by the red dot. (adapted from: http://earthobservatory.nasa.gov/IOTD/view.php?id=4933)

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

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

1.7 Population profile

According to the 2011 population census, the population of the Maltese Islands stood at 416,055 in that year (NSO, 2012) almost double the population a hundred years earlier (Figure 1-3). This gives a population density of around 1,320 persons per km^2, one of the highest country population densities in the world.

Distribution of the population across the islands that make up the Maltese archipelago varies. The largest concentration of the population is found in the area around the harbours flanking the capital city of Valletta. The Northern Harbour district (the area to the west of Valletta) and the Southern Harbour district (the area lying to the east and south-east of Valletta, including also the capital city) together form a population agglomeration that accounts for almost 48% of the total population of the country. The built-up aspect of this part of the country can easily be seen in (Figure 1-2). At the other end of the scale, the islands of Gozo and Comino account for just 7.5% of the total population.

Population density differences between Malta and Gozo are highly contrasting, with the former showing a density of 1,562 persons per km^2 while the latter has a density of 454 persons per km^2. This also correlates with the extent of built-up area on the two islands. Similarly, and reflecting the built-up nature of the two districts, the Northern Harbour district and the Southern Harbour district show a population density of 4,997 and 3,026 persons per km^2 respectively.

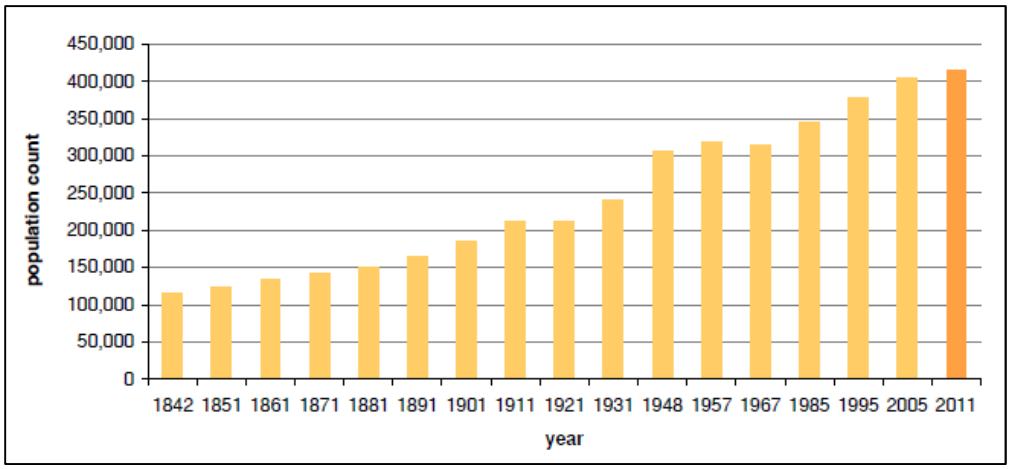


Figure 1-3 Population growth since 1842 (NSO, 2012)

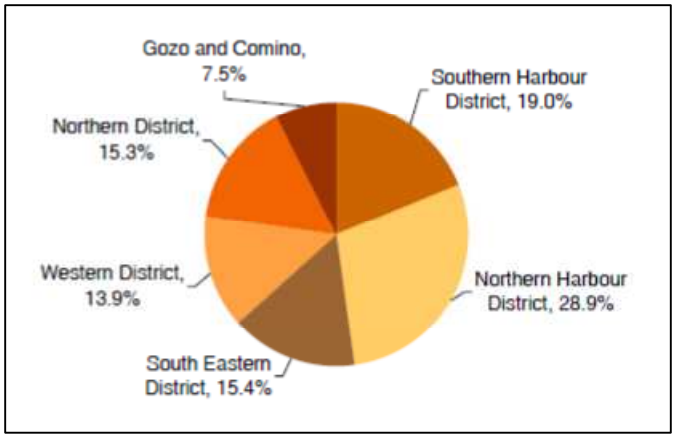


Figure 1-4 Population distribution in the Maltese Islands (NSO, 2012)

The population is projected to reach 429,000 persons by 2025 but go down to 350,000 persons by 2060. The population is also becoming increasingly an ageing one, with current and future population growth trends coupled with increased life expectancy: life expectancy is calculated at 83 years for females and 79 years for males (NSO, 2011).

1.8 Climate profile

The climate of the Maltese Islands can be described as typically Mediterranean, with hot, dry summers and relatively mild winters. Values for a number of climatic parameters are provided in Table 1-2. The monthly profiles of mean air temperature and relative humidity are presented in Figure 1-5 and Figure 1-6 respectively. The north-westerly winds are the most common (Galdies, 2011).

Table 1-2 Mean air temperature, sunshine, wind velocity and total rainfall for the years 2009 to 2012. (NSO, 2013)

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

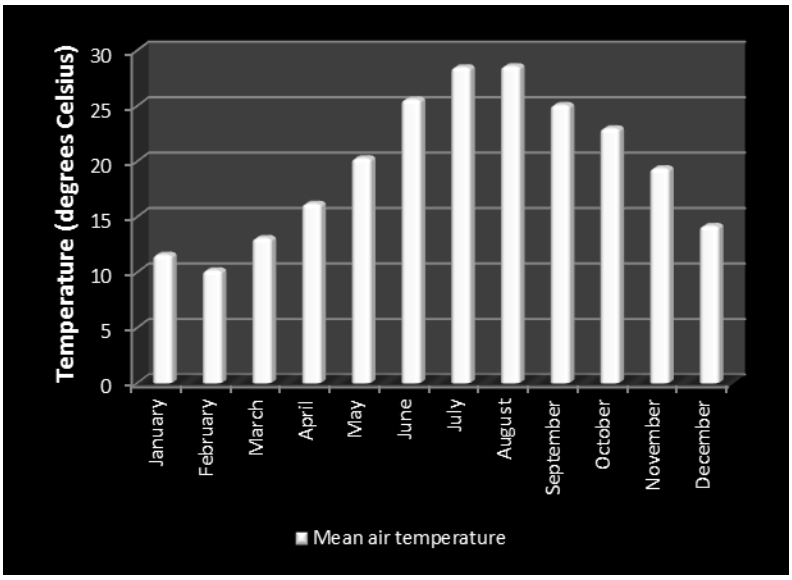


Figure 1-5 Monthly mean air temperature for 2012. (NSO, 2013)

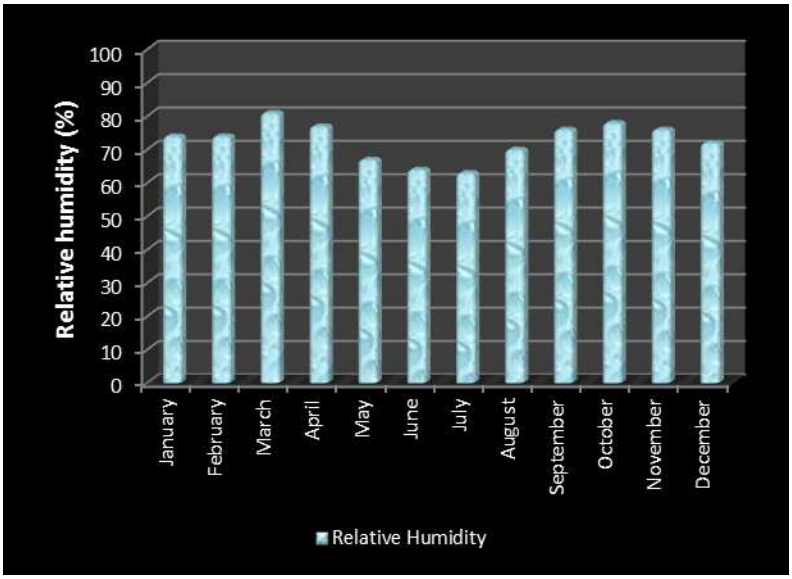


Figure 1-6 Monthly relative humidity for 2012. (NSO, 2013)

1.9 Economic profile

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

Overall, Malta's GDP has grown from €1.899 billion in 1990 to €6.829 billion in 2012 (NSO StatDB). Per capita GDP stood at around €22,100 in 2012 (NSO, 2013), this indicator also showing a steady increase over time.

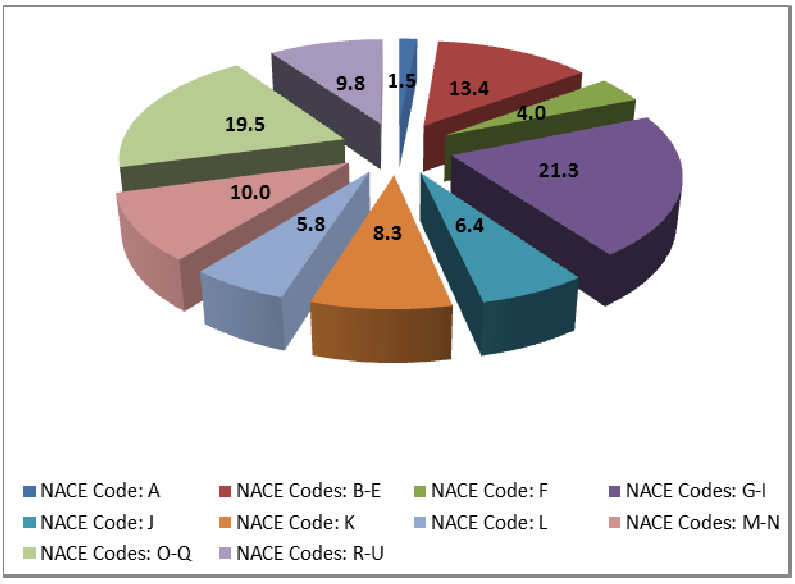


Figure 1-7 Percentage contribution of economic sectors (by NACE code) to Gross Added Value for 2012. (NSO, 2013)

1.10 Energy

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

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

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

Electricity generation capacity is anticipated to undergo another significant transition in the coming years, with the construction of a gas-fired plant at Delimara and the complete shut-down of the generating plant at Marsa Power Station. In parallel to these developments, Malta's system will link to the electricity grid on mainland Europe, to be achieved through an interconnection between Malta and Sicily.

Table 1-3 Electricity statistics for the years 2008 to 2012 (NSO, 2013)

	2008	2009	2010	2011	2012
Electricity generation (MWh)	2,275,892	2,167,640	2,113,112	2,168,553	2,268,627
Electricity maximum demand (average; (MW))	358	341	328	337	350

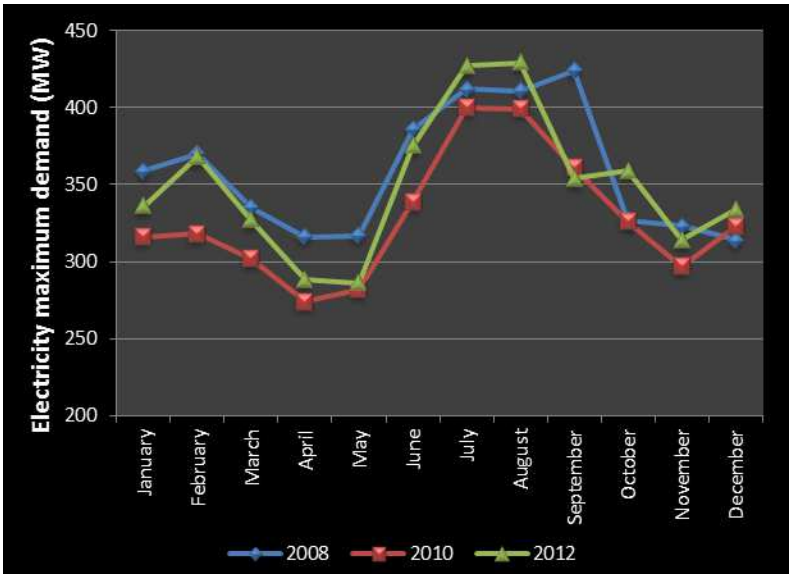


Figure 1-8 Monthly electricity maximum demand for recent select years. (NSO, 2013)

Disaggregation of fuel consumption by type correlates strongly with the distribution of greenhouse gas emissions from different sectors, as will be discussed in the next chapter. Indeed, fuel consumption for electricity generation dominates over all other uses of fuels, as can be seen in Figure 1-9 for 2012.

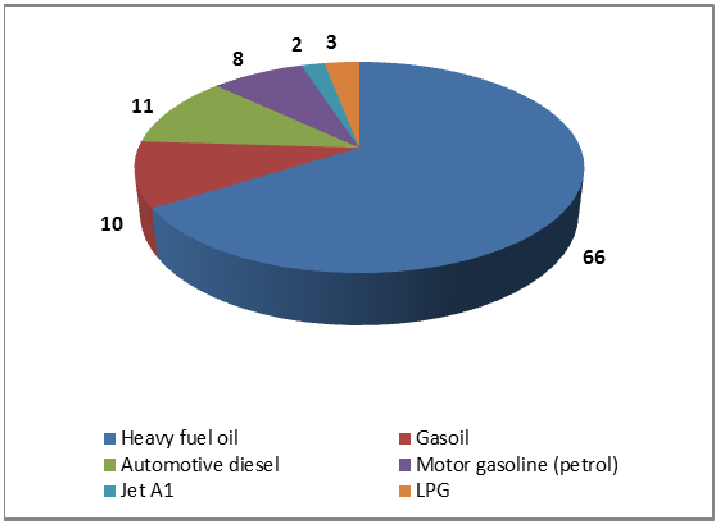


Figure 1-9 Fuel consumption by type (percent of total) in 2012. (NSO, 2013)

1.11 Transportation

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

Internal transport is mainly based on road transport, with rail systems non-existent. An extensive bus system services the two main islands; however private vehicle ownership and use remains high. The total number of licensed motor vehicles in 2012 was 314,510 (NSO, 2013), of which 242,149 were passenger cars and 45,650 commercial vehicles, the remainder being mainly motorcycles and other categories of vehicles. This equates to a rate of 746 licensed road vehicles per 1,000 inhabitants, or 592 passenger cars per 1,000 inhabitants, in 2012.

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

1.12 Natural resources

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

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

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

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

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

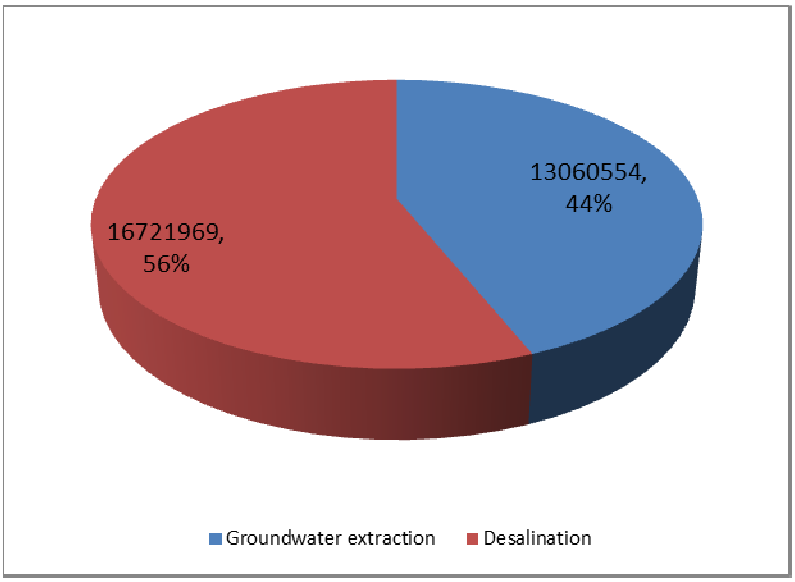


Figure 1-10 Production of potable water in Malta (m^3; % of total) for 2011. (WSC, 2012)

1.13 Waste

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

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

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

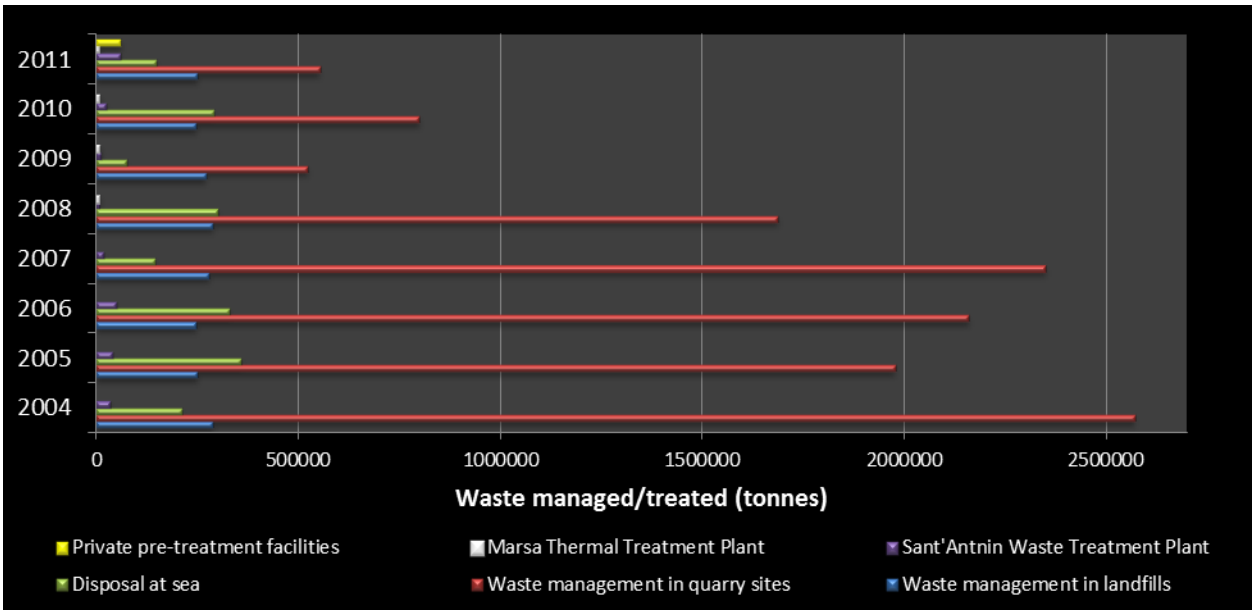


Figure 1-11 Waste management/treatment (tonnes). (NSO, 2013a)

1.14 Land use, building stock and urban structure

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

The 2005 Census of Population and Housing (NSO, 2007) reported a total stock of 192,314 dwellings, of which 27.6% were vacant[16]. 10 years earlier (census year 1995), the total dwelling stock was determined at 155,202 dwellings, with 23.0% of dwellings vacant (NSO, 1995). While total stock increased by almost 24.0% over the period 1995 to 2005, vacant dwellings increased by 49.0%, contrasting with an increase of under 17.0% in occupied dwellings . It is not expected that the results of the more recent 2011 census will show a substantial improvement in the number of unoccupied dwellings.

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

1.15 Malta as a contributor to international climate policy

The issue of changing climatic conditions and the consequential threats is not a new phenomenon; however, global political recognition of this problem is a relatively recent

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

occurrence, given strong impetus 25 years ago by a singular initiative that Malta took within the framework of the United Nations Organization.

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

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

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

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

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

2 GREENHOUSE GAS INVENTORY INFORMATION

> "*All Parties [...] shall: Develop, periodically update, publish and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties*."[17]

2.1 Introduction

The national inventory of greenhouse gas emissions from sources and removals from sinks (hereafter also referred to as the "national GHG inventory") is an obligation fulfilled by Malta pursuant to its status as a Party to the UNFCCC and the Kyoto Protocol. The compilation of such an inventory also meets obligations arising from the country's accession to the European Union, principally the so-called "Monitoring Mechanism", formerly Decision 280/2004/EC, which more recently has been superseded by Regulation (EU) No 525/2013.

This chapter describes the approach currently in place to prepare the national GHG inventory and gives a brief overview of emission trends for the period covering the years 1990 to 2011, including trends by gas and category. 1990 represents the default starting year for presentation of inventories of greenhouse gas emissions and removals. The end year 2011 coincides with the latest year for which a greenhouse gas inventory submission to the UNFCCC was available at the time of compiling this national communication.

2.1.1 What is a national greenhouse gas inventory?

A national greenhouse gas inventory provides a detailed mathematical picture of emissions of greenhouse gases by sources and removals by sinks from anthropogenic activities taking place in a country. With emissions from anthropogenic sources being considered as a prime culprit in the recent observed changes in climatic conditions, climate change mitigation policy will not effectively deliver on its goals unless a system is available to determine the state of play with respect to emissions and removals and to measure progress, in a quantified manner and on an ongoing basis, towards reaching emission limitation or reduction targets - the national inventory is a crucial tool in this respect.

Two main types of greenhouse gases, direct and indirect (or precursors), are discussed in national GHG inventories. Direct greenhouse gases contribute directly to climate change due to the positive radiative forcing effect of the chemical species. Six categories of such gases are covered, namely:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous Oxide (N_2O);
- Hydro fluorocarbons (HFCs);
- Per fluorocarbons (PFCs); and,
- Sulphur Hexafluoride (SF_6).

The radiative forcing effect for each of these greenhouse gas species is usually denoted as the Global Warming Potential (GWP). Global Warming Potentials of the direct greenhouse gases discussed in this inventory report are presented in Table 2-1.

As scientific knowledge on the effect of different gases has grown, the GWPs of many greenhouse gases previously established in the 2nd Assessment Report (2AR) of the Inter-

[17] United Nations Framework Convention on Climate Change, Article 4 (1)(a).

Governmental Panel on Climate Change (IPCC) were updated in the 4th Assessment Report (4AR), published in 2007. This discussion of greenhouse gas emissions and removals however is still based on 2AR GWP values in accordance with international rules. The use of 4AR values for inventory purposes comes into effect for greenhouse gas inventory submissions as of 2015, in accordance with the applicable decisions taken under the UNFCCC.

For purposes of aggregation of estimated emissions or removals of different greenhouse gases into a single total, and to facilitate comparison between different gases, quantities of greenhouse gases emitted or removed are often presented in terms of 'CO_2 equivalents', whereby a quantity of a particular gas is multiplied by the GWP of that gas. Thus, 1 tonne of CH_4 can also be represented as 21 tonnes of CO_2 equivalents; 1 tonne of N_2O can be represented as 310 tonnes CO_2 equivalents, and so on.

Table 2-1 Global Warming Potential (GWP) of direct greenhouse gases included in this inventory discussion.

Chemical species	Chemical formula	GWP (time horizon: 100 years) 2AR [4AR]
Carbon dioxide	CO_2	1 [1]
Methane	CH_4	21 [25]
Nitrous oxide	N_2O	310 [298]
Hydro fluorocarbons:		
HFC-23	CHF_3	11,700 [14,800]
HFC-32	CH_2F_2	650 [675]
HFC-125	CHF_2CF_3	2,800 [3,500]
HFC-134a	CH_2FCF_3	1,300 [1,430]
HFC-143a	CH_3CF3	3,800 [4,470]
HFC-227ea	CF_3CHFCF_3	2,900 [3,220]
Per fluorocarbons:		
Per fluoroethane (PFC-116)	C_2F_6	9,200 [12,200]
Per fluoropropane (PFC-218)	C_3F_8	7,000 [8,830]
Sulphur hexafluoride	SF_6	23,900 [22,800]

Indirect or precursor greenhouse gases are chemical species that when accumulating in the atmosphere undergo chemical transformation that causes an increase in tropospheric ozone which increases radiative forcing. A number of such gases are also covered by the national GHG inventory, namely:

- Nitrogen oxides (N_2O);
- Carbon monoxide (CO); and,
- Non-methane volatile organic compounds (NMVOCs).

Sulphur dioxide (SO_2) emissions are also usually included in national GHG inventories, primarily in view of the fact that chemical reaction of this gas in the atmosphere results in aerosol formation, which also has an important greenhouse effect.

Six main sectors of sources and sinks of greenhouse gases are addressed by the national GHG inventory, covering most of the known anthropogenic sources and sinks. Each sector is disaggregated into categories for each of which separate emissions or removal estimations are

performed in accordance with accepted methodologies and depending on their occurrence in the country. These sectors are:

- Energy (CRF sector 1);
- Industrial Processes (CRF sector 2);
- Solvents and Other Product Use (CRF sector 3);
- Agriculture(CRF sector 4);
- Land Use, Land-Use Change and Forestry (LULUCF) (CRF sector 5); and,
- Waste (CRF sector 6).

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

More detailed information on Malta's national GHG inventory, including aggregated and disaggregated quantified emissions and removals, is available in the annual national GHG inventory submissions that are readily accessible in the public domain. These submissions are a combination of a written report describing the approach and methods used for the preparation of estimations of emissions and removals and Common Reporting Format (CRF) tables which provide detailed data sets by gas, category and year together with information on methodology, in a tabular format. The discussion of emission and removal trends presented in this chapter is derived from the submission made to the UNFCCC Secretariat in April 2013 (MRA, 2013).

2.2 Greenhouse gas inventory preparation in Malta

2.2.1 The development of greenhouse gas inventory compilation in Malta

Greenhouse gas inventory compilation in Malta has a relatively short history, which can be linked to the manner in which climate action obligations for Malta have developed and expanded over the years.

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

In 2004, Malta became a full member of the European Union (EU). Despite retaining the non-Annex I status under the UNFCCC, reporting obligations relating to greenhouse gas emissions and removals became more systematic, and in line with the EU's Monitoring Mechanism included the requirement to report a national GHG inventory on an annual frequency with strict timeframes, namely: the submission of a 'provisional' inventory on 15th January of each year to the European Commission, covering the time series from 1990 (as base year) to the year before last (X-2); a 'final' inventory submission by the following 15th March, that may include changes to the January submission, again to the European Commission; and the submission under the UNFCCC by 15th April.

With Malta's 2010 change to Annex I status under the UNFCCC, reporting obligations relating to such a status became fully applicable to Malta.

The inventory reporting requirements under EU legislation, and then also under Annex I status, made it necessary to establish a process whereby annual inventory reporting could be fulfilled.

The Malta Environment and Planning Authority (MEPA) was initially entrusted to take on this obligation, subsequently followed by the migration of this and other climate action responsibilities to the Malta Resources Authority (MRA) as of 2010, following a change in Ministerial portfolios at the time.

2.2.2 Greenhouse gas inventory compilation today

The responsibility for the preparation of the national GHG inventory currently rests with a team of inventory compilers within the Climate Change Unit of the Malta Resources Authority. The inventory team is responsible for the majority of the functions relating to inventory compilation, starting with the sourcing of data from relevant data providers, to data management, including the necessary calculations to estimate emissions and removals of greenhouse gases, through to the preparation and submission of reports to the UNFCCC Secretariat and the European Commission in accordance with the relevant obligations.

Political ownership of the national GHG inventory is invested on the Ministry responsible for climate change action and policy, previously the Ministry of Resources and Rural Affairs (MRRA), and as of March 2013, the Ministry for Sustainable Development, Environment and Climate Change (MSDEC). Figure 2-1 presents a schematic representation of the current institutional set-up involved in the compilation of Malta's national greenhouse gas inventory.

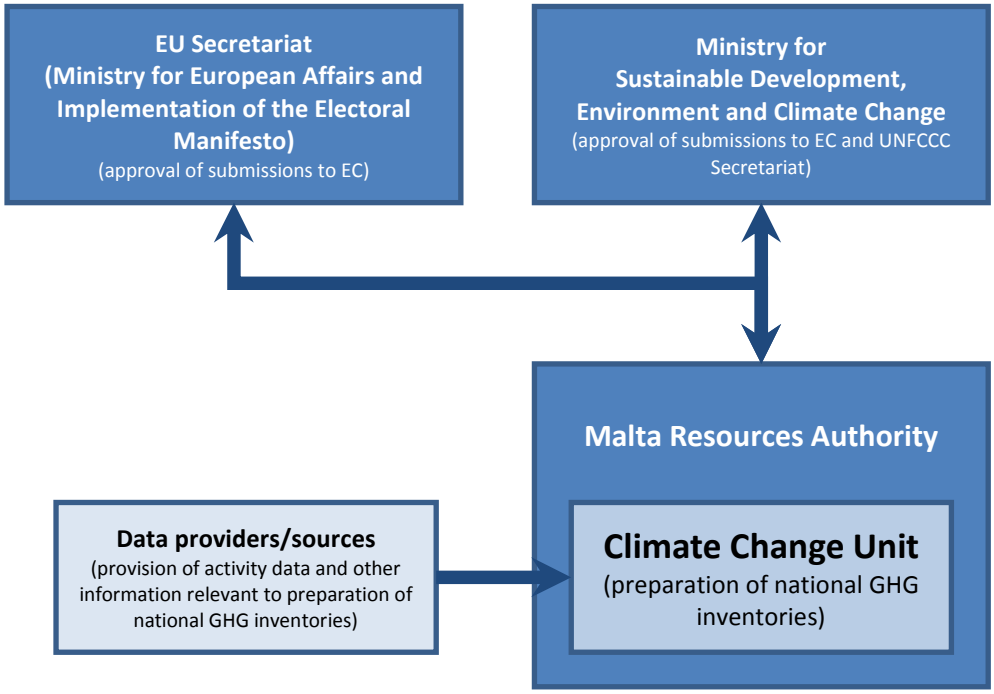


Figure 2-1 Schematic representation of the current institutional arrangement for the preparation and submission of national greenhouse gas inventories of Malta.

The preparation of the annual inventory submission is spread over a whole year cycle, with work on each year's submission starting immediately after the conclusion of an inventory cycle with the submission of the report to the UNFCCC Secretariat in April. An internal post-submission evaluation identifies areas where improvements need to be carried out, further informed by the

results of annual inventory peer reviews. Such peer reviews are carried out by both UNFCCC and EU expert review teams.

Communications with data providers commence during the summer period, with the quantification of emissions and removals done through the months leading to December, when the drafting of the inventory report and the inputting of data into the CRF software are carried out. Following the January submission, updates of the inventory are made to include, as may be required, any additional improvements that may be relevant, prior to finalizing the submissions of March and April respectively.

The current approach to inventory compilation may be schematically represented as in Figure 2-2.

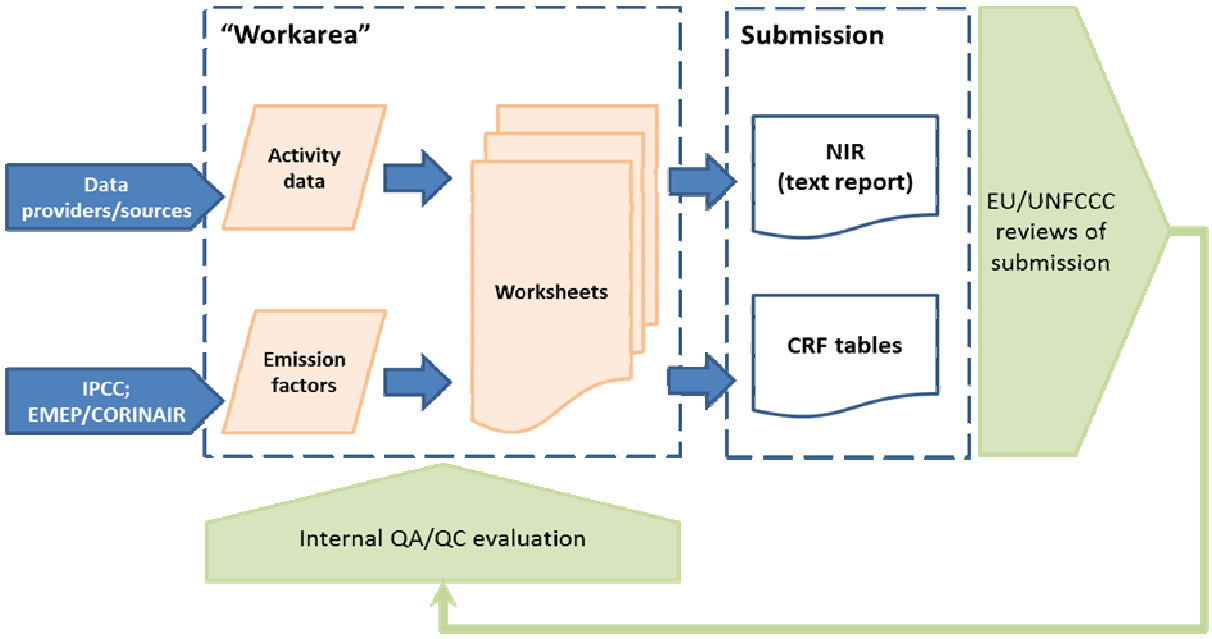


Figure 2-2 Schematic representation of the current approach to greenhouse gas inventory compilation applied by the Climate Change Unit.

Inventory preparation starts with communication with data providers that are the source of the all-important activity data, on the basis of which sectoral emissions and removals estimates can be performed.

Receipt of activity data is logged in order to ensure optimal traceability. The activity data received is then assessed for its validity as an input into the emission and removals estimation process. The estimations of emissions and removals are performed using spreadsheets developed internally and specifically for the national greenhouse gas inventory process; these spreadsheets describe the calculations involved in translating activity data and calculation factors (e.g. emissions factors, oxidation factors) into reportable emission and removal values. Each inventory compiler in the national greenhouse gas inventory team is responsible for a number of sectoral categories.

Once the quantification of emissions and removals is concluded, the next phase entails the drafting of the national inventory report (the written report) and the inputting of the quantified results of the estimation of emissions and removals into the CRF software. The written report provides detailed information on the overall set-up of inventory preparation in the country, the approach used to estimate emissions and removals and other information as required by the

relevant reporting rules and legislation. CRF tables serve to bring together, in a sequence of very detailed spreadsheets, the relevant quantitative information on emissions and removals as estimated, and activity data and calculation factors as used in the compilation of the inventory, covering the whole time series, starting from 1990 until the last year covered by that particular submission.

As already indicated above, a first submission to the European Commission is made by not later than mid-January, including both the written report and the CRF tables. It is sometimes the case that revised or previously missing data is found following this provisional submission, which justifies revisions to the estimations previously performed. It may also be the case where a change in the methodological approach is identified after the January submission which could improve the greenhouse gas inventory estimation process and which thus would also warrant an update of the inventory report and the CRF tables. Such updates are often carried out during the period of weeks leading up to mid-March, when a final submission of the national inventory report and final CRF tables have to be submitted.

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

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

Admittedly, a formally documented greenhouse gas inventory QA/QC system has yet to be developed in respect of the Maltese inventory process. However, this does not mean that the inventory process is not already subject to quality checks. Indeed, the inventory is subject to at least two peer review processes every year: a peer review in-line with requirements set out in the EU's Monitoring Mechanism and a peer review under UNFCCC rules. An important deliverable from these reviews is to highlight those areas where the respective review teams feel that inventory compilation practices need to be further developed in order to ensure better-quality reporting. These review reports form a basis for the internal evaluations of inventory submissions performed by the inventory team itself and thus help guide the inventory team in its preparation of future submissions.

Though the formal documentation of inventory processes, in terms of standard operating procedures, is yet to commence, there is already a process for documenting the work performed by the Climate Change Unit in preparing an inventory submission. Besides the spreadsheets that are used to estimate emissions, and thus serving to document the estimation process itself, a number of additional ancillary forms are already in use.

2.2.3 Towards establishing a national inventory system

Any Annex I Party to the UNFCCC has an obligation to establish a National Greenhouse Gas Inventory System, defined by Decision 19/CMP.1[18] as:

[18] Decision 19/CMP.1 'Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol'; FCCC/KP/CMP/2005/8/Add.3.

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

This obligation has also been transposed into EU law.

A first recommendation for the setting up of a national inventory system was made in 2005, following discussions with inventory experts from the Federal Environment Agency of Austria. This led to the recruitment of staff to work on national inventories (greenhouse gases and air quality) and the first steps towards a more structured inventory compilation process. In 2007/2008 MEPA commissioned a more in-depth assessment of inventory compilation practices at the time in order to draw up recommendations for the formal establishment of a national inventory system that would be in accordance with requirements under the Kyoto Protocol; at the time, the intention was to integrate inventory reporting relating to both climate change and air quality obligations. Unfortunately, due to a number of reasons, this assessment and its recommendations could not be followed-up with concrete action.

Malta's accession to Annex I status, the ratification requirements of the Doha Amendments to the Kyoto Protocol and the ever more strict obligations arising from EU law make it imperative that a fully functioning national inventory system that meets the requirements of decision 19/CMP.1 is established. To this effect, the MSDEC is assessing the legal and administrative requirements to establish a National Greenhouse Gas Inventory System for Malta in line with the recommendations of a technical report prepared by the Climate Change Unit at MRA for this purpose.

2.3 General Trends in Greenhouse Gas Emissions and Removals

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

2.3.1 Overview of emission trends

Figure 2-3 presents the overall trend in national greenhouse gas emissions (therefore excluding emissions for 'memo items') for the period covered by this discussion, namely 1990 to 2011. Two trends are shown: that for emissions 'including-LULUCF' (also known as 'with-LULUCF' or 'net' emissions), which represents the net difference between total emissions from all sources and total removals from the LULUCF sector; and, the trend in emissions without taking into account removals from the LULUCF sector, that is, the 'excluding-LULUCF' trend (also known as 'without-LULUCF' or 'gross' emissions). Obviously, emissions for the excluding-LULUCF trend are higher than for the including-LULUCF, though the difference is only slight, reflecting a rather minimal potential for removals from the LULUCF sector for Malta.

The general trend represents an overall increase of 51.9% for emissions with-LULUCF between the years 1990 and 2011, or an increase of 50.6% for emissions without-LULUCF. But one may also observe two distinct sub-trends for each trend profile: a clear growth in emissions for the years 1990 to 2007 (for the with-LULUCF, this represents an increase of 56.2% between 1990 and 2007) and a relatively flat, or slightly downward, trend profile for the years between 2007 and 2011 (Figure 2-4).

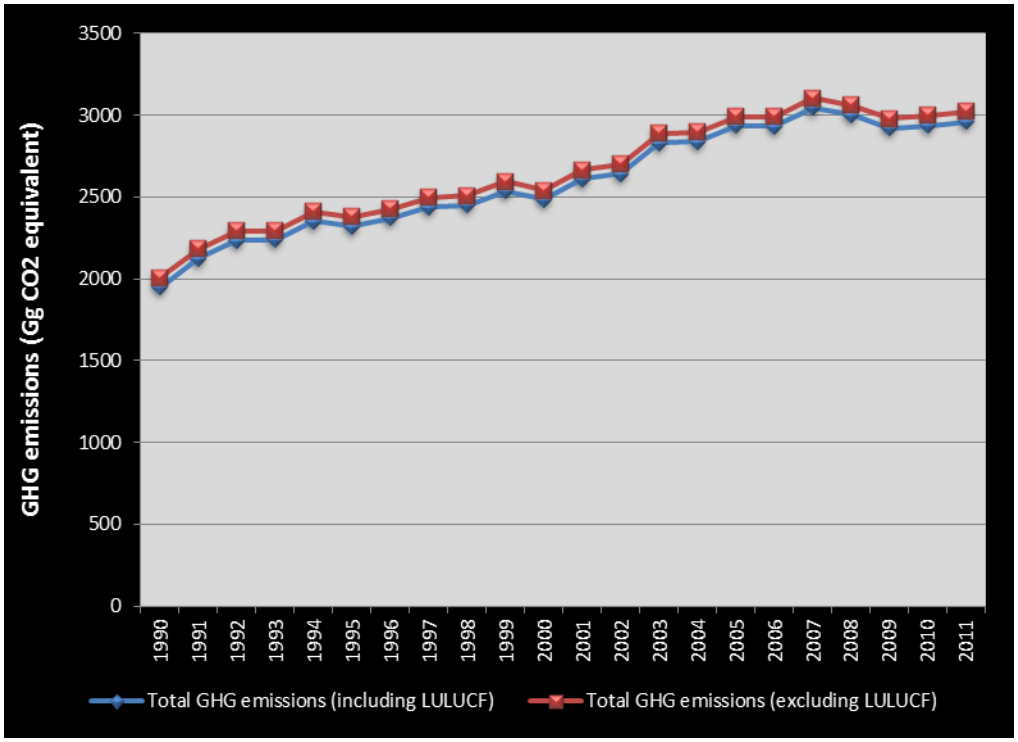


Figure 2-3 Total emissions with/without LULUCF for the years 1990 to 2011.

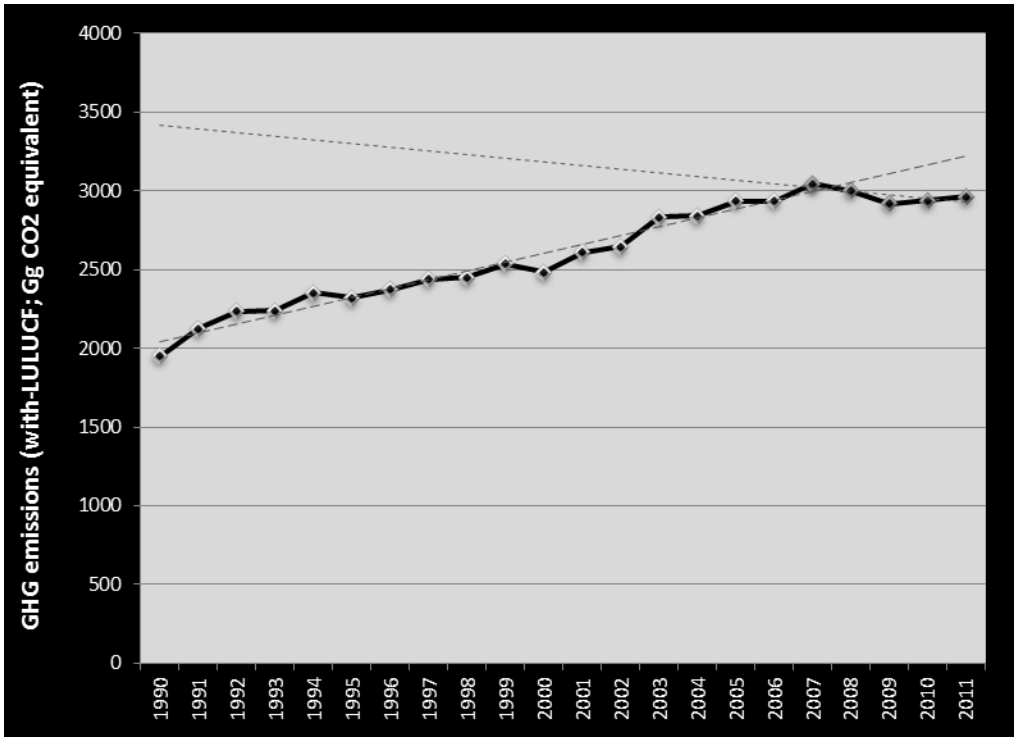


Figure 2-4 Total emissions with-LULUCF, showing the two distinct sub-trends for 1990-2007 and 2007-2011.

If one had to compare Malta's total national greenhouse gas emissions with the total greenhouse gas emissions for the European Union, as a comparative analysis of Malta's contribution to global greenhouse gas emissions, one realizes that in absolute terms Malta's total emissions is very small. Indeed, Malta's national greenhouse gas emissions in 1990 amounted to 0.04% of total EU emissions for that year, while for 2011 Malta's contribution was 0.07% of total EU emissions (EEA, 2013).

On the other hand, the increased share of Malta's emissions in total EU emissions between 1990 and 2011 is a matter of some concern, as it represents a divergent trend between EU emissions (decreasing) and Malta's emissions (growing). It remains to be seen whether the overall trend observed for the years 2007 to 2011 can be sustained, or even better, the trend up to 2007 can be more clearly reversed – this would bring emission trends for Malta in line with the overall trend for the European Union, and in line with the objectives of the Convention and the Protocol.

2.3.2 Emission trends and population growth

Trends in emissions over a period of time can be compared with trends of certain indicators that reflect the social or economic development of the country. In general, the trend in emissions per capita reflects the trend for overall national greenhouse gas emissions. This can be interpreted as an increase in emissions paralleling the increase in population for most of the period concerned, for example as a result of increased consumption patterns leading to increases in associated emissions of greenhouse gases. For the more recent few years, as has already been observed above, the emission trend profile has practically plateaued; a similar profile is also observed for emission per capita, while population growth continues. If this difference in trend between emissions of greenhouse gases and population continues, then one might perceive an important and positive decoupling between the two parameters.

Greenhouse gas emissions in Gg CO_2 equivalent per capita for the years 1990 and 2011 are 5.4 and 7.1 respectively (Figure 2-5). But the highest ratio of greenhouse gas emissions to population size is actually observed for the year 2007, which to-date is the year with the highest total national emissions in absolute terms.

2.3.3 Emission trends and economic development

If one compares the trend in emissions with gross domestic product, used here as an indicator for economic growth, the decoupling between national greenhouse gases and economic development tends to be more obvious. This seems to indicate that the economic growth seen over the past two decades has been achieved in an ever increasingly emissions efficient manner. Indeed, overall, greenhouse gas emissions per unit billion Euro GDP (Figure 2-6) in 2011 (460 Gg CO_2 equivalent per billion Euro) represent a 55% reduction in the rate of emissions per unit GDP for 1990 (1,026 Gg CO_2 equivalent per billion Euro).

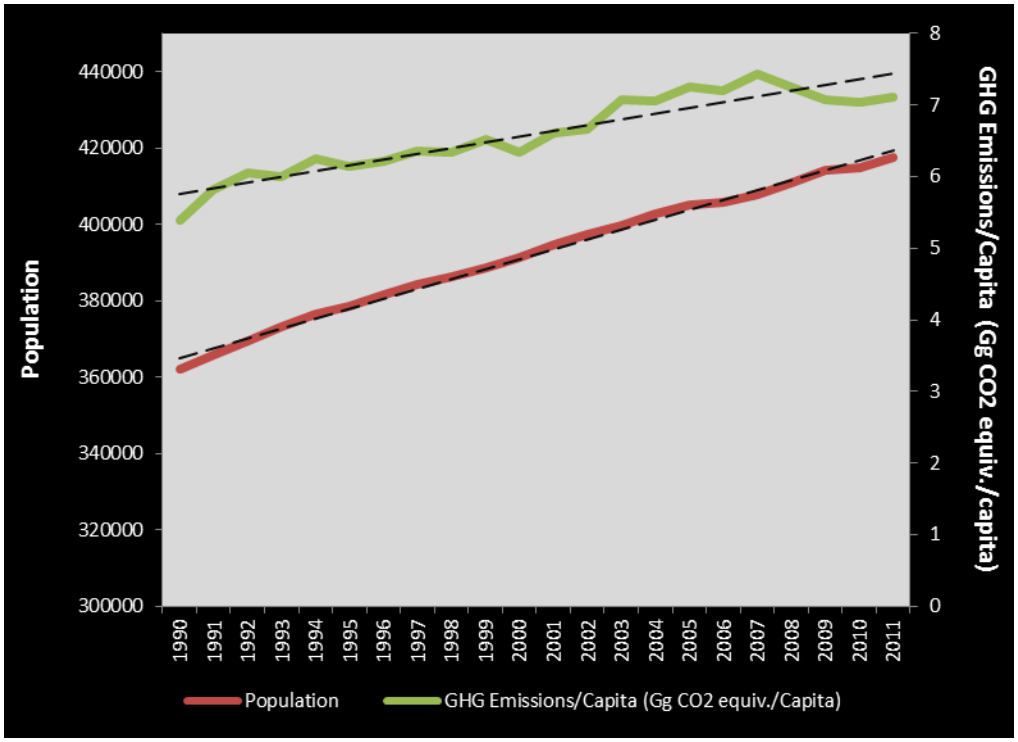


Figure 2-5 Trend in total emissions per capita for direct greenhouse gases.

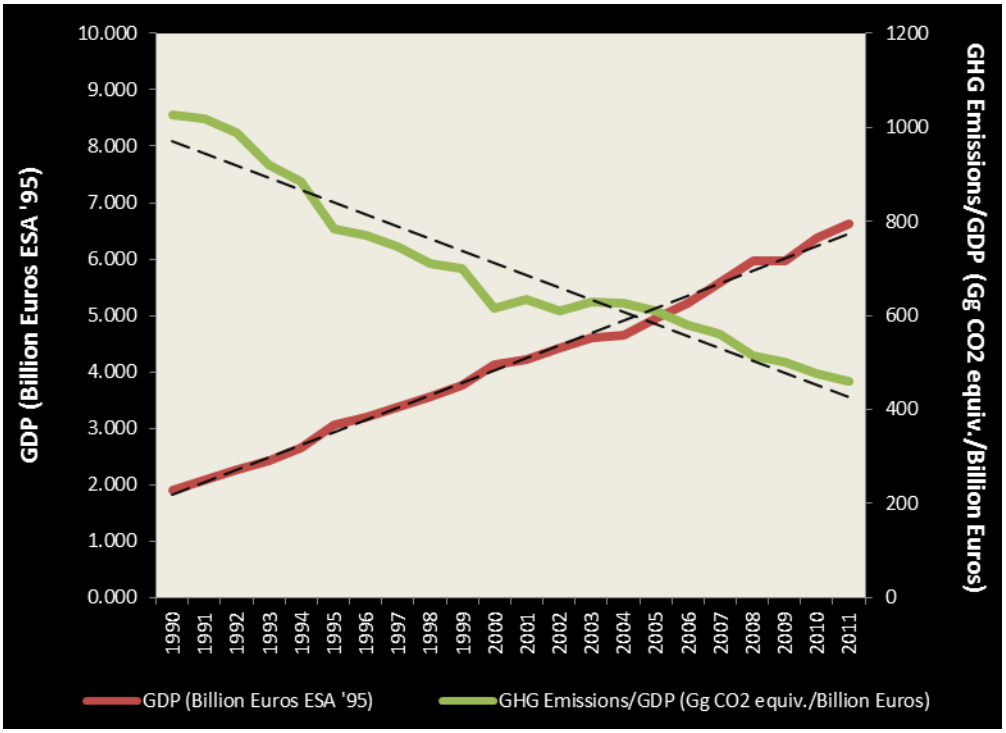


Figure 2-6 Trend in total emissions per unit billion Euro GDP for direct greenhouse gases.

2.4 Trends in greenhouse gas emissions by gas

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

2.4.1 Overview of emission trends by gas

Table 2-2 and Figure 2-7 present the emission trends for the six direct greenhouse gases covered by annual national GHG inventories to-date.

The dominance of carbon dioxide in total emissions can be easily noted, and this applies to the whole time series under discussion. One does however note a small, but notable reduction in the share of carbon dioxide emissions in total emissions over the time series, such a trend being sustained after 2003 (Figure 2-8). The reasons are two-fold. After a long period of practically continued increase in emissions of CO_2, especially up until 2003, emissions of this gas over more recent years have tended to stabilize at between 2,550 Gg and 2,650 Gg (Figure 2-9). This is coupled by an increase in total absolute emissions of other gases, in particular CH_4 and HFCs.

N_2O emissions comprised the third largest share up to the early 2000s, being well superseded by HFC emissions in recent years.

Emissions of PFCs and SF_6 continue to have a minor contribution in total emissions, albeit PFCs show a high of 27.9 Gg CO_2 equivalent in 2004, following which a gradual decrease to the level of 3.3 Gg CO_2 equivalent in 2011 is observed.

Table 2-2 Emissions of direct greenhouse gases by year (Gg CO_2 equivalent).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO_2 (Net)	1,809.0	1,984.5	2,088.9	2,084.9	2,196.3	2,156.5	2,208.7	2,198.7	2,202.1	2,292.2	2,289.3
CO_2 (Gross)	1,865.5	2,041.0	2,145.5	2,141.4	2,252.9	2,213.0	2,265.2	2,255.3	2,258.6	2,348.1	2,345.2
CH_4	91.1	91.4	94.4	98.1	100.9	104.7	107.0	110.4	112.2	113.8	125.0
N_2O	49.9	50.4	51.7	52.8	54.3	59.2	54.9	55.4	61.2	56.5	61.0
HFCs	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	73.9	73.9	73.9	8.3
PFCs	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	NA,NE, NO	0.0
SF_6	0.0	0.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Total Net Emissions	**1,950.0**	**2,126.3**	**2,236.5**	**2,237.3**	**2,353.0**	**2,321.8**	**2,372.1**	**2,439.9**	**2,450.9**	**2,537.9**	**2,485.1**
Total Gross Emissions	**2,006.6**	**2,182.8**	**2,293.0**	**2,293.9**	**2,409.5**	**2,378.4**	**2,428.6**	**2,496.5**	**2,507.4**	**2,593.8**	**2,541.0**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
CO_2 (Net)	2,408.9	2,428.9	2,606.7	2,560.4	2,647.0	2,612.1	2,698.0	2,656.8	2,569.6	2,580.9	2,603.4
CO_2 (Gross)	2,464.8	2,484.8	2,663.7	2,618.6	2,704.0	2,671.0	2,756.9	2,715.6	2,628.5	2,640.6	2,663.1
CH_4	125.5	126.9	126.8	132.8	139.9	148.7	158.8	158.0	167.2	175.4	167.4
N_2O	58.7	58.2	55.5	56.5	58.5	59.9	59.3	55.7	54.3	51.9	50.4
HFCs	15.3	28.7	40.1	60.4	64.5	87.5	106.2	116.7	120.3	121.6	132.2
PFCs	0.0	0.0	0.0	27.9	23.4	23.3	22.8	12.9	7.0	6.6	3.3
SF_6	1.6	1.6	2.2	1.6	1.6	1.7	1.7	1.8	1.6	1.8	4.8
Total Net Emissions	**2,610.0**	**2,644.3**	**2,831.1**	**2,839.7**	**2,934.9**	**2,933.2**	**3,046.7**	**3,002.0**	**2,920.1**	**2,938.2**	**2,961.5**
Total Gross Emissions	**2,665.9**	**2,700.2**	**2,888.1**	**2,897.8**	**2,992.0**	**2,992.0**	**3,105.6**	**3,060.8**	**2,979.0**	**2,997.9**	**3,021.2**

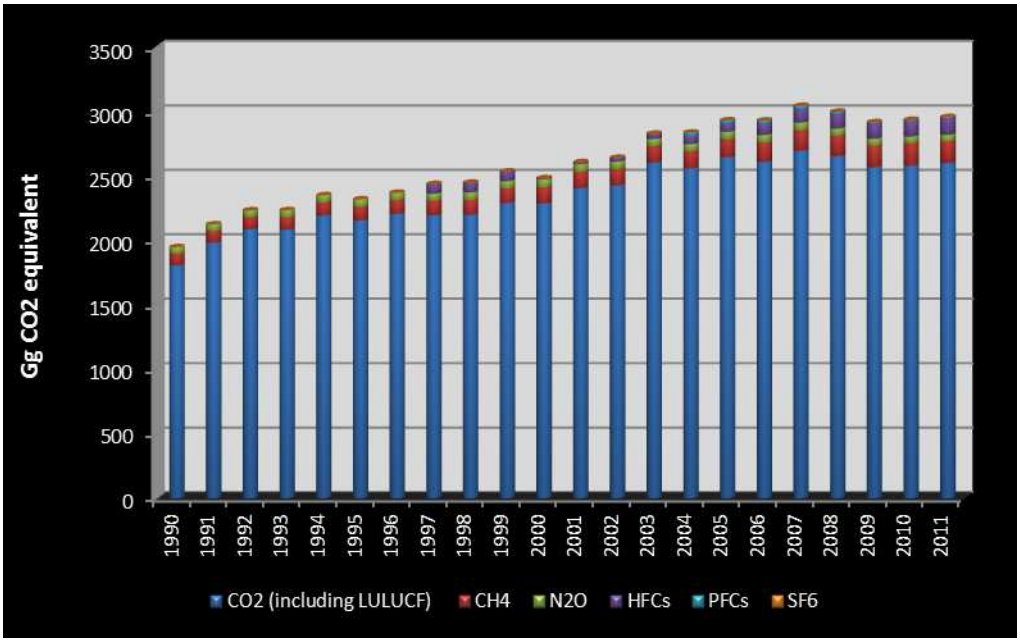


Figure 2-7 Trends in emissions of respective greenhouse gases (including LULUCF removals).

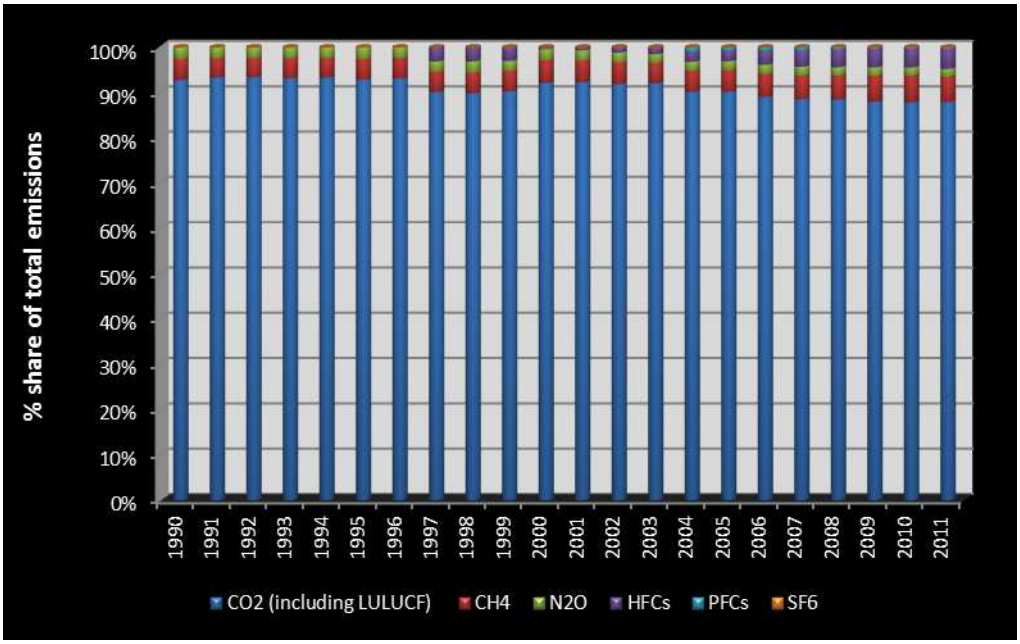


Figure 2-8 Percentage share of total national emissions for respective greenhouse gases (including LULUCF removals).

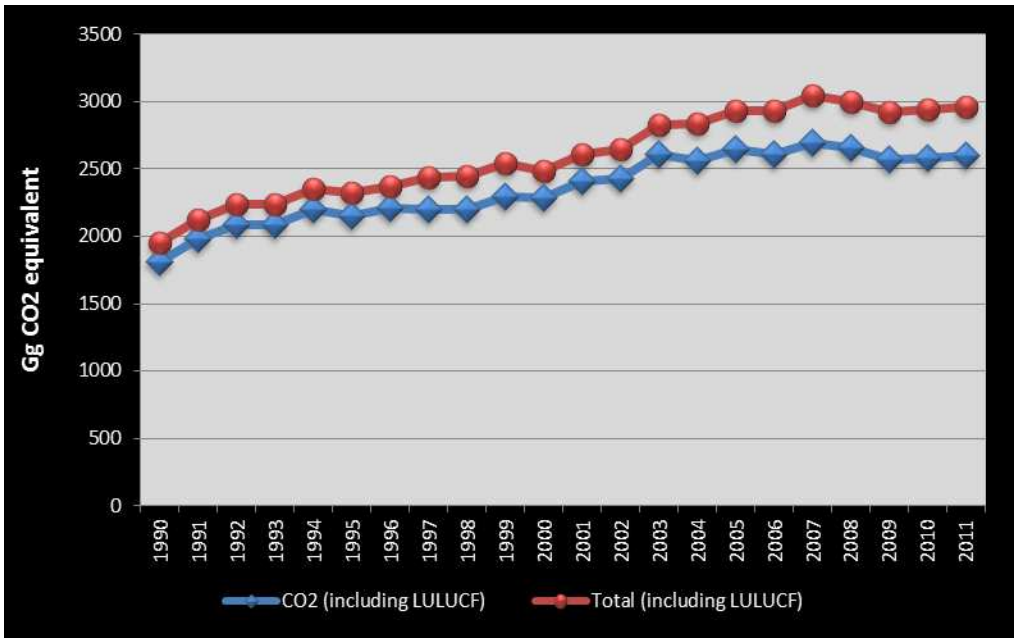


Figure 2-9 Correlation between emissions of CO_2 and total emissions showing a small but notable deviation between the two trends in recent years.

2.4.2 Carbon dioxide

As already noted above, carbon dioxide has always been the greenhouse gas with the highest share of total direct greenhouse gas emissions, with this share decreasing slightly for recent years. Its share in 1990 amounted to 93.8% (of total greenhouse gas emissions in terms of CO_2 equivalents), 92.9% in 1995, 92.1% in 2000, 90.2% in 2010 and 87.9% in 2011. The overall increase in estimated absolute quantities of CO_2 emitted from all sources (without taking into account LULUCF removals) covered by Malta's national GHG inventory, over the period 1990 to 2011, is of 42.8%. As will be seen later, the trend in CO_2 emissions, both over the whole time series, and year-to-year, is very much correlated with the trend in emissions from the energy sector.

At an estimated value of less than 60 Gg for each year, the rate of removal of CO_2 through the LULUCF category is substantially lower than the rate of emissions, as can be easily observed in Figure 2-10. The change in removals year-to-year is insignificant.

2.4.3 Methane

Methane is the greenhouse gas with the second highest share of total greenhouse gas emissions as estimated for Malta (see Table 2-2). The time series increase in absolute estimated emissions for this gas for the years 1990 to 2011 amounts to 83.7%. The year-on-year trend, split between the three sectors contributing to methane emissions can be seen in Figure 2-11.

The two main anthropogenic sources of methane emissions in Malta are the Agriculture and Waste sectors. Enteric fermentation and manure management account for the majority of emissions of methane from the agriculture sector. Activities typically leading to methane emissions in the waste sector include solid waste disposal and wastewater management, with the break-down of bio-degradable components of waste producing this gas. A minor share of total methane emissions is attributed to the energy sector, as a direct result of methane generated from the combustion of fossil fuels.

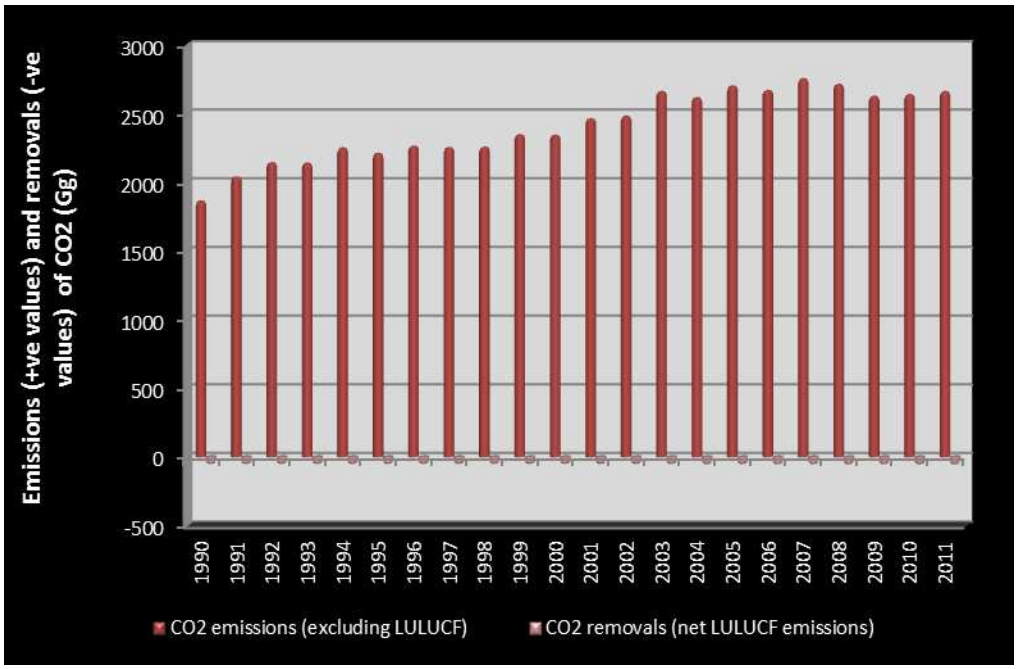


Figure 2-10 Trend in emissions and removals of CO_2.

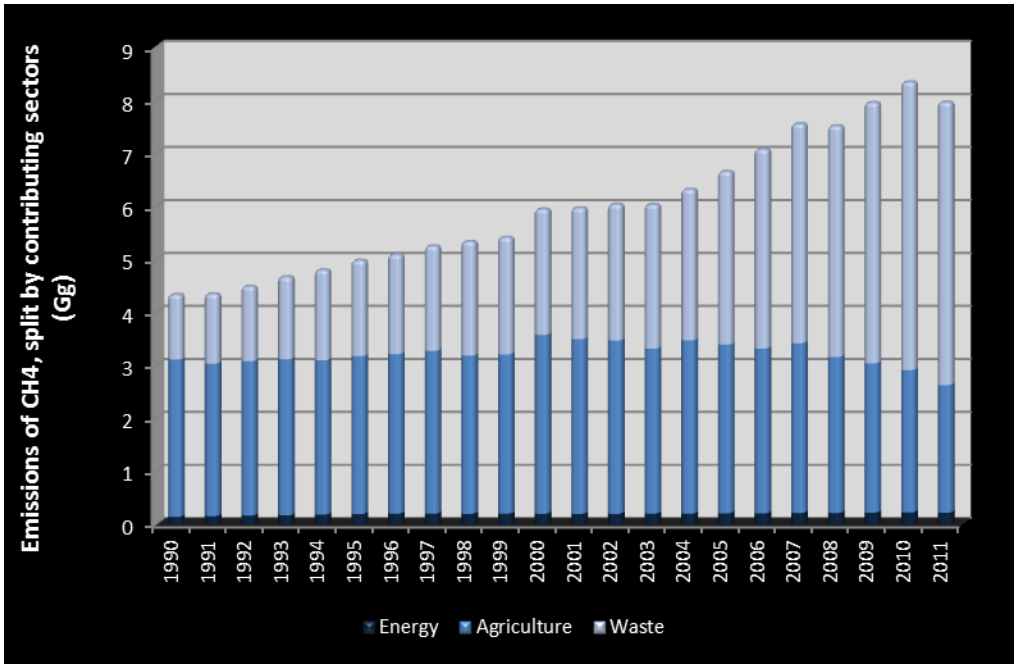


Figure 2-11 Trend in emissions of methane, split by sources.

2.4.4 Nitrous oxide

The overall share of nitrous oxide in total national emissions of greenhouse gases is less than that for methane and even more substantially less than that for carbon dioxide. Emissions of this gas, as estimated (Figure 2-12), have been relatively stable over the years covered by this discussion, with the lowest estimated figure being 49.9 Gg CO_2 equivalent in 1990, and the highest emission

value recorded being that in 1998, at 61.2 Gg CO_2 equivalent; this represents a difference of 22.7% between the year with lowest estimated nitrous oxide emissions and the year with the highest estimated emissions. More significant is the fact that estimated emissions of N_2O in 2011 are a mere 1.0% greater than the 1990 level, reflecting a certain level of stability in the overall trend in emissions of this gas over the 1990-2011 time series.

The Agriculture sector is the biggest contributor to national nitrous oxide emissions, followed by the Waste sector and by emissions from fuel combustion (i.e. the Energy sector). Source categories within the agriculture sector responsible for nitrous oxide emissions include manure management (N_2O emissions from manure management practices) and direct and indirect emissions from agricultural soils resulting from the application of animal manure and synthetic fertilisers to soils. Emissions of N_2O from human sewage accounts for the emissions of this greenhouse gas attributed to the Waste sector.

A minor contribution is attributed to the sector Solvent and Other Product Use, mainly from the use of this gas for anaesthetic purposes in medical practices.

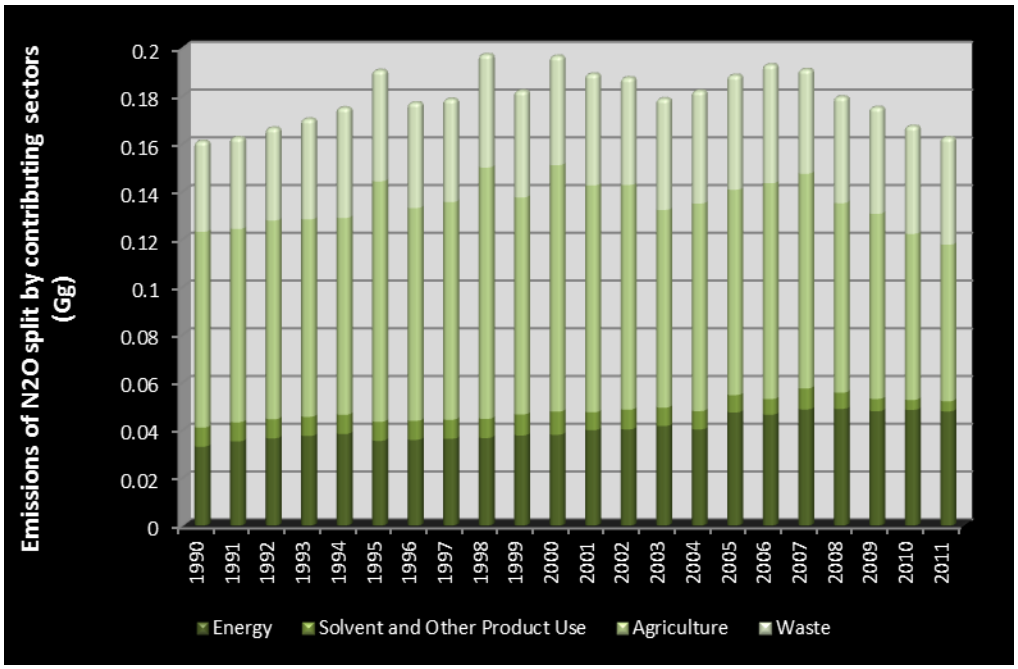


Figure 2-12 Trend in emissions of nitrous oxide, split by sources.

2.4.5 Fluorinated greenhouse gases

Fluorinated, or F-, gases are usually characterised by relatively high GWP values compared to the other direct greenhouse gases (see Table 2-1). Starting with a negligible contribution to national total GHG emissions in 1990, the cumulative share of F-gases in 2011 amounted to approximately 4.6% of total gross national emissions.

Sources including refrigeration and air conditioning equipment, foam blowing applications, fire extinguishing applications, metered dose inhalers, semiconductor manufacturing and some medical applications account for the majority of emissions of HFCs and PFCs. The use of SF_6 in switch-gear and circuit breaker equipment accounts for emissions of this gas.

2.4.6 Indirect greenhouse gases and sulphur dioxide

The trends in emissions of the three indirect greenhouse gases that are included in national GHG inventories and of sulphur dioxide are presented in Table 2-3 and Figure 2-13. For the most part of the time period concerned, carbon monoxide and sulphur dioxide retained the highest rate of emissions; however, a marked downward trend is visible for sulphur dioxide as of 2004.

Table 2-3 Emissions of indirect greenhouse gases and SO_2.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
NO_x	7.55	8.12	8.53	8.68	9.06	8.85	9.10	9.15	9.22	9.55	**8.38**
CO	23.63	25.28	26.95	28.23	29.24	29.93	30.62	30.98	30.70	30.74	**29.77**
NMVOC	6.20	6.55	6.91	7.23	7.47	7.63	7.94	8.16	7.84	7.79	**3.36**
SO_2	**15.78**	**17.84**	**19.72**	**20.40**	**23.93**	**27.17**	**28.71**	**29.82**	**30.93**	**27.99**	**24.43**

Gas	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
NO_x	9.11	9.22	9.47	9.05	9.83	9.20	9.74	9.58	9.30	9.33	**8.87**
CO	29.01	28.53	28.41	27.88	28.83	28.67	29.92	30.06	31.22	31.82	**31.10**
NMVOC	3.39	3.29	3.05	3.11	3.54	3.70	3.59	3.28	2.97	3.45	**2.67**
SO_2	**26.07**	**25.34**	**27.53**	**11.96**	**12.31**	**12.38**	**12.76**	**11.69**	**8.27**	**7.76**	**7.88**

The trend in emissions of carbon monoxide is closely correlated with the trend in fossil fuel use in the transport sector, dominated in particular by the trend in amount of fuels used in road transport.

On the other hand, the sulphur content of fuels used for combustion to generate electricity is the principal influencing factor in the trend in emissions of sulphur dioxide – a substantial improvement in the sulphur content of fuels used in the two power plants as from 2004 underpins the substantial decrease in estimated emissions of this pollutant between the years 2003 and 2004 and the continued lower levels in emissions for subsequent years.

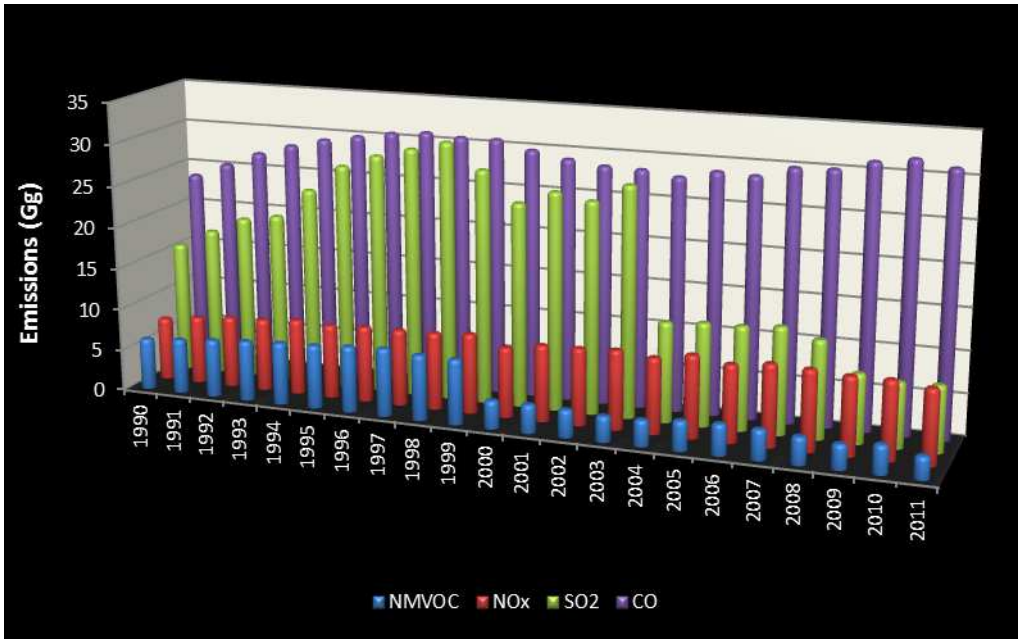


Figure 2-13 Trends in emissions of indirect greenhouse gases (NMVOC, NOx and CO) and SO_2.

2.5 Trends in greenhouse gas emissions by sector

This section will discuss sectoral trends in greenhouse gas emissions. Table 2-4 presents the development of greenhouse gas emissions as estimated for the five source sectors that make up a national inventory and net greenhouse gas removals for the sink sector LULUCF. These trends are pictorially presented in Figure 2-14. Each source sector's share in total gross greenhouse gas emissions is presented pictorially in Figure 2-15.

Table 2-4 Trends in GHG emissions by sector (Gg CO_2 equivalent).

	1990	1991	1992	1993	1994	1995	1996	1997
1. Energy	1,878.10	2,054.36	2,159.82	2,156.12	2,267.74	2,226.04	2,278.68	2,268.69
2. Industrial Processes	0.33	0.53	1.65	1.69	1.99	3.21	3.04	77.11
3. Solvents and Other Product Use	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48
4. Agriculture	87.81	85.53	86.96	87.53	86.80	93.83	90.93	92.85
5. LULUCF	-56.54	-56.54	-56.54	-56.54	-56.54	-56.54	-56.54	-56.54
6. Waste	37.84	39.88	42.08	46.04	50.51	52.81	53.49	55.34
Total (net emissions)	**1,950.02**	**2,126.25**	**2,236.45**	**2,237.32**	**2,352.98**	**2,321.85**	**2,372.09**	**2,439.93**

	1998	1999	2000	2001	2002	2003	2004	2005
1. Energy	2,272.74	2,363.35	2,360.56	2,480.70	2,500.77	2,680.35	2,634.63	2,722.43
2. Industrial Processes	76.54	75.80	10.11	17.27	30.61	42.43	90.34	89.92
3. Solvents and Other Product Use	2.48	2.72	3.01	2.33	2.56	2.38	2.37	2.26
4. Agriculture	95.39	91.27	102.95	98.77	97.94	91.10	95.65	93.58
5. LULUCF	-56.54	-55.91	-55.91	-55.91	-55.91	-57.00	-58.17	-57.08
6. Waste	60.25	60.62	64.40	66.84	68.29	71.88	74.86	83.76
Total (net emissions)	**2,450.86**	**2,537.86**	**2,485.12**	**2,610.00**	**2,644.26**	**2,831.14**	**2,839.68**	**2,934.88**

	2006	2007	2008	2009	2010	2011
1. Energy	2,689.09	2,775.93	2,734.83	2,647.29	2,659.62	2,681.65
2. Industrial Processes	112.80	130.90	131.66	129.17	130.24	140.57
3. Solvents and Other Product Use	2.03	2.71	2.10	1.60	1.29	1.31
4. Agriculture	93.36	95.23	86.45	83.26	78.04	70.90
5. LULUCF	-58.87	-58.86	-58.86	-58.87	-59.67	-59.67
6. Waste	94.76	100.78	105.77	117.64	128.73	126.76
Total (net emissions)	**2,933.18**	**3,046.69**	**3,001.96**	**2,920.09**	**2,938.24**	**2,961.52**

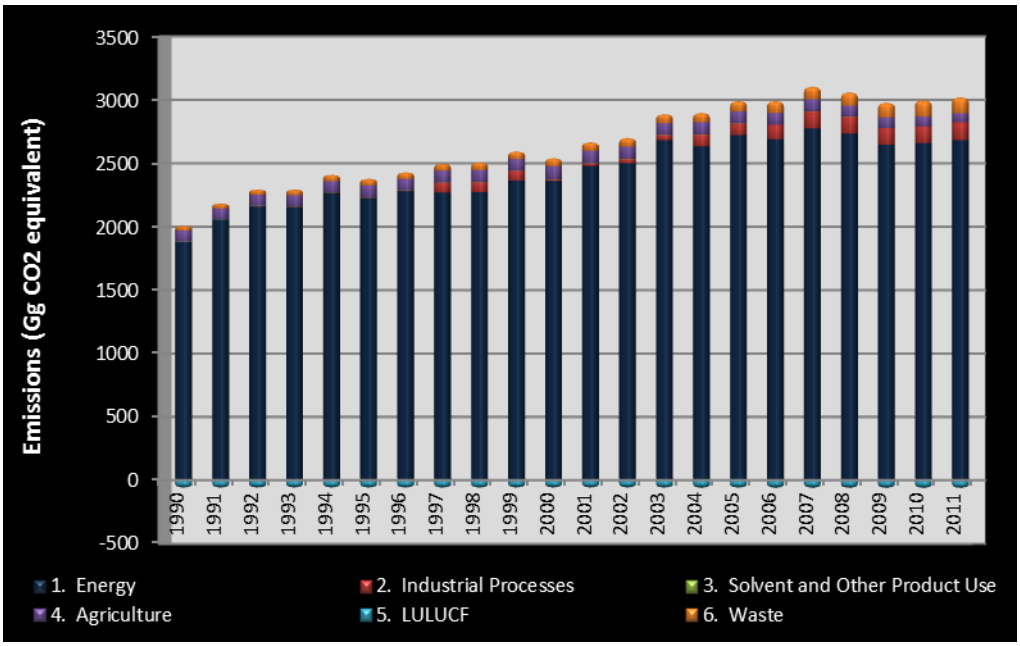


Figure 2-14 Trend in GHG emissions and removals by sector.

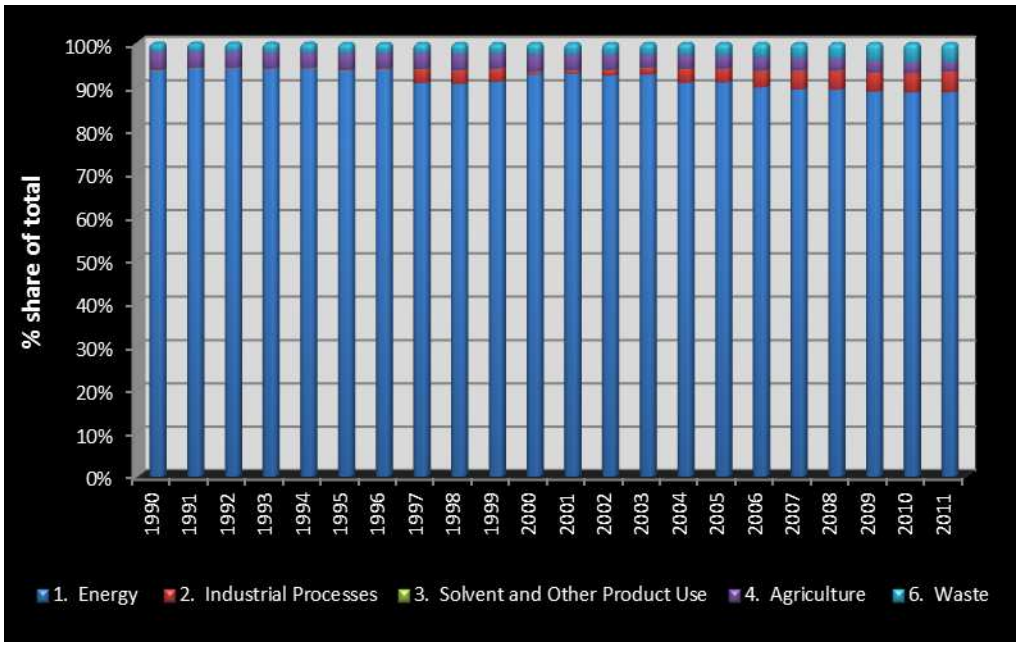


Figure 2-15 Sectoral share in total emissions for source sectors.

The changes between 1990 and 2011 in the respective share in gross greenhouse gas emissions for the five source categories is more clearly observed in Figure 2-16. All sectors except the Energy sector show a higher share in total emissions in 2011 compared to 1990. As the contributing share of the other sectors increased, the share for the Energy sector naturally had to decrease; however, the predominance of emissions from this sector in total greenhouse gas emissions can be noted in the relatively smaller decrease in the Energy sector's share between 1990 and 2011.

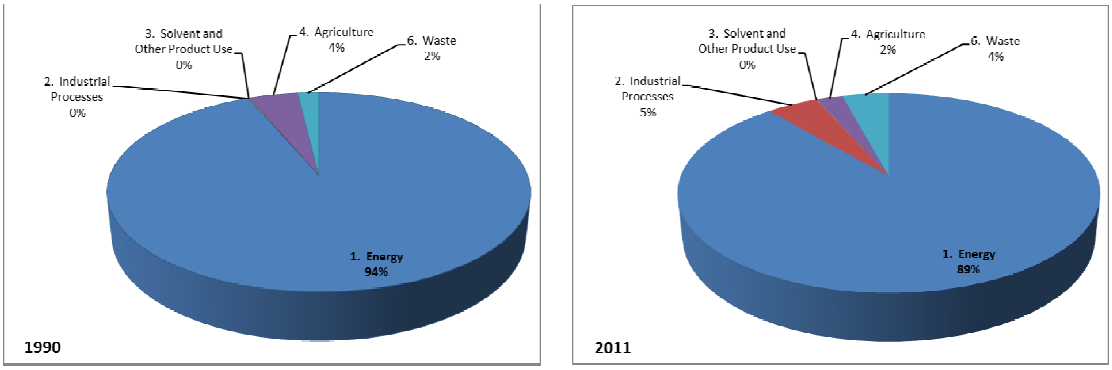


Figure 2-16 Comparison of source sector shares in gross national greenhouse gas emissions for 1990 and 2011.

2.5.1 Energy (CRF sector 1)

The Energy sector has, over the period 1990-2011, maintained its status as the most significant contributor to national total greenhouse gas emissions. And while its share of total emissions has, as already described, decreased slightly, the general trend in sector emissions remains one of generally sustained growth, with emissions in 2011 being 42.8% greater than in 1990. The relative importance of this sector is so strong that one can also note that the year-to-year changes in total national emissions is very much influenced by the year-to-year change in emissions for this sector.

Figure 2-17 provides an overview of the trends in emissions for the different main source categories that, for the purposes of greenhouse gas inventory compilation, make up the sector Energy. A quantified comparison of the share of respective source categories in total sector emissions, for the years 1990, 2000, 2010 and 2011 is presented in Figure 2-18.

The importance of the source category Energy Industries (1A1) in respect of Malta's greenhouse gas emissions is evident. It is pertinent to note here that in Malta's case, emissions reported under this source category are solely attributed to the two local electricity generation plants. This is a case where in the context of a small country, a small number of relatively large point sources can have a far reaching effect on the environmental performance of the country. From a mitigation policy perspective, actions targeted towards a limited number of emission sources could potentially have a huge impact in meeting emission-related commitments of the country.

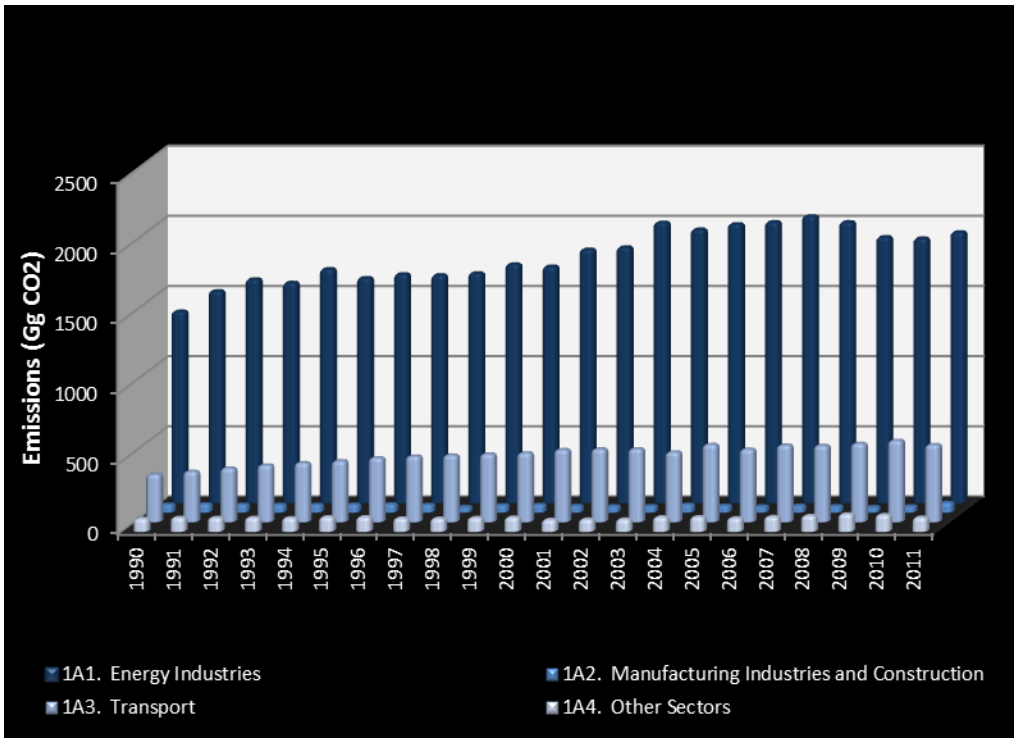


Figure 2-17 Emission trends for source categories in the Energy sector.

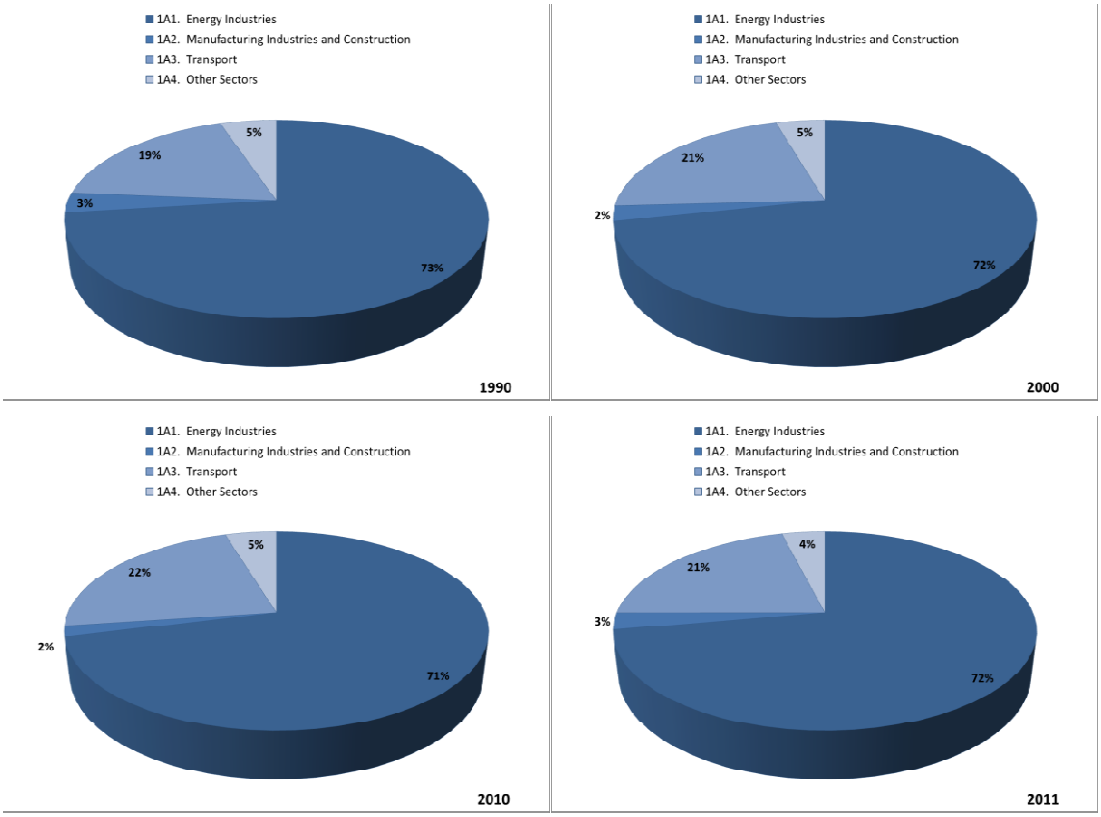


Figure 2-18 Comparison of the share of source categories in Energy sector emissions for the years 1990, 2000, 2010 and 2011.

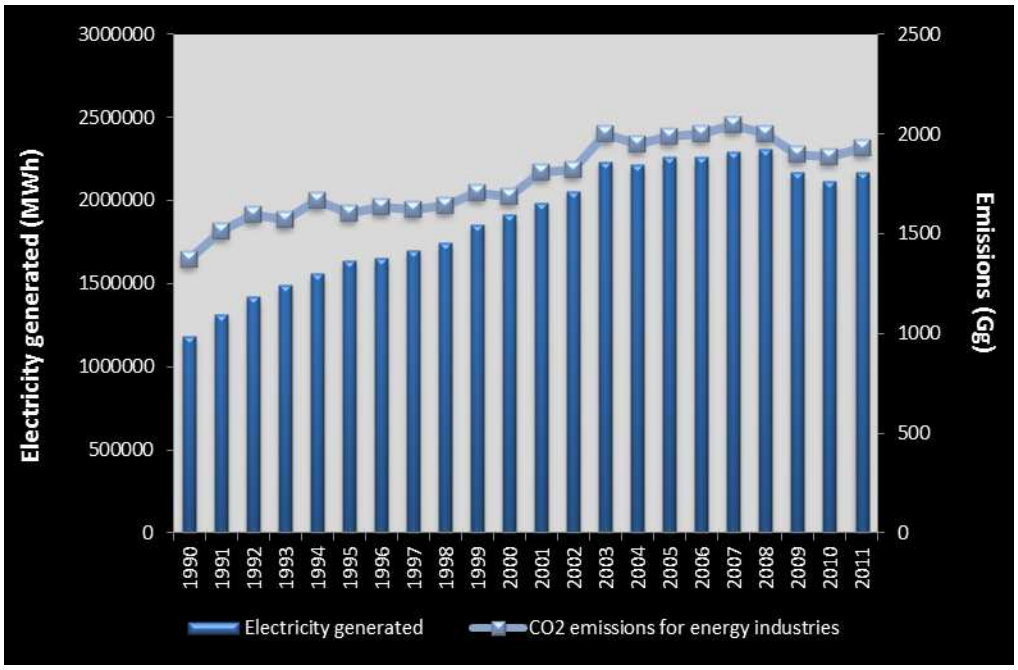


Figure 2-19 Emissions of CO_2 by source category Energy Industries compared to total electricity generated.

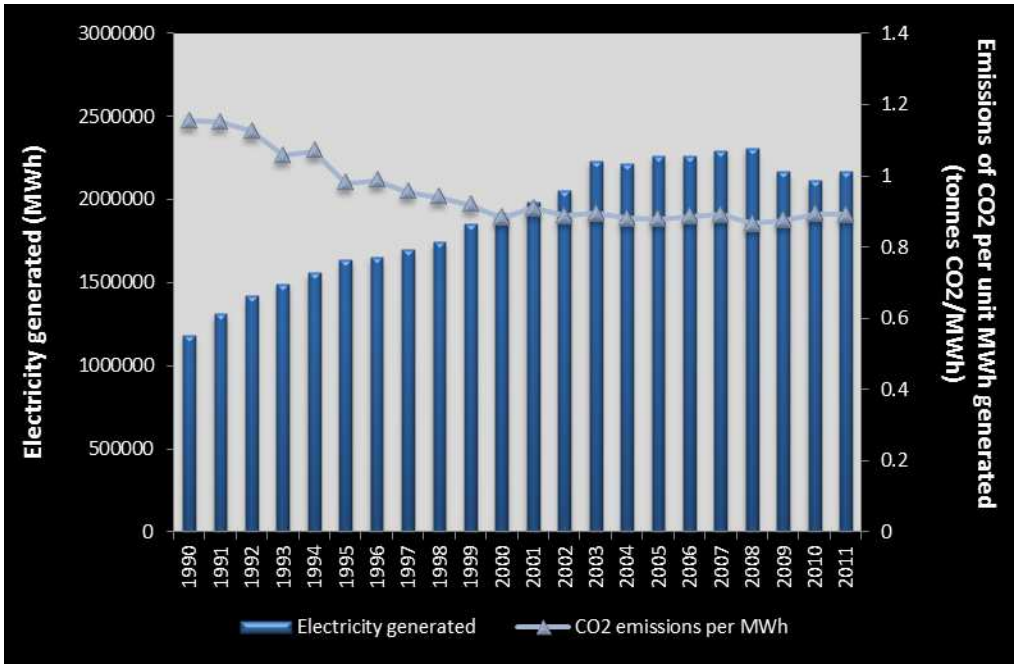


Figure 2-20 Rate of CO_2 emissions per unit MWh generated by the local power plants compared to total electricity generated.

As may be observed in Figure 2-17 and Figure 2-18, transport (source category 1A3) is the second highest contributor to overall emission levels in the Energy sector. This source category incorporates emissions from road transport, domestic aviation and national navigation, with emissions from railways not being applicable for Malta. For the transport source category as a whole, emissions of CO_2 by far surpass emissions of other gases reported in the national inventory (Table 2-5).

Table 2-5 Emissions of direct and indirect greenhouse gases (in Gg) for Transport for the years 1990 and 2011.

	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
1990	342.39	0.10	0.02	3.38	23.30	4.39	0.51
2011	553.28	0.13	0.03	3.48	30.48	0.94	0.01

Among the different sub-categories making up Transport, road transport (sub-category 1A3b) is the most important source of greenhouse gas emissions. Taking CO_2 emissions as a basis, Figure 2-20 presents a comparison of the share of respective sub-categories for 2011, showing the relative importance of road transport in contrast to the other sub-categories.

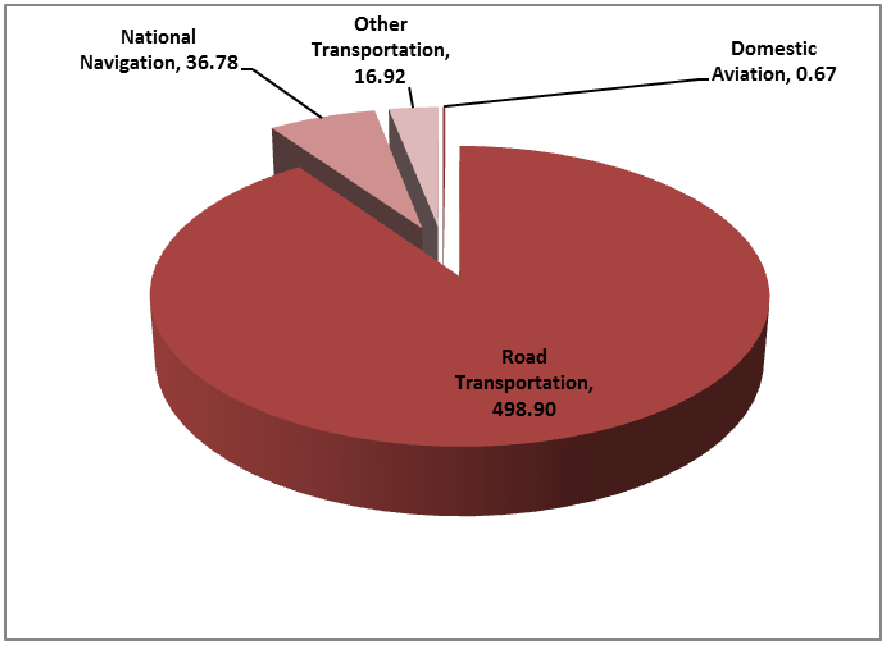


Figure 2-21 CO_2 emissions (Gg) for locally occurring sub-categories under source category Transport, for 2011.

CO_2 emissions for road transport can be easily correlated to total fuel consumption in this source category (see Figure 2-22). One does note however a greater affinity of emissions of this greenhouse gas with consumption of diesel, than is the case for petrol. Once diesel took over as the predominant fuel used for road mobility, it has tended to influence the overall trend of CO_2 emissions substantially more than petrol (Figure 2-23) and has tended, considering also the greater efficiency of diesel engines compared to petrol ones, to somewhat stabilise emissions around the 500Gg mark for the years since 2001.

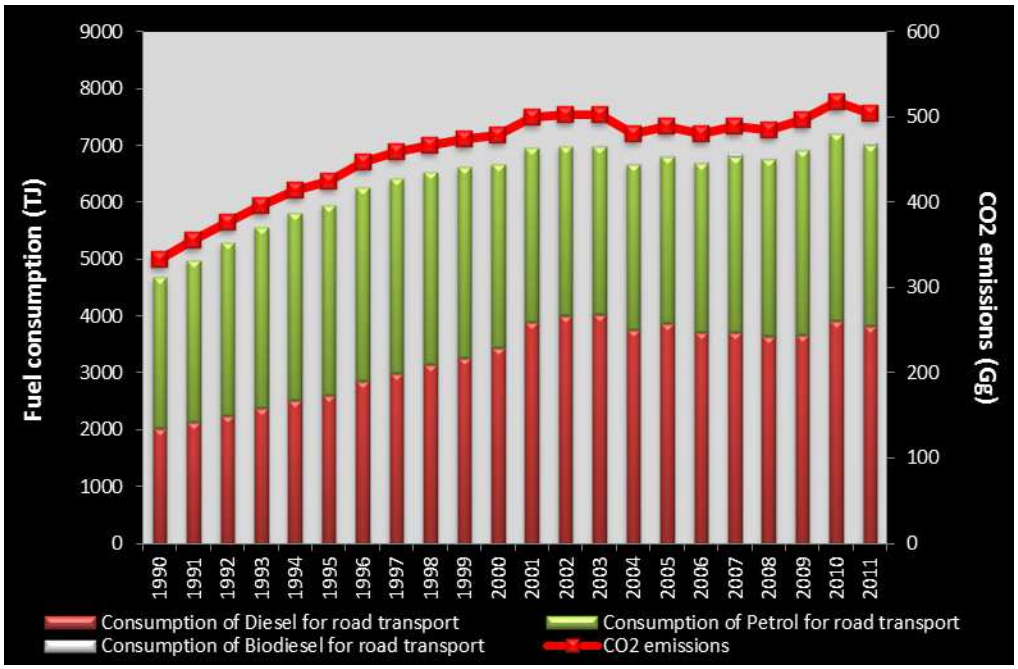


Figure 2-22 Correlation between CO_2 emissions from road transport and total fuel consumption.

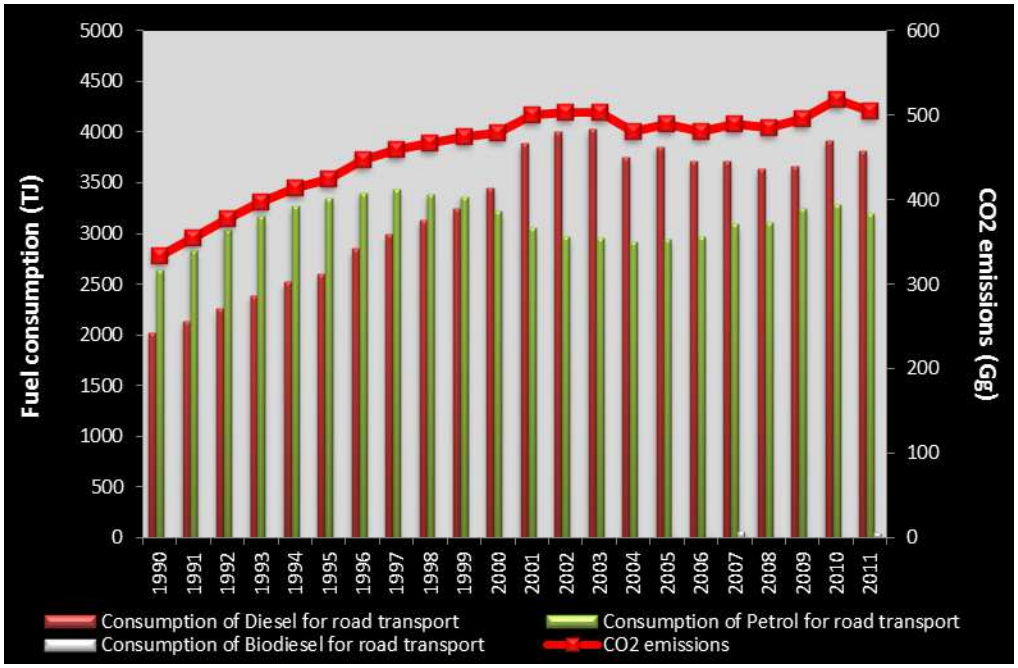


Figure 2-23 Correlation between CO_2 emissions from road transport and respective consumption of diesel, petrol and biodiesel.

Another useful correlation that one can make when analysing road transport is that between emissions of carbon monoxide and fuel consumption. Figure 2-24 shows how strongly the profile of CO emissions is influenced by the rate of use of petrol as opposed to diesel usage; this is understandable considering the much higher CO emission factor attributed to petrol in the estimation of emissions for inventory purposes.

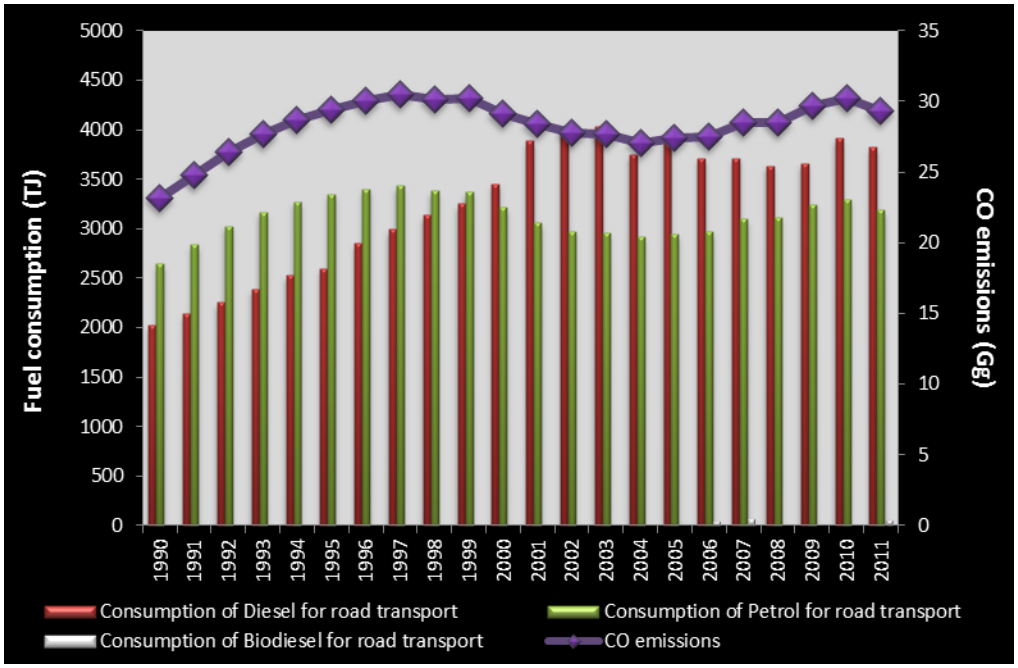


Figure 2-24 Correlation between CO emissions from road transport and fuel consumption.

The other two source categories under the Energy sector, namely category Manufacturing and Construction Industries and the category Other Sectors (which includes sub-categories Commercial/Institutional, Residential, and Agriculture/Forestry/Fisheries) are attributed a much lower share of total sector emissions, as can be observed in Figure 2-18.

2.5.2 Industrial Processes (CRF sector 2)

While the sector Industrial Processes represents a relatively small share of total greenhouse gas emissions when compared to the previously discussed sector, its contribution is growing throughout the years, primarily driven by the growth in emissions of HFCs. This sector had a share of less than 0.02% of total national greenhouse gas emissions in 1990; the share in 2011 was of just less than 5%. Indeed, this sector has, in recent years, taken over from Waste as the second highest contributor to national emissions of greenhouse gases.

Source categories under this sector that are responsible for emissions of fluorinated greenhouse gases include: refrigeration and air conditioning equipment (source category 2F1); foam blowing (2F2); fire extinguishers (2F3); metered-dose inhalers (2F4); semiconductor manufacturing (2F7); electrical equipment (2F8); medical applications (2F9). In 2011, these source categories together accounted for 99.82% of total emissions for the sector. In 1990, the total share of these source categories amounted to a paltry 3.03%.

A small amount of CO_2 emissions is attributed to lime production (2A2); soda ash production and use (2A4); road paving with asphalt (2A6); carbide production (2B4). NMVOC emissions are also reported from road paving with asphalt (2A6) and the production of food and drink products (2D2).

2.5.3 Solvent and Other Product Use (CRF sector 3)

The share of the emissions from the sector Solvent and Other Product Use in total net emissions of greenhouse gases has always been minimal. The only greenhouse gas accounted for under this sector is nitrous oxide, from its use for anaesthetic purposes (source category 3D1). With 2011 emissions of this gas from this activity amounting to just 0.004Gg, the share in total national emissions of this sector amounted to less than 0.05%.

A relatively higher contribution is seen in respect of emissions of NMVOCs from the use of solvents and products containing solvents (source category 3D5). The national GHG inventory estimates emissions of NMVOCs for this sector at 1.14Gg in 2011.

2.5.4 Agriculture (CRF sector 4)

Agriculture includes a number of source categories responsible for emissions of either methane or nitrous oxide. This sector's overall contribution to national total emissions has decreased over time, with a share of 2.4% in 2011 (CH_4: 50.55Gg CO_2 equivalent; N_2O: 20.34Gg CO_2 equivalent; total emissions: 70.90Gg CO_2 equivalent) compared to a share of 4.5% in 1990 (CH_4: 62.37Gg CO_2 equivalent; N_2O: 25.44Gg CO_2 equivalent; total emissions: 87.81Gg CO_2 equivalent). Total emissions as estimated for this sector had, by 2011, decreased by almost one-fifth compared to emissions for 1990. Indeed, while up until the middle of the first decade of this century, Agriculture was the second highest overall contributing sector behind the sector Energy, it was then surpassed by the sectors Industrial Processes and Waste.

Three source categories are represented in national GHG inventories compiled by Malta, namely: Enteric Fermentation (source category 4A) with methane emissions; Manure Management (4B) with both methane and nitrous oxide emissions; and, Agriculture Soils (4D) responsible for nitrous oxide emissions.

The overall trend in emissions for the Agriculture sector (Figure 2-25) reflects the decline in emissions from the respective source categories. Total emissions from Enteric Fermentation have gone down from 33.70Gg CO_2 equivalent in 1990 to 28.76Gg CO_2 equivalent in 2011 while emissions from Manure Management have decreased from a total of 33.36Gg CO_2 equivalent in 1990 to 25.53Gg CO_2 equivalent in 2011. Emissions from these two source categories are the result of animal husbandry activities. The application of synthetic nitrogen-containing fertilisers and manure to soils is the source of N_2O emissions from the source category Agricultural Soils, which also shows a decreasing trend in emissions: from 20.75Gg CO_2 equivalent in 1990 to 16.60Gg CO_2 equivalent in 2011.

2.5.5 Land Use, Land-use Change and Forestry (CRF sector 5)

Malta's national GHG inventories to-date have attributed a net sink effect for the sector LULUCF for all years covered by the time series 1990 to 2011 (Figure 2-26). Carbon dioxide removals from above ground biomass have been estimated for categories Forest Land (5A) and Cropland (5B). The total removal contribution of the sector was equivalent to 56.54Gg CO_2 equivalent in 1990, going up to 59.67Gg CO2 equivalents in 2011, a relatively minor increase. The slight increase was mainly due to an increase in the estimated removals attributed to category Cropland.

One must note that this sector is expected to undergo substantial development in respect of the methodological approach to estimating emissions and removals from the source categories incorporated within the sector, as its importance from an inventory reporting perspective under the Kyoto Protocol grows with Malta's accession to Annex I status.

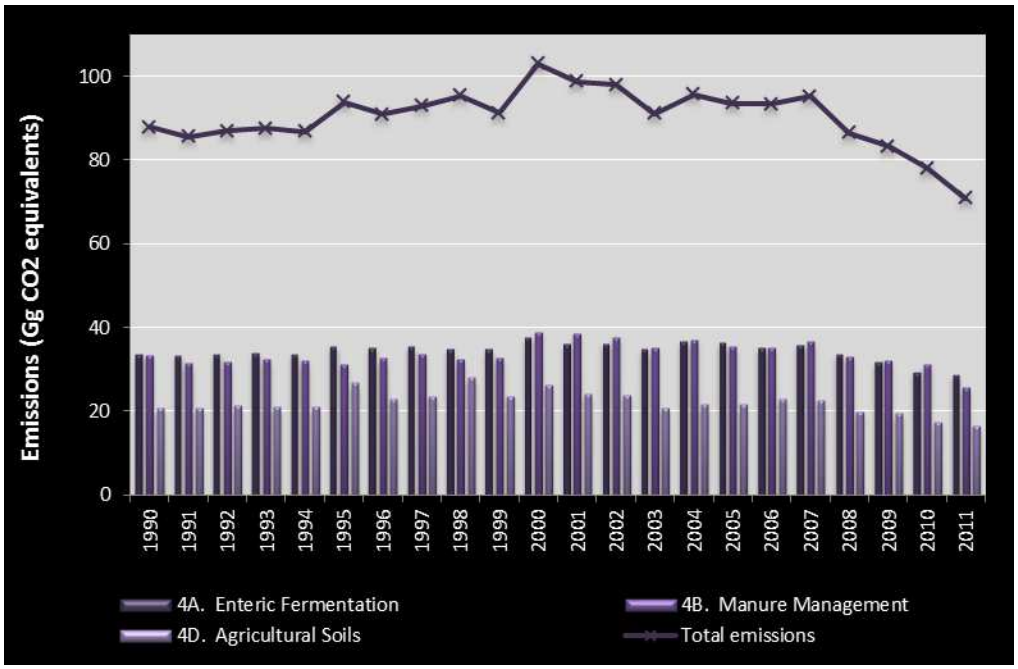


Figure 2-25 Greenhouse gas emission trends for sector Agriculture and for source categories that occur in Malta.

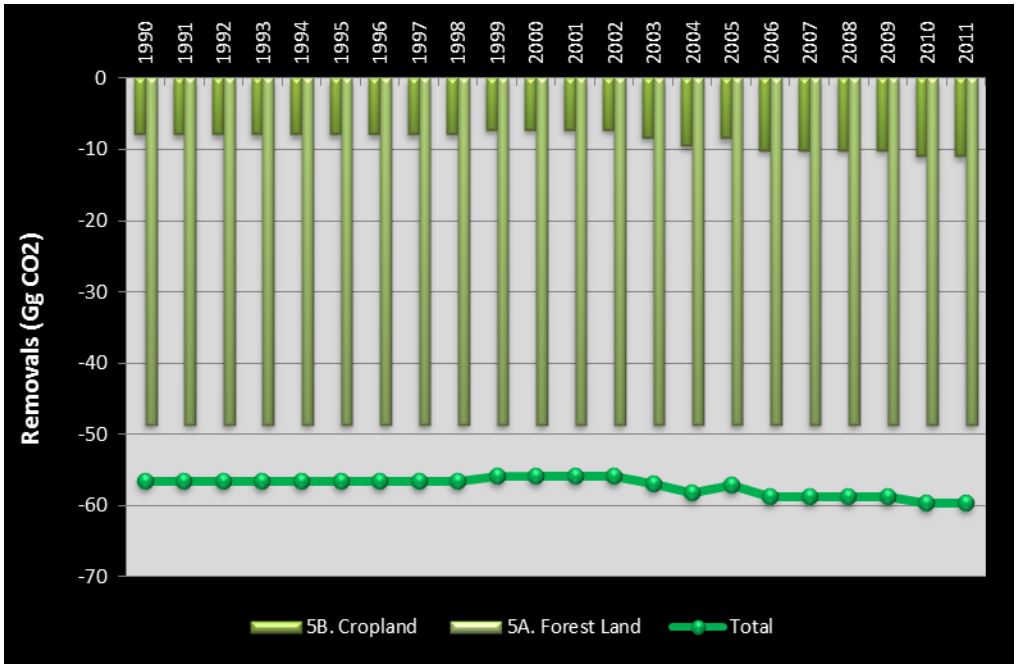


Figure 2-26 CO_2 removals in sector LULUCF.

2.5.6 Waste (CRF sector 6)

From just under 2.0% of total national greenhouse gas emissions in 1990, the share of the sector Waste more than doubled over the years, reaching 4.28% in 2011. Emissions estimated for this sector have continued to increase throughout the 1990-2011 time series, from a total 37.84Gg CO_2 equivalent in 1990 to 126.76 Gg CO_2 equivalent in 2011; the latter value shows a slight decrease compared to the highest ever emission levels attributed to this sector, for the year 2010 (128.73Gg CO_2 equivalent). Notwithstanding this observed slight decrease between 2010 and 2011, emissions in the latter year represent an increase of more than 230% compared to levels in 1990.

Three greenhouse gases are emitted by activities making up this sector, namely CO_2, CH_4 and N_2O. CH4 emissions predominate, in 2011 estimated at 112.14Gg CO_2 equivalent, followed by N_2O with 2011 emission at 13.93Gg CO_2 equivalents and a minimal 0.69Gg CO_2 equivalent for carbon dioxide. From a source category perspective (Figure 2-27), source category Solid Waste Disposal on Land (6A) is attributed almost all methane emissions in the sector; source category Liquid Waste Handling (6B) is a contributor to both methane and almost all nitrous oxide emissions under this sector, while Waste Incineration (source category 6C) is the source of all CO_2 emissions attributed to the sector Waste and very small quantities of CH_4 and N_2O. For a period, between 1993 and 2006, some composting of biodegradable fractions of waste took place, resulting in emissions of CH_4 and N_2O.

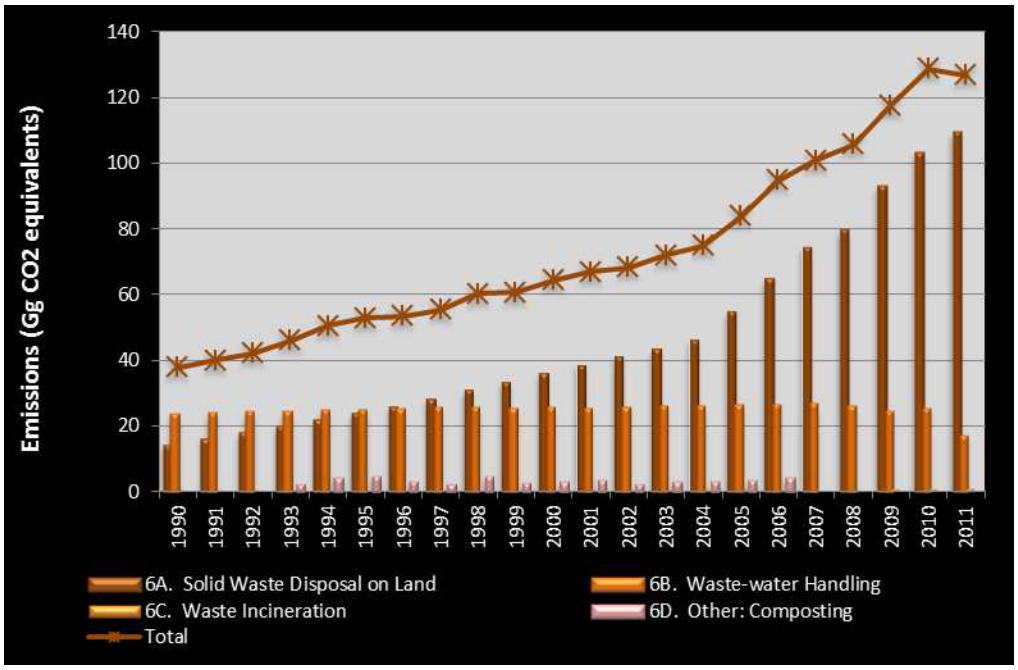


Figure 2-27 Greenhouse gas emission trends for sector Waste and for source categories in the sector.

2.5.7 Key category analysis

A 'key category' is an individual source or sink category that has a significant influence on the national inventory, in terms of the absolute level of emissions or removals, the trend in emissions or removals, or both. This influence also means that the national inventory compilation process would be expected to pay particular attention to a key category in the emissions or removal

estimation process. It was previously usually referred to as 'key source category'[19], which was thus limited to emission source categories. More recently, the reference to 'source' has been largely discontinued in order to also cover LULUCF removals by sinks.

A key category analysis assesses the influence of different categories of emissions and removals on both the level of the national inventory, and where possible, on the trend of the inventory. This assessment is usually presented as a listing of all those categories that cumulatively account for up to 95% of the total inventory when summed up in descending order of magnitude.

This discussion will focus on two sets of key category listings, namely with-LULUCF (includes estimated removals in the LULUCF sector, taking into consideration the quantified absolute values without due account to the sign) and without-LULUCF (ignores estimates of removals from the LULUCF sector), for 1990 and for 2011. This should make even more clear which are those source and sink categories of highest significance to an in-depth analysis of Malta's greenhouse gas inventory, and whether changes can be observed.

2.5.7.1 Key categories: level assessment.

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

Comparing with-LULUCF and without-LULUCF key category assessments for both 1990 and 2011(see Table 2-6 and Table 2-7) shows the inclusion of CO_2 removals for category 5A1: Forest Land in the with-LULUCF as a key category as opposed to the without-LULUCF list; this category is obviously not represented in a without-LULUCF inventory. No other difference is noted for each year.

It is worth noting the respective positions for the fuel-type-disaggregated level contributions of category 1A1a: Energy Industries. CO_2 emissions from the combustion of residual fuel oil and coal in the local energy generation sector in fact accounted for around 66.0% of total national emissions in 1990, while the relative importance of CO_2 emissions from the combustion of gas oil in the local energy industries is substantially lower. The picture is somewhat different for 2011. As use of coal as an energy source in energy generation was discontinued in the mid-1990's, this source category does not feature in the 2011 lists. On the other hand, the position of emissions from the use of gas/diesel oil in category 1A1a: Energy Industries relative to other key categories changes, with this category increasing in relative importance.

Road transport is one of the highest rated key categories for 1990. The increase in road transport emissions over the period 1990 to 2011 means that this category gains in relative importance.

Other significant differences between the first year and the most recent year covered by this discussion include the appearance of HFC emissions from category 2F1: Refrigeration & Air Conditioning Equipment as a prominent key category in 2011, this category being absent from the 1990 list of key categories and CH4 emissions from category 6A1: Managed Waste Disposal on Land also being listed for 2011, as opposed to the situation for 1990. On the other hand, CH_4 emissions from category 4A1: Cattle and N_2O emissions from category 4D1: Direct Soil Emissions lose in terms of relative importance between 1990 and 2011.

[19] Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC, 2000.

Table 2-6 Level assessment key category list for 1990.

1990 with-LULUCF key category list			1990 without-LULUCF key category list		
1A1a	Energy Industries - Residual Fuel Oil	CO2	**1A1a**	Energy Industries - Residual Fuel Oil	CO2
1A1a	Energy Industries - Other Bituminous Coal	CO2	**1A1a**	Energy Industries - Other Bituminous Coal	CO2
1A3b	Road Transportation	CO2	**1A3b**	Road Transportation	CO2
1A4a	Commercial/Institutional	CO2	**1A4a**	Commercial/Institutional	CO2
5A1	Forest Land	CO2	**1A2**	Manufacturing Industries and Construction	CO2
1A2	Manufacturing Industries and Construction	CO2	**1A4b**	Residential	CO2
1A4b	Residential	CO2	**1A1a**	Energy Industries - Gas/Diesel Oil	CO2
1A1a	Energy Industries - Gas/Diesel Oil	CO2	**4A1**	Cattle	CH4
4A1	Cattle	CH4	**6A2**	Unmanaged Waste Disposal on Land	CH4
6A2	Unmanaged Waste Disposal on Land	CH4	**4D1**	Direct Soil Emissions	N2O
4D1	Direct Soil Emissions	N2O	---		

Table 2-7 Level assessment key category list for 2011.

2011 with-LULUCF key category list			2011 without-LULUCF key category list		
1A1a	Energy Industries - Residual Fuel Oil	CO2	**1A1a**	Energy Industries - Residual Fuel Oil	CO2
1A3b	Road Transportation	CO2	**1A3b**	Road Transportation	CO2
1A1a	Energy Industries - Gas/Diesel Oil	CO2	**1A1a**	Energy Industries - Gas/Diesel Oil	CO2
2F1	Refrigeration & Air Conditioning Equipment	HFCs	**2F1**	Refrigeration & Air Conditioning Equipment	HFCs
6A1	Managed Waste Disposal on Land	CH4	**6A1**	Managed Waste Disposal on Land	CH4
1A2	Manufacturing Industries and Construction	CO2	**1A2**	Manufacturing Industries and Construction	CO2
1A4a	Commercial/Institutional	CO2	**1A4a**	Commercial/Institutional	CO2
1A4b	Residential	CO2	**1A4b**	Residential	CO2
5A1	Forest Land	CO2	**1A3d**	National Navigation	CO2
1A3d	National Navigation	CO2	**6A2**	Unmanaged Waste Disposal on Land	CH4
6A2	Unmanaged Waste Disposal on Land	CH4	---		

2.5.7.2 Key categories: trend assessment.

A trend assessment takes into account the trend in emissions or removals of a category over time in addition to the level of emissions or removals for that category. This assessment approach can highlight categories that may not appear to be key categories under a level assessment but whose trend is significantly divergent from that of the overall inventory. As a trend assessment requires an analysis against a previous year's inventory (usually against the base year), this discussion is limited to a trend assessment for 2011.

The trend assessments for 2011 (see Table 2-8) with- and without-LULUCF again reflects the relative importance, this time to emission trends, of emissions of CO_2 from combustion of residual fuel oil and of gas oil. CO_2 removals for category 5A1: Forest Land also features as an important key category in respect of trend assessment for the with-LULUCF list, this category being of course absent in any without-LULUCF assessment. Road transport, one of the highest contributing source categories to total emissions also features as an important trend key category.

Table 2-8 Trend assessment key category list for 2011.

2011 with-LULUCF key category list			2011 without-LULUCF key category list		
1A1a	Energy Industries - Residual Fuel Oil	CO2	1A1a	Energy Industries - Residual Fuel Oil	CO2
1A1a	Energy Industries - Gas/Diesel Oil	CO2	1A1a	Energy Industries - Gas/Diesel Oil	CO2
2F1	Refrigeration & Air Conditioning Equipment	HFCs	2F1	Refrigeration & Air Conditioning Equipment	HFCs
6A1	Managed Waste Disposal on Land	CH4	6A1	Managed Waste Disposal on Land	CH4
1A3b	Road Transportation	CO2	1A4a	Commercial/Institutional	CO2
1A4a	Commercial/Institutional	CO2	1A3b	Road Transportation	CO2
5A1	Forest Land	CO2	1A3d	National Navigation	CO2
1A3d	National Navigation	CO2	4A1	Cattle	CO2
4A1	Cattle	CH4	1A2	Manufacturing Industries and Construction	CO2
1A2	Manufacturing Industries and Construction	CO2	4D1	Direct Soil Emissions	N2O
4D1	Direct Soil Emissions	N2O	6A2	Unmanaged Waste Disposal on Land	CH4
6A2	Unmanaged Waste Disposal on Land	CH4	4B1	Cattle	CH4
4B1	Cattle	CH4	---		
6B	Domestic and Commercial Wastewater	N2O	---		

2.5.8 Uncertainty and completeness

The measure of every quantity (e.g. activity data, emission factors) that serves as input to the estimation of emissions and removals in greenhouse gas inventories is subject to a degree of 'uncertainty'. Uncertainty reflects the lack of absolute certainty on the true value of a variable parameter.

A Tier 1 approach, in accordance with the IPCC Good Practice Guidance has been applied to uncertainty assessment of the emissions and removals estimations discussed here. Overall uncertainty has been estimated at 4.84% of total national emissions (MRA, 2013). One should note that for the source category responsible for the greater part of total national emissions, namely Public Electricity and Heat (source category 1A1a), data reliability is considered to be high, in view of the fact that input data used for inventory purposes for the years since 2005, is already subject to stringent verification in accordance with rules provided for under the EU ETS Directive.

The level of completeness in inventory compilation represents the extent to which all sources and sinks as well as gases are covered by the inventory. There are instances where full coverage is not possible either because certain activities do not occur within the country or because of data availability or methodological issues. The inventory submission on the basis of which this chapter has been compiled gives more details on the level of completeness, the source categories for which emission or removal estimations have not been carried out, and the reasons why (MRA, 2013).

2.6 National registry system

Parties to the Kyoto Protocol are required to establish national registry systems for the purpose of tracking the issuance, transfer, acquisition, cancellation and retirement of assigned amount units (AAUs), emission reduction units (ERUs), certified emission reduction units (CERs), temporary certified emission reductions units (tCERs), long-term certified emission reduction units (lCERs) and removal units (RMUs), and the replacement of tCERs and lCERS. A national registry system is thus

an important element in the accounting for emissions and to show a Party's compliance with emission limitation or reduction targets that it may have under the Kyoto Protocol.

In the light of the fact that Malta has only recently acceded to Annex I status, and this accession not having been associated with any quantified emission limitation or reduction targets for the Kyoto Protocol's first commitment period, Malta has to-date not required, and thus has not established, a Kyoto Protocol national registry system.

Notwithstanding this, it is important to note that pursuant to its obligation to implement EU legislation, Malta does require a system for the accounting of emissions pursuant to the EU Emissions Trading Scheme Directive. Following a number of years where the EU Member States maintained their own respective separate national registry systems for the EU ETS, the adoption of Directive 2009/29/EC[20] to amend the original EU ETS Directive opened the way for centralization of EU ETS registry operations into a single European Union registry system, which caters for the accounting of emissions by all operators of stationary installations and aircraft operators falling within the scope of the scheme. Malta administers a number of accounts relevant to the administration of the EU ETS in this registry. This means that Malta has a registry system connected to the EU Transaction Log (EUTL) but without a direct connection to the International Transaction Log (ITL).

In view of the inclusion of Malta in the list of Parties with a quantified emissions limitation or reduction target for the second commitment period of the Kyoto Protocol, pursuant to the Doha amendments to the Protocol, it is envisaged that in the near future Malta will also have a registry for Kyoto Protocol accounting.

[20] 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 emission allowance trading scheme of the Community; OJ L 140, 5.6.2009, pg 63.

3 POLICIES AND MEASURES

> "*All Parties [...] shall: Formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol [...]*"[21]

3.1 Introduction

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

This chapter looks at the suite of policies and measures adopted in Malta which directly or indirectly address greenhouse gas emissions and removals. This discussion, and thus also the discussion in the subsequent chapter on projections, presents and reflects the state of play of greenhouse gas mitigation policies and measures as at the end of 2012 (MRA, 2013a).

3.2 Policy context

The overarching policy context to-date has been very much driven by commitments that Malta makes at the supra-national sphere. For the period up to 2012, Malta had not taken on any greenhouse gas emission limitation or reduction obligations in the context of the UNFCCC or the Kyoto Protocol. With the agreed extension of the Protocol until 2020, this situation has now changed, with a target of 20% reduction in overall greenhouse gas emissions, as compared to emission levels in 1990, inscribed for Malta in respect of the Second Commitment Period under the Protocol. This target reflects the overall 20% reduction commitment, compared to 1990, that the EU has made as its contribution towards global efforts to control greenhouse gas emissions until 2020.

One should clarify here that the target inscribed for Malta under the amended Kyoto Protocol does not necessarily reflect the actual effort that the country has to make in respect of emissions until 2020. It has been agreed that the EU target under the Protocol will be achieved jointly. This means that the overall Union target (20% reduction compared to 1990, by 2020) could be redistributed within the bloc in a manner that allows for a more cost-effective and flexible fulfilment of the overall commitment than would have been the case if Kyoto Protocol targets as inscribed had to be met by the respective Member States. This redistribution forms the basis of the EU emission mitigation policy framework until 2020, and is provided for thus:

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

[21] United Nations Framework Convention on Climate Change, Article 4 (1)(b).

The participation of local industrial enterprises in the EU ETS is limited to the two electricity generation installations operated by Enemalta Corporation, whose carbon dioxide emissions are subject to the accounting provisions of the Directive. Despite the limited scope of the EU ETS in terms of the number of emitting installations falling within the scope of the scheme, the coverage in terms of emissions is substantial, in 2011 this being equivalent to around 65% of total net national greenhouse gas emissions (Figure 3-1).

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

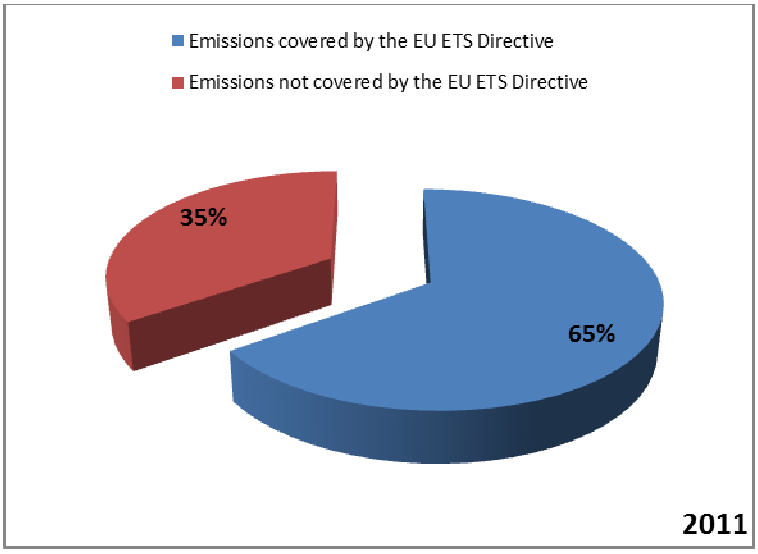


Figure 3-1 Share of national emissions covered by the EU Emissions Trading Scheme. Emissions from source category Domestic Aviation are not included while emissions from international aviation activities covered by the EU ETS Directive have also not been taken into account in this figure. As of 2013, emissions not covered by the EU ETS (with the exception of emissions from domestic aviation activities, emissions and removals from LULUCF and emissions from international aviation and maritime bunkering activities) will be subject to the emission limitation or reduction targets set out for each EU Member States in the Effort-Sharing Decision.

The European Union's 2020 Climate Change and Energy Package, apart from presenting the policy framework for greenhouse gas emission mitigation up to 2020, also revisits previous Union policy in respect of renewable energy sources and energy efficiency. In an effort towards consolidating progress in increasing the share of renewable energy sources and enhancing energy efficiency, the Package establishes relevant targets for each Member State. Thus, under the Renewable Energy Sources Directive[22] Malta is required to reach, by 2020, a 10% share of energy from renewable sources in gross final consumption, including a 10% share of renewable

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

energy for the transport sector. In respect of energy efficiency, the Energy End-Use Efficiency Directive[23] provides for a target of 9% increase in efficiency by 2016 for Malta.

3.3 Policy-making process

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

In certain instances, emissions mitigation policy is included as an element of multi-sectoral policy frameworks. To take an example, the National Energy Policy[24] adopted in 2012 mainstreams climate mitigation considerations within the policy framework on the basis of which the country's energy future is being planned. This is an important development in local policy-making, looking at climate change mitigation as an integral part of the national policy process and putting the issue at the forefront of the planning of the country's economic and social development.

More recently, an even more holistic dimension to climate policy has also become prevalent. The 'A Sustainable Development Strategy for the Maltese Islands'[25] of 2006 identified the reduction of greenhouse gas emissions as a priority area that warrants "*foremost attention for the attainment of sustainable development goals in Malta*". In 2012, the 'National Environment Policy'[26] highlighted the reduction of national greenhouse gas emissions as an important national environment policy element.

A further development in local greenhouse gas emission mitigation policy-making was the appointment, for the first time, of an *ad hoc* Climate Change Committee with a mandate to draw up a National GHG Mitigation Strategy[27]. The strategy was the subject of a public consultation process and a parliamentary debate. This initiative can be considered as being a first attempt at a more coordinated top-down approach to climate mitigation. Though the strategy focusses very much on energy generation and energy demand, it does go beyond the usual emission-source-oriented approach to emission mitigation planning. Indeed, it explores aspects such as:

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

In 2013, an Inter-Ministerial Committee on Climate Change was set up involving the relevant Ministries to ensure synergy between the different governmental policies having a bearing on climate change or which may be impacted by climate change and the effects thereof.

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

3.4 Policies and measures and their effect

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

3.4.1 Energy

The Energy sector, being the sector with the highest contribution to national greenhouse gas emissions, is of course a principal target of national greenhouse gas emission mitigation activity.

As already noted, controlling greenhouse gas emissions forms an important element of the National Energy Policy of 2012. The Policy is based on five fundamental principles, namely: energy efficiency and affordability; security; diversification; flexibility; and, sustainability. These principles underpin a number of policy areas, including, among others, energy efficiency, reducing reliance on imported fuels, and reducing emissions.

The Policy obviously also takes into account the energy-related obligations that Malta has under EU legislation, including in particular the targets for renewable energy sources and energy efficiency already discussed above. Further to the overarching national policy, the National Renewable Energy Action Plan (NREAP)[28] and the National Energy Efficiency Action Plan (NEEAP)[29] provide more detailed indications of how Malta expects to meet these targets. The overall emphasis remains very much on the introduction of more efficient technologies and the use of lower-carbon sources of energy, coupled with demand side management.

3.4.1.1 Conventional electricity generation

With almost all electricity utilised in Malta being supplied by the two power generation plants operated by Enemalta Corporation, it is no surprise that these plants are the focus of substantial investment, with a number of linked technical measures having already been implemented in recent years, or are currently under consideration.

The need to decommission the generating plant in Marsa is being offset by the installation of new and more efficient plant in Delimara Power Station and the installation of an electrical interconnector to Sicily. The interconnection to Sicily will link the Maltese electricity system with the European electricity grid, thus diversifying Malta's energy sourcing and providing scope for benefitting from the much more favourable economies of scale one finds in mainland Europe.

The possibility of switching from the currently oil-dependent generation of electricity to gas-fired technology is also under active detailed assessment. A number of options may be considered, including getting the fuel through a gas pipeline from nearby mainland sources or bringing gas in liquefied form to Malta by ship and regasification at the site where it is to be used. Fuel switching to gas would represent a very significant reduction in greenhouse gas emissions for local electricity generation plants.

[28] *Malta's National Renewable Energy Action Plan as required by Article 4(2) of Directive 2009/28/EC*, Malta Resources Authority, 2010.
[29] *2nd National Energy Efficiency Action Plan – Malta*, Malta Resources Authority, 2011.

3.4.1.2 Renewable energy sources

Malta's first action plan for renewable energy sources indicates the trajectory towards meeting Malta's 2020 target for share of renewables, and presents a detailed overview of the manner in which that target was envisaged to be achieved at the time. This is schematically presented in Figure 3-2.

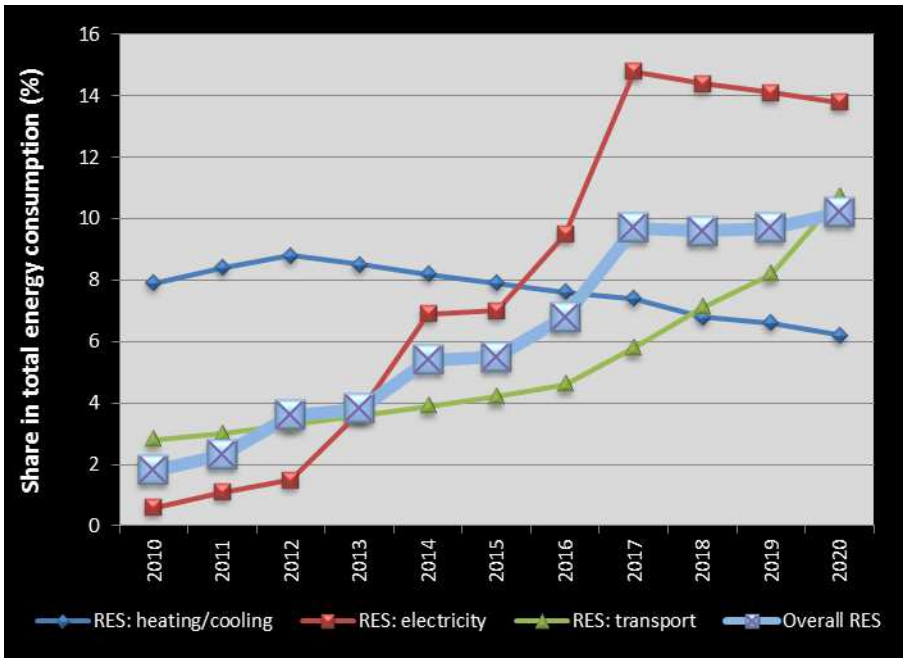


Figure 3-2 The envisaged approach towards Malta's achieving the 2020 renewable energy sources target. (MRA, 2010)

Grant schemes provided by the central government over the years have encouraged households and businesses to invest in solar water heating technology, with the penetration of solar water heaters at more than 15,800 units installed by the end of 2012, with an estimated total solar energy capture capacity of 31GWh. The uptake of photovoltaic systems has also matured over recent years, assisted by the introduction of a feed-in tariff coupled with grants to offset part of the capital costs involved in installing such systems. By mid-2012, total capacity of photovoltaic systems already installed, authorised or in the process of being authorised amounted to 16MW, potentially generating 25GWh per annum when fully operational.

Stand-alone renewable energy projects of a more substantial generating capacity have also been assessed, and, in some cases, have proceeded to realization. A prime example is a combined heat-and-power installation for which a licence was granted to WasteServ Malta Ltd[30] in late 2011, and which will be operated at the Sant' Antnin Solid Waste Treatment Plant. This plant has a capacity of 1.74MW operating on biogas produced by mechanical biological waste treatment on the site.

Wind energy has lagged behind solar energy as a contributor to achieving national renewable energy targets. Uptake of micro and medium wind technologies remains negligible, reasons for this including uncertainty about energy yields, relatively higher installation costs and planning permitting issues. The latter has to an extent been addressed by guidelines[31] published in 2010

[30] WasteServ Malta Ltd is a government owned company established to operate waste management facilities owned by the Maltese government.

[31] *Planning Guidance for Micro-Wind Turbines*, Malta Environment and Planning Authority, 2010.

by the Malta Environment and Planning Authority for micro wind turbines with capacities not greater than 20kW.

Large scale wind farms, though providing substantial scope for contributing to national energy sourcing, have also encountered difficulties. The NREAP envisages the setting up of three wind farms, the largest of which would be a 72-95MW offshore installation, an another two smaller installations on land. The offshore project would contribute between 3 and 4 percentage points of Malta's 10% renewables target. However, concerns about the environmental impacts of such a wind farm in the location identified for the project have stalled progress until further studies are carried out to better understand the full implications of the proposed installation. Similar environmental concerns have also limited progress so far in respect of the proposed onshore farms.

3.4.1.3 Energy end-use efficiency

The NEEAP of 2011 envisages a growth from 3.8% savings in 2010 to at least 9.0% savings in 2016, through a number of energy use efficiency measures aimed at the industrial, commercial and residential sectors. The measures are, for the most part, supported by the central government through the provision of financial assistance or regulatory mechanisms; the government is also leading by example.

A number of schemes have been launched in recent years to assist in investment in energy efficiency measures in industry, including in particular small and medium enterprises, and the hospitality sector. Industry has also been able to benefit from access to subsidised energy auditing. The hospitality sector has been provided loans financed by Malta Enterprise and covering up to 80% of total investment, for utilisation in the installation of renewable and energy efficiency technologies in establishments.

The buildings sector has also been a beneficiary of a number of initiatives targeting enhanced energy efficiency. Of prime importance is the implementation of the Energy Performance in Buildings Directive through the establishment of a Buildings Regulations Office, the enactment of national legislation, the issuance of 'A Technical Guidance Document on Minimum Requirements on the Energy Performance of Buildings'[32], and the issuance of the 'Energy Performance Rating for Dwellings in Malta' software[33], thus providing the necessary guidance to building sector professionals in ensuring that the development of the buildings sector in the country is directed towards increased energy efficiency. Furthermore, large scale residential and commercial development projects are required to submit energy and water management plans as part of the development planning permitting process.

The residential sector is further incentivized towards energy efficient choices through the granting of financial support to cover the installation of roof insulation, double glazing for apertures and the purchase of energy efficient household appliances.

The public sector is also contributing through its own actions. A corporate environmental policy published by the government in 2007 sets energy efficiency targets for a number of government owned enterprises. For example, Water Services Corporation[34] has over the years been a major single user of electricity particularly due to the operation of a number of sea water desalination plants which provide more than half of the potable water used in the Maltese islands. Significant

[32] *Technical Guidance F: Conservation of Fuel, Energy and Natural Resources (Minimum requirements on the energy performance of buildings regulations 2006)*, Buildings Regulations Office, 2006.

[33] May be accessed at https://secure2.gov.mt/epc/about-epc?l=1.

[34] Water Services Corporation was set up by the government to produce and distribute potable water in the Maltese Islands. In 2003, the Corporation also took on responsibility for waste water management.

energy efficiency improvements have been made, accompanied by aggressive actions to detect and report water distribution system leakages. The corporate environmental policy also provided for a program of energy audits for buildings utilised by the public service including government offices, schools and community centres.

The provision of social housing by the government also incorporates energy efficiency considerations particularly during the planning and building of new residential units. Similarly, energy conservation and inclusion of renewable energy technologies is an important element adopted by the Foundation for Tomorrow's Schools[35] in the design and construction of new schools across the country.

As an example of the adherence to the principle that all economic sectors should participate in a country's efforts to achieve its greenhouse gas goals, notwithstanding their respective contribution to total national emissions, one can mention funding specifically made available for investment in energy-related measures that form part of modernization of agricultural holdings and fishing vessels.

3.4.1.4 Energy-related cross-sectoral measures

Probably one of the most significant initiatives in respect of encouraging energy efficiency at end-user side is the installation of smart meters for electricity and water consumption monitoring. A project initiated in recent years by ARMS Ltd.[36] on behalf of Enemalta Corporation and Water Services Corporation should lead to the replacement of existing metering technology throughout the Maltese islands. Smart meters provide consumers with real-time information on their consumption, thus facilitating a change in energy consumption behaviour, while also providing scope for implementing demand management measures, such as flexible tariff systems, once the replacement project is concluded.

3.4.1.5 Transport

With road-transport being the second highest contributor to national total emissions of greenhouse gases, one should not be surprised that this activity continues to be a prime target for emission mitigation measures. This has to be taken in the context of Malta not having an indigenous car manufacturing or transport fuel production industry and that any regulatory actions taken at a supra-national level that increase fuel or emission efficiency of new vehicles do not necessarily have the immediate effect on the local vehicle fleet that one usually sees in larger countries.

One can identify a number of classes of measures related to road transport: switching to less emitting fuels or technologies; improving efficiency in transport; and, incentivizing modal shift and practices that reduce demand for transport.

The first years following the introduction of biofuels for road transport did not present the type of progress one would have envisaged, to the extent that between 2007 and 2009, biodiesel use fell from 1.75% to 0.68%. This instigated a rethink of biofuel policy for the transport sector, leading

[35] Foundation for Tomorrow's Schools was set up by the Maltese government in 2001 to manage the development, building, upgrading and refurbishment of state schools.

[36] Automated Revenue Management Services (ARMS) Ltd. is a joint venture between Enemalta Corporation and Water Services Corporation to manage electricity and water billing functions on behalf of the two enterprises. It is also responsible for implementation of Smart Metering Technology throughout the country.

Table 3-1 Summary of policies and measures related to energy generation and energy end-use.

Name Type of instrument	GHGs affected	Status	Estimation of GHG savings (Gg CO_2 equivalent) 2020	 2030
Plant loading, fuel switching and new, more efficient generating capacity				
Economic	CO_2, CH_4, N_2O	implemented	1152.01	1186.78
Conversion of existing and future generating plant to gas-fired, and installation of new generating capacity in 2020 and in 2025				
Economic	CO_2, CH_4, N_2O	planned	1527.19	1597.44
On-shore wind farms				
Planning	CO_2, CH_4, N_2O	planned	17.41	18.13
Off-shore wind farms				
Planning	CO_2, CH_4, N_2O	planned	98.77	102.91
Rebates on energy efficient domestic appliances				
Economic	CO_2, CH_4, N_2O	expired	1.09	1.14
Distribution of energy saving lamps				
Economic	CO_2, CH_4, N_2O	expired	18.62	19.40
Promotion of solar water heaters				
Economic	CO_2, CH_4, N_2O	implemented	8.32	8.68
Incentives for the uptake of PV systems				
Economic	CO_2, CH_4, N_2O	implemented	21.49	22.39
Grant on purchase of micro-wind turbines				
Economic	CO_2, CH_4, N_2O	adopted	0.07	0.07
Energy-related action in the public sector				
Information	CO_2, CH_4, N_2O	adopted	2.81	2.92
Energy saving measures in government corporations (Water Services Corporation)				
Planning	CO_2, CH_4, N_2O	adopted	19.17	19.98
Support scheme for energy efficiency investment in industry, SMEs and the commercial sector				
Economic	CO_2, CH_4, N_2O	adopted	12.55	13.08
Intelligent metering				
Regulatory	CO_2, CH_4, N_2O	implemented	11.41	11.89
Subsidy schemes for improvement of energy efficiency of buildings				
Economic	CO_2, CH_4, N_2O	implemented	0.46	0.47
PV parks				
Other	CO_2, CH_4, N_2O	planned	0.00	0.38

to the adoption of a 'substitution obligation' for all importers and, or, wholesalers of fuels used for transport purposes. A mandatory substitution target was established, in 2011 this being set at 1.5%, rising incrementally to 9.5% in 2019 and 10% in 2020.

The focus to-date has been on the blending of biodiesel with EN590 diesel. The introduction of bio-ethanol as a part substitute for petrol has on the other hand been subject to concerns due to the local climatic conditions potentially resulting in the combustion of bio-ethanol-containing petrol releasing other harmful chemical species. Blends that would satisfy the local needs can be considered (e.g. E85, a blend of 85% bioethanol and 15% petrol); however these could

impose difficulties where existing engines are not compatible with the fuel blend. Substantial infrastructural changes would also be required to handle such blends.

A relatively more recent development is the introduction of autogas. Apposite legislation has been published that establishes a regulatory framework for the retrofitting of car engines to take this new fuel, together with codes of practice providing guidance for the installation of autogas kits and the design of autogas service stations. Possibly the greatest challenge for the penetration of this fuel in local transportation is the change in the mind-set of local car owners to recognize the benefits that such a fuel represents.

Efforts towards shifting to alternative technologies have been aimed primarily at electric vehicles. A target of 5,000 such vehicles in the local vehicle fleet by 2020 has been set. These types of vehicles already benefit from reduced registration tax rates and have been further incentivized through government grant schemes. Actual projected greenhouse gas emission savings for electric vehicles have so far been estimated to be negative, that is, net increase in emissions may be expected; however, the contribution of electric vehicles is fundamental for Malta to reach its renewables target. To assess the potential for achieving carbon neutrality, tests are being carried out to demonstrate the use of photovoltaic installations to generate electricity for electric vehicles.

Several actions are being implemented or are under active consideration to reduce fuel consumption in road transport and thus reduce emissions, and to provide a more efficient, less congested and safer flow of traffic, with the resultant co-benefit of further reducing emissions. Thus, a recent reform of the vehicle registration tax system includes emission rates and the length of the vehicle as factors on the basis of which registration tax is calculated. A number of car scrappage schemes have been introduced. Certain towns and areas are subject to controlled vehicular access or benefit from the provision of park-and-ride systems, while a comprehensive integrated traffic management system covering all the country is also under consideration. Green travel plans and campaigns further emphasize such practices as car-pooling and efficient vehicle handling. And with the continued high dependence of workers on their private vehicles to travel to work, the promotion of e- and tele-working, especially in the public sector, may also offer further scope for reducing emissions of greenhouse gases through savings in overall fuel consumption.

Promoting modal shift towards means of mass public transport is an area where substantial effort continues. A major overhaul of the national bus system includes the replacement of the bus fleet with Euro V buses, an expansion of the route coverage and introduction of night services, in conjunction with improvements to the public transport infrastructure and emphasis on quality of service provided. Furthermore, improvements of the overall national road network continue to feature in government transport policy, taking also into consideration the need to provide for alternative modes of transport on local roads such as cycling, and the incentivization of means of transport that may offer viable alternatives, such as water taxis in the main harbours.

3.4.2 Industrial Processes and Other Product Use

Emissions of fluorinated greenhouse gases dominate this sector and as expected, the main focus for emission mitigation effort will be these gases. The measure that is expected to contribute to the highest extent to reduce emissions of such gases is the implementation of European Union Regulation (EC) No 842/2006[37] which has been transposed into local legislation, providing, among others, requirements for minimum qualifications for personnel who make use of such chemicals. Courses have been established in order to provide the necessary training.

[37] Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases; OJ L 161, 14.6.2006, pg 1.

Table 3-2 Summary of policies and measures related to transport.

Name Type of instrument	GHGs affected	Status	Estimation of GHG savings (Gg CO_2 equivalent) 2020	 2030
Introduction of autogas				
Fiscal	CO_2, CH_4, N_2O	implemented	0.95	0.95
Introduction of a biofuel substitution obligation				
Regulatory	CO_2, CH_4, N_2O	implemented	54.28	58.38
Uptake of electric cars				
Fiscal	CO_2, CH_4, N_2O	implemented	-1.56	-1.70
Promotion of e-working and tele-working				
Other	CO_2, CH_4, N_2O	implemented	0.66	0.66
Promotion of transport modal shift through public transport reform				
Regulatory	CO_2, CH_4, N_2O	implemented	39.89	43.21
Improving energy efficiency in road transport through vehicle scrappage and licencing reform				
Economic/regulatory	CO_2, CH_4, N_2O	implemented	0.11	0.11

Table 3-3 Summary of policies and measures related to industrial processes and product use.

Name Type of instrument	GHGs affected	Status	Estimation of GHG savings (Gg CO_2 equivalent) 2020	 2030
Implementation of F-gases Regulation				
Regulatory	HFCs, PFCs, SF_6	implemented	127.93	233.68

3.4.3 Agriculture

This sector accounts for a relatively small share of total national greenhouse gas emissions. Yet, scope for reducing the contribution of agriculture to national emissions still exists. The sector is subject to a number of measures that while aimed principally at addressing the manner by which agriculture is practiced locally, also provide opportunities for limiting emissions.

The Rural Development Programme (RDP) 2007-2013[38] outlines the strategic plan for the utilisation by the local agricultural sector of the financing opportunities provided by the EU's European Agricultural Fund for Rural Development[39] (EAFRD). The EAFRD's aim is to promote sustainable rural development through support targeted towards improving the competitiveness of agriculture and forestry sectors, improving the environment by supporting good land management practices and improving quality of life in rural areas. To this effect, the RDP includes measures (Measure 121 of the RDP in particular) aimed at supporting investments in environment-friendly technologies and practices in the local agricultural sector.

A complementary measure is the Nitrate Action Programme[40], pursuant to the EU Nitrates Directive[41]. The Nitrates Action Programme aims at controlling the polluting of water bodies, air

[38] *National Rural Development Strategy for the Programming Period 2007-2013*, Ministry for Resources and Rural Affairs, 2007.
[39] Council Regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development; OJ L 277, 21.10.2005, pg 1.
[40] *Nitrates Action Programme*, Ministry for Resources and Rural Affairs, 2011.

and soils by nitrates, through proper management of manure from livestock, and control of use of fertilisers. Manure management is now subject to stringent requirements, including the manner in which manure is handled and stored on farms, and disposed of. Furthermore, users of organic and inorganic fertilisers are required to register with the relevant implementing authority, ensuring that proper records and control are kept on the level of application of fertilisers and when such application takes place. The Programme also provides for training for farmers in the aspects covered by it.

3.4.4 Land Use, Land-use Change and Forestry

Population density coupled with limited availability of land area and local climatic conditions are not features conducive to a high coverage of land by forests. Therefore, human intervention is required to bolster the sink potential of the islands, principally through afforestation projects. Various areas in the Maltese islands have been earmarked for extensive tree planting projects, featuring principally indigenous tree and shrub species. It is estimated that between 2004 and 2011, around 107,000 trees and shrubs had been planted in Malta and a little more than 60,000 in Gozo.

Table 3-4 Summary of policies and measures related to agriculture.

Name			*Estimation of GHG savings (Gg CO_2 equivalent)*	
Type of instrument	*GHGs affected*	*Status*	*2020*	*2030*
Nitrates Action Programme				
Regulatory	CH_4, N_2O	implemented	32.63	30.76

Table 3-5 Summary of policies and measures related to land use, land-use change and forestry.

Name			*Estimation of GHG savings (Gg CO_2 equivalent)*	
Type of instrument	*GHGs affected*	*Status*	*2020*	*2030*
Afforestation projects				
Voluntary/education	CH_4, N_2O	implemented	7.48	8.31

3.4.5 Waste

The management of solid and liquid waste in a small country such as Malta is not an easy matter to deal with. The small share of this sector in national greenhouse gas emissions does not reflect the difficulties encountered in this sector when seen in terms of volume of waste generated and how this can be disposed of. Indeed, waste management has been subject to substantial policy and investment effort over the years, and looking into the future. This effort has the benefit of also contributing directly to reducing the impact of waste in respect of greenhouse gas emissions.

3.4.5.1 Solid waste management

For a long time, solid waste disposal was concentrated in open landfills. Magħtab (in Malta) and Qortin (in Gozo) landfills, despite now no longer being in use, continue to be sources of emissions as the waste accumulated on the two sites slowly decays. Since 2008, landfill gas

[41] Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources; OJ L 375, 31.12.1991, pg 1.

extraction with combustion of extracted methane has been ongoing in conjunction with rehabilitative works, such as re-contouring of the waste mass to improve stability and prepare the site for eventual alternative uses in the future.

The open landfills have now been replaced with better managed, engineered landfills, an interim one at Ta' Żwejra, and a larger landfill at Għallis, both of which are situated near the now-closed Magħtab landfill. In these new waste disposal facilities, the waste mass is capped and gases extracted for flaring or for generation of energy.

The running of new landfills is complemented by measures targeting the diversion of certain types of waste from landfill disposal. These measures include the mechanical and biological treatment of waste at the Sant' Antnin Waste Treatment Plant, which processes biological waste for the generation of biogas for use in a combined heat and power installation. To complement the Sant' Antnin plant, which is situated towards the south of the island of Malta, similar plants are also under active consideration for the northern region of Malta and for Gozo.

Another potential alternative to landfilling of solid waste is also under consideration, namely a waste-to-energy facility for streams of waste with a high calorific value and which thus provide significant potential for the generation of energy through their combustion. One must note however that such a plant in itself would at first represent a source of emissions rather than savings in emissions; however, in the longer term, the overall benefit would be of a net decrease in emissions.

3.4.5.2 Waste water treatment

Until recently, only a small fraction of waste water was treated prior to disposal to sea. However, infrastructural developments in recent years have seen the commissioning of three new Urban Waste Water Treatment Plants (UWWTPs) leading to hundred percent processing of locally generated sewage. Furthermore, the Malta South UWWTP, the largest of the three plants, will incorporate anaerobic sludge digestion technology and biogas production facility so that sludge generated from the processing of waste water can be treated prior to disposal, with biogas generated being used in a combined heat and power plant for generation of energy for use by the plant itself.

Table 3-6 Summary of policies and measures related to waste.

Name			*Estimation of GHG savings (Gg CO_2 equivalent)*	
Type of instrument	*GHGs affected*	*Status*	*2020*	*2030*
Aerial emissions management in closed and still-operational landfills				
Other	CH_4	implemented	33.99	39.65
Mechanism biological treatment of waste at Sant'Antnin				
Planning	CH_4	implemented	3.18	3.30
New mechanical biological treatment plants				
Other	CH_4	planned	15.62	15.86
Malta South UWWTP				
Planning	CO_2, CH_4, N_2O	implemented	3.60	3.74
Manure treatment at a cattle farm in Siggiewi				
Planning	CO_2, CH_4, N_2O	planned	1.14	1.18
Waste-to-energy facility				
Planning	CO_2, CH_4, N_2O	planned	-70.00	-68.47

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

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

3.4.6.1 The EU Emissions Trading Scheme

Malta's participation in the EU Emissions Trading Scheme remains limited to the two electricity generation plants operated by Enemalta Corporation and a number of aircraft operators. The focus of this discussion will be the power generation plants. The inclusion of local aircraft operators in the EU Emissions Trading Scheme covers only aviation emissions considered not to be part of 'national' greenhouse gas emissions.

The allocation of allowances to the two plants for Phases 1 and 2 of the scheme has been provided for by the 'National Allocation Plan for Malta 2005-2007'[42] and the 'National Allocation Plan for Malta 2008-2012'[43] respectively. Both plans provide for full free allocation to the two plants, with the former also providing for an amount of allowances in a reserve for new entrants, which reserve was never utilised and was subsequently cancelled.

Figure 3-3 provides an overview of the trend in total emissions of the two participating plants compared to the total allocation given to them in the allocation plans. The level of actual emissions has always been lower than the allocation, resulting in a substantial surplus of allowances. The surplus for the first period (2005-2007) was eventually cancelled, as envisaged under the allocation plan for that period. The allocation as approved by the European Commission for the second period (the original Phase 2 allocation profile submitted by Malta had to be reduced following the review of the draft plan by the Commission) was felt to be rather strict in the light of projections available at the time. In reality, efficiency (in terms of emissions of CO_2 per unit energy generated) did not change significantly over the period of years between 2008 and 2012; other factors, such as limited growth in demand due to the international economic crisis have however, to some extent, contributed to keeping actual emissions significantly lower that had originally been projected.

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

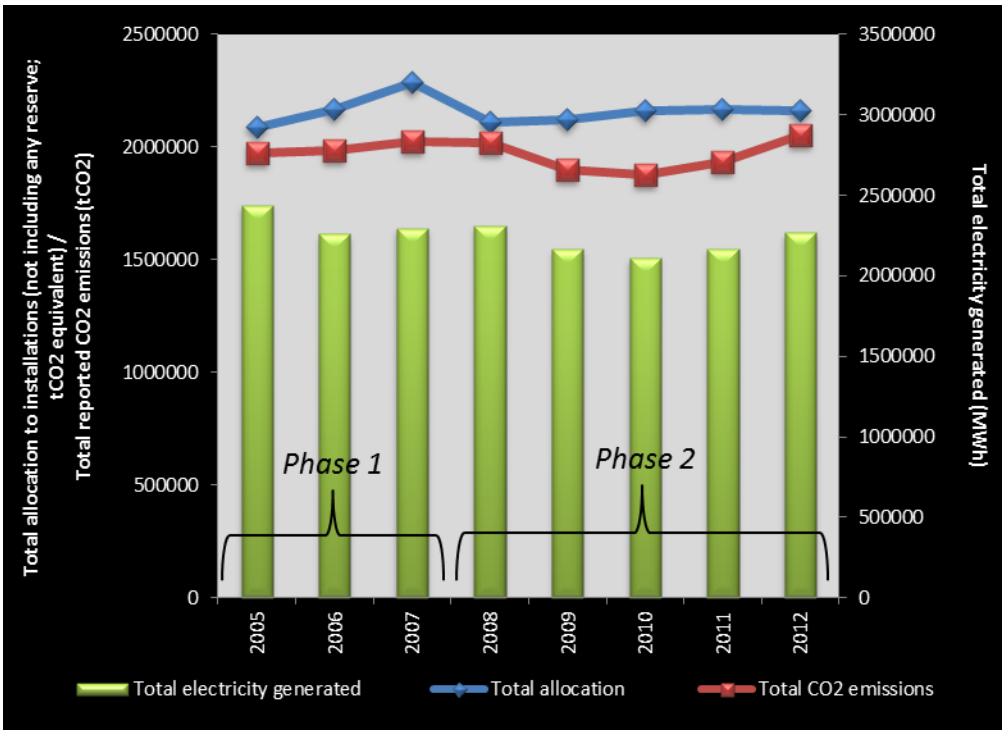


Figure 3-3 Comparison of annual total emissions for the two electricity generating plants falling within the scope of the EU ETS and the allocation provided for in the two National Allocation Plans of Malta (2005-2007; 2008-2012). Emissions represented here are verified emissions reported by Enemalta Corporation pursuant to EU Directive 2003/87/EC.

A crucial development of interest to the operator of the two installations under discussion here is the fact that as of 2013, the plants will no longer be eligible for any free allocation. Thus, once the surplus Phase 2 allowances remaining to the operator is exhausted (by surrendering for Phase 3 emissions or due to selling or voluntary cancellation), compliance requirements would need to be met by allowances acquired through auctions or purchased on the market, or, to the extent allowed by the Directive, by international credits. This represents a cost for every tonne of CO_2 emitted – it would thus be in the interest of Enemalta to try and keep emissions as low as possible. To what extent carbon prices may be a factor that influences investment in new plant and, or, new sources of electricity that bring about a reduction in overall emissions to be accounted for by Enemalta remains to be seen. However, for sure, the measures already discussed earlier in this chapter will surely contribute to lowering direct compliance costs under the EU ETS.

3.4.6.2 The use of Kyoto Protocol flexible mechanisms and international credits

Until the change in status to Annex I Party in 2010, Malta was eligible to make use of the Clean Development Mechanism (CDM), by hosting projects. As a non-Annex I Party, Malta could obviously not participate in Joint Implementation (JI) projects. No CDM projects were however initiated.

With the change in status being limited to Malta being inscribed as Annex I country, without however taking on any quantified emission limitation or reduction target, Malta also lost the opportunity to host or participate in JI projects and furthermore could not participate in CDM projects. This was due to the fact that having a quantified target is a requisite for eligibility to participate in CDM as a project sponsor or in JI as either a project host or sponsor.

With the inclusion of Malta as an Annex I Party with a quantified emission target for the second commitment period of the Kyoto Protocol, and subject to ratification of the Doha Amendments, the situation for Malta is expected to change, at least in terms of eligibility. It remains to be seen however whether Maltese participation in projects will actually come into fruition. So far, any emission reductions that have taken place or that are projected to occur in Malta under current scenarios have all been or will be due to domestic action and do not constitute offsetting of local emissions by emission reduction activities taking place in other countries. In respect of EU ETS compliance, Enemalta Corporation has utilised international credits as units surrendered to account for reported emissions. This however represents a substitution for the use of allowances already available to Enemalta rather than to make good for any shortfall in compliance needs.

4 PROJECTIONS AND THE TOTAL EFFECT OF POLICIES AND MEASURES

> "*All Parties [...] shall: Formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol [...]*"[44]

4.1 Introduction

The objective of this chapter is to provide an indication of future trends in emissions and removals of greenhouse gases for Malta, based on projections that take into account current national circumstances and the suite of mitigation policies and measures discussed in the previous chapter (policy state of play as at end of 2012). The discussion starts with an analysis of projections for specific sectors, the sectoral projections being then combined to provide a single cross-sectoral projection of emission trends up to 2030.

Two main policy scenarios are discussed. The 'with existing measures' scenario (WEM; also described as the 'with measures' (WM) scenario) takes into account currently implemented and adopted policies and measures. The 'with additional measures' (WAM) scenario adds the projected effect of planned policies and measures. In both cases, and for most of the sectors discussed, actual emission estimates for 2011 as presented in Chapter 2 of this Communication are used as the starting point for projecting emissions. For the sector Energy, the reference year is however taken to be 2010. Where relevant, a 'without measures' (also known as 'baseline' or reference') scenario is also presented: this scenario excludes all policies and measures implemented, adopted or planned after the year used as the starting point for emission projections.

4.2 Projections by sector

4.2.1 Energy

Underpinning the projection of emission trends for the energy sector is a modelling exercise undertaken by the Economic Policy Division of the Ministry of Finance. Two demand forecasting approaches were adopted: the first was to forecast demand for electricity differentiated between electricity consumption in households and in industry; the second, building on the first approach, was to project demand for fuel types for different energy categories. Variables taken into consideration in the modelling exercise include, among others, population, GDP (real and per capita), electricity prices, fuel prices and historic consumption of fuels. Forecasts generated by this process were initially used as a basis for preparing the National GHG Mitigation Strategy referred to in Chapter 3, and later used to produce the energy-related projections discussed in this chapter.

4.2.1.1 Fuel combustion in energy industries

Emission projections relating to energy industries are graphically represented in Figure 4-1. The 'with existing measures' and 'with additional measures' profiles take into account, besides the savings occurring directly at the energy generation source, additional savings from demand-side measures and renewable energy projects and schemes. These include emission savings due to energy generation by waste facilities and waste water treatment plants, emissions due to a waste-to-energy facility, emissions from charging electrical vehicles, and savings from energy efficiency measures which in general will meet or reduce part of the demand that would

[44] United Nations Framework Convention on Climate Change, Article 4 (1)(b).

otherwise have to be met by electricity generated at the power plants or imported from the European grid.

The estimation of emission savings from demand-side measures and measures related to renewable energy sources are calculated on the basis of emissions per unit MWh as estimated for each year, taking into account the contribution of both the local electricity generating plants and electricity imported via the interconnection with mainland Europe.

4.2.1.2 Road transport

Figure 4-2 compares projected future emissions from road transport taking into account existing measures (WEM scenario) against a 'without measures' scenario. For the purposes of this projection, no differentiation is made in respect of emission efficiency of different types of vehicles. It is assumed that autogas will partially substitute petrol, while biogenic emissions from biodiesel and the biogenic part of bio-ETBE are not included. Public transport modal shift is projected to increase from 1% shift in 2012 to 8% shift by 2019, while the projecting of emission savings due to the public transport reform does not differentiate between efficiencies of the old and new bus fleets; the change in fleet is expected to have a more marked impact on air quality rather than greenhouse gas emissions. With such a methodological approach, the fact that the new public transport system covers a total route distance greater than the coverage under the previous bus network, an increase in emissions has been projected for the public transport reform measure.

With regards to the measure related to the introduction of electric vehicles, the overall effect will depend very much on the nature of the source of electricity used. Assuming that electricity will be sourced from conventional local electricity generation plant, the effect of this measure is better described as a displacement of an amount of emissions from the transport sector to the electricity industries sector.

4.2.2 Industrial Processes and Other Product Use

In view of the limited nature of activities under the sectors Industrial processes and Solvent and Other Product Use, the main potential for emission savings is the implementation of the F-gases Regulation. A reliable estimation of the effect of this measure is not yet possible; however, the regulation is expected to influence greatly the manner and extent to which fluorinated gases are used in future, and thus, for the purposes of this discussion, it is assumed that emissions will eventually almost stabilise. Figure 4-3 shows projected emissions from industrial processes and product use for a 'without measures' and a 'with measures' scenario.

4.2.3 Agriculture

In agriculture, future greenhouse gas emission trends may be influenced both by measures taken to address directly emissions or measures that indirectly contribute towards decreasing emissions, and by inherent trends in activity in the sector. In animal husbandry for example, the restructuring of the sector to conform to animal welfare, food safety, veterinary and waste management requirements, particularly those arising from EU legislation, will lead directly to a decrease in emissions due to reduced activity or reduction in emissions from the realization of the requirements already mentioned. Land under cultivation is also decreasing and water scarcity could further compound this trend; this could have a beneficial effect in terms of greenhouse gas emissions.

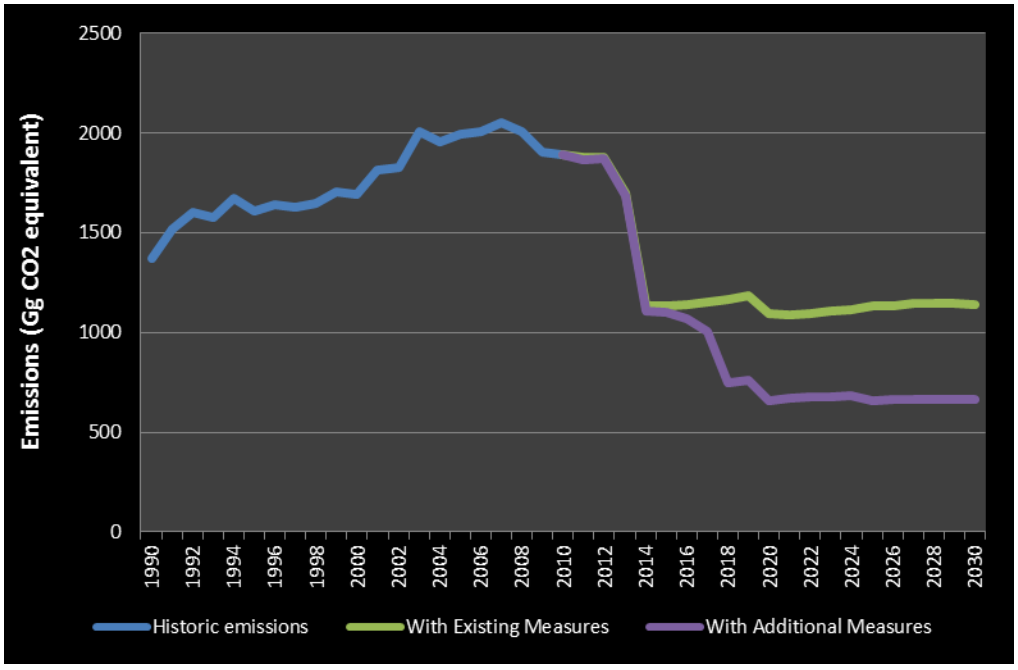


Figure 4-1 Projections of greenhouse gas emissions for electricity generation.

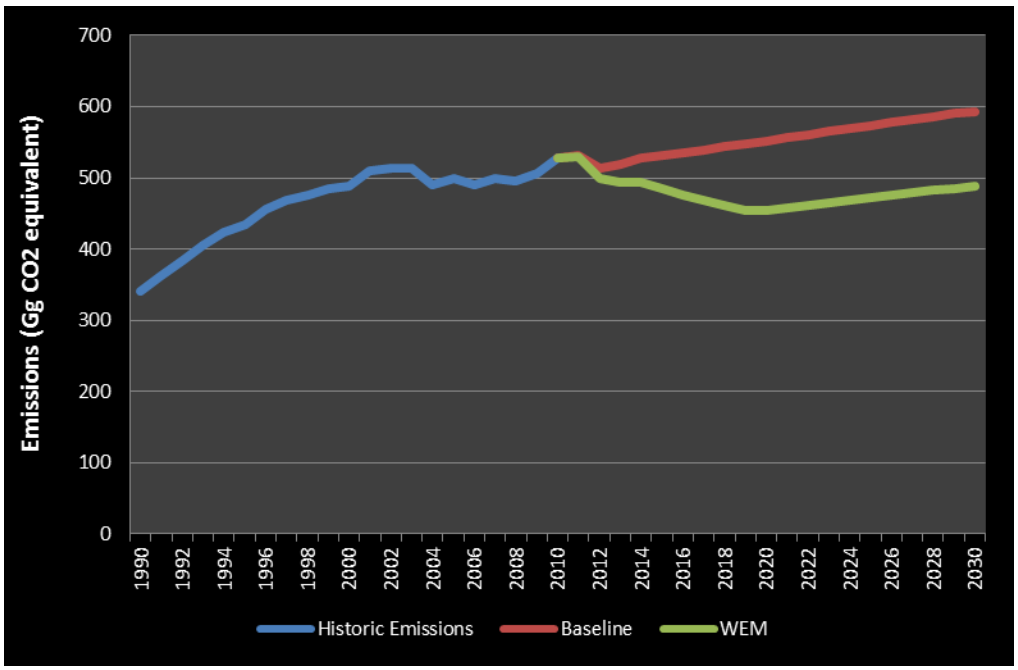


Figure 4-2 Projections of greenhouse gas emissions for road transport.

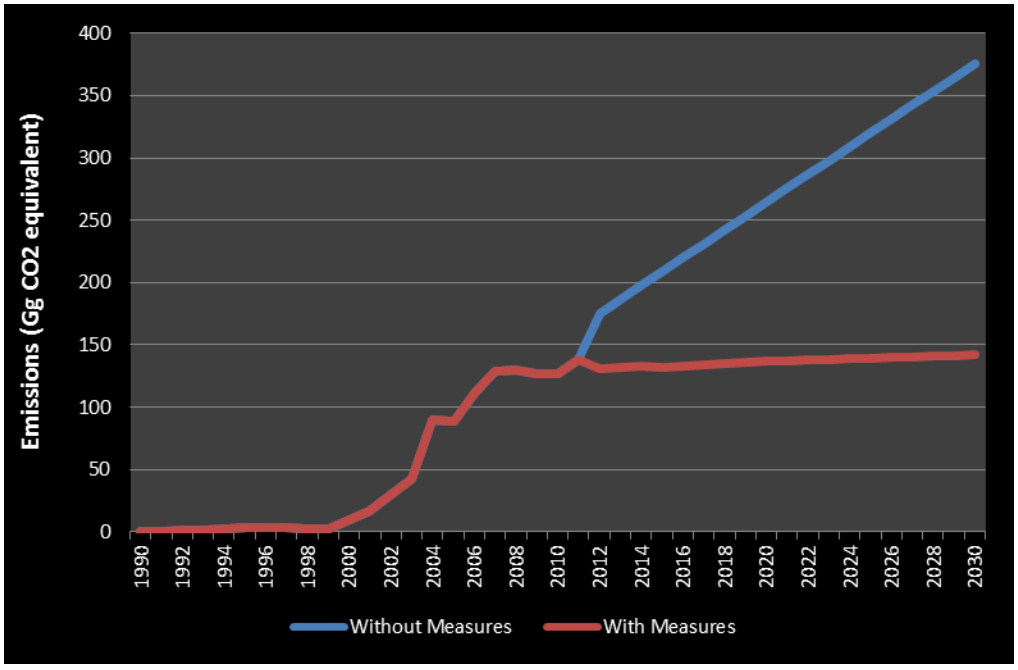


Figure 4-3 Projections of greenhouse gas emissions for industrial processes and product use.

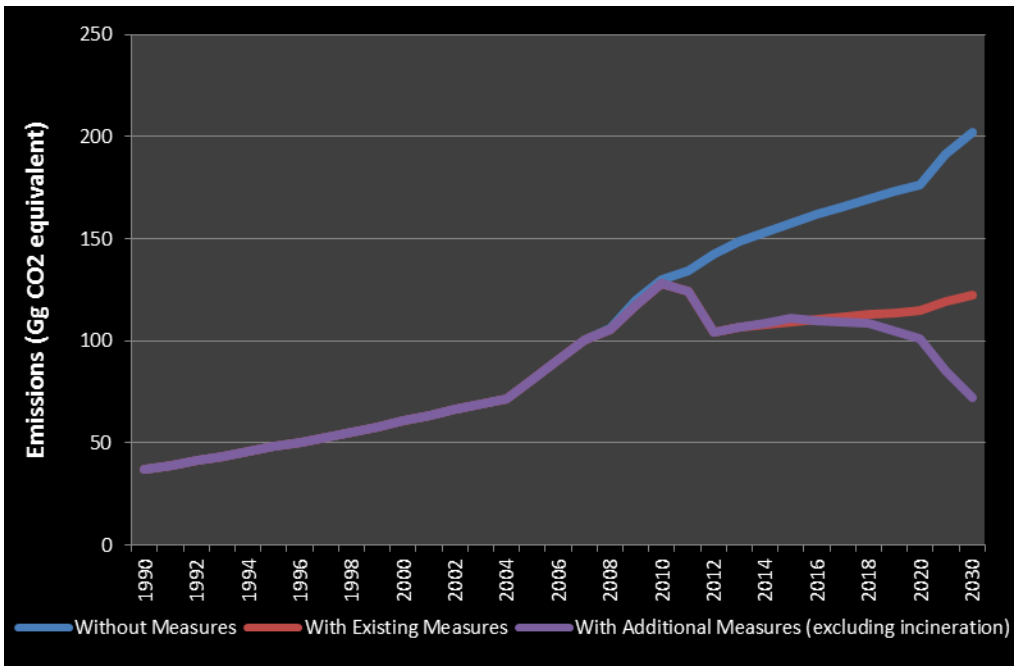


Figure 4-4 Projections of greenhouse gas emissions for waste.

4.2.4 Land Use, Land-use Change and Forestry

The growth in the level of sequestration of carbon by trees is not expected to be major. While a small increase in the net removal effect has been estimated for the period from 2012 to 2020, as a result of an assumed continuation of planting of new trees and shrubs at the rate of 10,000 per year, for the purposes of projecting emissions savings, further tree planting after 2020 is assumed to stop.

4.2.5 Waste

The approach to projecting future trends for emissions (see Figure 4-4) from the waste sector is based on the same methodology used for the estimation of historic sector emissions for the national greenhouse gas inventory, whilst incorporating a number of assumptions, including that current trends in generation of municipal solid waste per capita and industrial waste per unit GDP remain applicable for the projection time-series, that the composition of municipal solid waste remains the constant, that future landfilling facilities are managed to current standards and that methane generated from biological treatment of waste is flared with all emissions resulting from this being considered as biogenic.

4.3 Assessment of aggregate effects of policies and measures

Table 4-1 presents emission projections split by sector and by gas for the years 2015, 2020, 2025 and 2030, for the 'with existing measures scenario. Projected emission trends differentiated by sector and by gas are then shown pictorially in Figure 4-5 and Figure 4-6 respectively.

The aggregated effect of the policies and measures discussed is described in Figure 4-7. The significant impact that measures implemented and adopted in the energy generation sector have on total projected national emissions is clearly reflected in the drop in projected emissions between 2011 and 2015. This shift downwards in emission could be made even more substantial if a conversion of generating capacity to gas had to also be brought into effect, though this if not yet reflected in these projections.

Table 4-1 Emission projections (in Gg CO_2 equivalent) split by sector and by gas and total aggregated emissions projected for 2015, 2020, 2025 and 2030, for the 'with existing measures' scenario.

		2015	2020	2025	2030
Power generation	CO_2	1128.71	1093.12	1126.69	1138.95
	CH_4	0.93	0.90	0.93	0.94
	N_2O	2.75	2.65	2.74	2.77
		1132.38	1096.66	1130.36	1142.65
Transport	CO_2	474.24	444.43	461.90	477.70
	CH_4	2.61	2.50	2.53	2.58
	N_2O	7.55	7.33	7.58	7.82
		484.39	454.27	472.02	488.10
Other energy	CO_2	260.46	292.03	316.33	333.71
	CH_4	0.65	0.71	0.75	0.78
	N_2O	0.55	0.62	0.68	0.72
		261.66	293.36	317.77	335.21
Industrial Processes	CO_2	0.27	0.27	0.27	0.274253
	CH_4	0.00	0.00	0.00	0.00
	N_2O	0.00	0.00	0.00	0.00
	F-gases	129.07	133.23	136.25	138.6264
		129.34	133.50	136.53	138.90
Agriculture	CH_4	50.57	62.01	61.59	61.18
	N_2O	20.34	23.87	23.18	22.52
		70.91	85.87	84.78	83.71
Waste	CO_2	0.70	0.70	0.70	0.70
	CH_4	94.97	100.45	104.6578	107.87
	N_2O	13.75	13.84	13.91	13.87
		109.42	114.99	119.27	122.45
LULUCF	CO_2	-61.46	-63.53	-63.94	-63.94
TOTAL EMISSIONS BY GAS	CO_2	1802.92	1767.03	1841.96	1887.39
	CH_4	149.73	166.56	170.46	173.36
	N_2O	44.94	48.31	48.10	47.71
	F-gases	129.07	133.23	136.25	138.63
TOTAL EMISSIONS		2126.654	2115.133	2196.778	2247.088

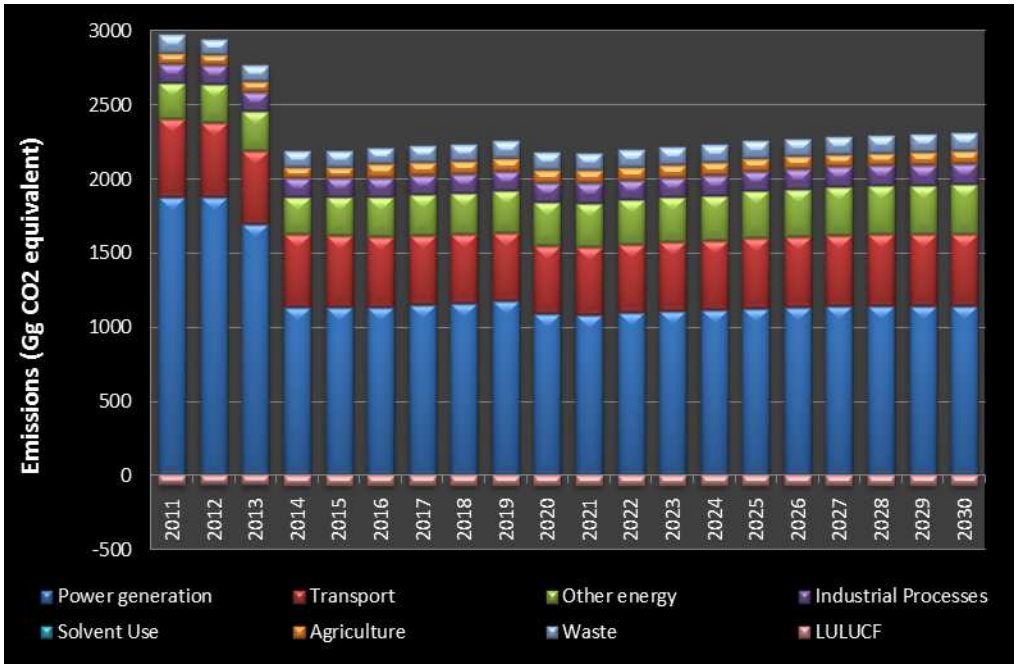


Figure 4-5 Projections (WEM) of total emissions differentiated by sector.

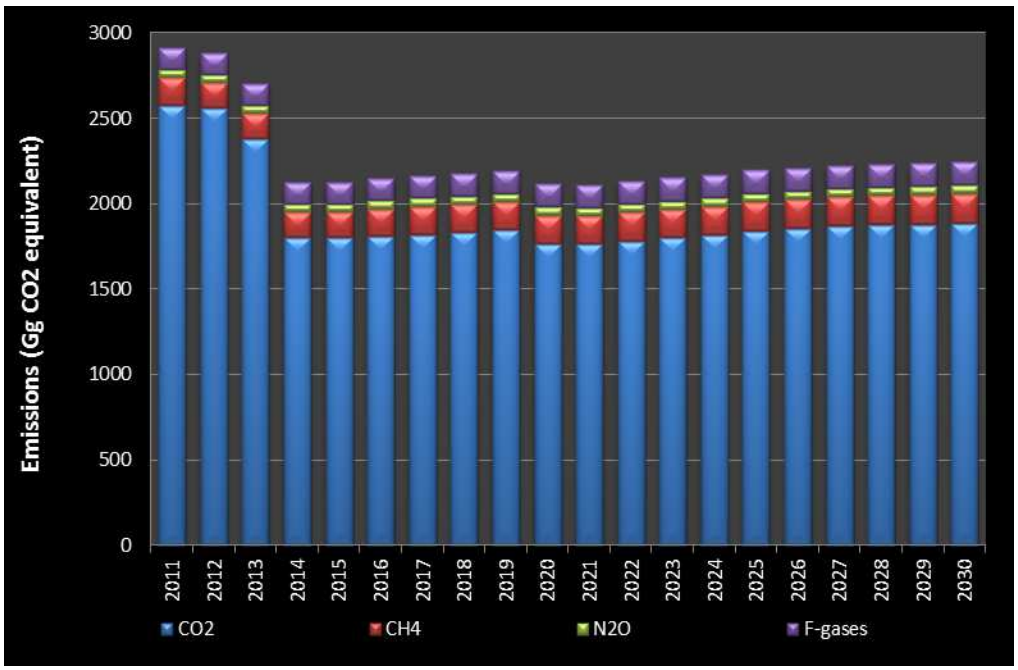


Figure 4-6 Projections (WEM) of total emissions differentiated by gas.

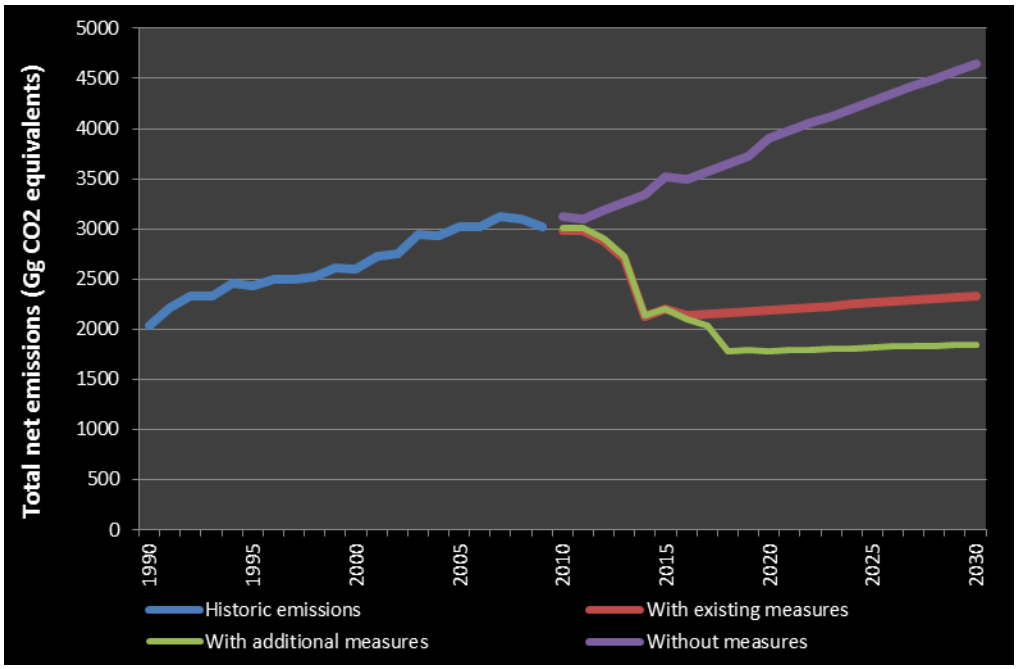


Figure 4-7 Projections of the aggregated effect of policies and measures.

4.4 Meeting greenhouse gas emission commitments

It will be interesting at this juncture to look at how projected emissions correlate with emission targets that Malta has under the Effort-Sharing Decision. As already indicated earlier, this decision sets a target for Malta limiting emissions to a level not higher that 5% over 2005 levels, by 2020. Furthermore, the decision establishes a trajectory of interim targets for the years up to 2020, in accordance with the rule that "*each Member State with a positive limit under Annex II* [to the Effort-Sharing Decision] *shall ensure* [...] *that its greenhouse gas emissions in 2013 do not exceed a level defined by a linear trajectory, starting in 2009 on its average annual greenhouse gas emissions during 2008, 2009 and 2010,* [...] *ending in 2020 on the limit for that Member State as specified in Annex II*".

Figure 4-8 shows how the total of the emissions covered by the Effort-Sharing Decision compares to the trajectory of targets under the decision. Emissions not covered by this decision include CO_2 emissions from the electricity generation plants that fall within the scope of the EU Emissions Trading Scheme and emissions from domestic civil aviation. Emissions and removals from LULUCF activities are also not covered by the Effort-Sharing Decision, as is also the case for emissions due to international bunkering - maritime and aviation - activities.

As Figure 4-8 indicates, Malta is expected to be in a position to meet both the 2020 target and the interim targets for 2013-2019. The compliance situation however is dependent on a number of factors that highlight the particular situation that small countries such as Malta have to deal with when considering emission mitigation policies and measures. For example, the expectation that Malta will meet its commitments under the Effort-Sharing Decision is subject to emissions from a waste-to-energy facility falling under the scope of the EU Emissions Trading Scheme Directive (therefore not subject to the emissions limitation under the Effort-Sharing Decision). If however it is established that such a facility had to fall within the scope of the Effort-Sharing Decision instead, the anticipated level of emissions from this facility added to currently projected emission levels could lead to Malta exceeding the emission limitations under the Effort-Sharing Decision. This shows how, in a small country, one single emission source can have a relatively

more significant impact on the country's emissions, and on its meeting quantified obligations than would be the case in a much larger country.

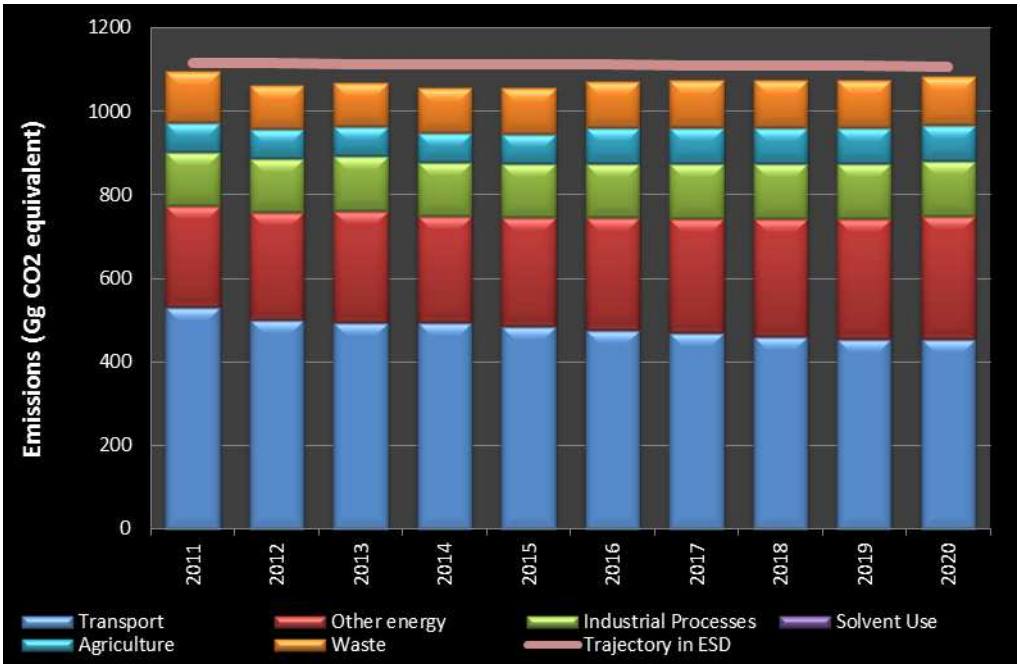


Figure 4-8 Emissions covered by the Effort-Sharing Decision (ESD) in relation to the linear trajectory to the 2020 target indicated for Malta by the same decision.

The effect of public transport reform discussed in Chapter 3 and taken into consideration in the projections discussed in this chapter is based on a projected modal shift from private vehicle use to public transport use of 8%. A higher modal shift, say 22%, would result in a substantial further increase in future greenhouse gas emission savings from transport. However, the rate of modal shift depends very much on the choices made by the individual citizens and visitors to the country as to which means of transportation they want to utilise, and thus on the willingness of the general public, or the extent to which the public is incentivized, to shift to modes of transport other than private vehicle use. Compared to private vehicles, alternative modes of transport have to offer a substantial improvement in mobility in terms of efficiency and time spent travelling, and have to be significantly more attractive from a cost perspective.

5 VULNERABILITY ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

> "*All Parties [...] shall: Formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures [...] to facilitate adequate adaptation to climate change*"[45]

5.1 Introduction

Climate change will impact on all facets of life. The study of the impacts of climate change starts first and foremost in identifying changes that are occurring and modelling the potential for further changes in the future. The results obtained from such work coupled with assessment of vulnerability provide the basis for informed decisions at all levels and across all sectors on ways and means for reducing the vulnerability of, and adapting the country, its citizens and economic sectors to the impacts of climate change.

This chapter discusses work currently ongoing in the field of forecasting climate change and its impacts, provides an assessment of vulnerability from the perspective of a number of important elements of Maltese life and describes actions being taken to adapt to the consequences of climate change.

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

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

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

[45] United Nations Framework Convention on Climate Change, Article 4 (1)(b).

A summary of observed and projected changes in climatic conditions are provided in Table 5-1.

Table 5-1 Observed and projected changes in climatic conditions. (EEA, 2012)

Climate Variable	Observed Change	Projected Change without mitigation
Temperature	Global: three independent long records of global average (land and ocean) annual temperature show that the decade between 2002 and 2011 was 0.77 °C to 0.80 °C warmer than the pre-industrial average. The Arctic has warmed significantly more than the globe as a whole. Europe: The average temperature for the European land area for the last decade (2002–2011) is 1.3 °C above the pre-industrial level, which makes it the warmest decade on record. Heat waves have increased in frequency and length.	Global: the further rise in global average temperature is projected to be between 1.1–6.4 °C by 2100 taking climate model uncertainties into account. Land temperature in Europe is projected to increase between 2.5 °C and 4.0 °C by 2071–2100. The largest temperature increases during the 21st century are projected over eastern and northern Europe in winter and over southern Europe in summer. Heat waves are projected to become more frequent and last longer across Europe over the 21st century.
Precipitation	Precipitation changes across Europe show more spatial and temporal variability than temperature. Since the mid-20th century, annual precipitation has been generally increasing across most of northern Europe, most notably in winter, but decreasing in parts of southern Europe. In Western Europe intense precipitation events have significantly contributed to the increase. There are no widespread significant trends in the number of either consecutive dry or wet days across Europe.	Most climate model projections show continued precipitation increases in northern Europe (most notably during winter) and decreases in southern Europe (most notably during summer). The number of days with high precipitation is projected to increase.
Sea Level	Tide gauges show a global mean sea-level rise of around 1.7 mm/year over the 20th century. Satellite measurements show a rise of around 3 mm/year over the last two decades. Sea level is not rising uniformly at all locations, with some locations experiencing much greater than average rise. Coastal impacts also depend on the vertical movement of the land, which can either add to or subtract from climate-induced sea-level change, depending on the location.	Projections of global mean sea-level rise in the 21st century range between 20 cm and about 2 m by the end of the century. Modelling uncertainty contributes at least as much to the overall uncertainty as uncertainty about future greenhouse gas emission scenarios. It is likely that 21st century sea-level rise will be greater than during the 20th century. Current projections suggest that it is more likely to be less than 1 m than to be more than 1 m.

5.2 Expected impacts of climate change

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

For the Second National Communication of Malta, the modelling system MAGICC/SCENGEN (version 5.3) was used to come up with projections for surface temperature and precipitation for the Central Mediterranean region, extending in time over the next one-hundred years. The conclusions drawn from these projections are reproduced in Table 5-2 (MRRA, 2010).

Table 5-2 The main model results generated using MAGICC/SCENGEN version 5.3 applicable to the region of the Maltese Islands for the years 2025, 2050, 2075 and 2100. Note that the scenario year is the central year for a climate averaging interval of 30 years.

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

Projections of variability in temperature, precipitation and mean sea level pressure were not very reliable and the conclusions drawn from those model results had to be interpreted with caution. In addition, using the MAGICC/SCENGEN it was not possible to estimate sea level change for the Central Mediterranean and the information provided was from published scientific peer-reviewed literature.

It was noted that there is the possibility of a shift and prolonging of the summer season and a shifting of precipitation events to shorter time windows with other time periods becoming drier. The conclusions reached in the Second National Communication seem to be realistic and probable as borne out by the modelling outputs presented in this document (see Table 4); nevertheless it is also recognized that a more reliable modelling system and a more thorough analysis are required.

Table 5-2 gives the main model results for the region of the Maltese Islands for the years 2025, 2050, 2075 and 2100. These are based on the no-climate-policy emission scenario A1T-MES and were generated using the 14 selected atmosphere-ocean general circulation models. Their use in vulnerability and adaptation studies for the Maltese Islands was recommended although the main problem with the results is associated with the horizontal resolution.

The Second Communication was also suggested that a sensible solution to the abovementioned problem is to employ a numerical atmosphere-ocean general circulation model for the Central Mediterranean region. This requires a dedicated and a fast computing facility, and additional capacity building to set up and run such models. In this regard, research in regional climate modelling and analyses that focus specifically on the Central Mediterranean were identified to be sorely needed.

In the Second National Communication it was argued that further downscaling of MAGICC/SCENGEN scenarios to a finer scale do exist but are not advisable since the remaining area of the grid cell containing the Maltese Islands is mostly covered by sea.

Since 2011, the Department of Physics at the University of Malta secured financial assistance through the European Regional Development Funds (ERDF-80) to set up and run a substantial

computer cluster on which a numerical weather prediction model and a regional climate modelling suite could be installed. Staff are being trained to run and modify these models to make them applicable to the challenging Central Mediterranean region.

The results presented in this communication are a follow-up of the Second National Communication, where a higher resolution regional climate model has been used to provide future projections. The spatial horizontal resolution of the regional climate model used was 20 km × 20 km, which is a high and suitable resolution for impact assessments, vulnerability and adaptation studies since the Maltese Islands cover a total of 11 cells within a 100 × 100 cell domain area. Some modelling challenges associated with the Central Mediterranean area are still unresolved. RegCM4 is an atmosphere only model and thus cannot be used to give sea-level rise projections.

Table 5-3 provides a summary of the findings from projections of near-surface air temperature using the regional climate model RegCM4 as compared to the global model data (HadGEM2), extracted for Malta [14.5 °N, 35.9 °E], for the emission scenarios: Representative Concentration Pathway (RCP) 2.6, 4.5 and 8.5. Data from Table 5-3 seems to support what was indicated in the Second National Communication that the increase in temperature will continue at different rates according to the emission scenario route during the 21st century.

Table 5-3 Global model (HadGEM2) and regional model (RegCM4) increase in near-surface temperature data extracted for the Maltese Islands for the years 2025, 2050, 2075 and 2099 for emission scenarios RCP 2.6, 4.5 and 8.5 with respect to 2005. (Driving data for Year 2100 was not available for RegCM4).

	2025	2050	2075	2099	Scenario	Comments
Increase in Temperature (°C)	1.2	1.6	1.1	1.5	RCP 2.6	HadGEM2
	No data					RegCM4
	0.7	0.7	2.3	2.3	RCP 4.5	HadGEM2
	0.8	1.0	2.7	2.9		RegCM4
	0.8	1.6	3.6	4.0	RCP 8.5	HadGEM2
	0.9	1.8	3.9	5.0		RegCM4

Table 5-4 outlines the percentage change in precipitation from the global model data (HadGEM2), extracted for Malta [14.5 °N, 35.9 °E], for the emission scenarios RCP 2.6, 4.5 and 8.5. No regional model data was presented as the changes are not realistic for a single point in the domain representing the Maltese Islands, possibly due to the fact that the RegCM4 configuration is not yet optimised to model precipitation adequately for the Central Mediterranean area.

Table 5-4 Global model (HadGEM2) change in precipitation (%) extracted for the Maltese Islands for the years 2025, 2050, 2075 and 2099 for emission scenarios RCP 2.6, 4.5 and 8.5 with respect to 2005.

	2025	2050	2075	2099	Scenario
Change in Precipitation (%)	0.6	0.4	0.8	0.0	RCP 2.6
	0.5	1.1	0.2	0.4	RCP 4.5
	0.8	0.8	0.3	0.2	RCP 8.5

With reference to the Thematic Focus Elements TFE.1 – Water Cycle Change of the Fifth Assessment Report (Stocker, et al., 2013) the changes in precipitation are harder to measure with the existing records, namely because it is difficult to sample precipitation and secondly because

it is expected that precipitation will have a smaller fractional change than the water vapour content of air as the climate warms. It appears that some regional precipitation trends are robust, but when virtually all the land is filled using a reconstruction method the resulting time series of global mean land precipitation shows little change since 1900. At present there is *medium confidence* that there has been a significant human influence on changes in precipitation patterns on a global scale, including increases in Northern Hemisphere mid-to-high latitudes.

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

For the Representative Concentration Pathway RCP8.5, drought is relatively uncertain but in the case of the Mediterranean, drying in this region with global temperatures increase is *likely* for several degrees of warming. As indicated in Figure 5-1, the change in precipitation around the Maltese Islands is set to either remain the same or decrease towards the end of the 21st century (Figure 5-4). Table 5-4, for the same RCP 8.5, indicates a fractional increase in precipitation as opposed to what was concluded in the Second National Communication (Table 5-2). This highlights the uncertainty in global model data at such a small scale.

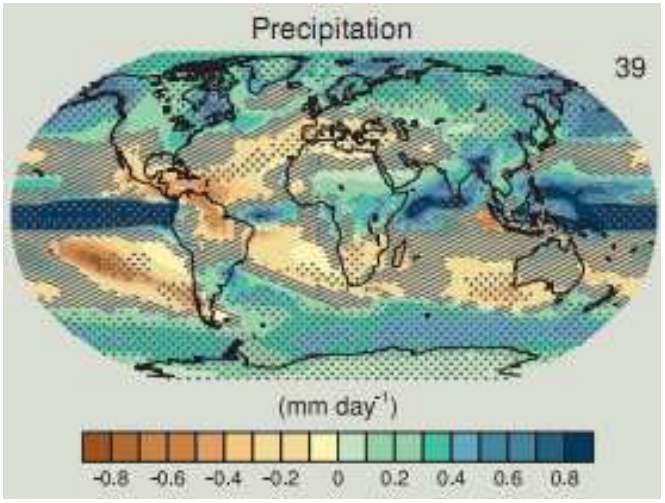


Figure 5-1 Annual mean changes in precipitation for 2081-2100 relative to 1986-2005 under RCP8.5 [Adapted from Stocker *et al*., 2013, TFE.1 Figure 3].

5.2.2 Analysis of data with focus on the Maltese Islands

The analysis that follows is based on data obtained from the CMIP5 HadGEM2-ES simulation. Figure 5-2 illustrates the global mean temperature based on moving averages of monthly means. This plot shows an increasing trend from about 14.5 °C in 2005 up to the mid-century where it reaches about 16 °C, for all scenarios. For the RCP 8.5 the increase in trend will continue till the end of the century. For the second part of the 21st century, with RCP 4.5 the temperature would stabilize at almost 16.5 °C whilst with RCP 2.6 a stabilisation at about 15.5 °C is being projected.

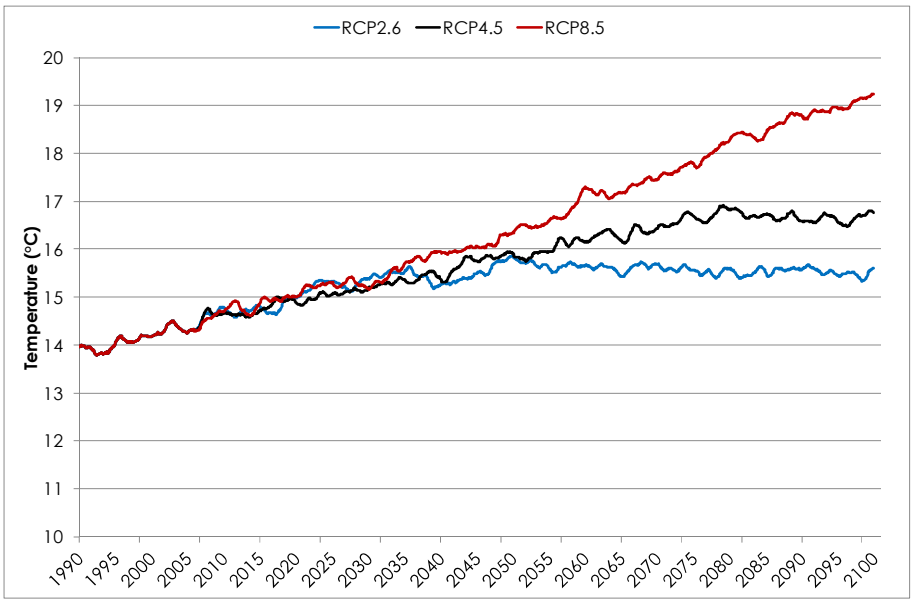


Figure 5-2 Global mean near-surface air temperature for emission scenarios RCP 2.6, 4.5 and 8.5.

Figure 5-3 and Figure 5-4 show projections constructed for Malta [14.5 °N, 35.9 °E], using moving averages of monthly mean values of the Met Office Hadley Centre (additional realizations contributed by the Instituto Nacional de Pesquisas Espaciais) HadGEM2-ES model data obtained from the CMIP5 data archives[46]. The same dataset was used as driving data for the regional climate model.

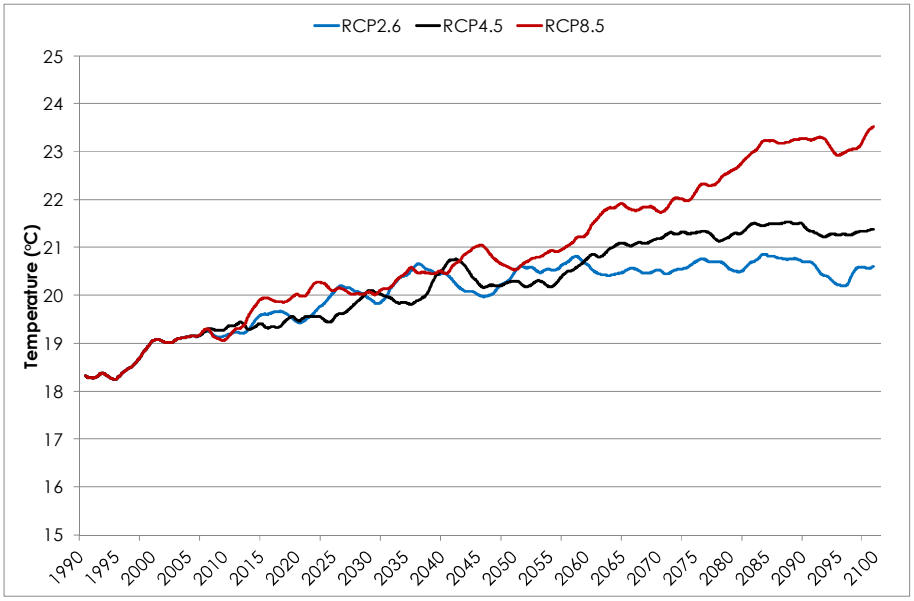


Figure 5-3 Near-surface temperature projections for the Maltese Islands (1990-2100) based on emission scenarios RCP 2.6, 4.5 and 8.5.

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

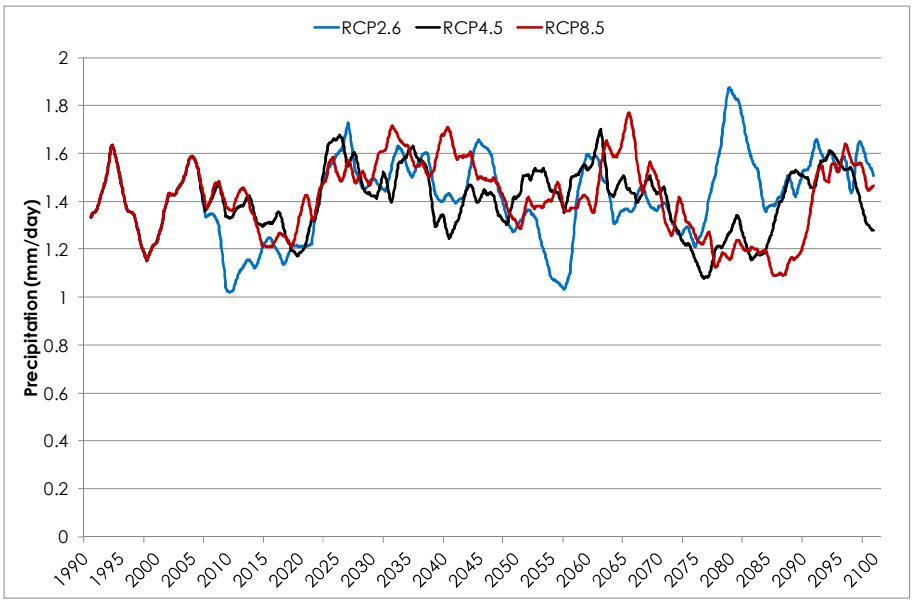


Figure 5-4 Projections of precipitation over the Maltese Islands (1990-2100) based on emission scenarios RCP 2.6, 4.5 and 8.5.

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

Projections of precipitation in mm/day in Figure 5-4 show no significant deviation between the three scenarios for the Maltese Islands. It is not clear why there are outstanding different peaks for RCP 2.6 scenario as compared to the RCP4.5 and RCP 8.5 scenarios at around 2056 and around 2080, nevertheless the outcome appears to be similar to the projections in Figure 5-1.

The change in average temperature based on the annual and seasonal means is shown in Figure 5-5, Figure 5-6 and Figure 5-7 and monthly means are projected in Figure 5-8, Figure 5-9 and Figure 5-10 for the years 2025, 2050, 2075 and 2099 compared to the average for the year 2005 (which is the baseline year for the CMIP5 HadGEM2-ES simulation) for different emission scenarios.

Figure 5-11, Figure 5-12, Figure 5-13, Figure 5-14, Figure 5-15 and Figure 5-16 show the average percentage change in precipitation on annual, seasonal and monthly averages for the years 2025, 2050, 2075 and 2099 compared to the same averages for the year 2005 (which is the baseline year for the CMIP5 HadGEM2-ES simulation).

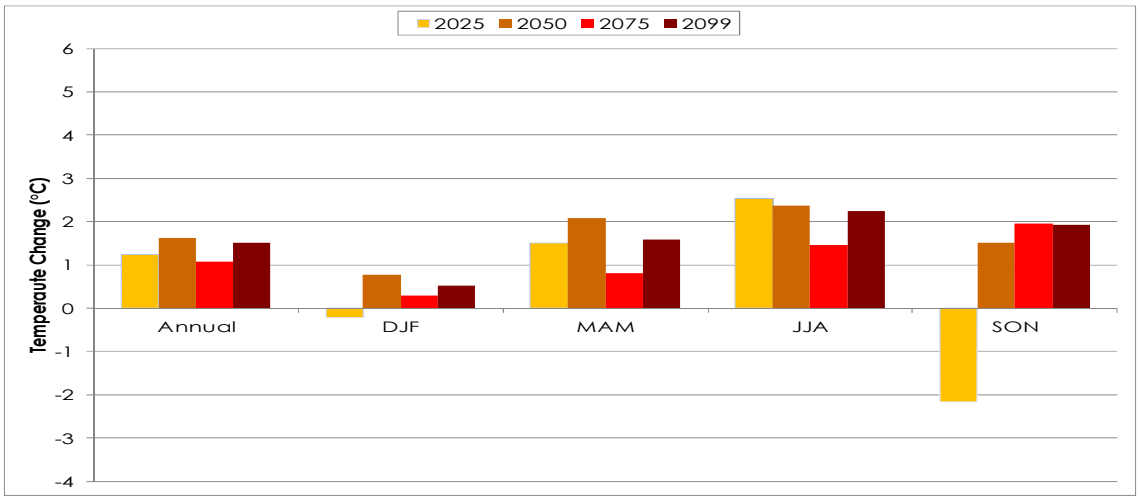


Figure 5-5 HadGEM2-ES annual and seasonal change in near-surface average air temperature for emission scenario RCP 2.6.

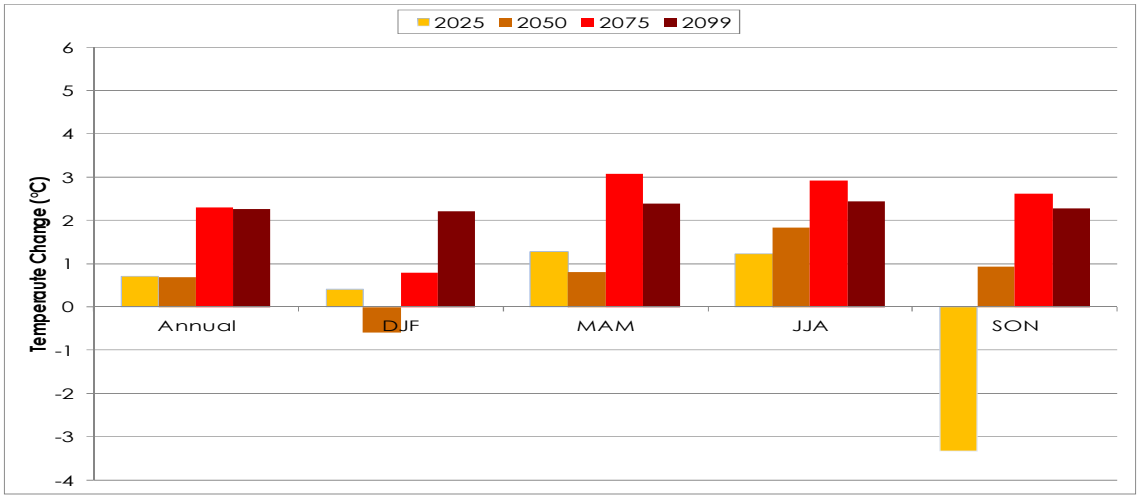


Figure 5-6 HadGEM2-ES annual and seasonal change in near-surface average air temperature for emission scenario RCP 4.5.

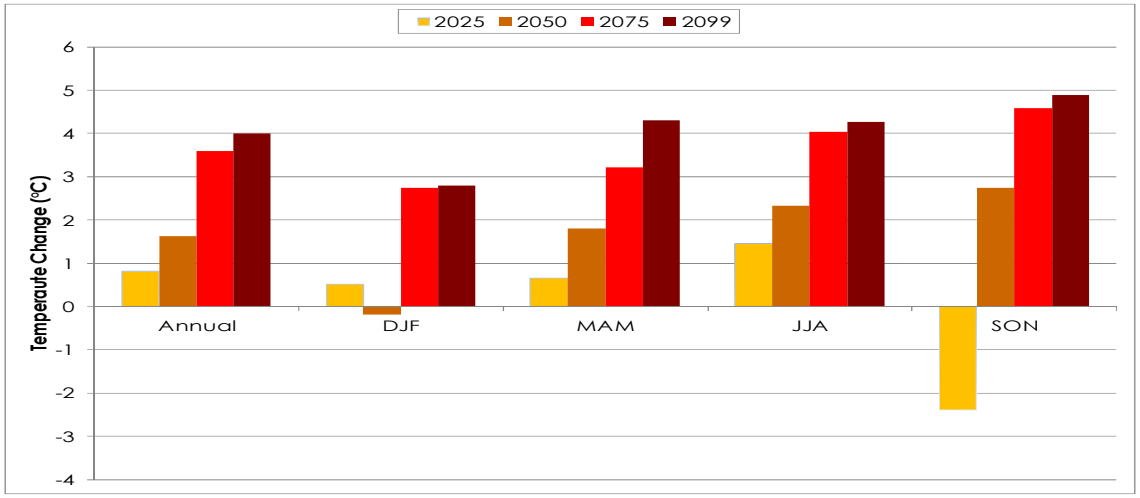


Figure 5-7 HadGEM2-ES annual and seasonal change in near-surface average air temperature for emission scenario RCP 8.5.

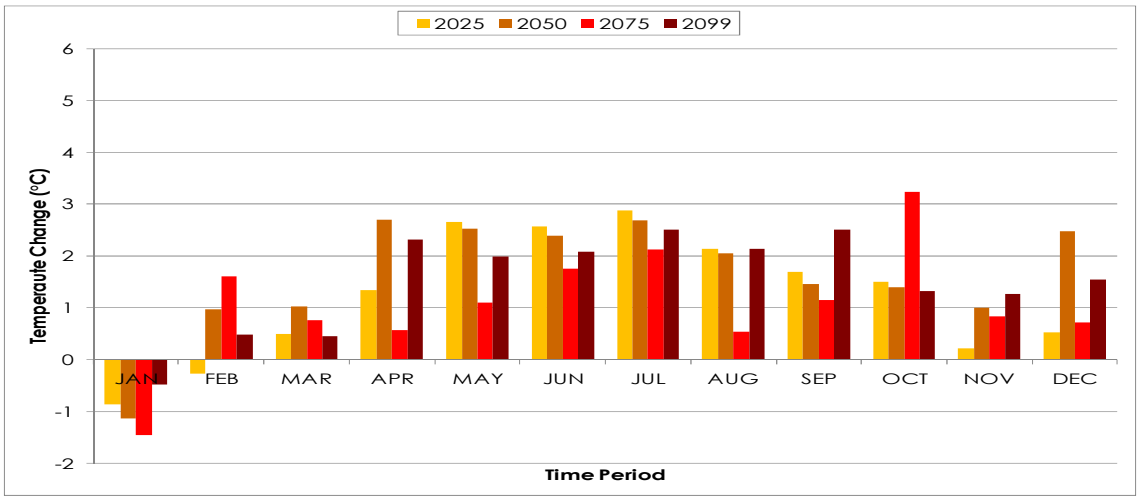


Figure 5-8 HadGEM2-ES change in near-surface monthly average air temperature for emission scenario RCP 2.6.

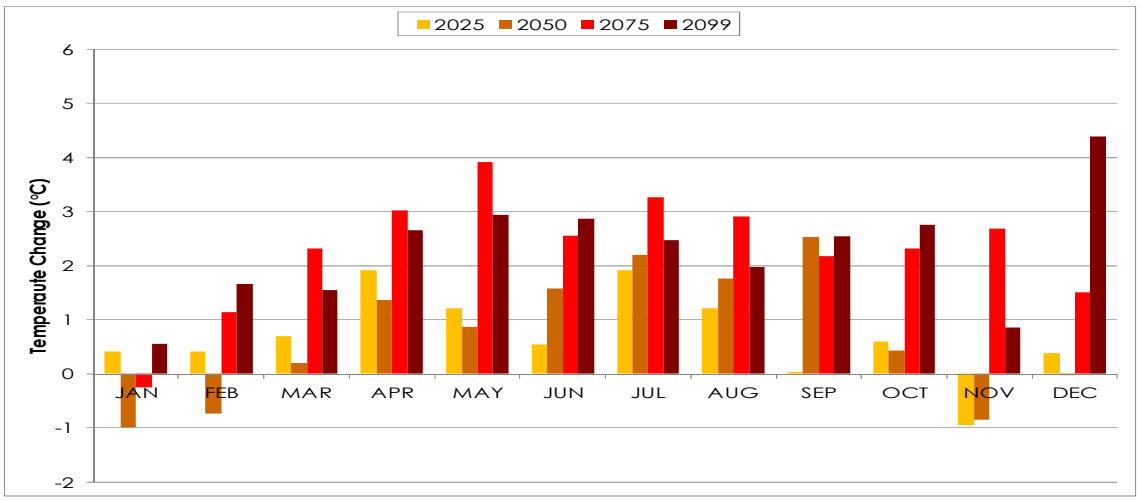


Figure 5-9 HadGEM2-ES change in near-surface monthly average air temperature for emission scenario RCP 4.5.

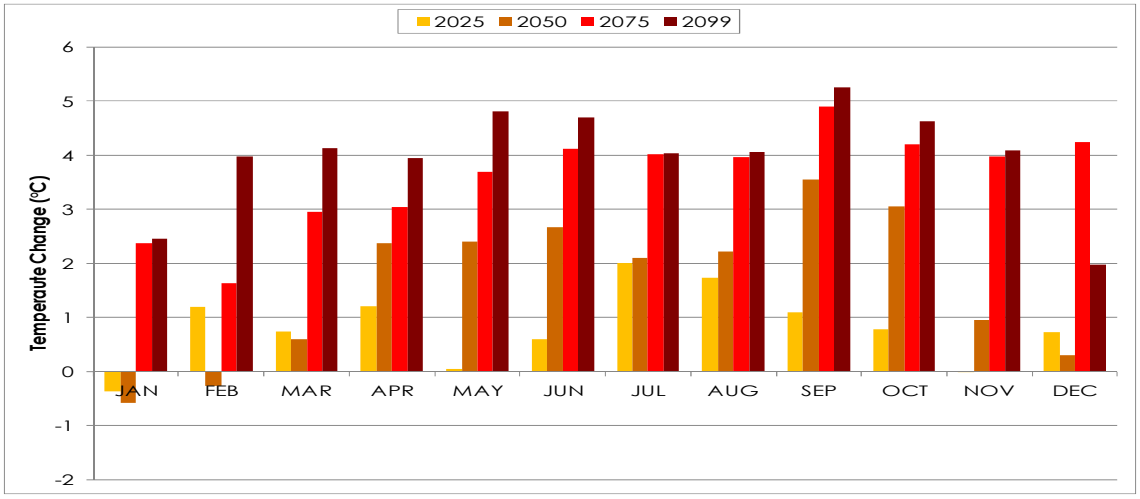


Figure 5-10 HadGEM2-ES change in near-surface monthly average air temperature for emission scenario RCP 8.5.

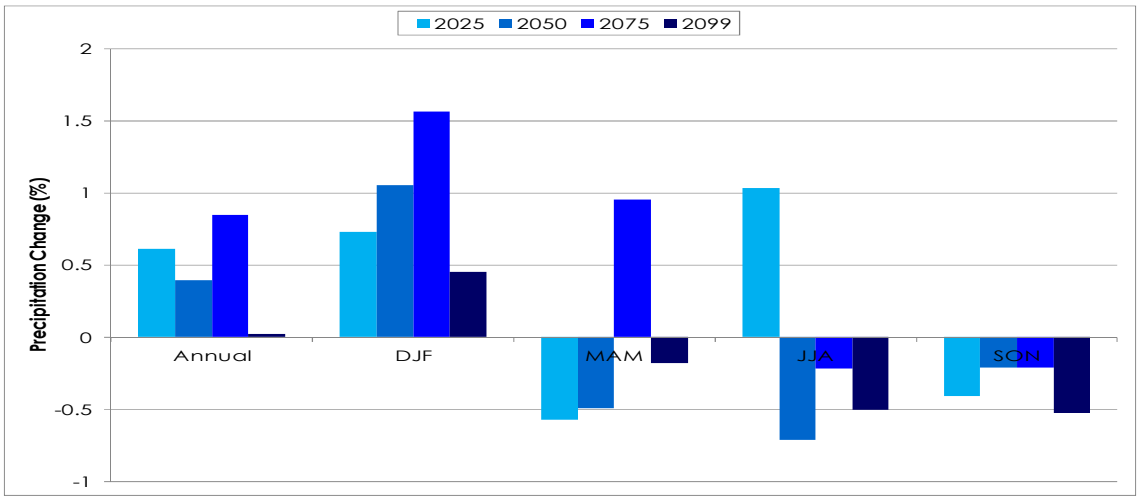


Figure 5-11 HadGEM2-ES change in annual and seasonal average precipitation for emission scenario RCP 2.6.

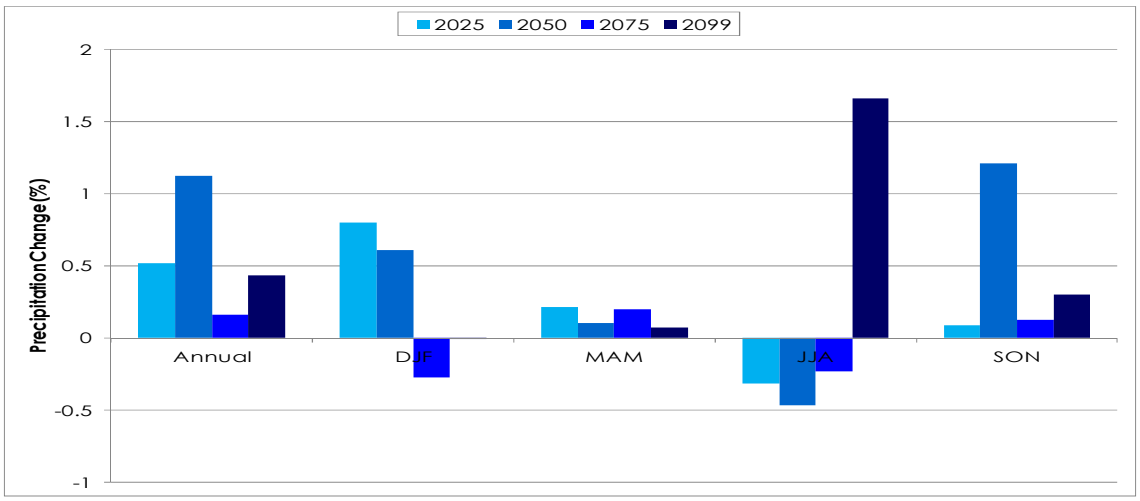


Figure 5-12 HadGEM2-ES change in annual and seasonal average precipitation for emission scenario RCP 4.5.

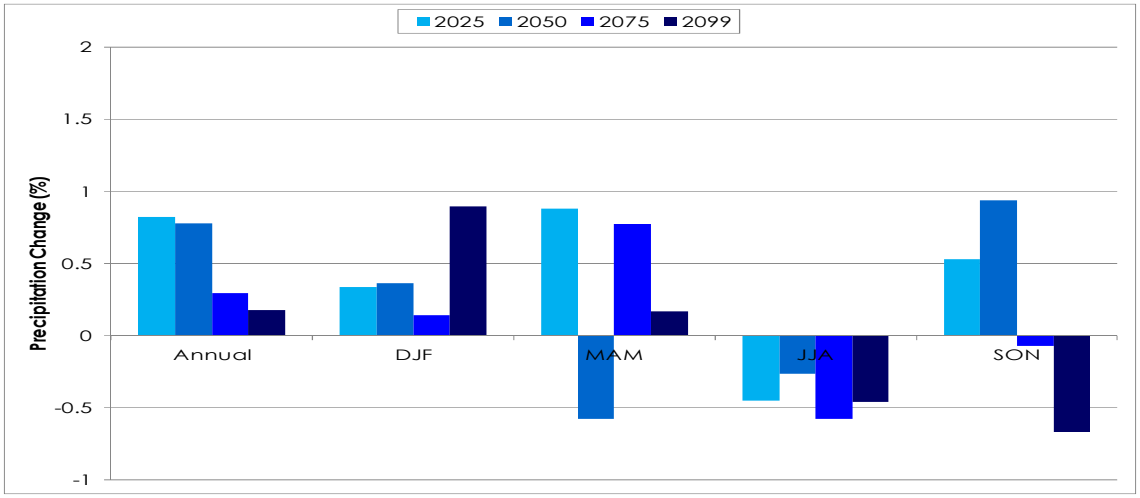


Figure 5-13 HadGEM2-ES change in annual and seasonal average precipitation for emission scenario RCP 8.5.

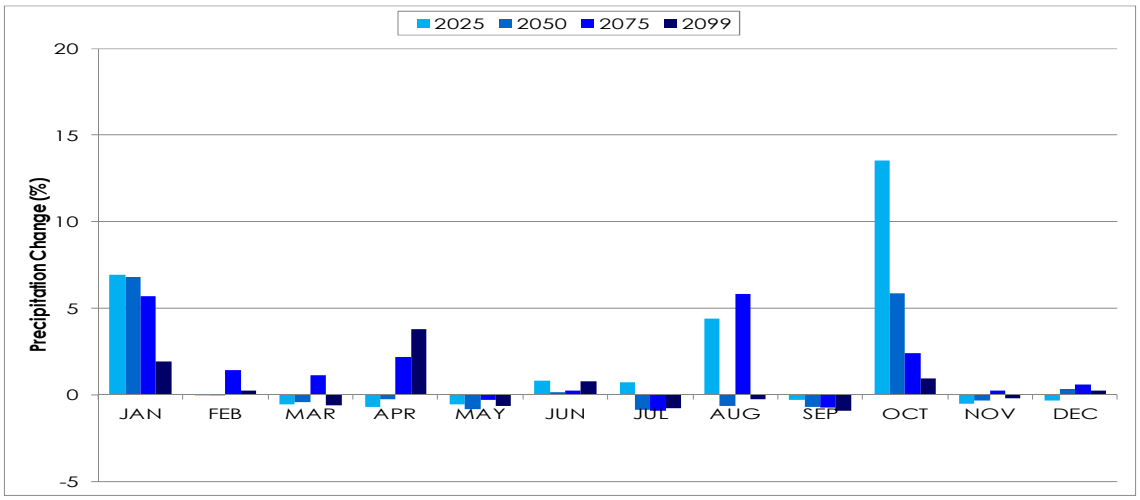


Figure 5-14 HadGEM2-ES change in monthly average precipitation for emission scenario RCP 2.6.

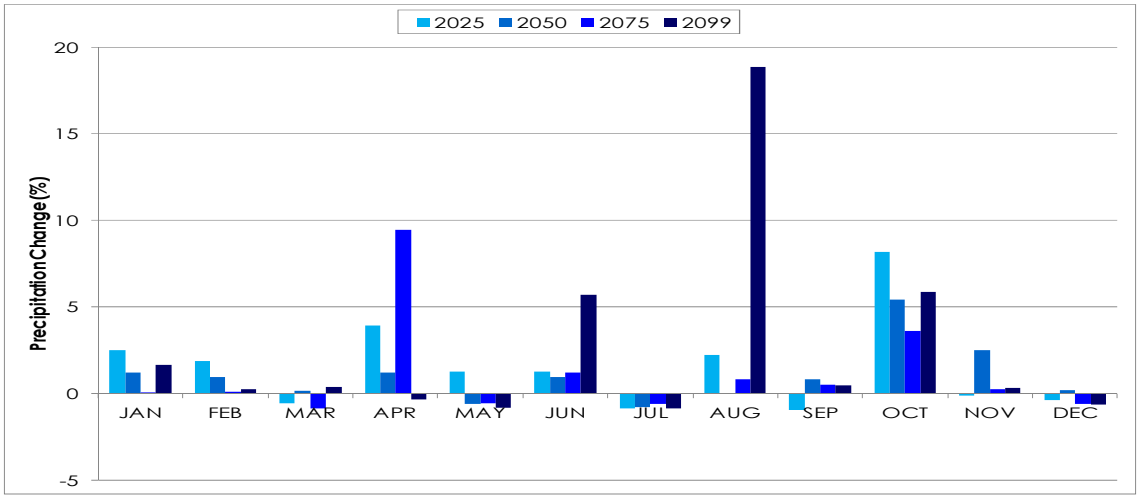


Figure 5-15 HadGEM2-ES change in monthly average precipitation for emission scenario RCP 4.5.

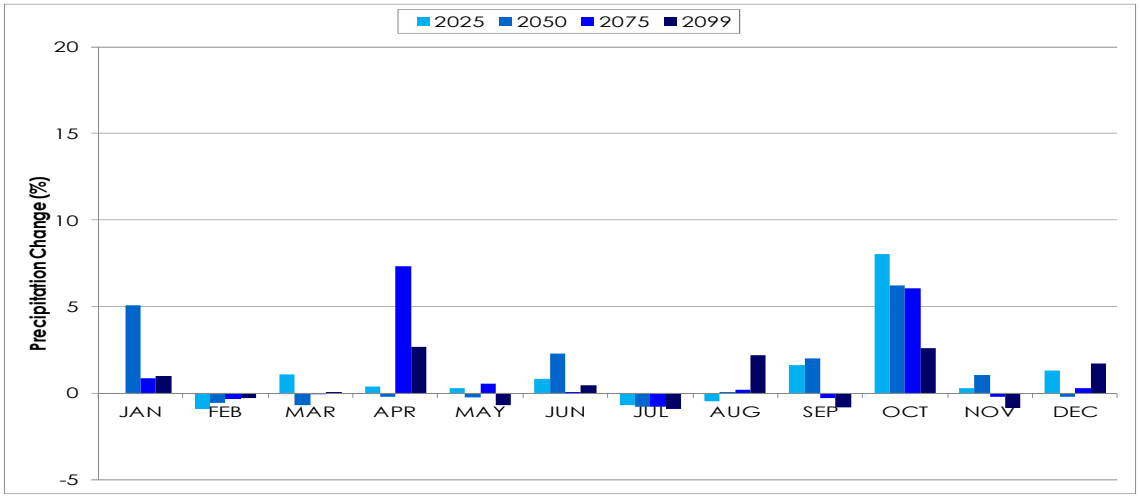


Figure 5-16 HadGEM2-ES change in monthly average precipitation for emission scenario RCP 8.5.

5.2.3 Regional climate simulation with focus on the Central Mediterranean region

The domain shown in Figure 5-17 was defined for the projections to be used in the downscaling simulations run on RegCM4.4-rc8 (update label r3675 17/04/2013), hereinafter referred to as RegCM4. A 100×100 grid cells domain (each of 20 km horizontal resolution) defined by 6 °E to 25 °E and 31 °N to 47 °N was set up. The RegCM4 driving data were the CMIP5 HadGEM2-ES. The scenarios used for these projections were the RCP4.5 and RCP8.5 (RCP2.6 was not used as currently it is unavailable for RegCM4). Time series for Malta were extracted from coordinates 14.5 °N, 35.9 °E. The results in this section are based on annual, seasonal and monthly averages for the years 2025, 2050, 2075 and 2099 compared to the same averages for the year 2005 (which is the baseline year for the CMIP5 HadGEM2-ES simulation). Modelled data was compared to CDC Derived NCEP Reanalysis Products Surface Flux data.

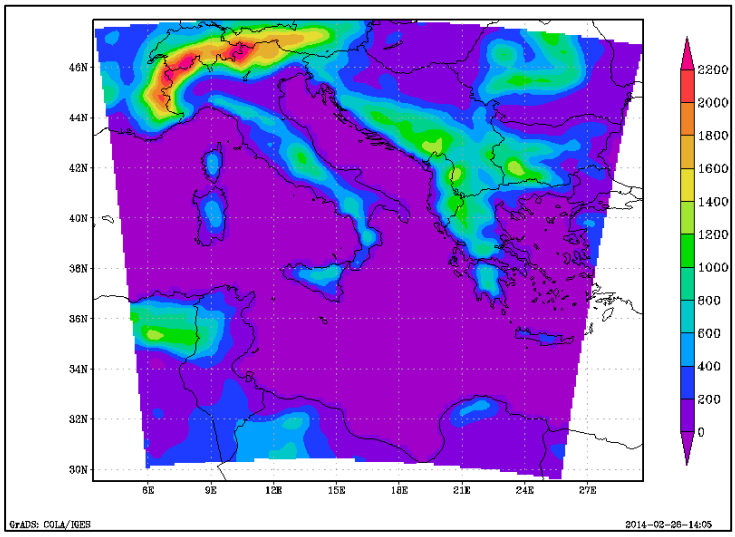


Figure 5-17 Central Mediterranean domain defined for model runs with RegCM4.

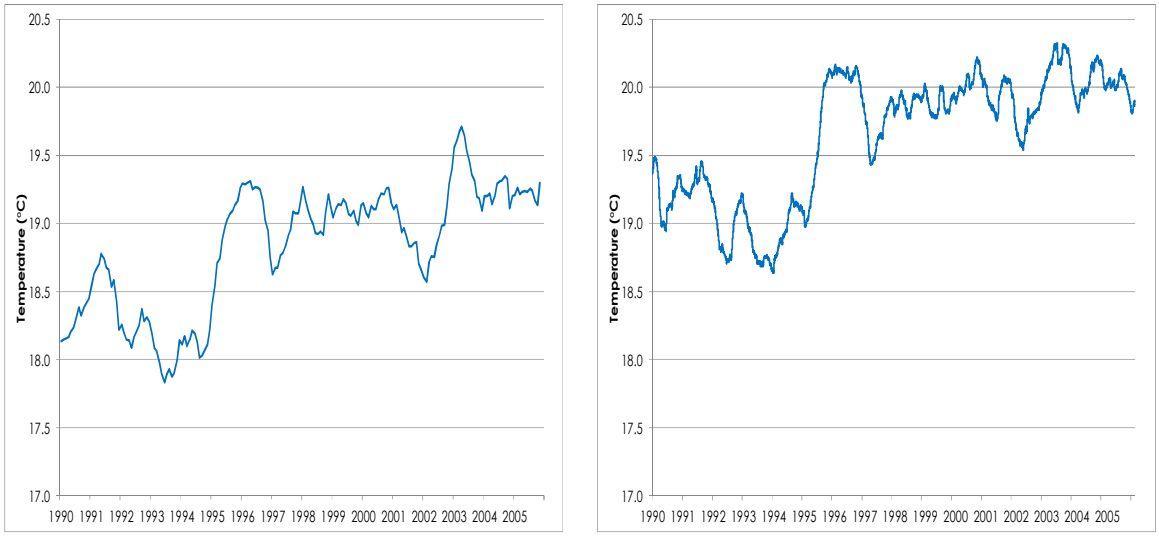


Figure 5-18 Moving average near-surface air temperature in Malta (1990-2005) for HadGEM2-ES driving data (left) and for RegCM4 simulation data (right).

Figure 5-18 compares the hindcast simulation output of RegCM4 to the simulation data for HadGEM2 for the average near-surface air temperature in Malta. This reveals a difference of about 1°C between the two datasets. It is apparent that the RegCM4 data has a larger overall error than the HadGEM2 data. This RegCM4 simulation was based on one configuration and could be significantly improved following an ensemble approach to make up for intra-model differences.

Figure 5-19, Figure 5-20, Figure 5-21 and Figure 5-22 also conform to the results of Figure 5-18 which reveal a larger over prediction from the RegCM4 data. However, both the RegCM4 and HadGEM2 suggest similar ranges of variability of average near-surface air temperature (see Table 5-5).

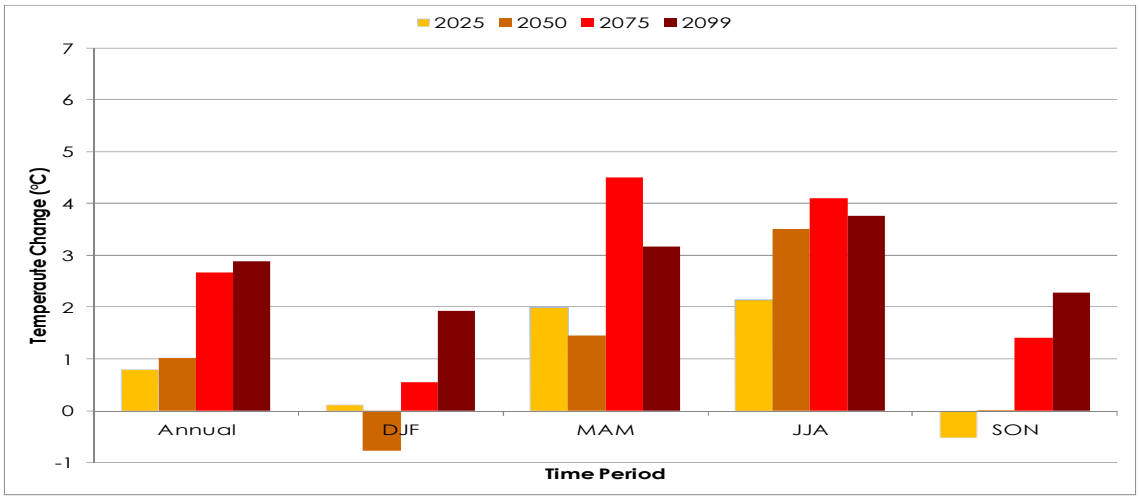


Figure 5-19 RegCM4 modelled annual and seasonal change in near-surface average air temperature in Malta based on emission scenario RCP 4.5.

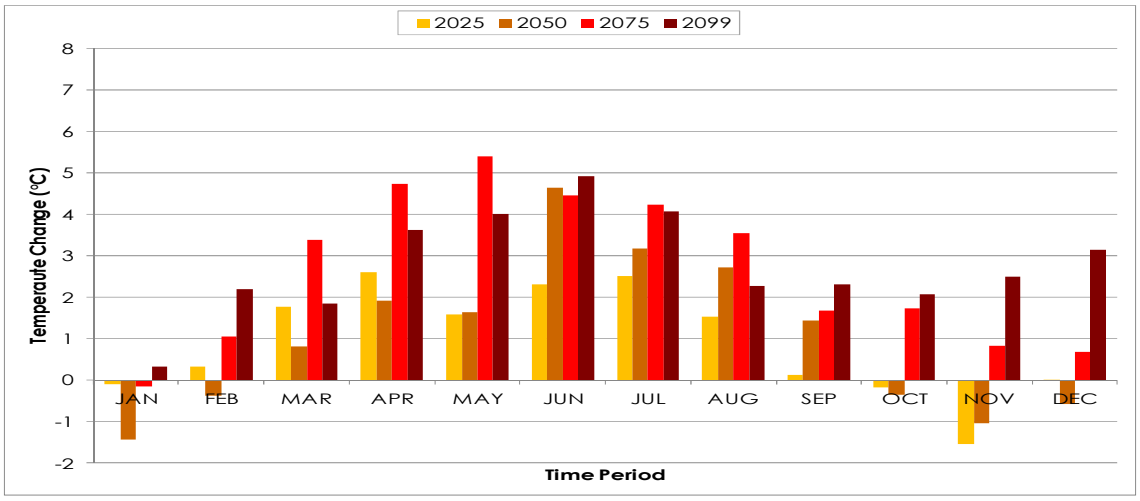


Figure 5-20 RegCM4 modelled monthly change in near-surface average air temperature in Malta based on emission scenario RCP 4.5.

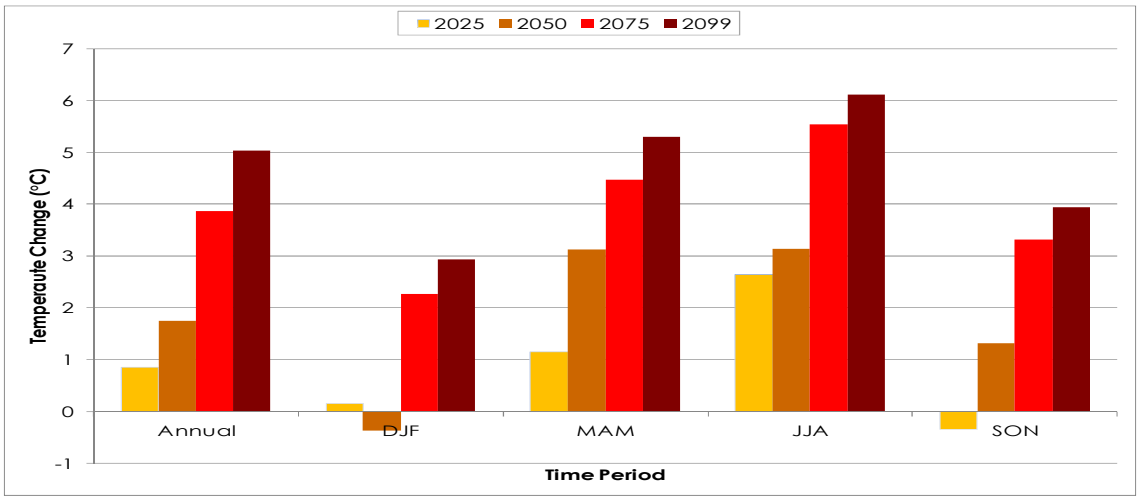


Figure 5-21 RegCM4 modelled annual and seasonal change in near-surface average air temperature in Malta based on emission scenario RCP 8.5.

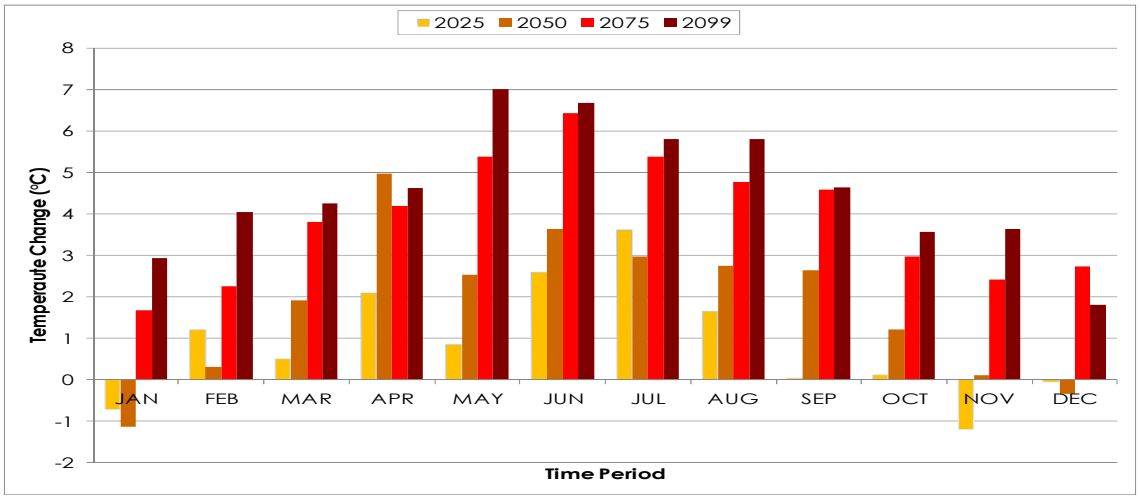


Figure 5-22 RegCM4 modelled monthly change in near-surface average air temperature in Malta based on emission scenario RCP 8.5.

Figure 5-23 represents the regional average temperature error for the annual and seasonal averages between HadGEM2 vs NCEP data and between the RegCM4 modelled vs NCEP data. Similarly, Figure 5-24 represents the regional error for monthly averages. It is clearly visible from these figures that the RegCM4 model outputs are higher than for the global model with respect to the reanalysis data possibly meaning mesoscale phenomena within the Central Mediterranean area are not being well represented by the regional model.

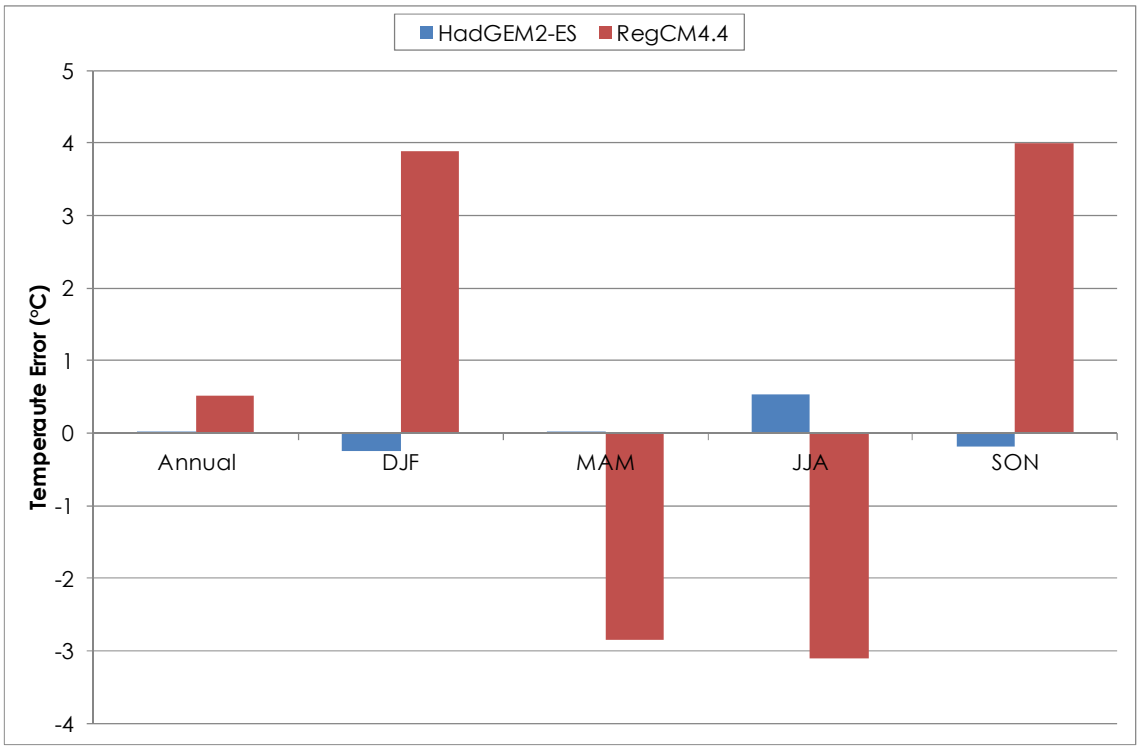


Figure 5-23 Regional average temperature error for annual and seasonal averages.

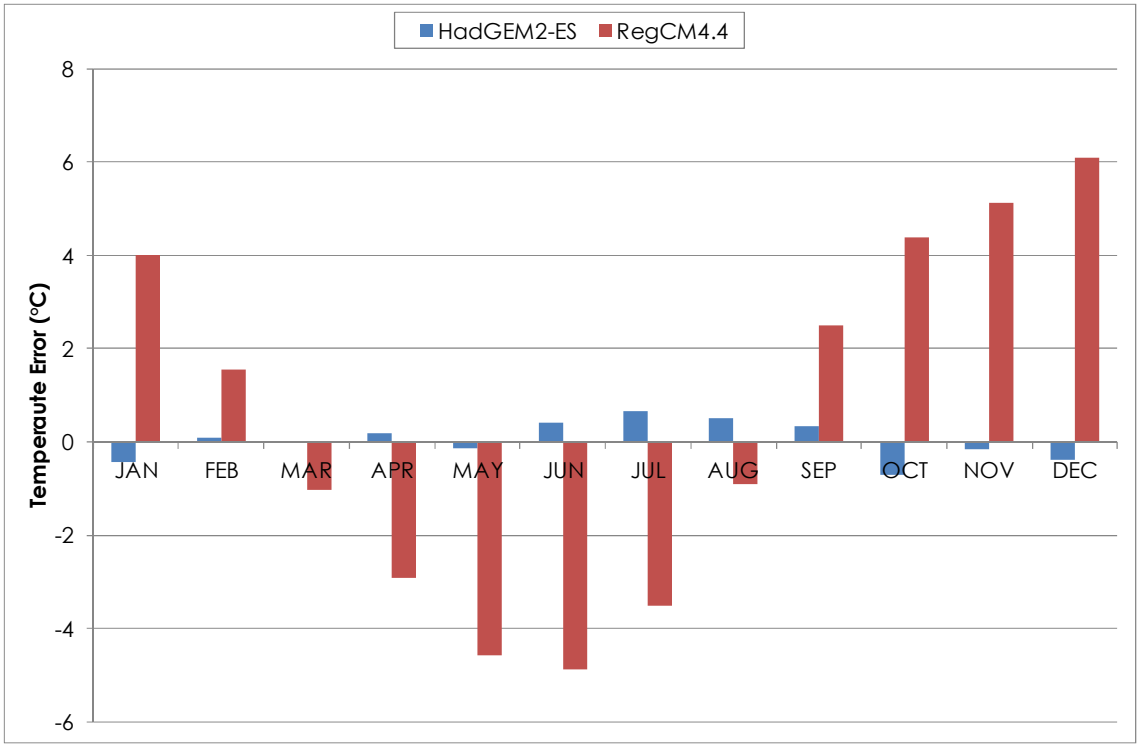


Figure 5-24 Regional average temperature error for monthly averages.

Figure 5-25 represents the regional average precipitation error for the annual and seasonal averages between HadGEM2 vs NCEP data. Similarly, Figure 5-26 represents the regional error for monthly averages. In this case only errors between the driving (HadGEM2-ES) and the reanalysis (NCEP) data are presented to show that even at regional level, the errors between the modelled and reanalysis are substantial. For modelled data the errors are even higher, indicating that the current model setup is not adequate to model precipitation with confidence whatsoever.

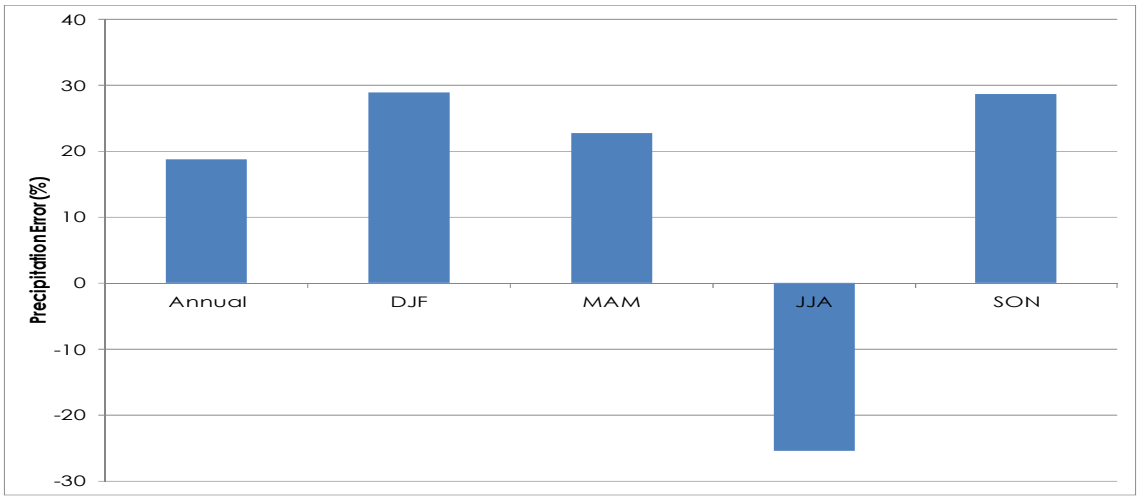


Figure 5-25 Regional average precipitation error for annual and seasonal averages. (HadGEM2-ES data only)

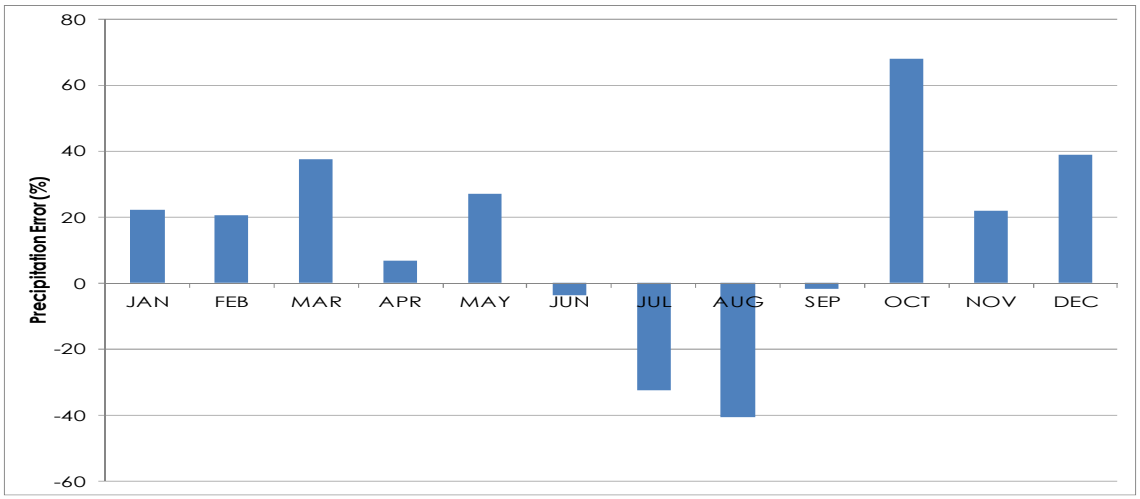


Figure 5-26 Regional average precipitation error for monthly averages. (HadGEM2-ES data only)

From Figure 5-27 and Figure 5-28 (showing the average temperature error for annual and seasonal averages and for the monthly averages, for the Maltese Islands, respectively), as for Figure 5-23 and Figure 5-24, it is noted that the RegCM4 model outputs are higher than for the global model with respect to the reanalysis data reiterating the fact that mesoscale and local scale phenomena within the Central Mediterranean area are poorly represented by the regional model.

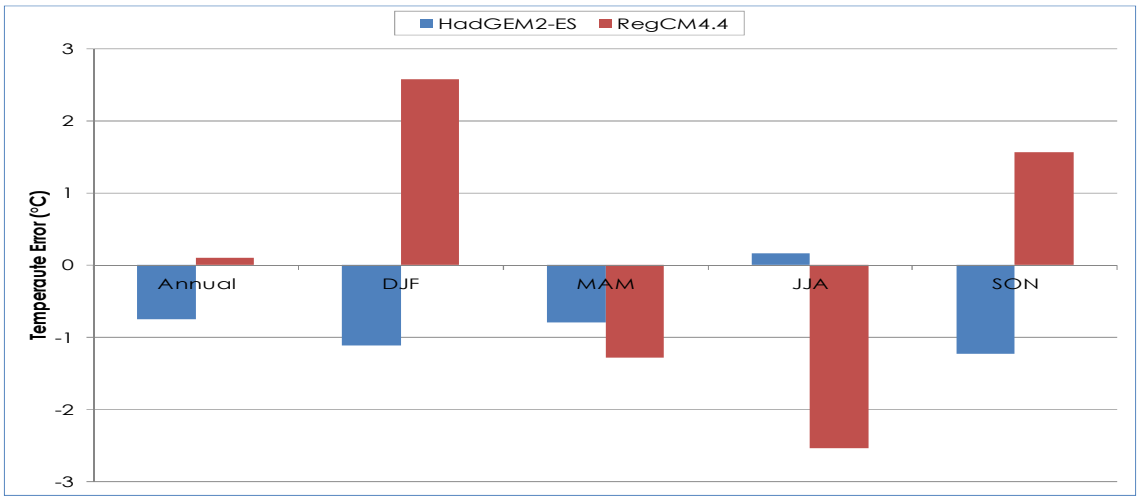


Figure 5-27 Average temperature error for annual and seasonal averages for the Maltese Islands.

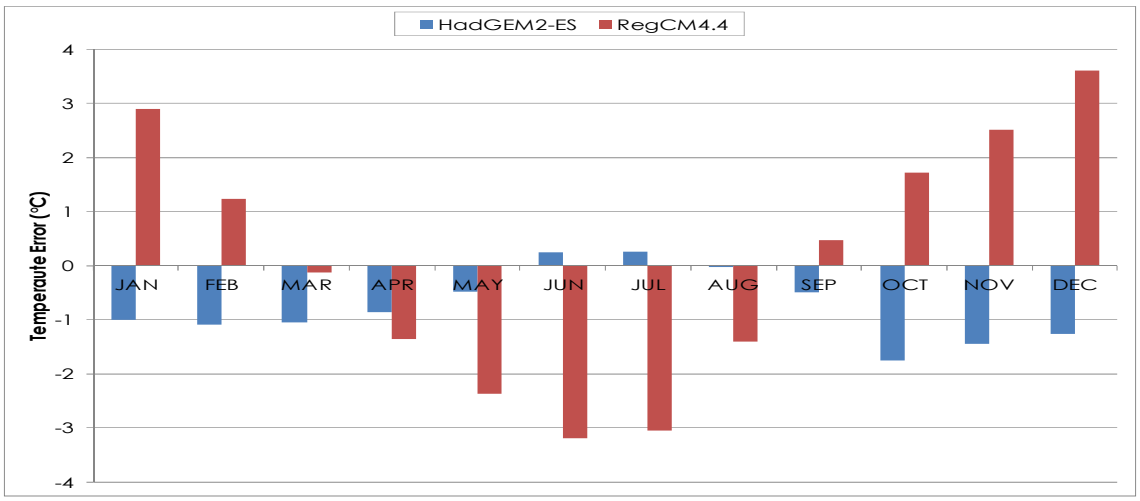


Figure 5-28 Average temperature error for monthly averages for the Maltese Islands.

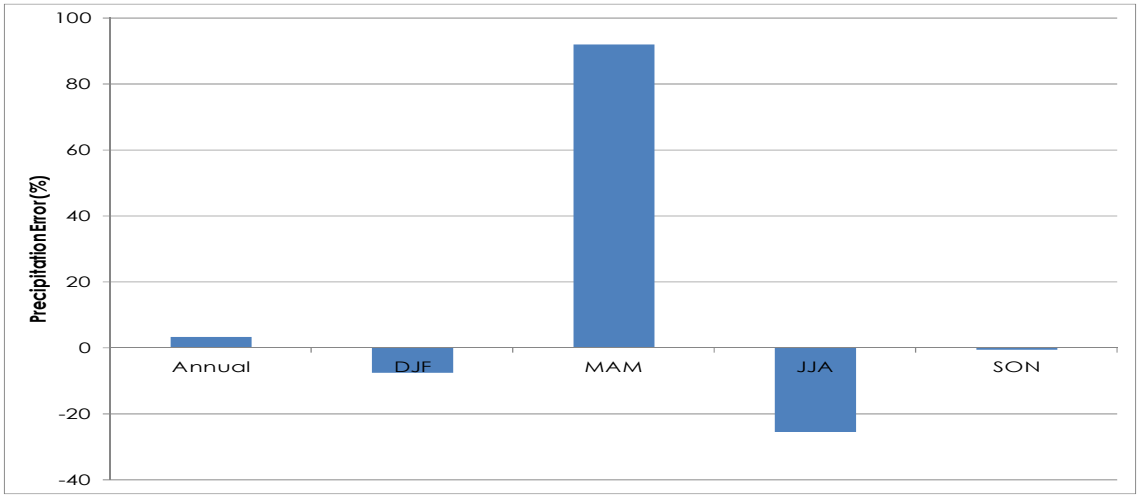


Figure 5-29 Average precipitation error for annual and seasonal averages for the Maltese Islands. (HadGEM2-ES data only)

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

Malta RCP2.6		**Year**	**Annual**	**DJF**	**MAM**	**JJA**	**SON**
HadGEM2	Change in Temperature (°C)	2025	1.24	-0.21	1.50	2.53	-2.17
		2050	1.63	0.78	2.09	2.38	1.51
		2075	1.08	0.29	0.81	1.47	1.97
		2099	1.51	0.52	1.59	2.24	1.92
	Change in Precipitation (%)	2025	0.61	0.73	-0.57	1.03	-0.41
		2050	0.39	1.06	-0.49	-0.71	-0.21
		2075	0.85	1.57	0.95	-0.22	-0.21
		2099	0.02	0.45	-0.18	-0.50	-0.53
Malta RCP4.5		**Year**	**Annual**	**DJF**	**MAM**	**JJA**	**SON**
HadGEM2	Change in Temperature (°C)	2025	0.70	0.40	1.28	1.23	-3.34
		2050	0.69	-0.59	0.81	1.84	0.93
		2075	2.30	0.80	3.09	2.91	2.62
		2099	2.27	2.20	2.38	2.44	2.28
	Change in Precipitation (%)	2025	0.52	0.80	0.21	-0.32	0.09
		2050	1.12	0.60	0.10	-0.47	1.21
		2075	0.16	-0.28	0.20	-0.23	0.13
		2099	0.43	-0.01	0.07	1.66	0.30
RegCM4	Change in Temperature (°C)	2025	0.80	0.12	1.99	2.14	-0.53
		2050	1.02	-0.76	1.46	3.52	0.01
		2075	2.66	0.55	4.50	4.10	1.41
		2099	2.88	1.93	3.16	3.76	2.28
Malta RCP8.5		**Year**	**Annual**	**DJF**	**MAM**	**JJA**	**SON**
HadGEM2	Change in Temperature (°C)	2025	0.81	0.52	0.66	1.45	-2.40
		2050	1.61	-0.18	1.79	2.32	2.75
		2075	3.59	2.75	3.23	4.03	4.58
		2099	4.00	2.80	4.29	4.26	4.88
	Change in Precipitation (%)	2025	0.82	0.33	0.88	-0.45	0.53
		2050	0.78	0.36	-0.58	-0.27	0.94
		2075	0.29	0.14	0.77	-0.58	-0.08
		2099	0.17	0.90	0.17	-0.46	-0.67
RegCM4	Change in Temperature (°C)	2025	0.86	0.15	1.15	2.64	-0.34
		2050	1.75	-0.36	3.13	3.14	1.31
		2075	3.86	2.26	4.47	5.54	3.32
		2099	5.03	2.93	5.30	6.11	3.94

5.2.4 Developing the local capability to study impacts of climate change

Since 2011, the Climate Research Group (CRG) was set up within the Department of Physics of the University of Malta with the intent of building local capacity in the study of the impacts of climate change, particularly as would be relevant to the Maltese Islands.

The Department of Physics through the University of Malta financial support through European Union funds (Operational Programme I & II - Cohesion Policy 2007-2013, ERDF-80) to set up a supercomputing cluster facility, 'Albert'. The CRG, in collaboration with the Earth System Physics (ESP) section of the Abdus Salam International Centre for Theoretical Physics (ICTP) installed the community regional climate model RegCM4, a model maintained by the same centre. Since then, staff from the Department of Physics attended seminars and training workshops to be able to operate the regional climate model and fulfil the abovementioned role. A PhD student has been granted a developer's status within the RegCM4 model community. Research using and, or, developing the RegCM4 is currently ongoing at Masters and PhD level.

The first project undertaken was associated with defining a domain centred over Europe to study the teleconnection patterns and how they affect dust concentrations over Europe and the Mediterranean region (Figure 5-30).

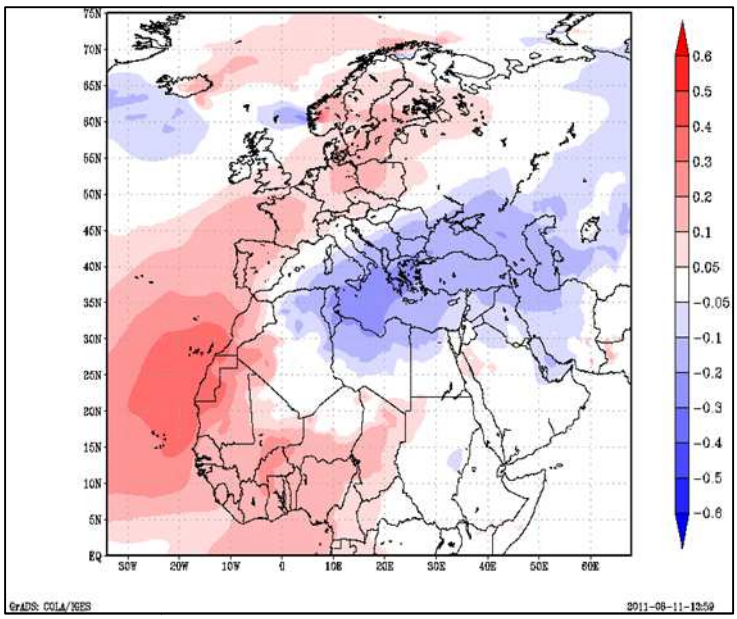


Figure 5-30 Modelled (1989-2008) temporal correlation of changes in dust concentration (0.1-1 µm) as a result of changes in the North Atlantic Oscillation Index (NAOI). (Ciarlo`, 2011)

Figure 5-31 shows the temporal correlation (1989-2008) of the sea level pressure (SLP) with the North Atlantic Oscillation Index (NAOI). The SLP is crucial in determining parameters such as temperature and precipitation. For islands, variations in SLP will strongly influence the model outputs as can be observed in Figures 5-23 to 5-26 indicating regional errors.

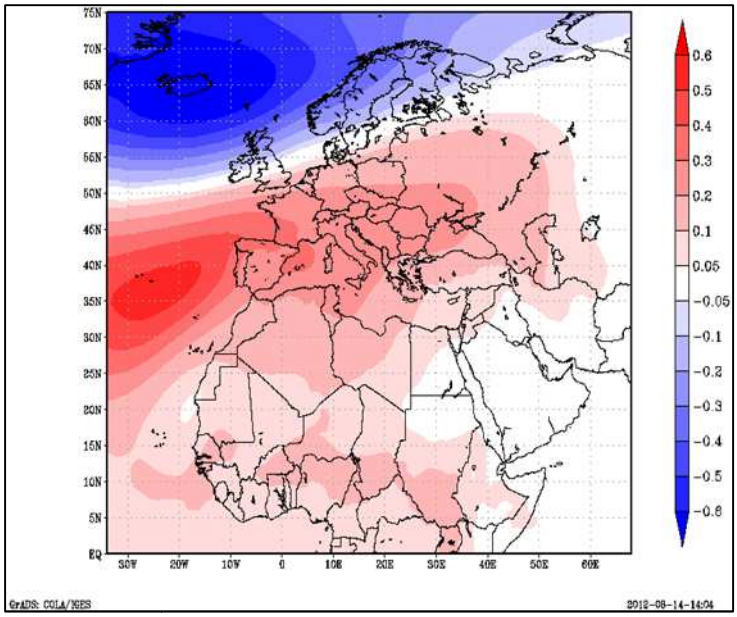


Figure 5-31 Modelled (1989-2008) temporal correlation of the North Atlantic Oscillation Index with the Sea Level Pressure in the surrounding the Mediterranean region. (Ciarlo`, 2011)

The Department of Physics in collaboration with the ESP of the ICTP is involved in the development of RegCM4 by looking into modelling the radiative forcing impacts of Secondary Organic Aerosols (SOAs).

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

Most climate models, in their calculations of projections of future atmospheric conditions do not take into account SOAs; however these are expected to minimize biases for organic aerosol mass and aerosol optical depth. When compared to available observations, the biases of climate models, for parameters directly or indirectly influenced by aerosols, are still high and considerable amount of research is required to further improve the results of climate change simulations. The current regional climate model in use is limited in its ability to adequately simulate climate change scenarios, and would show an improvement if the radiative effects of SOAs were introduced.

Based on information acquired from Figure 5-32, incorporating these SOA processes in the existing chemical scheme of the RegCM4 model is likely to reduce the biases of the model output and hence improve the quality of climate change projections provided by the model. In this configuration, the model would also be useful in the projection of various atmospheric pollutants and hence, project the pollutant influence on climate change; both of which are very important issues within European countries.

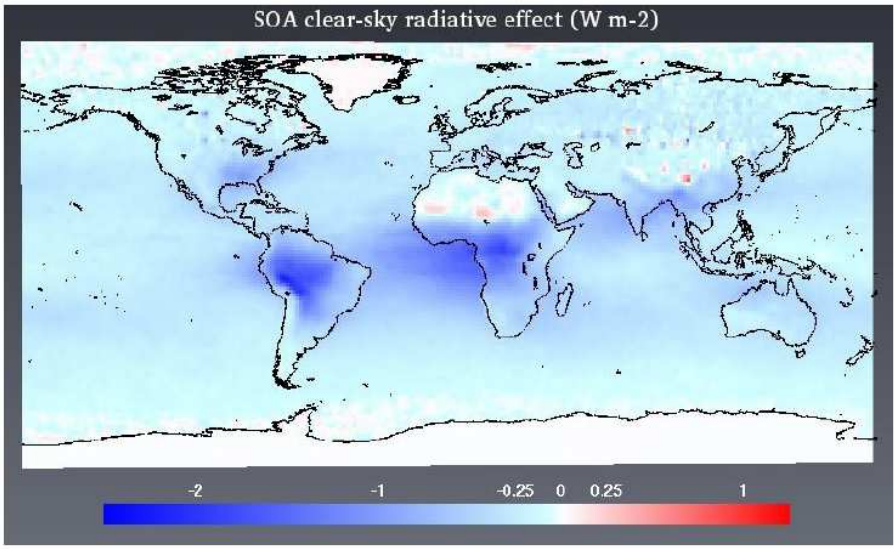


Figure 5-32 The annual direct SOA radiative forcing obtained by calculating the difference in clear-sky top of atmosphere shortwave flux between SOA and no-SOA model runs. (O'Donnell, et al., 2011)

On the computing facility, Albert, the Department of Physics has also installed the numerical weather prediction model Weather and Research Forecasting (WRF). Although this model is not a climate model it is being used to address the horizontal resolution issue, amongst others, that is a persistent problem when modelling the Maltese Islands.

In order to study wind flows around the Maltese Islands, simulations of atmospheric flow using a WRF-LES (Large Eddy Simulation) setup for a final 400m nested domain was validated against measured data at a height of 80 m obtained from the wind mast situated at L-Aħrax tal-Mellieħa (data provided by MRA) as well as with other data obtained from the Earth System Research Lab (ESRL) and the European Center for Medium range Weather Forecasting (ECMWF). Following this project, a 5-nested domain, starting from a 24 km resolution (Figure 5-33(a)) and downscaling it to a 100 m resolution domain (Figure 5-33(b)) was set up. Increasing the horizontal resolution resulted in a slight improvement when comparing with the previous project results (Figure 5-34) however not enough to justify the additional computational expense, given that the WRF-LES output results overestimated the reanalysis data ESRL and ECMWF. Since the measured data available to test these two configurations where from 1st till 6th October 2011, any interpretation of the results needs to be cautious. Longer time series would be required to verify if any of the abovementioned configurations are suitable since there are other important issues that need to be addressed as outlined later in this section.

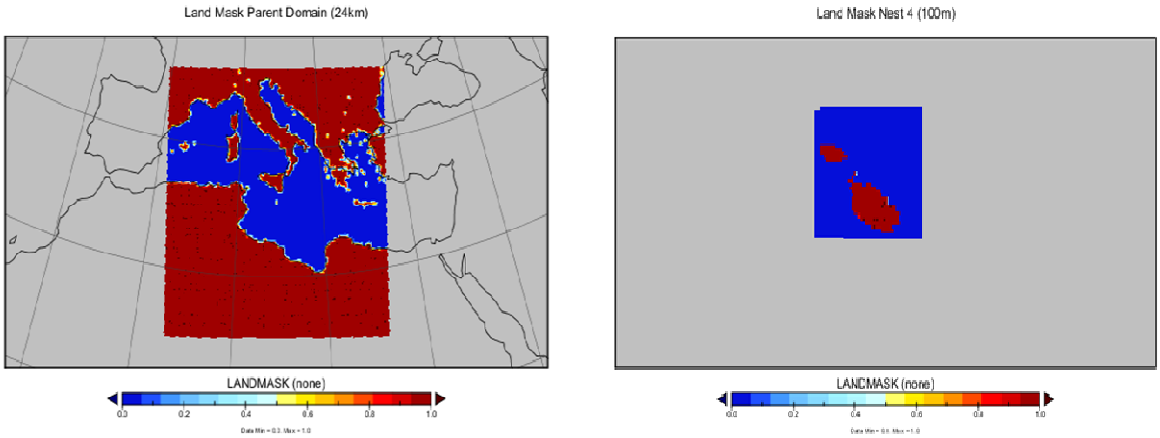


Figure 5-33 WRF parent domain set at 24 km resolution (a) and final nested domain set at 100 m resolution (b) within WRF. (Fenech, 2013)

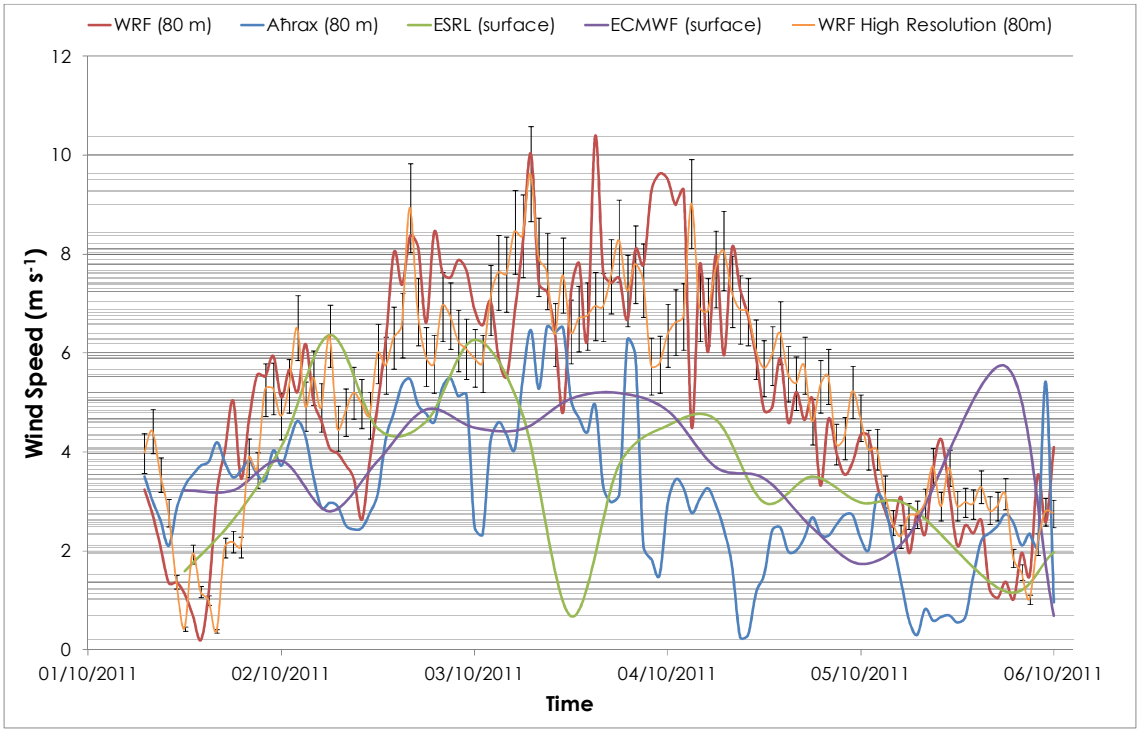


Figure 5-34 Wind speed profiles for measured and modelled data available from 1st-6th October 2011. (Fenech, 2013)

The main problem encountered with this high resolution setup was the land-use definition for the Maltese Islands in the smallest nest as outlined in Figure 5-35. The land use category index that the WRF has associated with it for Malta to date classifies the Islands to be made up of dryland (colour code: 2) and irrigated (colour code: 3) cropland and pasture and shrubland (colour code: 8) surrounded by a water body (colour code: 15).

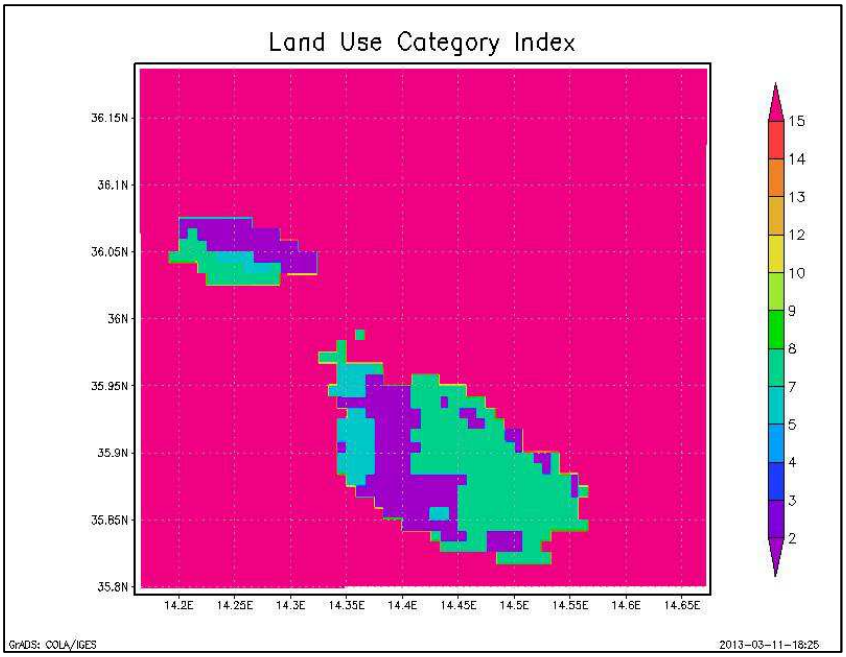


Figure 5-35 Land use categories defined for Malta by the U.S. Geological Survey (USGS) and used within WRF. (Fenech, 2013)

In a bid to improve the current WRF configuration and make it more suitable to be used for small islands, the following research elements are in hand:

i) A sensitivity analysis is currently being carried out to evaluate the WRF performance to progressive input of sea surface temperatures. The fact that the Maltese Islands are small and surrounded by the sea, it is believed that this input parameter is crucial to the model outputs which depend on wind parameters.

ii) Evaluating the different physics schemes within the model. The aim of this project is to focus more on the various physics schemes found within the model rather than increasing the horizontal resolution, following the results obtained from the previous projects. The domain chosen for this study is the Central Mediterranean region. This two nested domain includes a number of coastal areas, including the Maltese Islands with the smaller nest having a 9.6 km horizontal resolution. Results from this project would therefore set a base case to obtain a possible 'best case' scenario of the model leading to output data which can be used in conjunction with higher resolution computational fluid dynamics models and climate impact models.

iii) A project has been set up to modify the land use categories within WRF for the high resolution simulations. Simulation runs would be required to test the effect on the model performance. This ground work would be implemented at a later stage in RegCM4.

iv) Another project is aimed at inserting a feedback loop in WRF and eventually in RegCM4 associated with the calculation of release of latent heat due to condensation and formation of ice crystals at the top of deep convective clouds. These processes are believed to affect aerosols that have a bearing on the precipitation mechanisms. The scope of this research aims to further develop the understanding and parameterisation of precipitation processes that to date are not yet fully understood.

5.3 Vulnerability assessment and adaptation measures

This section provides an analysis of vulnerabilities for Malta as a result of climate change, building upon discussions on vulnerability in the First and Second National Communications submitted by Malta, as well as the National Adaptation Strategy[47] finalized in 2012. The sectors subject to a vulnerability assessment have been chosen on the basis of their being of priority concern for Malta given also the current state of play of these resources and activities. Both the Second National Communication and the National Adaptation Strategy stress the need to focus on priority sectors in the first years and to move on to further study vulnerability in other sectors aiming at a comprehensive approach to the extent possible. It is the intention of the Maltese authorities to extend the vulnerability assessment to other sectors in staggered fashion.

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

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

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

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

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

water policy is in itself an indispensable measure that safeguards above all food security and hygiene.

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

Malta's size and insularity are particularly important in defining the economy in its relation to climate change. The fact that islands contribute insignificant amounts to global emissions does not preclude them from impacts which will mostly result from effects such as sea level rise.

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

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

The limited space and resources and relative isolation, in addition to urgent economic growth and development targets are some of the features of island states to adapt. In the Second Communication a vulnerability index was developed for the production activities as well as for the expenditure activities. The results are reproduced below in Table 5-6 and Table 5-7.

Table 5-6 A qualitative assessment of climate change vulnerability of production activities. (MRRA, 2010)

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

Table 5-7 A qualitative assessment of climate change vulnerability of expenditure activities. (MRRA, 2010)

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

As demonstrated above the Second National Communication of Malta to the UNFCCC identified various vulnerability and adaptation issues in individual sectors such as health, water resources, migration and demographic changes, biodiversity conservation, waste management, the built environment, telecommunications and transport. These reports on individual sectors supplement an earlier report on 'Technology Needs for Adaptation to Climate Change'[48]. The National Adaptation Strategy built upon the work on adaptation carried out by the Second National Communication. The primary focus of the Strategy was to highlight also the need for awareness on adaptation to climate change and for instilling a sense of ownership across all sectors to mainstream climate change into cross-sectoral and sectoral policies so as to facilitate the implementation of such measures.

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

This part of this chapter follows upon the work carried out since the launch of the Strategy and first identifies the state of play and then the measures that are being taken and/or proposed to be taken to address adaptation. The part is split into cross-sectoral and sectoral issues for reasons explained above. The cross-sectoral aspect is split into two main categories, the institutional and

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

the regulatory framework and the Technical and Capacity Building Framework. The sectoral part which follows tackles the most salient sectors that have been identified as most vulnerable to climate change. Both the cross-sectoral and the sectoral aspects give first an over view on the current state of play and then report what is currently being done to address vulnerability in relation thereto.

5.3.1 Cross-sectoral vulnerability to climate change

5.3.1.1 Institutional organization and the regulatory framework

(1) STATE OF PLAY

Since the submission of its Second National Communication Malta has changed its status under the UNFCCC and is now an Annex I Party. It has formulated a National Mitigation Strategy and a National Adaptation Strategy as well as published and implemented a cohort of laws that establish emission reduction targets on the sectors that participate in emissions trading namely power plants and the aviation industry as well as laws imposing targets to generate energy from renewable including bio fuels. On the other hand adaptation has only been addressed in the Second National Communication and more recently through the formulation of the National Adaptation Strategy. Although existing laws and policies on resource management may already serve to facilitate adaptation to climate change, it clearly apparent that a more thorough preparedness exercise needs to be undertaken at the cross-sectoral and sectoral level to address vulnerability to climate change and implement therefore the requisite adaptation measures.

The Strategy on Adaptation highlights the need to improve the existing institutional machinery. The change in government administration in March 2013 brought climate change within the portfolio for the Ministry responsible for sustainable development, environment and climate change. A process to establish a new authority that would be responsible for environment and resources has commenced, which authority may be expected to support the Ministry in work related to implementation of climate change policy. Under consideration is also the drafting of legislation laying down a legal framework for climate change action, which together with the strengthening of the institutional set up can ensure an efficient administrative, policy and legal approach to, *inter alia*, adaptation measures. The process to mainstream climate change across all sectors and to facilitate cooperation accordingly is currently facilitated by Inter Departmental and Inter Ministerial Committees.

(2) ADDRESSING VULNERABILITY AT THE INSTITUTIONAL AND REGULATORY LEVEL

The Adaptation Strategy was the most direct step taken to address climate change adaptation since the publication of the Second National Communication. The following elements have been identified by the Strategy and stakeholder discussions that followed its publication as essential to address the vulnerability of the current institutional and regulatory framework relating to climate change adaptation:

- The need to adopt appropriate legislative instruments that would strengthen the existing regulatory framework on climate change and supplement it,
- Continuous mainstreaming of climate change adaptation,
- The need to facilitate the provision of information from various public entities to determine better preparedness and adequate options for adaptation,
- A delineation of roles that specifies who is the lead competent authority and the other competent authorities that will implement the adaptation measures that must be adopted.

- A road map determining which sectors need to adapt to what, by when, to what extent.

These elements are interrelated and interdependent. The more available information there is on the current status of vulnerable resources and sectors, the risks involved and the degree of resilience they can muster, the more straight forward it will be for competent authorities to determine whether the best adaptation measure in the circumstances needs to be reactive, preventive or precautionary. Mainstreaming serves to drive the flow of information and vice versa. The formulation of an adequate legal framework is in turn dependent on a sound knowledge base and an institutional set up that facilitates cooperation. For better organization this part of the Chapter will first discuss addressing vulnerability via strengthening the regulatory framework and then through the institutional/administrative set up.

(A) *IMPROVING THE REGULATORY FRAMEWORK*

Mainstreaming and better exchange of information are the principles underlying the motive behind a legislative instrument which would seek to address adaptation via cross-sectoral cooperation and through the good governance of natural resources that would be affected negatively as a result of climate change. Existing laws may facilitate adaptation if they are well implemented and complied with. On the other hand, certain legal instruments regulating the use of such resources may fail to be "adaptation-proof", exposing the same resources or entire sectors to more risk. A legal instrument focusing on climate action would serve to coordinate under one legal instrument, public and private stakeholders' obligations to provide the required information and data required to address vulnerabilities and preparedness as appropriate. The aim of such an adaptation measure is to improve the knowledge base as a result of obligatory flow of information from a coherent and efficient institutional set up, which would enable the necessary tweaking of the existing administrative and regulatory machinery and where necessary generate new laws and policies to enhance the resilience of the various sectors and natural resources to climate change.

The same applies to the regulation of adaptation to certain activities or industries such as agriculture or tourism that are discussed further on in the sectoral part of this Chapter. In the latter case, providing the right regulatory framework to ensure the resilience of these sectors to climate change is more complex as it involves the management of resources and anthropogenic activities from a cross-sectoral and multi-disciplinary perspective. Nevertheless climate change legislation may impose a legal obligation which would require the competent authorities to carry out such a risk assessment in major activities that have a high socio economic and environmental impact in Malta and are thus likely to be most vulnerable to climate change.

The promulgation of a legal instrument on climate change would also bestow enabling powers on the individual public entities and the lead Ministry to prevent risks as much as possible. This new legal instrument will empower one or more public entities, to ensure that all sectors are considering adaptation in their policies. Since the various sectors are answerable to different competent authorities the law must ensure integration without causing fragmentation or creating a supra national institution that becomes a bottle neck. Different competent authorities responsible for the different sectoral policies and obligations should remain, but these must be answerable to an institution that has executive powers to ensure compliance and to coordinate long term and short term planning with respect to climate change targets and impacts. This law would not duplicate the role of public entities that are regulators for various sectors. It would however empower one entity to take enforcement measures against the said institutions if they fail to do so. The new law on climate change should also delineate benchmarks for the implementation and enforcement of existing legislation that regulates the various sectors to rationalize their sustainable use and provide for conservation measures. This would benefit both the implementation of mitigation and adaptation measures.

As already mentioned, the climate action legislation that would encompass these recommendations and bestow such powers on the relevant competent authorities is under consideration. The existing cohort of Regulations on Mitigation published under the Environment and Development Planning Act as well as other existing pieces of legislation that regulate the quality of natural resources such as soil, water, biodiversity and others may also be subjected to a review process to assess their validity in ensuring resilience to climate change.

(B) *IMPROVING THE INSTITUTIONAL FRAMEWORK*

Apart from the possibility of adopting a legislative instrument targetted specifically at climate change issues and other existing laws that may be reviewed as already indicated, vulnerability needs to be also tackled at the administrative/institutional level. A robust administrative set up with a clear delineation of roles would need to support implementation at the regulatory level to ensure flexibility to function in a coherent and effective manner. Adaptation is inter-disciplinary and cross-sectoral, consequently public authorities will establish memoranda of understanding to facilitate cooperation for the formulation and adoption of anticipatory adaptation measures, which may include:

- increasing the robustness of infrastructure and investments,
- enhancing flexibility of vulnerable managed systems and operations,
- allowing flexibility for adaptation of vulnerable natural systems,
- reversing trends that increase vulnerability, and
- improving awareness building and preparedness at all levels.

All these issues were referred to as priority issues under the National Strategy on Adaptation. MSDEC, as the lead Ministry on Climate Change will facilitate coordination on a cross-sectoral level. Whilst some benchmarks may be included in the legal framework others may be purely administrative and would serve to assess progress that adaptation measures are being pursued both on a sectoral and cross-sectoral level. Additionally, MSDEC as well as the individual public entities and other stakeholders involved in climate change adaptation will be supported by a parallel capacity-building process in the various entities that run the day-to-day implementation functions. On an administrative level stakeholder dialogue will ensure cooperation facilitating compliance with the regulatory framework and policy measures that would aim at addressing Malta's vulnerability to climate change. Ensuring effective monitoring and stakeholder engagement, particularly the involvement of NGOS and Local Councils is intended to increase public awareness on climate change issues, leading to a cross fertilization of ideas as well as ensuring that the momentum towards combating vulnerability to climate change prevails.

Providing for administrative linkages between the different sectors will help to overcome the risk of maladaptation to climate change or to conflicting adaptation measures that prevent natural and human systems in Malta to adjust and respond to climate change by moderating harm. The mainstreaming exercise that will be carried out to integrate adaptation will lead Malta to tap on possible opportunities that will arise as a result of climate change such as increase in the demand for financial instruments to counter the effects of climate change. Adaptation measures will include also the exploitation of such opportunities and clear policy direction to evaluate the merits of available adaptation options that may be successfully utilized on a local level.

The mainstreaming of climate change impacts into national policies will facilitate the adoption of adaptation measures and guarantee synergy and linkages amongst various public plans and programmes. By mainstreaming climate change into national policy making, any adaptation measures should take place at a strategic level to assess beforehand their socio-economic implications as well as the cost of doing nothing. The intention of the Maltese authorities is to promote pro-active adaptation measures such as for example in development planning, rather

than take reactive adaptation measures. National security issues relating to climate change will also be addressed when formulating mitigation and adaptation strategies.

5.3.1.2 Technical and capacity building gaps in the implementation of adaptation measures

(1) STATE OF PLAY

There is a gap in the identification of criteria for assessment when selecting key technologies that should facilitate adaptation to climate change. There are gaps related to the transfer of and access to environmentally sound technologies and know-how that would facilitate adaptation to climate change on a national level. Gaps are predominant in research and systematic observation systems relevant to adaptation to climate change. There are also technological constraints with respect to the development of local climate change impact scenarios. There are gaps in providing ongoing technical programs and projects relevant to adaptation to climate change.

Lack of funding for research in technical adaptation measures and for building scientific data bases relating to adaptation of natural and managed ecosystems as well as human adaptation to climate change in Malta, will constrain any attempt to address the gaps referred to above under this section. The University of Malta aims to continue to give priority to using funding opportunities relating to climate change, particularly on adaptation. The University has the potential to address such gaps subject to the required funding being available.

There are currently various major gaps in capacity building in Malta which contribute to Malta's vulnerability in dealing with climate change adaptation. Climate change adaptation research focused on the local scenario is sparse. This is mainly due to lack of funding and scarce human resources with climate change expertise.

(2) ADDRESSING VULNERABILITY BY ADDRESSING TECHNICAL AND CAPACITY BUILDING GAPS

The government, in accordance with the National Adaptation Strategy, will endeavour to address the gap in the technical knowledge base and human expertise by:

- Carrying out a cost assessment of adaptation measures in order to ensure a proper allocation of human and financial resources and the creation of an adequate enabling environment for implementation of adaptation measures;
- Enhancing investment opportunities relating to climate change to entice the private sector and the public at large to aim at preparedness and opportunity building;
- Launching scholarships and similar incentives for further studies in climate change adaptation;
- Strengthening the information base on the resulting benefits of climate change to address any constraints that hamper opportunities for investment and human resources;
- Sustaining awareness-building programmes to educate and promote a change in behavioural patterns to improve adaptation to climate change;
- Developing a research programme for improved capacity building on climate change that:
  - assesses negative socio-economic implications as a result of Malta's increased vulnerability from climate change,
  - explores the potential for the generation of green jobs,
  - examine which financial measures are best suited to address adaptation particularly amongst vulnerable groups and sectors, and

  - identify the particular needs of vulnerable groups via the formulation of contingency plans;
- The technical measures identified by government to counter vulnerability to climate change in the coming years are:
  - setting up of data and observation systems,
  - improvement in data modelling on climate change impacts' scenarios at a local scale,
  - monitoring systems on adaptation to vulnerability and enhancing resilience,
  - maintaining a Geographic Information System (GIS) to integrate data related to climate change.

The Platform of Academics on Climate Change was set up at the University of Malta precisely to support government in this area and to consolidate the existing knowledge base and enhance academic expertise and research on climate change adaptation. The Platform has representatives from all faculties, institutes and centres of the University of Malta and also encompasses a Pan European Forum of Legal Experts on Adaptation to Climate Change. The University of Malta is committed to become a Centre of Excellence of Climate Change Adaptation with the aim of launching inter disciplinary research at the doctoral and post-doctoral levels on the subject. The first step was the establishment of a highly specialized International Master in Law Programme on Energy, Environment and Climate Change Law. Other Faculties have introduced climate change studies in their *curricula* and in 2013 the Institute for Climate Change and Sustainable Development has assumed also the remit of Climate Change under its mandate with a particular focus on interdisciplinary learning and research on climate change. The aim of the Institute therefore is to supplements the individual faculties, institutes and centres which focus on climate change studies within their respective disciplines. An overview of the intensive drive of the University of Malta to address technical and capacity building gaps via its course programmes at the undergraduate, post graduate and research doctorate levels is provided in Chapter 7.

5.3.1.3 International and regional cooperation for adaptation to climate change

Malta aims also to facilitate cooperation between the EU and Mediterranean states in the compilation of data and study of observation systems to enhance climate change resilience in teh Euro Med region. Cooperation may improve data modelling including emission scenarios and climate change impacts scenarios at a local scale as well as monitoring systems. A regional GIS base may be set up to integrate data related to climate change, and any other data required apart from spatial information[49]. Even within this context the regional adaptation strategy may benefit from EU experience in the implementation of the EU INSPIRE directive[50], which requires that common Implementing Rules[51] are adopted in a number of specific areas (Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting).

The EU and the third party Mediterranean states may enhance mutual cooperation by participating in regional capacity-building programmes. It is also essential to include as a regional legal obligation, the publication of information acquired as a result of research conducted or carried out locally to civil society. The Mediterranean states have a legacy to

[49] This involves the implementation of Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE); OJ L 108, 25.4.2007, pg 1.

[50] Ibid.

[51] These Implementing Rules are adopted as Commission Decisions or Regulations, and are binding in their entirety.

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

5.3.2 Sectoral vulnerability to climate change

5.3.2.1 Water resources

(1) STATE OF PLAY

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

Malta is amongst the world's top ten water scarce countries with only 60 cubic meters of naturally occurring freshwater per capita, if one considers groundwater (this would rise to 120 cubic meters if potentially harvestable rainfall runoff is also taken into consideration). The limited water resource makes the country dependent on desalinated water for around 57% of its potable water production.

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

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

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

- an increase in the mean annual air temperature of about 0.5 °C in 77 years in line with the regional value over the Mediterranean during the last century. The maximum local temperature increased by 1.5 °C, while the minimum decreased by 0.8 °C over the same period. Observed extremes in the maximum and minimum temperatures are typical of desert regions;
- rainfall patterns show a relatively high spatial variability over the Maltese territory and no definite trend in the observed precipitation. Since 1923, there has been little change in rainfall during winter and summer, whereas there has been a decrease of 0.14 mm per year during spring and an increase of 0.8 mm per year during autumn;

- during the rainy season, the number of days per year with thunderstorms has increased by nine since 1950;
- the existence of convective rainfall is corroborated by the positive trend in the daily maximum rainfall between 1923 and 2000, since this type of rainfall is of short duration and often heavy;
- an increase in the daily maximum rainfall is observed notwithstanding the fact that, over a full year, the absolute number of days with rainfall in the range 1-50 mm is decreasing;
- the recorded decrease in the mean annual cloud cover over Malta amounts to –0.3 oktas since 1965;
- the duration of bright sunshine has decreased by an average of 0.6 hours per day since 1923. This decrease is attributed to changes in atmospheric composition, predominantly due to the higher atmospheric loading by suspended particles. The trapping of pollutants and dust in the lower atmosphere is favoured by anti-cyclonic situations that are accompanied by lower level inversions and slack pressure gradients, thereby lacking sufficiently strong air currents that could disperse particles. This would necessarily increase the incidence of haze, especially at low elevations of the sun.

(2) VULNERABILITY OF MALTA'S WATER RESOURCES

Water security has always been a challenging issue for civilization on the Islands. Behavioural trends and tourism over the years have exerted more and more pressure on water consumption and this has led to increased desalination and unsustainable groundwater extraction. By the end of 1980s, 30% of Malta's energy bill was devoted to desalination and although this figure has gone down, the illegal extraction of groundwater has remained to the detriment of this highly vulnerable natural resource. Since becoming a member of the EU in 2004 Malta has strengthened its policy and legal framework regulating water but more remains to be done and since water resources will suffer the highest negative impact as a result of climate change[52], water resource management is ear marked as a priority in order to ensure the resilience of this vulnerable and scarse resource

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

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

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

The Second Communication detailed some of the characteristics of the main aquifers in the islands and the potential impact of climate changes. It is in this context that the potential outcomes that might prevail are to be seen to have the following potential effects on water resources in Malta namely:

a) any lowering in annual rainfall volumes will mean a decreased contribution to volumes of freshwater resources thus consolidating Malta's dependence on desalinated water;
b) variability in inter-annual and intra-annual rainfall will have corresponding effects on demand as well on the amount of water potentially available for recharge;

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

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

The problems that are envisaged to cause water shortages as a result of changes related to climate are identified with respect to lower annual rainfall volumes, high rainfall intensity, increased evapotranspiration and sea water level rise.

(3) ADDRESSING VULNERABILITY OF WATER RESOURCES

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

- A comprehensive national Water Catchment Management Plan which mainstreams climate change adaptation obligations[53];
- A holistic approach to water management, by maintaining the quantity and quality and status of ground water sources, via the introduction of a robust legal framework;
- The treatment of sewage water to provide alternative supply of water for industry and agriculture;
- Maximizing on rain water harvesting;
- An assessment of the relationship and risks between climate change/water resources/food security/public hygiene.

Malta has greatly benefitted from the EU's policy and legal framework on water management, which addresses the management of all water resources, particularly through the Water Framework Directive[54]. Maltese water law establishes "*a framework of action*" for the protection of inland surface waters, transitional waters, coastal waters and ground water. Since climate change in the Malta would not only affect the quantity but also the quality of water resources, Maltese water law aims also to:

- address emissions and discharges that affect water, whether via point or diffuse sources, irrespective from where they originate, such as for example from fertilizers and pesticides in soils
- prevent the deterioration of the status of all the bodies of water which is closely linked to the above and
- implement the measures necessary to reverse any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity in order to reduce progressively water pollution.

As discussed above, desalination of sea water and extraction of groundwater are the only two sources of fresh water in Malta. Desalination is a costly and energy intensive process, so the need to address adequate management of groundwater already an over-exploited resource,

[53] https://www.mepa.org.mt/topic-wcmp.

[54] Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy; OJ L 327, 22.12,2000, pg 1.

becomes even more crucial for adaptation in the water sector. The primary drivers of the national water policy and legal framework that supports it, are the curbing of illegal extraction of groundwater, the improvement of rain harvesting methods and the provision of an alterative source of water to facilitate compliance with controls in groundwater abstraction. The competent authorities, namely the Malta Resources Authority and the Environment Directorate of the Malta Environment and Planning Authority are working upon a *programme of measures*, for each water catchment district which shall include a number of *basic measures* and also where necessary, *supplementary measures*. *Basic measures* are the minimum requirements with which to comply. One of the basic measures is the establishment of controls including a requirement for prior authorization of the artificial recharge or augmentation of groundwater bodies. *Supplementary measures* are those measures designed and implemented in addition to the basic measures.

The Malta Resources Authority, as the regulator for water management, has embarked on a programme to install meters on boreholes as a first step to monitor ground water extraction from the private sector. In the coming years, the Government will continue to implement incentives schemes directed at the farming and livestock breeding sector to construct or rehabilitate existing reservoirs to capture rainwater for irrigation and other appropriate uses, to use water more efficiently as well as to use the best-available irrigation technologies. Similarly the Government will introduce incentive schemes directed at commercial and industrial entities to assist them to build reservoirs and other rainwater catchment measures; to re-use captured water; and to recycle grey water for non-potable purposes as well as to introduce efficient water use technologies. Additionally, the Government will introduce incentive schemes directed towards domestic households for better rain water catchment practices and water saving techniques.

Coupled with the incentives referred to above, the government is evaluating the appropriate incentives to encourage the agricultural, industrial, commercial, and domestic sectors to use sewage treatment effluent within pre-defined guidelines instead of using groundwater. The Government will carry out the appropriate studies to assess whether through the introduction of facilities for the distribution and supply of quality treated effluent, the government should seek to achieve the following targets (MRRA, 2010):

- provide 5 million m^3/year by 2015 as a replacement of groundwater used for agriculture, commercial, and industrial need;
- provide 10 million m^3/year from 2016 to 2020 as a replacement of groundwater used for agriculture, commercial, and industrial need;
- provide 15 million m^3/year from 2021 to 2030 as a replacement of groundwater used for agriculture, commercial and industrial need.
- replace groundwater demand by 2 million m^3/year by 2020;
- replace groundwater demand by 3 million m^3/year from 2021 to 2030.

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

5.3.2.2 Infrastructure and land use.

(1) STATE OF PLAY

As a densely populated island nation of around 1,400 persons per square kilometre, infrastructure and land use requirements have long been considered as a major competing force against the conservation of natural habitats and eco systems. Development Planning policies and laws have curbed urban sprawl to some extent but the need for better infrastructure for new development projects whether demanded by socio economic needs or the leisure industry remain subject to a highly polarized debate. As Maltese society becomes more affluent, developers and the government are investing more and more money in state of the art land use and infrastructural projects. The most predominant effects of climate change such as sea level rise, changes in temperature, extreme weather events will have strong negative impact upon the built environment, buildings and infrastructure.

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

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

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

(A) LAND COVER AND LAND USE IN MALTA

The National Statistics Office published the latest report on land use in Malta for 2006 (Table 5-8).

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

The major changes in land cover were experienced prior to the introduction of formal planning in the early 90s. Following the setting up of a planning authority the loss of agricultural/naturally vegetated areas to buildings slowed down. However the current planning system lacks a holistic strategy and is largely based on *ad hoc* decisions on single developments, taking its toll on the land, with further substantial losses being reported (Mallia, et al., 2002).

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

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

Table 5-8 Land use in Malta (2006). (NSO, 2011)

Description	Km²	% of total area
Agriculture with significant area of natural vegetation	149.93	47.5
Airports	3.72	1.2
Complex cultivation patterns	10.71	3.4
Coniferous forest	0.67	0.2
Built-up area	70.39	22.3
Dump sites	0.41	0.1
Green urban areas	1.81	0.6
Industrial or commercial units	8.11	2.6
Mineral extraction sites	3.86	1.2
Mixed forest	1.43	0.5
Non-irrigated arable land	0.59	0.2
Port areas	2.32	0.7
Salines	0.25	0.1
Sclerophyllous vegetation	49.69	15.8
Sparsely vegetated areas	8.11	2.6
Sport and leisure facilities	3.09	1.0
Vineyards	0.27	0.1
Total	**315.35**	**100.0**

(B) THE INFRASTRUCTURE IN MALTA

Specific infrastructure identified in the Second Communication, have also been assessed for their vulnerability. Within this coastal zone lie also some of the most important infrastructures for Malta. In the case of energy, the islands are dependent on an isolated national grid with all the electricity requirements generated locally in two power plants, one in Marsa, located within the Grand Harbour and the other in Delimara, located within Marsaxlokk Bay (in the south of the island).

The current Government is considering plans for a shift from fuel oil to gas. This will be achieved through the building of a new power station and gas facilities, as well as the interconnector with Sicily which would end the isolation of Malta's energy grid.

Fuel storage is carried out at the following installations:

- 31st March 1979 at Birzebbugia;
- Wied Dalam Depot ;
- Has-Saptan underground installation;
- Ras Hanzir underground installation; and
- Aviation fuel installation at the Malta International Airport.

Malta has over 2,000km of road, mostly built to supply the growing demand for private mobility, experienced during the 1990s and early 2000s. This policy has also encouraged significant use of the car, to the detriment of public transport infrastructures which have lost patronage and continue to struggle and compete for road space with increasing congestion. Some of the major link roads in the network have been constructed in low lying areas (valleys) which are naturally prone to flooding and will be impacted by sea level rise. The increase in the number of surfaced roads (and therefore run-off following rain) compound the flooding problem by removing any absorption ability of the ground during rain events. Msida, Birkirkara, Balzan and

Qormi are some examples of areas which will require considerable investment to remove the flooding threat.

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

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

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

These infrastructures play an important role for the future development of the island. To date however, very little in terms of studies have been carried out to assess the impact of climate change and sea level rise.

The Second Communication also reported on the rapid developments in the telecommunication sectors in the islands. The mobile phone operators alone have over 400 base stations. In addition to these there are public land mobile antennas, microwave links, TV repeaters and over 200,000 landlines. Internet technology is mainly through ADSL and Wireless LAN, with Government providing free WIFI some public areas, and more recently a mobile phone operator launching WIFI services for its users across the islands. Television and radio stations use fixed radio links from relay stations and hybrid fibre/coaxial cable.

Malta's waste is managed through WasteServ a company set up for the purpose of promoting and facilitating waste management. The infrastructure includes an engineered landfill, a waste treatment plant, a thermal treatment facility, over 400 bring-in sites and five civic amenity centres. Sewage treatment plants are located both in Malta and Gozo.

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

Malta is blessed with a relatively large built heritage which includes amongst other three UNESCO World Heritage Sites (Valletta, Ħal Saflieni Hypogeum and six megalithic temples). These require costly and constant protection and maintenance. A recent project to protect the megalithic temples has been the construction of temporary protective shelters, funded through ERDF (2004-2006), which will reduce the impact of weather conditions on the vulnerability of the stone[55].

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

(A) *CLIMATE CHANGE IMPACTS ON LAND*

[55] http://ec.europa.eu/regional_policy/projects/stories/details_new.cfm?pay=MT&the=79&sto=1735&lan=7&region=ALL&obj=ALL&per=2&defL=EN.

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

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

The Second Communication identified a number of vulnerabilities associated with sea level rise, particularly related to coastal development, but also to protected areas, ports, infrastructures and roads. The most obvious ones are summarized in Table 5-9.

Table 5-9 Summary of land use vulnerability from climate change. (adapted from (MRRA, 2010))

Land use vulnerability
Low lying transport infrastructure in the North of Malta.
Any land reclamation projects near the coast which the Government is currently considering.
Low lying coastal areas that have been modified over the years through development on the coast, and which will be prone mostly to storm surges.
A total land area of 1.11 Km^2 or 0.36% of the land area will be affected by sea level rise.
Beaches will be particularly affected as they might be obliterated, reduced in size or, in the case of new beaches, replenishment will be very costly.
Increased rain intensity leading to more flooding in some urban areas, with some needing to eventually relocate to alleviate the problem.
Loss of soil and nutrients for agriculture from intense rain events.
Longer drought periods can lead to desertification, in particular the areas under dryland production.
Increase in wind gusting intensity will also affect the increasingly tall buildings which are being constructed mostly near the coast.
Extreme weather events, including the incidences of heavy hailstorms and thunderstorms will affect road surfaces, rubble walls (for the retention of soil in fields), retaining walls and power lines.
These impacts on agriculture, buildings and infrastructure will have a secondary impact on property values and insurance.

Coastal zone density was studied by the Malta Environment and Planning Authority in 2005 and showed an increased density of 5 to 26% between 1990 and 2004. The developments were mainly tourism and recreation (Figure 5-36).

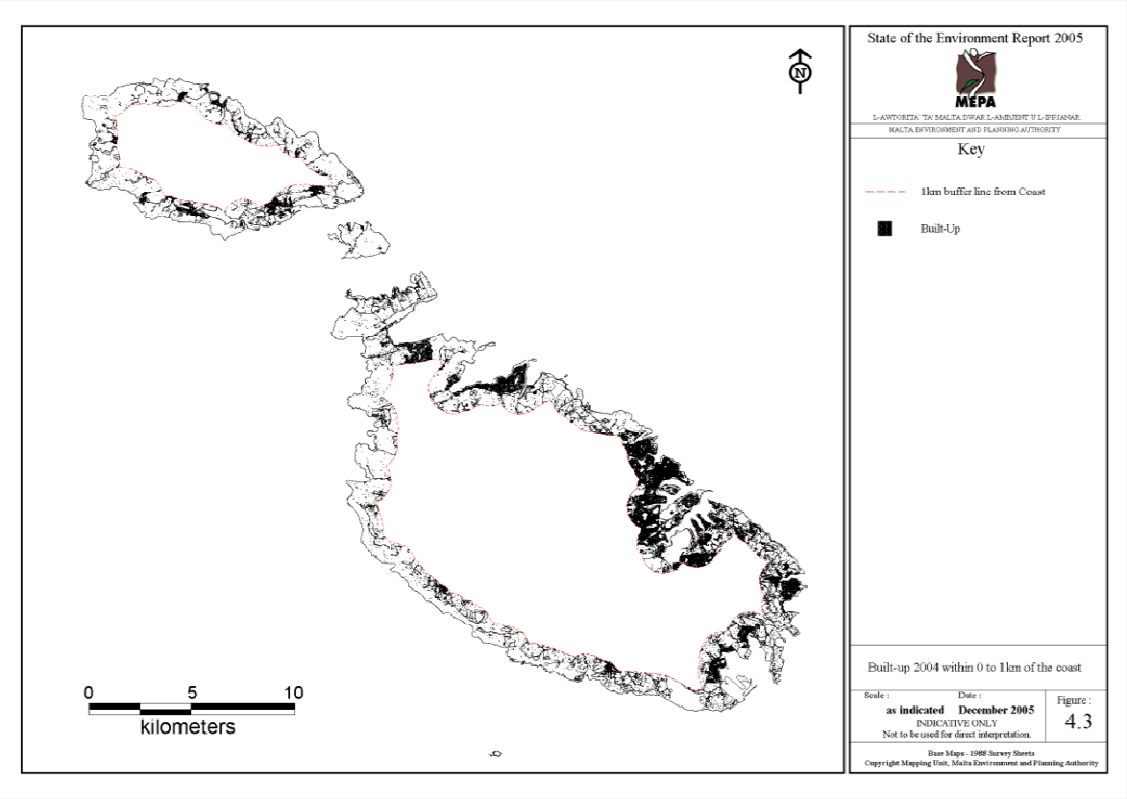


Figure 5-36 Built-up areas within 0 to 1km of the coast (2004). (MEPA, 2006)

(B) *CLIMATE CHANGE IMPACTS ON THE INFRASTRUCTURE*

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

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

An analysis of the electricity generation over the past decade shows an overall increase in demand for electricity (Figure 5-37) with a particular dip in the power generation over the period 2009 and 2011. Electricity generation escalated again in 2012. Seasonality (Figure 5-38) reflects the peak use of electricity in summer during the hot months, for the use of air conditioning. It is most likely that these peaks will increase. Most of the electricity (70%) goes into heating and cooling of buildings, showing to a certain extent the inefficiency of our buildings to retain ambient temperatures.

Any damage to electricity infrastructures, particularly during heat events will negatively affect the vulnerable groups who are least able to cope with heat stress.

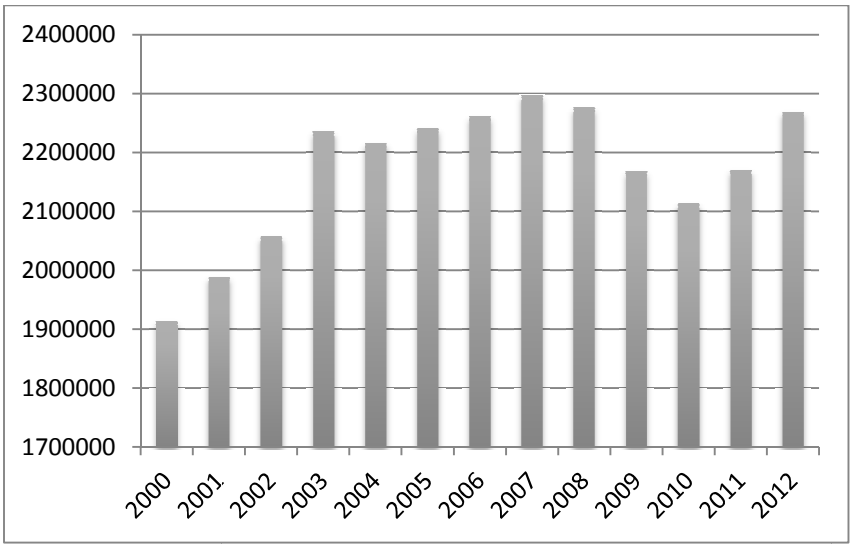


Figure 5-37 Annual electricity generation (MWh) between 2000 and 2012. (NSO, 2013b)

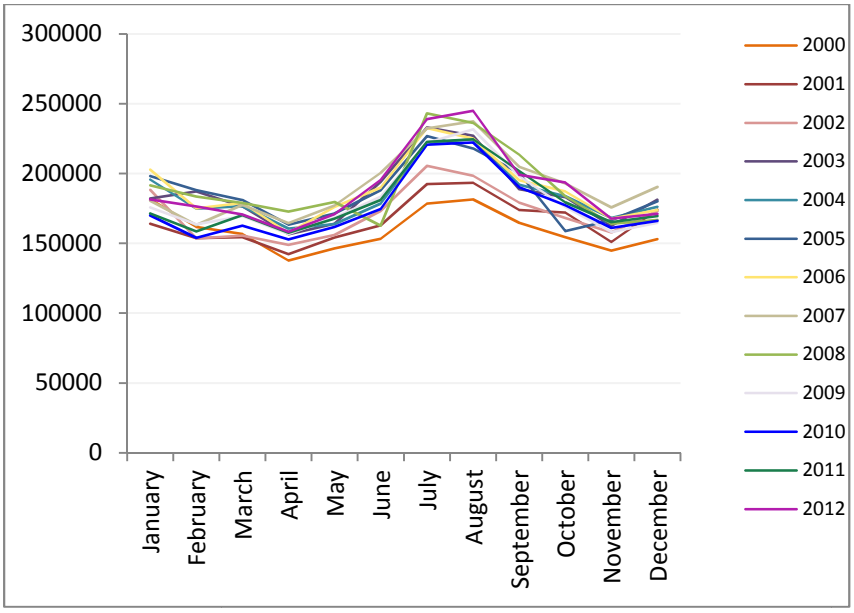


Figure 5-38 Electrical power generation by month for 2000 to 2012. (NSO, 2013b)

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

Transport nodes and links, such as ports, airports, bus interchanges and stops and roads are impacted by weather events which may lead to closure, but also damage over time. The low-lying links in the road network, situated close to the coast are vulnerable to flood damage and inundation. This is particularly critical for the islands TEN-T Network (Figure 5-39).

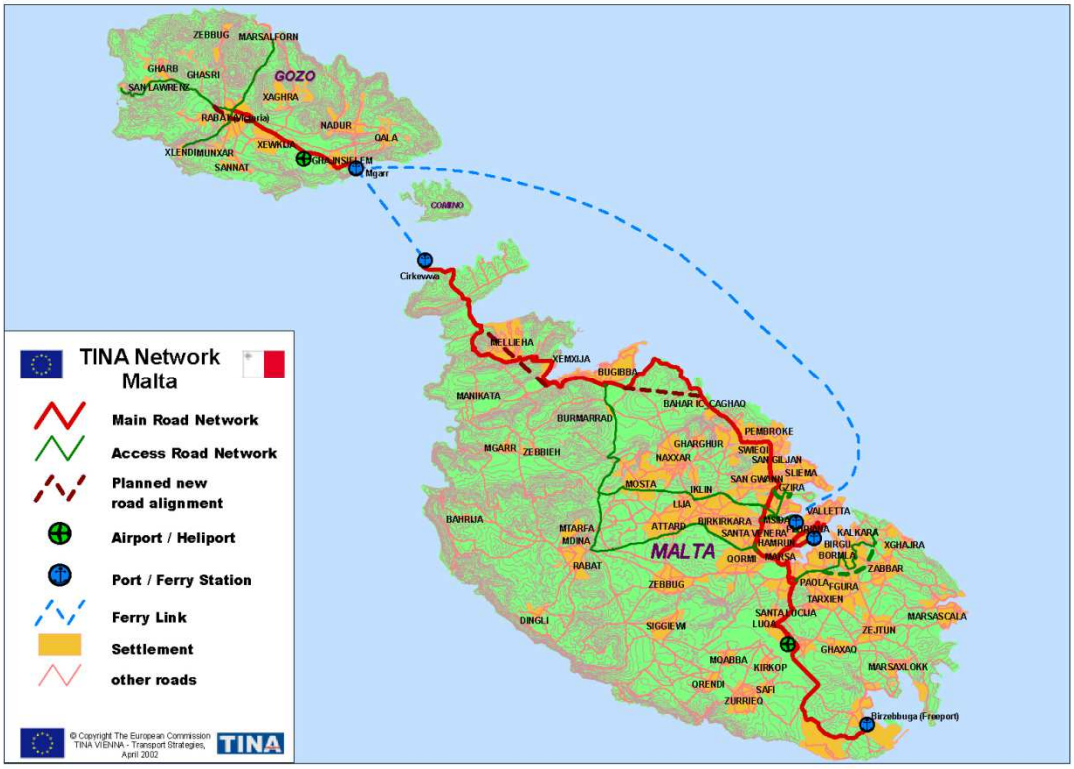


Figure 5-39 Malta TEN-T Network as identified in the TINA study. (TINA Vienna, 2002)

Excess heat causes also damage to infrastructure, such as thermal expansion on road surface, airport tarmac and concrete structure along the transport network. As reported in the Second Communication this impact will shorten the life of infrastructure, increasing cost and potential structural failure during extreme events.

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

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

(3) ADDRESSING VULNERABILITY OF THE INFRASTRUCTURE AND LAND USE

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

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

- Assessing if water courses and coast lines are at risk from flooding;
- Mapping the flood extent and assets and humans at risk in these areas;
- Taking adequate and coordinated measures to reduce this flood risk;
- Reinforcing the rights of the public to access this information and to have a say in the planning process;.
- Carrying out a preliminary assessment to identify the "*river basins*[56]" and associated coastal areas at risk of flooding;
- Drawing up flood risk maps;
- Establishing flood risk management plans focused on prevention, protection and preparedness, notably by flood risk management plans and river basin management plans being coordinated;
- Synergizing public participation procedures in the preparation of these plans making them available to public.

The Malta Environment and Planning Authority is implementing the regulatory framework referred to above relating to the maintenance and preservation of valleys via a thorough review of the status of existing storm water reservoirs, soak ways, and dams. The conservation of valleys will help control flooding and act as a natural reservoir allowing the captured water to sink into the aquifer. This process is part of the implementation of the National Flood Relief Plan by the projected 2015 target date. The flood relief infrastructure is being examined for feasibility for rain water harvesting. The design or refurbishment of roads or road landscaping will aim at integrating reservoirs to act as water catchment areas to cushion flooding, as well as allow for the seepage of such water into the aquifer. The intention is to increase the number of existing soak ways along the road infrastructure to divide the catchment area into manageable smaller catchment areas which allow for recharge of the aquifer. The results of these project appraisals, will enable the authorities to select the most suited options to develop and enhance malta's infrastructural needs, with the required value-added to adapt to the adverse impacts of climate change. The government shall continue to carry out studies between 2014-2021 and 2022-2029 to assess the technical, environmental and financial viability of a wide range of alternatives for enlarging existing rain harvesting infrastructure, as well as for enhancing the potential of reuse through the existing infrastructure.

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

Furthermore MEPA is taking action to prevent the further extension of the urban sprawl and to preserve valleys and natural habitats from development. The University of Malta, particularly through the Faculty for the Built Environment has also embarked on research project for

[56] River basins include areas where water collects and eventually drains to the sea.

sustainable living. This involves research in improving the quality of design, and life, in urban areas, both by providing quality green (and not just) open areas as well as providing quality amenities and facilities required by young families and the elderly in particular.

5.3.3 Natural ecosystems, agriculture and fisheries

(1) STATE OF PLAY

(A) *TERRESTRIAL AND MARINE ECOSYSTEMS*

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

The impacts on the marine ecosystem on the hand include changes in faunal and floral diversity, spread of alien species, epidemiological outbreaks, changes in hydrodynamics and water circulation, coastal erosion and loss of habitat. The most important resource in the Mediterranean Sea, the *Posidonia oceanica* is particularly vulnerable to these impacts.

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

(i) *Terrestrial Ecosystems:* Malta is home to some 1,000 different species. Schembri et al. (1999[57]) grouped Malta's terrestrial habitats into three categories:
- Steppic communities, garrigue, maquis and Mediterranean sclerophyllous woodland;
- Saline marshlands, sand dunes, transitional coastal wetlands and coastal fringe;
- Communities of disturbed grounds and afforested areas.

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

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

Already many species have been identified as under threat or are in decline. This is due mostly to development in the rural and marine areas, the introduction of alien species, polluting discharge and the exploitation of wildlife.

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

As discussed above the competition between landuse for anthropogenic needs and the conservation of natural habitats has left an indelible mark on the Maltese natural landscape and ecosystems. The agricultural and fisheries sector have also significant impacts upon the terrestrial and marine environment. More recently, the formulation of management plans for natural ecosystems which incorporate even agricultural use as well as integrated marine spatial planning that involves also the fisheries sector, has drawn the previously polarised factions closer together. Adaptation to climate change provides a unique opportunity for these once rival sectors to work in unison to facilitate resilience to climate change both in natural ecosystems and agro and fisheries sectors.

(B) *FISHERIES AND AQUACULTURE*

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

(i) *Marine Capture Fisheries:* It is evident from Table 5-10, that landings from marine capture fisheries in Malta are dominated by tuna, lampuki (dolphin fish) and swordfish. There are of course seasonal differences for each species. Whilst the landings for lampuki occur mainly between August and December, the landings for swordfish occur throughout the year with the peak fishing period between May and August. Other landings such as shrimp originate exclusively from trawling which takes place throughout the year with quantities decreasing during winter months due to unfavourable weather.

Table 5-10 Fish Landings (in kg) by key species. (adapted from news releases on fish landings published by NSO between 2008 and 2014)

Species	2007	2008	2009	2010	2011	2012	2013
Dolphin Fish	264,269	245,316	332,435	429,610	193,963	136,593	274,612
Blue-fin Tuna	123,814	142,246	185,480	130,933	81,207	120,844	80,321
Swordfish	213,487	261,024	236,884	330,997	416,562	228,506	338,152
Shrimp	32,076	31,203	37,823	44,080	41,796	32,812	9,900
Stone Bass	15,557	14,279	9,125	15,320	9,427	11,311	9,514
Dog Fish	29,205	25,703	19,469	26,120	26,977	38,259	25,145
Bogue	22,069	15,075	11,733	12,633	22,926	21,124	16,608

(ii) *Aquaculture:* Since the late 1980s the aquaculture industry has operated in the islands focusing efforts on finfish (Sea Bass and Sea Bream) in offshore cages and subsequently Tuna through penning. Much of the fish is exported to European and Asian markets. Table 5-11 shows the Aquaculture Annual Production for the years 2007-2012.

Table 5-11 Aquaculture Annual Production (in kg) 2007-2012. (adapted from news releases on aquaculture published by NSO)

Species	2007	2008	2009	2010	2011	2012
Tuna	6,813,000	5,039,000	3,441,000	4,955,000	1,759,000	3,904,000
Sea Bass	75,000	97,000	93,000	102,000	54,000	126,000
Sea Bream	1,097,000	1,574,000	1,984,000	175,000	2,159,000	2,604,000
Other	604,000	21,000	101,000	69,000	100,000	806,000

(C) *AGRICULTURE*

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

Agricultural holdings increased by an additional 1,542 between 2007 and 2010. The major increase was in the number of holdings of less than 1ha (Figure 5-40). There was also an increase in the hectares of utilised agricultural area, following a decline during the period 2003-2007 (Figure 5-41). It is also evident that the growth of particular crops changes from year to year.

In 2010 there were a total of 18,539 employed in the agricultural sector. This sector was dominated by men (79%) and mostly employed as part-time farmers (93%). The Second Communication reported urbanization as the major threat to agricultural land, as well as other issues such as abandonment of agricultural land, farm intensification, and fragmentation of land ownership. Of direct relevance to climate change impacts are factors that could lead to further land abandonment. Any assessment of climate change impacts need to take into account the socio-economic background to the sector.

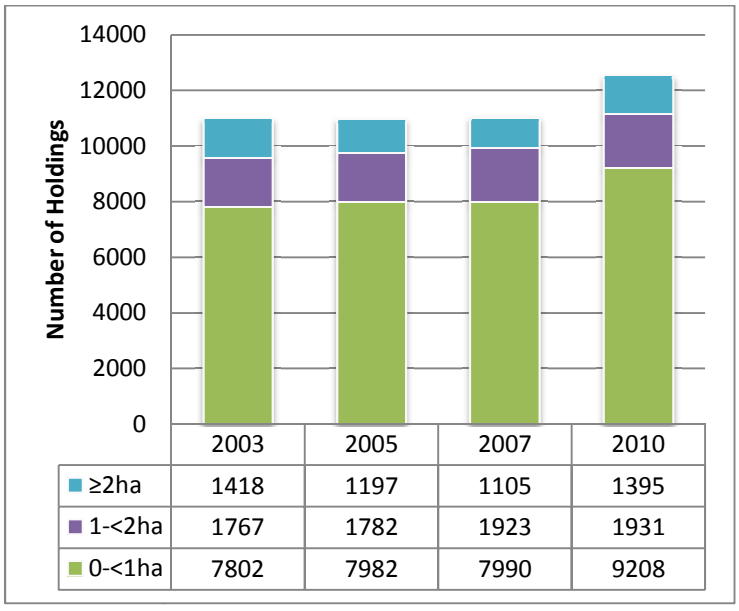
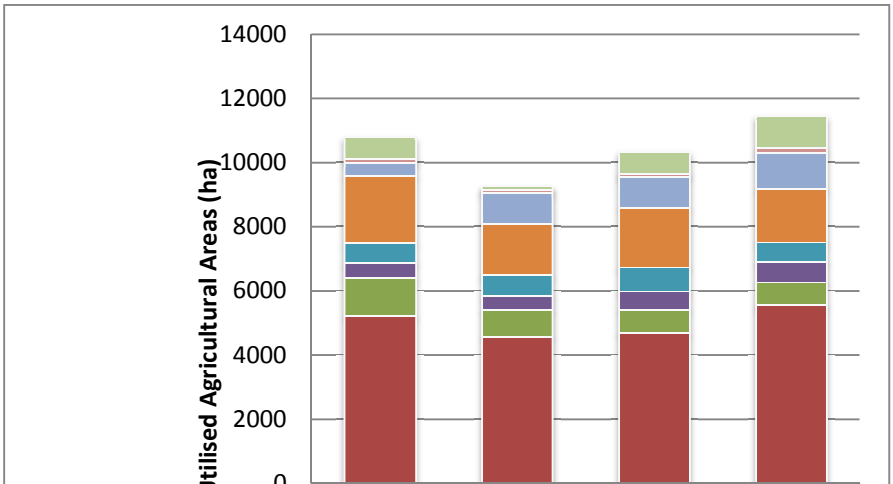


Figure 5-40 Number of agricultural holdings by size for 2003 to 2010. (NSO, 2012)



	2003	2005	2007	2010
Fallow Land	696	115	676	1007
Other Areas	107	93	89	157
Kitchen Gardens	423	968	987	1123
Market Gardening	2083	1594	1851	1661
Vineyards	615	661	751	614
Permanent Cropping excl. Vineyards	465	429	570	637
Potatoes	1207	820	712	701
Forage	5197	4574	4690	5553

Figure 5-41 Size of utilizable agricultural area by type of crop for 2003 to 2010. (NSO, 2012)

(2) VULNERABILITY OF NATURAL ECOSYSTEMS, AGRICULTURE AND FISHERIES

(A) *NATURAL ECOSYSTEMS*

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

The Second Communication reported some impacts which are summarized below in Table 5-12.

Table 5-12 Climate change impacts and vulnerability for terrestrial and marine ecosystems. (adapted from (MRRA, 2010)).

Terrestrial Ecosystems	**Loss of biodiversity and increased risk of extinction** - Studies in Europe and about the Mediterranean project a 30-40% extinction risk for species beyond 2050 if unable to disperse, and as a result of climate change (Thomas, et al., 2004). - Species populations in Malta are already small which could push many taxa to extinction. - All terrestrial flora and fauna are considered vulnerable to climate change. **Shift in the distribution of species** - Changes in temperature, precipitation and sea level will affect ecosystem boundaries. - Climate change might also affect habitat. - All terrestrial flora and fauna will be affected by distributional shifts. **Sea level rise** - Inundation of low-lying areas can obliterate habitats, push migration inland (where this is possible), and increase salinization which in turn will affect the sea-level aquifer and will favour halophytic vegetation. - Coastal areas are most vulnerable habitats, including some already protected sites such as Natura 2000 sites, Special Areas of Conservation and Specially Protected Areas[58]. A full list of vulnerable habitats was produced for the Second Communication. **Temperature increase** - Temperature increases will favour species with a higher affinity to subtropical climates. - Warming and drying is most likely to induce species-range shifts, with migration rates exceeding the capacity of many endemic species to do so. - Higher temperatures are predicted to decrease species richness in freshwater ecosystem across SW Europe. Some spread of pests and disease causing organisms can also occur. - Warming will impact phenology (timing of seasonal activities). - Water availability will change as temperatures rise and increasing the demand for water. - Desertification and fires will severely impact terrestrial ecosystems. **Decrease in precipitation** - Water availability will reduce due to a decrease in rainfall, leading to a loss of hydrophilic species and increase in soil salinity. - Droughts will occur. - Potential sea water contamination of the groundwater from over abstraction, affecting also the populations of migratory birds residing in inland wetlands. **Effects of CO_2 emissions** - A fertilization effect causing greening of the Mediterranean.

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

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

(B) *FISHERIES AND AQUACULTURE*

The climate trends described earlier and the uncertainties over their impacts expose the fisheries sector to a high risk of collapse. Climate change impacts have a direct and indirect effect on fish stocks (Brander, 2007) as stated earlier in the section on marine ecosystems. The Second Communication already made reference to the trend in Maltese waters for both subtropical Atlantic species and Lessepsian immigrants to increase their occurrence with time, although this may be due to other reasons apart from a general warming of the sea.

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

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

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

(C) *AGRICULTURE*

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

No studies exist on the quantification of impacts of climate change in the agricultural sector in Malta, and similar to the Second Communication much of the conclusions presented in this section are drawn from findings in other European and Mediterranean countries. This report confirms the original findings and supports the conclusion that issues identified above will be further exacerbated in the future. These include:

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

Table 5-13 reports on the impacts expected on important components within agriculture in the islands.

Table 5-13 The impacts expected on important components within agriculture in Malta. (adapted from (MRRA, 2010)).

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

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

Adaptation measures addressing natural ecosystems are very challenging to devise. The vulnerability of biodiversity and the negative impact which various human activities have upon natural habitats will only be further exacerbated as a result of climate change. Unfortunately however the species may be unable to adapt to change so quickly so the best way to address adaptation measures in this context is to strengthen legal and policy measures aimed at the conservation of species and their habitat in order to ensure resilience in this sector. The

discussion under the previous section has identified how the authorities aim to protect natural habitats even by curbing further development outside urban areas.

Closely linked to this issue is the better management and the sustainable exploitation of natural resources by the farming and fishing communities. Adaptation measures by farmers and fishermen would also lead to better resilience for natural ecosystems since they would be strengthening the conditions for a favourable conservation status. An intensive revision of existing laws and policies in the coming years aims to promote soil conservation to identify the action needed to ensure a high level of soil protection[59]. The conservation of soils is an obligation Malta has even within the context of the United Nations Convention on Desertification which requires it to adopt certain conservation measures with respect to soils against the negative impacts of climate change. Adaptation measures for Malta under the agricultural and fisheries sector include also the assessment of various veterinary laws, plant health laws, fisheries and agriculture related laws to assist this sector to adapt to climate change. As agriculture is one of the sectors that is likely to register severe impacts, the revision of applicable national laws would identify the most adequate policy and legal instruments that can be used to prepare this sector for adaptation and if considered necessary, supplement it with new laws, policies and plans. The same applies to fisheries, where the affects of climate change upon migratory fishing patterns is relatively unknown. A cost benefit exercise will be carried out to assess socio economic impacts which climate change would have upon these vulnerable sectors.

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

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

As another adaptation measure the agricultural sector is also intending to promote research in liaison with the University of Malta on how:

- climate change affects Maltese agriculture;
- agriculture can suitably adapt to these effects;
- to design and introduce specific indicators for Maltese agriculture, such as an index for adaptive capacity and vulnerability;
- to study how local breeds and crop varieties together with new species and hybrids could play an important role in agricultural adaptation;
- To involve stakeholder dialogue re the above bullet points.

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

5.3.4 Health issues, civil protection and immigration.

(1) STATE OF PLAY

Malta enjoys very high health standards not least because of its benevolent climate. Extreme high summer temperatures accompanied by months of dry weather or freak heavy rainfall demonstrate various effects upon human, plant and animal health, food hygene and mortality rates especially amongst the elderly. Furthermore illegal and unregulated migration from third states, which Malta is constantly subjected to, is already sometimes caused by food and water security issues in States already afflicted by drought and conflict over access to natural resources. The situation is most likely to exacerbate as a result of climate change

(A) *HEALTH AND CIVIL PROTECTION*

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

A recent study (Akerlof, et al., 2010) included amongst others the Maltese perception of impacts of climate change on health (Figure 5-42). The study provided an insight into better engagement with individuals about the issues of climate change and has provided for the first time an insight into the perceived relationship between climate change and human health in Malta.

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

The commonest causes of death in the islands reported in the 2012 are presented in Figure 5-43. There were 1,596 deaths due to diseases of the circulatory system, an increase of 133 deaths from the year 2011. Diseases of the circulatory system were the leading cause of death and appear to be accounting for an increasingly larger proportion of the total number of deaths (46.7% of all deaths in 2012 vs. 44.8% in 2011).

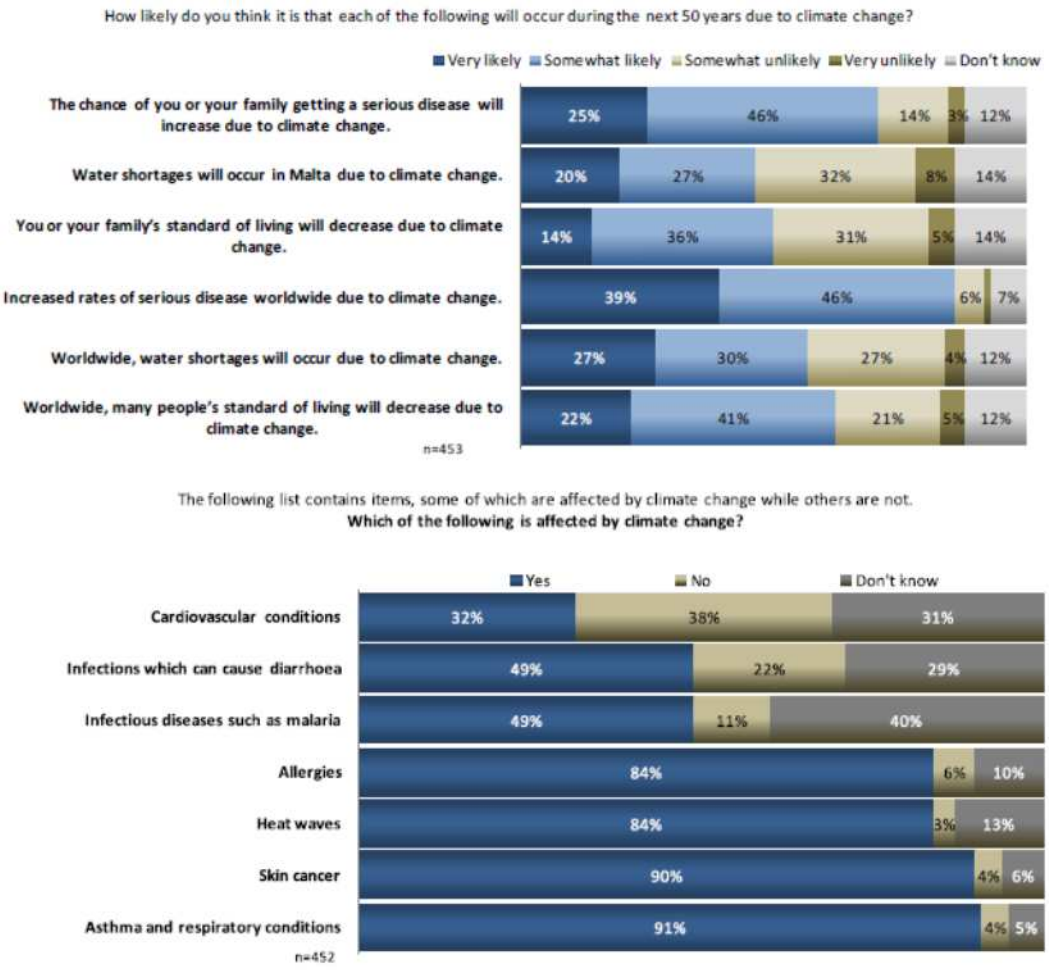


Figure 5-42 Maltese perceptions of likelihood of health risks resulting from climate change. (Akerlof, et al., 2010)

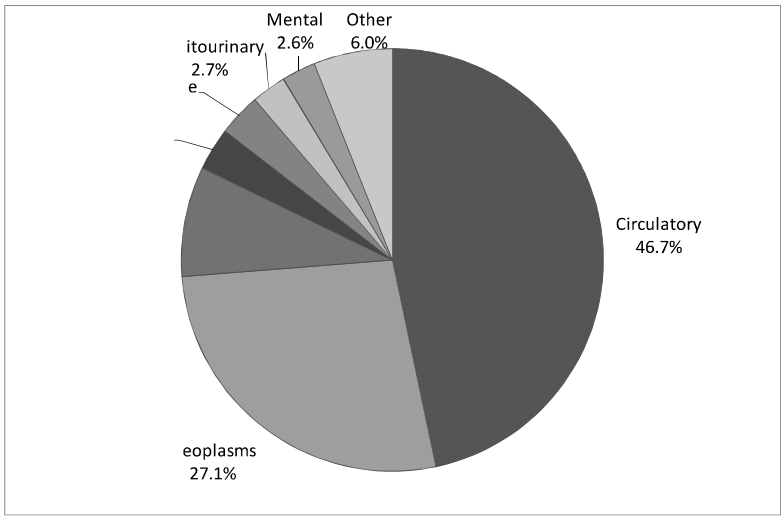


Figure 5-43 Commonest causes of death using broad categories. (DHIR, 2013)

(B) *MIGRATION*

Located at the centre of the Mediterranean, the Maltese Islands have always attracted migrants and settlers from various parts of the Sea and beyond. The nature and character of Mediterranean migration changed dramatically in the last century, mainly due to changes in the broader political and economic context of the region (de Haas, 2011). Southern Europe, in particular has played a pivotal role in reshaping migration flows as it joined the European Union and changed from a region of mass emigration (to the North) to one of mass immigration especially since the 90s, with illegal immigrants from sub-Saharan Africa and Asia (Fonseca, 2001).

The overall foreign population in the islands has increased from 2% to 5% in the 26 year span between 1985 and 2011, when compared to the national population enumeration (Table 5-14) The actual immigrant population increased four-fold during the same period, increasing faster following Malta's accession to the EU.

Table 5-14 Percentage distribution of Maltese and immigrant population by age-groups (1985 to 2011). (Schembri, et al., 2013)

	1985		1995		2005		2011	
	Maltese	Foreign	Maltese	Foreign	Maltese	Foreign	Maltese	Foreign
0-14	24.1%	17.7%	21.9%	11.7%	17.2%	10.9%	14.8%	10.4%
15-64	66.0%	61.9%	66.7%	75.2%	69.1%	76.7%	68.9%	76.1%
65+	9.9%	18.4%	11.4%	13.1%	13.7%	12.4%	16.3%	13.2%
Total	345,418	4,798	378,132	7,213	404,962	12,112	416,055	20,084

A marked socio-economic and cultural contrast is identified with respect to boat people when compared to that of the Maltese returned migrants or the expatriates. Figure 5-44 reports the number of boats arriving in Malta between 2002-2012 carrying illegal immigrants to Malta. The substantial decline in the number of landings in 2010 is mainly attributed to the economic crisis in Europe but also to the initiatives set in place by Frontex, particularly in the central Mediterranean, with collaboration and joint patrols between Italy and Libya in 2009 ((Anon., 2010); (Frontex , 2010)).

The procedures to protect the irregular immigrants in Malta, although heavily criticized by the European Union's watchdog administrators, are in place and generally follow established lines. Following rescue, boat people are taken into custody at the police headquarters for administrative, medical and other matters. They are then placed in either closed or open centres, mostly located in the south of the island, depending on their statues of refugees or otherwise.

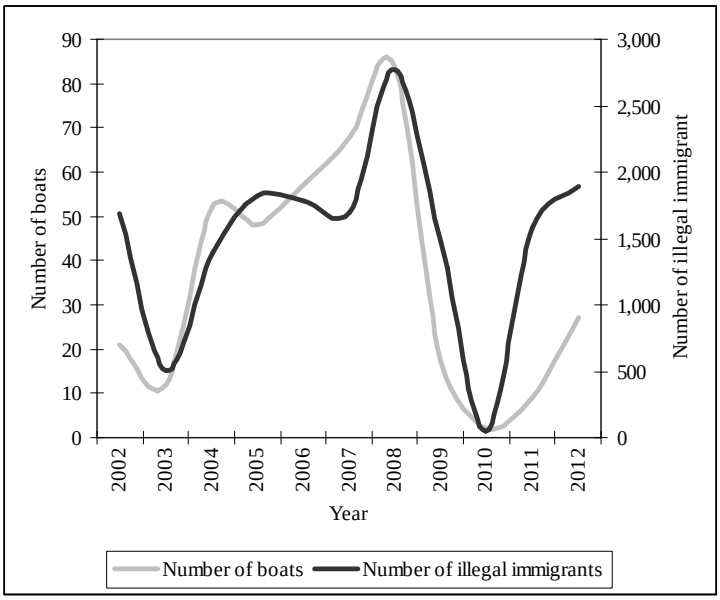


Figure 5-44 Number of boats and illegal immigrants arriving in Malta 2002-2012. (Schembri, et al., 2013)

(2) VULNERABILITY ON HEALTH, CIVIL PROTECTION AND MIGRATION

(A) *HEALTH AND CIVIL PROTECTION*

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

Malta's population projections point towards an increase in the number of elderly people (Figure 5-45). An ageing population becomes vulnerable to climate changes with higher exposure to system collapse particularly the stress of increased cases for beds in the current health care system.

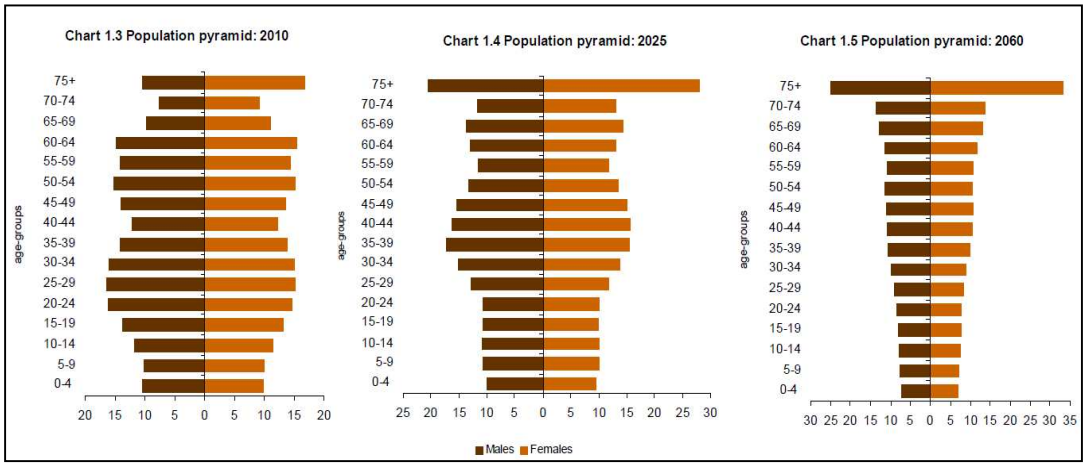


Figure 5-45 Population projections for Malta 2010-2060. (NSO, 2012)

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

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

The Second Communication stated that the impact of climate change on vector-borne diseases is uncertain and each vector would be affected in a different way. Studies have already been conducted on the introduction of new species of mosquitos (e.g. Asian Tiger mosquito) but further investigation will be required to determine their impact in various climate change scenarios.

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

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

Children remain particularly vulnerable and are sensitive to changes, not only in temperature but also in air quality, affecting amongst other functions the pulmonary functions of the young. The ISAAC study looked at the distribution of wheezing children in Malta between 1994 and 2002 and found already that the prevalence of wheezing in the 5-8 year old age group increased between the period 1994 and 2002 (Fsadni, et al., 2012). Further investigation into the causes and the possible impact from climate changes would be required to assess the vulnerability of these young children.

(B) *MIGRATION*

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

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

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

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

possible. The Health Authorities will assess and determine the local entomological expertise required for the relevant identification and mapping of distribution of vectors that carry disease and to take appropriate measures to address arising gaps.

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

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

- address the negative impacts envisaged as a result of climate change particularly upon vulnerable groups;
- assess socio-economic implications, which increased insurance covers for risks resulting from the likely impacts of climate change;
- identify financial guarantees and incentives amongst the various stakeholders in all sectors;
- intensify awareness and promote a change in behavioural patterns to improve adaptation to climate change;
- increase awareness of climate change impacts within the government, industry, and community sectors will support cultural change transitions that are required for the adoption of more climate change friendly technologies, designs, and operations by public and private operators;
- Carry out further research with the support of multilateral and regioanl institutions on the effects which climate change will have upon irregular migration.

5.3.5 Tourism

(1) STATE OF PLAY

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

(2) VULNERABILITY OF TOURISM SECTOR

The impacts of climate change upon tourism are largely unknown and still subject to rudimentary research that needs to be intensified to ensure the sectors resilience. Furthermore the tourism

sector is likely to find niche opportunities that may arise due to more favourable climatic conditions in what are now considered to be the low season months.

(3) ADDRESSING VULNERABILITY IN THE TOURISM SECTOR

The sector has, under the direction of the Malta Tourism Authority, the Malta Hotels and Retailers Association, and other stakeholders, commenced a detailed and comprehensive analysis of international and local data with regards to the impact of climate change on the Southern Mediterranean in general, and on Malta specifically. The study will identify the macro as well as micro impacts on the tourism industry in Malta.

The study will focus on other sectors that will suffer from negative impacts of climate change namely:

- how water scarcity will affect the tourism industry in general, and micro segments of the tourism industry specifically, such as for example, agro- and eco-tourism;
- the impact of winter and summer energy and power demand of hotels and other tourist establishments as a result of anticipated climate changes;
- a comprehensive analysis of the impact of the anticipated climate changes on energy, water, and road infrastructure;
- on the historical heritage;
- on the landscape and on the rural environment;
- the actual physical cost of repair arising from damages to the infrastructure; the actual and opportunity cost this may have on the tourism services sector; and present specific adaptation measures in this regard.

In carrying out this study the Malta Tourism Authority should have the support of the University of Malta through research studies undertaken by under-graduates, postgraduate and doctoral students. The study aims to assess how climate change will impact upon the competitiveness of the tourism industry in Malta and which are the best adaptation options required to counter climate change effects and retain Malta as an attractive and competitive destination.

Apart from striking a partnership to carry out research with the University of Malta, the Malta Tourism Authority will seek to establish strong institutional links with other stakeholders to undertake a series of focused studies targeting different aspects of the tourism industry and the related potential of the climate change impact. The Malta Tourism Authority is drawing up a Tourism Action and Contingency Plan that incorporates both mitigation and adaptation measures specific to the tourism sector.

5.3.6 Concluding remarks

National entities entrusted with the overall responsibility for climate change law and policy, must be legally empowered to ensure the implementation of national adaptation strategy and the various measures identified in this chapter. They must also coordinate the various sectors to carry out the necessary research to adopt and implement mitigation and adaptation measures. Ultimately they must be supported by a parallel capacity-building process in the various entities that run the day-to-day implementation functions. Climate change adaptation measures aim to promote monitoring and stakeholder engagement, particularly the involvement of NGOs and Local Authorities to increase public awareness on climate change issues. They take into consideration national security issues relating to climate change when formulating adaptation strategies. The development of a research programme for climate change should primarily include access to funding programmes. This will provide local industry with the necessary technology, it will generate specialized local expertise in a rapidly growing sector that is

assuming a tremendous economic potential. All sectors should be legally bound to maintain a Geographic Information System to integrate data related to climate change, and any other data required apart from spatial information. Emphasis is made upon the need to ensure the compilation and exchange of reliable and comparable data, of promoting research and empowering the capacity of national human resources to meet the challenges and the opportunities resulting from climate change across all sectors.

Authorities should initiate immediately, where these have not already started, studies to assess local vulnerability due to climate change, how new opportunities may be tapped, how to meet with the negative consequences of climate change in each sector and across sectors.

Further studies and recommendations should also be made on how to integrate climate change into socioeconomic and environmental policies in Malta. These recommendations take into consideration Malta's role to identify the relationship between its national Sustainable Development Policy, the eight Millennium Development Goals and climate change. The recommendations should also aim at facilitating participation by civil society and non-governmental organizations to play a more active role in decision making, education and public awareness activities on the subject.

A holistic approach is highlighted since gaps and constraints in adopting mitigation and adaptation measures to climate change are interrelated. The mitigation measures Malta is obligated to adopt, should be seen as a measure that lessens our vulnerability arising from the importation of fossil fuels and our sole dependency on these resources for power generation. Additionally, this would lead to better air quality and a cleaner environment. A more efficient and cleaner transport system would definitely improve upon our quality of life and severely reduce incidence of respiratory complaints in congested areas.

As a small island State, Malta is considered under the UNFCCC and the Kyoto Protocol to have increased vulnerability compared to other States. The constraints of small island States in meeting with the challenges of adaptation to climate change and their restrictions to increased options in the taking of mitigation and adaptation measures is a reality, which cannot be ignored. The adaptation measures identified in this chapter need coordination and forward planning based on a proper understanding of the environmental as well as socio-economic impacts of any measures that should be adopted. Each of the adaptation measures to be taken requires more detailed study in terms of its magnitude, certainty, likely impact and economic cost. This is required to identify the best mix of measures to undertake, within the context of the socio-economic fabric of the Maltese Islands. This assessment however must also take into consideration business-as-usual scenarios and what the cost of doing nothing involves.

The Maltese Islands must prepare themselves to avoid, as far as possible, from having to face climate change as "*a negative supply shock*". Malta should brace itself, against anything that disturbs productive activities or which, absorbs resources away from alternative consumption and investment activities.

Malta's small size and relative isolation could also serve to help policy makers to identify better the threats posed by climate change and to provide more or less a thorough and comprehensive adaptation plan that is harder to achieve in bigger countries forming part of the continental land mass. Malta's size and its limited human and financial resources have always been a reality, which the Maltese have managed, at times, to exploit to their advantage. This should be the underlying objective of Malta's climate change law and policy. To do so all the sectors must be both well informed and well organized. All in all, the adoption of sound climate change law and policies should benefit Malta in attaining sustainable development as this is primarily an exercise of integrating environment concerns into socio-economic policies. A sound climate change policy is based on rational use of natural resources and better governance of the environment with all the intrinsic benefits on our quality of life that this entails. Malta needs to

take vital policy and legal decisions that require cross-sectoral concerted action. The mitigation and adaptation measures that need to be adopted in some cases entail heavy investment and in most cases must be carried out within specific and relatively short time frames. Nevertheless these measures will be beneficial for the islands' resilience and competitiveness, besides guaranteeing a better quality of life and leading to sustainable development.

6 FINANCIAL RESOURCES AND TRANSFER OF TECHNOLOGY

> "*All Parties [...] shall: Promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the energy, transport, industry, agriculture, forestry and waste management sectors; [...]*"[60]
>
> "*The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties* [...]"[61]

6.1 Introduction

Despite it being a small country with constrained financial capabilities, and despite not being an Annex II Party to the Framework Convention on Climate Change, Malta has started to also contribute financial and capacity support for climate action in developing third countries, including support resulting in the transfer of technologies and know-how. This chapter discusses the efforts made, using examples of projects that have been supported during the years 2011 and 2012.

6.2 Support through public finances

Support to developing countries during 2011 and 2012 has been primarily focussed on grants by the government for specific projects related to climate change mitigation or adaptation activities. During 2011, a total amount of €300,000 (US$405,405[62]) was disbursed on projects in Ethiopia, Ghana, Tanzania and Uganda. A similar sum of money was granted in 2012 for projects in the Philippines, Kenya, India, Madagascar, Ghana, Uganda and Ethiopia. This funding of projects serves as the country's contribution to the pledge made by developed country Parties during the Conference of the Parties to the UNFCCC held in 2009 in Copenhagen, to provide new and additional resources to support mitigation and adaptation activities in developing countries. The collective pledge of US$30 billion for the period 2010 to 2012 is often referred to as Fast Start Finance.

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

A summary of projects sponsored through grants given by Malta in 2011 and 2012 is given in Table 6-1 and Table 6-2 respectively. Subsequent sections provide more detailed information on the individual projects.

[60] United Nations Framework Convention on Climate Change, Article 4 (1)(c).
[61] United Nations Framework Convention on Climate Change, Article 4 (5).
[62] For the purposes of this discussion, the currency exchange rate used is €0.74 for US$1 as applicable on 2nd October 2013.

Table 6-1 Overview of financial contributions to projects in 2011.

Recipient country and project description	Total amount granted (€)	Total amount granted (US$)	Type of project	Sector
Ethiopia **Community managed environmental sanitation and biogas development**	32,570	44,025	Mitigation and adaptation	Water; Energy
Ethiopia **Integrated environmental intervention in Meki's rural area providing biogas, compost, soil and water conservation**	18,767	25,367	Mitigation and adaptation	Water; Agriculture; Energy
Ghana **Borehole project for the HopexChange Health Centre and neighbouring villages, including solar water heating project**	113,295	153,141	Mitigation and adaptation	Water; Energy
Tanzania **Construction of a biogas plant and delivery system at Makiungu Hospital**	25,000	33,793	Mitigation and adaptation	Energy
Uganda **Rainwater harvesting for natural resource management and sustainable development**	50,550	68,328	Adaptation	Water
Uganda **Installation of a mini-grid, as a means of establishing renewable energy sources in the Kids of Africa Orphanage in Garuga/Entebbe**	59,818	80,856	Mitigation	Energy

Table 6-2 Overview of financial contributions to projects in 2012.

Recipient country and project description	Total amount granted (€)	Total amount granted (US$)	Type of project	Sector
Ethiopia **Environmental education, model organic farming and water harvesting**	33,205	44,893	Mitigation	Agriculture; Energy; Water
Ghana **Biogas system for the production of gas for cooking in a hospital and hospital residences**	93,991	127,076	Mitigation and adaptation	Energy; Waste Management
India **Solar lighting for two educational institutions**	37,691	50,958	Mitigation and adaptation	Energy
Kenya **Construction of boreholes**	39,500	53,404	Adaptation	Water
Madagascar **Water harvesting project**	14,752	19,944	Mitigation and adaptation	Water; Sanitation
Philippines **Construction of water canals and access roads**	24,334	32,913	Mitigation and adaptation	Water (flooding)
Uganda **Water and food scarcity projects**	56,525	76,421	Adaptation	Water

6.3 Projects sponsored in 2011

This section describes in some more detail the projects funded by Malta in 2011 (see also Table 6-1 above).

Project title: Community managed environmental sanitation and biogas development – project by Koperazzjoni Internazzjonali – Malta (KOPIN)			
Purpose: To provide a new source of energy from treatment of organic waste.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Ethiopia	Water; Energy	€32,570 (US$44,025)	12 months
Description of project: The construction of a bio-digester at Shashemene in the Oromia region of Ethiopia, will provide access to the local community to a viable alternative fuel source, by way of biogas production originating from anaerobic decomposition of organic wastes; the bio-gas produced may be utilised as a fuel for cooking, heating and lighting, offering a sustainable form of energy to be used for the everyday needs of the community.			
Technology transferred: Bio-gas production technology.			

Project title: Integrated environmental intervention in Meki's rural area providing biogas, compost, soil and water conservation – project by Signum Fidei			
Purpose: To improve agricultural activities through the reduction of desertification and the introduction of new technologies for the supply of clean and safe water, the generation of alternative energy, as well as increase local awareness in relation to issues of sustainability.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Ethiopia	Water; Agriculture; Energy	€18,767 (US$25,367)	12 months
Description of project: The project aims at enhancing the local community's knowledge and understanding of the region's environment and appropriate practices, while tackling issues such as the lack of sources of clean water, lack of access to affordable electricity, the heavy burden placed on women and children, desertification, deforestation, land deterioration and low productivity. The project includes capacity building in agricultural activities and technology, and the setting up of a bio-gas plant.			
Technology transferred: Bio-gas production technology.			

Project title: Borehole project for the HopexChange Health Centre and neighbouring villages, including solar water heating project – project by The Ghana Mission Foundation			
Purpose: To supply viable and clean alternatives to relieve the current water and energy issues experienced by the HopeXchange Medical Centre, Ghana and the surrounding community.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Ghana	Water; Energy	€113,295 (US$153,141)	12 months
Description of project: The project includes the digging of two boreholes and installation of associated water purification and storage systems in order to supply potable water to the community, and the installation of a solar thermal system for water heating purposes in the HopeXchange Medical Centre, thus also offering a reduction in dependency on fossil fuels.			
Technology transferred: Water extraction, purification and storage system, and solar thermal technologies.			

Project title: Construction of a biogas plant and delivery system at Makiungu Hospital – project by Mission Fund			
Purpose: To treated organic latrine waste through the construction of a biogas plant, as an alternative source of energy.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Tanzania	Energy	€25,000 (US$33,793)	12 months
Description of project: Untreated waste is a serious contaminant to local ground water sources, and the project aims at setting up a system to treat such waste and generate bio-gas, providing an alternative source of energy to pre-existing sources such as the burning of wood from local forests, and reducing the impact of untreated waste on the local community's health.			
Technology transferred: Bio-gas production technology.			

Project title: Rainwater harvesting for natural resource management and sustainable development – project by SOS Malta.			
Purpose: To provide safe drinking water and sanitation facilities.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Uganda	Water	€50,550 (US$68,328)	12 months
Description of project: This project will bring water security to the schools of Njeru, Uganda, through the construction of rain water harvesting systems and the digging of two wells. The project also includes interactive workshops on climate change, water, hygiene and sanitation for the pupils and the teachers.			
Technology transferred: Rain water harvesting system and wells			

Project title: Installation of a mini-grid, as a means of establishing renewable energy sources in the Kids of Africa Orphanage in Garuga/Entebbe – project by Rotary Club Malta			
Purpose: To reduce dependency on expensive and polluting sources of energy through the installation of photovoltaic panels.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Uganda	Energy	€59,818 (US$80,856)	12 months
Description of project: The installation of photovoltaic panels and the associated mini distribution grid system will provide electricity to the Kids of Africa Orphanage, as an alternative to conventional fossil fuel-based generation. Output is expected to be around 47KWh/day.			
Technology transferred: Solar (Photovoltaic) mini grid technology			

6.4 Projects sponsored in 2012

This section provides details on projects granted financial support by Malta in 2012 (see also Table 6-2 above).

Project title: Improvement of water, environmental education and farming – project by KOPIN.			
Purpose: To provide environmental education, model organic farming and water harvesting.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Ethiopia	Agriculture; Energy; Water	€33,205 (US$44,893)	8 months
Description of project: The project aims at improving access to clean water in order to ameliorate the health status of the benefitting community. The project will also provide education on environment and climate related matters. Additionally, assistance in organic farming practices will be given to local farmers, as a basis for enhanced resilience to changes in climatic conditions, particularly though the diversification of crops and livestock. The concept of organic farming should also contribute to reducing emissions of greenhouse gases from agriculture.			
Technology transferred: Not applicable. The focus is primarily on transfer of knowledge to the local community.			

Project title: Biogas installation – project by Ghana Mission Foundation.			
Purpose: To finance a biogas system for the production of gas for cooking in a hospital and associated hospital residences.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Ghana	Energy; Waste Management	€93,991 (US$127,076)	8 months
Description of project: A 220 cubic metre biogas system is to be installed providing a source of energy for cooking in a facility that aims at providing quality healthcare in Kumasi, with running costs being reduced by optimising the use of alternative sources of energy. This project follows up on a previous project in the same facility involving the setting up of solar water heating equipment.			
Technology transferred: Biogas production technology.			

Project title: Solar energy – project by the Mission Fund.			
Purpose: Finance for solar lighting for two educational institutions.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
India	Energy	€37,691 (US$50,958)	8 months
Description of project: The project involves the installation of photovoltaic electricity generation equipment in educational institutions, including a school, hostel and residences for missionaries running these institutions, situated in areas that lack access to basic electricity services. Besides providing a basic amenity, the project is also contributing to the community's development in a sustainable manner.			
Technology transferred: Photovoltaic energy equipment.			

Project title: Construction of boreholes – project by Franciscan Sisters.			
Purpose: Construction of a borehole in an educational facility.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Kenya	Water	€39,500 ($53,404)	8 months
Description of project: The project aims at providing water for an educational facility run by missionaries and situated in Nairobi, through the construction of a borehole. This project will also serve to showcase adaptation approaches in a region susceptible to drought conditions.			
Technology transferred: Water extraction system.			

Project title:			
Water harvesting project – project by Signium Fidei.			
Purpose:			
Construction of a water harvesting system in an educational facility.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Madagascar	Water	€14,752 (US$19,944)	6 months
Description of project:			
The project involves the construction of a water harvesting system in a school run by missionaries in Toliara, a town situated in the semi-arid south-west of the country. The system will include a well, reservoir, water tower, and a water distribution system incorporating water lines and associated pumping equipment. As rain water tends to accumulate on the clay soil in the area, facilitating the spread of diseases, the new system should also assist in the better management of rainwater and thus enhance the health of the community.			
Technology transferred:			
Water harvesting infrastructure.			

Project title:			
Resilience to floods – project by the Daughters of the Sacred Heart.			
Purpose:			
The construction of water canals and access road.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Philippines	Flooding	€24,334 (US$32,913)	8 months
Description of project:			
The project focuses on preventing damage caused by heavy rainfall through the construction of a system of water canals in a compound run by the sponsored organisation. The system will collect rain water, particularly during the rainy season, and dispose of it in a manner that does not adversely affect the local community. The project also included the construction of an access road, thus facilitating mobility in the area.			
Technology transferred:			
Flooding-prevention infrastructure.			

Project title:			
Financing education and agriculture – project by SOS-Malta.			
Purpose:			
To finance an educational programme on agricultural practices.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Uganda	Agriculture	€56,525 (US$76,421)	8 months
Description of project:			
Targeted at rural families in rural areas near Jinja, dependent primarily on subsistence farming, the project will provide education on agricultural practices that increase resilience to climate change and enhance security of water and food resources. The aim is to establish rural women groups which can continue to disseminate information on climate-resilient agricultural practices long after the project proper ends.			
Technology transferred:			
Not applicable. The focus is primarily on transfer of knowledge to the local community.			

7 RESEARCH AND SYSTEMATIC OBSERVATION

> "*All Parties [...] shall: Promote and cooperate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives related to the climate system and intended to further the understanding and to reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitude and timing of climate change and the economic and social consequences of various response strategies*"[63]

7.1 General policy on research

7.1.1 Climate research policy context

Research policy in Malta falls under the responsibility primarily of the Malta Council for Science and Technology (MCST), as well as the Ministry for Education. These bodies are responsible for national research funding and student grant schemes (scholarships) respectively. In their choice of funding areas, they drive directly and indirectly the national policy on research.

A first National Research and Innovation Strategy was published by the MCST, for the period 2007-2010[64], with the aim of encouraging and strengthening the research community in Malta. It did not specifically identify climate change issues as important areas of research, prioritising more sustainability-related aspects such as environment and energy resources: "*Environment and energy resources: with focus on solar, wind, and bio energy together with energy efficiency technologies, as well as water, desalination, waste rehabilitation technologies, soil and marine management*."

A new National Research and Innovation Strategy 2020 was launched for public consultation in early 2014[65]. It looks at building critical mass and capacity in select areas, giving the country a competitive edge. In doing so it "*avoids over-prescriptive, narrow niches and seeks to identify clear, well defined priority areas which still allow the possibility of collaboration both within and between different areas identified*".

A specific area identified in the new strategy for the purpose of building capacity for excellence is in climate change adaptation:

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

[63] United Nations Framework Convention on Climate Change, Article 4 (1)(g).

[64] *National Strategic Plan for Research and Innovation 2007-2010: Building and Sustaining the R&I Enabling Framework*, Malta Council for Science and Technology, 2006.

[65] *National Research and Innovation Strategy 2020 – Draft for Public Consultation*, Malta Council for Science and Technology, 2014.

adaptation, the time is ripe for Malta to consolidate its expertise, augment and valorise it through the development of a centre of excellence on climate change adaptation."

The need for climate change knowledge to guide policy as well as business decisions is widely acknowledged. The realisation of this Centre will include efforts to build and strengthen communication channels with private enterprise as well as policy makers since its outputs will undoubtedly shape many priority sectors in future years, such as tourism, health and aquaculture. This centre of excellence should also give value to the findings and recommendations contained in Malta's Climate Change Adaptation Strategy of 2012."

In this regard, the University of Malta has the intention of setting up the Centre of Excellence in Climate Change Research with the Government expressing its intention to support this initiative by possibly including it in the upcoming Smart Specialisation Strategy.

7.1.2 Actions to support research

Efforts by the Ministry of Education focus on increasing the research population and set up funding schemes for further studies leading to master and doctoral degrees. In 2006 the Ministry set up the Malta Government Scholarship Scheme (MGSS) and between 2006 and 2013 supported 204 Master and 193 PhD scholarships. Eleven of the PhDs awarded and 15 of the Master scholarships were related to studies and research into sustainability, environment and climate change.

Quality of the proposal and the contribution of the research to the Maltese economy were criteria for the awarding of scholarships under this programme. Despite accepting applications for any area of study, a list of priority areas of study was identified which included climate change:

"Environment

Energy efficiency and alternative energy (solar energy, solar cooling, wind energy, bio-energy/biofuel, energy from waste and energy efficient buildings);
Water (conservation of rainwater, consumption efficiency, regeneration of the aquifer and efficient desalination);
Waste (Waste Rehabilitation Technologies);
Soil erosion;
Marine Sciences, Marine Management, Maritime affairs and fisheries;
Maritime Law and Business;
Climate change;
Physical sciences, in particular seismology and atmospheric monitoring;
Environmental Law;
Rural and Urban Planning." [66]

Between 2009 and 2012, the Ministry launched another scholarship scheme, funded through the European Social Funds, to complement the MGSS. This scheme, entitled Strategic Educational Pathways Scholarships (STEPS) also provided support through scholarships for masters and doctoral studies, with a special emphasis on science and technology programmes of study. Between 2009 and 2012, a total of 260 Scholarships for Master (222) and Doctorate (38) studies in fields related to science and technology were awarded under STEPS, at a total cost of over €4.2million.

[66] *Malta Government Scholarships Scheme – Post Graduate Awards 2013 Regulations*, Directorate for Life Long Learning, 2013.

The STEPS scholarships were financed based on the quality of the proposal and the contribution of the research to a number of areas. The STEPS programme had identified environmental technologies and resources as one of its priority areas. Indeed studies were sponsored in areas considered as Malta's major challenges related to the environment, including, among others energy efficiency and alternative energies, water and waste.

In 2013, the Government launched the 'Master it! Scholarship Scheme' aimed at supporting further studies at masters levels. The scholarships are part-funded by the 'European Union Operational Programme II - Cohesion Policy 2007-2013 - Empowering People for More Jobs and a Better Quality of Life' through the European Social Fund. Environmental topics for which specialization studies will be financed by this scheme include: Alternative Energy; Waste Management; Climate Change; Green Technology; Crop production; Marine Management; Oil and Resources Management[67].

The increased focus of such funding programmes on issues relating to climate action will not only support scholarship but will also channel research in this important area of study.

7.2 Research activities: the role of the University of Malta in spearheading climate research and systematic observation

The University of Malta is the primary institution to develop and support research in the area of climate change. The recent setting up of the **University Platform for Climate Change** (in 2012) and the establishment of the **Institute for Climate Change and Sustainable Development[68]** (in 2013) should serve to better coordinate research activities within the different faculties, institutes and centres of the University. The aim of the Platform is indeed to bring together the various bodies involved in research on climate change issues in the University. The Institute was established to support the development of the centre for excellence on climate change already mentioned above and is currently looking for funding to assist capacity building on climate change.

The activities of a wide range of bodies working under the auspices of the University of Malta are described here, providing a case study of the role of this academic institution in spearheading research in Malta in the various facets of climate change. Aspects of systematic observation of climatic conditions and parameters related to climate change are also described. The section does not purport to provide a detailed resumé of research and systematic observation work that has been, and continues to be, undertaken, but rather provides an overview of the broad extent of work relating to climate change issues that is taking place within the University, reflecting also the complex nature of the topic.

Climate Research Group, Department of Physics - Faculty of Science

The Climate Research Group[69] (formerly known as the Malta Climate Team) was set up in 2008 following the leading role that the Department of Physics was entrusted with in the preparation of Malta's First and Second National Communications to the UNFCCC. The team has, since then, gained momentum in the various activities that have been set up. An understanding of the structure and variability of the climate system is a central role in these activities.

[67] *Master It! Scholarship Scheme 2013 Regulations - 2nd call*, Directorate for Life Long Learning, 2013.
[68] http://www.um.edu.mt/isd.
[69] http://www.um.edu.mt/science/physics/climate.

The group has installed two numerical weather prediction models called WRF and Enviro-HIRLAM, and two regional climate models (RCMs) called PRECIS and RegCM4 on a super computer cluster (ALBERT) at the University of Malta. With these facilities the Department of Physics is offering research opportunities from undergraduate to post-doctoral levels. Furthermore, contribution to the international scientific community will be given through new experiments, testing and developing components of the models.

The research interests of the group include:

- Development of chemistry of an aerosol module in a RCM;
- Implementation of code for new chemical reactions in a RCM;
- Improvement of RCM performance over small islands;
- Regional analysis of meteorological extremes;
- Development of Air Quality predictions over Small Islands;
- Develop new physics experiments with WRF.

Ongoing projects include two PhD research projects on *Modelling the formation and radiative effects of secondary organic aerosols in a climate model* in collaboration with ICTP Trieste and *Implementing feedback loops in Enviro-HIRLAM dealing with latent heat and charged aerosols* in collaboration with the Danish Meteorological Institute and the University of Copenhagen.

The Climate Research Group is active in the European research community through participation in the COST ESSEM Domain. The group is active in Action ES1102 - Validating and Integrating Downscaling Methods for Climate Change and Research (VALUE) and ES1004 European Framework for Online Integrated Air Quality and Meteorology Modeling.

The Climate Research Group has also been active in outreach activities with a series of public talks, radio and newspaper interviews, summer schools in climate research and design of new study units.

Institute of Earth Systems

In 2010 the University approved the setting up of the Institute of Earth Systems[70] which brought together the former International Environment Institute and the Institute of Agriculture.

The Institute of Earth Systems at the University of Malta is carrying out the following studies related to the understanding of regional climate:

- Climatic trends in rainfall over the central Mediterranean region (including Malta);
- Climatic trends in hours of bright sunshine (atmospheric transparency) over the central Mediterranean region (including Malta);
- Perception of local farmers on the impact of climate change and adaptation issues;
- Regional climatic trends in UV levels (including Malta) and local perception.

The Institute has a number of postgraduate students working on the modelling of sea level rise and coastal flooding, with an assessment of impacts on coastal communities and adaptation measures. It is also setting up new technical facilities to assist students to perform research on climate change and coastal inundation.

Marine Ecology Research Group, Department of Biology – Faculty of Science

The Marine Ecology Research Group (MERG) has carried out research[71] for the Mediterranean Science Commission's (*Commission Internationale pour l'Exploration Scientifique de la Mer*

[70] http://www.um.edu.mt/ies.

Mediterranee (CIESM)) 'Tropical Signals' project[72], as part of a systematic research observation programme carried out by 21 research teams from 15 different Mediterranean countries to detect, monitor and understand the effects of climate warming on Mediterranean marine biodiversity using representative biological indicators of change. The entry and spread of non-indigenous species in the Mediterranean has been linked to a changing marine environment. Consequently monitoring such species, using common biological monitoring protocols across all participating countries, is an important component of the Tropical Signals project. MERG was given the role to implement such research in Malta under the auspices of the Programme, building on its track record of research on species and habitats in Maltese waters.

Apart from implementing the monitoring surveys, MERG has carried out two fundamental tasks in this respect as part of the programme:

- An inventory of non-indigenous species reported from Maltese waters to act as a baseline for future comparisons; and,
- An extensive survey of the scientific and other literature and of authenticated but unpublished reports of non-indigenous marine species recorded from the Maltese Islands and surrounding waters.

It resulted that in Maltese waters up to the start of the Tropical Signals Programme (early 2008) there were recorded 39 authenticated alien species and another nine unconfirmed ones. According to the accepted records, of the authenticated alien species, 25 had become established[73] while 14 were either casual[74] or questionable[75].

According to the research carried out by MERG the most represented groups were molluscs (14 species), fish (13 species) and macrophytes (seagrasses and large seaweeds; 10 species). Six species were classified as invasive in Maltese waters[76].

The research also demonstrated that since the early 1900s, there has been an increasing trend in the number of marine alien species reported (Figure 7-1). The most common causes of entry of the alien species included in the review appear to be transportation via shipping (20%), aquaculture (11%) and range expansion of Lessepsian immigrants (32%).

Since the start of the Tropical Signals Programme additional non-indigenous species have been reported from Maltese waters[77] by researchers from MERG and by others. These include: a sponge; two jellyfish; seven molluscs; a sea-squirt; five fish.

The study concludes that at least 55 non-indigenous species have been confirmed to have reached Maltese waters, of which some 56% are established. The study argues that this is almost certainly an underestimate, "*because there are other potentially non-indigenous species that*

[71] Information compiled from information courtesy of Schembri P,J., Department of Biology, Faculty of Science, University of Malta.

[72] http://www.ciesm.org/marine/programs/tropicalization.htm.

[73] Species present as reproducing and self-perpetuating populations in the wild.

[74] Species only recorded once or twice and have not established breeding populations.

[75] Species for which insufficient information exists to decide if they are established or casual.

[76] Species whose population has undergone a very rapid growth phase and which may affect the diversity or abundance of native species and the ecological stability of the ecosystem. These species are the seaweeds *Lophocladia lallemandii*, *Womersleyella setacea* and *Caulerpa racemosa* var. *cylindracea*, the crab *Percnon gibbesi*, and the fish *Fistularia commersonii* and *Sphoeroides pachygaster*.

[77] Seven of these are Lessepsian immigrants, another seven derive from the Atlantic. Two are Pacific species that do not occur in the Red Sea and for which the Maltese records are the first for the Mediterranean, suggesting that these were introduced due to human activities, in one case shipping and in the other, trade.

have been reported from Maltese waters whose identity is being investigated to determine exactly what they are and therefore if they are aliens or not"[78].

An update to the first review of alien marine species in Malta and an analysis of the status of these species in Maltese waters is currently under preparation.

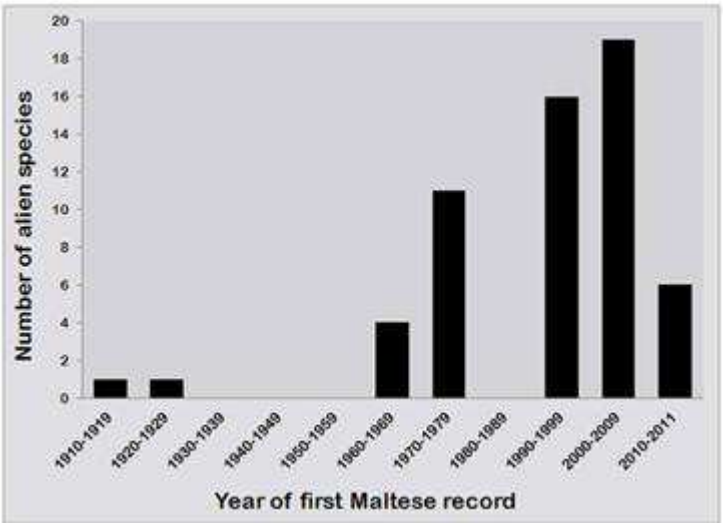


Figure 7-1 Trend in arrival of non-indigenous marine species in Maltese waters as indicated by the number of new records of such species per decade since 1910. (courtesy MERG, unpublished).

International Ocean Institute – Malta Operational Centre

Through its research arm, the Physical Oceanography Unit, the International Ocean Institute – Malta Operational Centre (IOI-MOC)[79] undertakes research in coastal meteorology, hydrography and physical oceanography with emphasis on the experimental study of the hydrodynamics of the sea in the vicinity of the Maltese Islands. The Insititute offers facilities for the gathering, processing, analysis and management of high quality physical oceanographic observations both for long term and baseline studies as well as for general applications in marine environmental research and assessments.

The IOI–MOC is also participating in the Tropical Signals project[80], deploying water temperature data loggers at depths ranging from the surface down to 40m. Loggers have been deployed at 2 different offshore locations, off the north-west and the south-east of the islands, the loggers being left in the water for a continuous period of 12 months and then recovered to retrieve the data, with re-deployment in the same location soon after. The IOI-MOC, has already gathered a full annual set of sea temperature data from one location (at all depths). In September 2014, the Centre will have a second annual dataset of sea temperature and thus would be in a position to start comparing annual fluctuations in sea temperature. Currently IOI-MOC is running statistical comparisons between satellite sea surface temperature values and values obtained through the in situ data loggers in order to assess the validity of remote sensing data.

[78] http://www.um.edu.mt/science/biology/staff/profpatrickschembri/non-indigenous_marine_species_as_indicators_of_change_in_the_marine_environment/tropical_signals.
[79] http://www.um.edu.mt/ioi-moc.
[80] Information compiled from information courtesy of IOI-MOC researchers involved, namely Deidun A., Gauci A., Cutajar D., Drago A.

Islands and Small States Institute

The Islands and Small States Institute[81] promotes research and training on economic, social, cultural, ecological and geographical aspects of islands and small states. The Institute has climate change as one of its areas of interest and is involved in a number of research initiatives. Furthermore, its academics have been involved in climate change research at an international level for a number of years, including Prof. Lino Briguglio as the only Maltese academic to-date involved in the work of the Intergovernmental Panel on Climate Change (IPCC). Through his involvement in Working Group II of the IPCC, he is a lead author for the chapter on Small Island Development States in the Third, Fourth and Fifth assessment reports and thus formed part of the team that was awarded the Nobel Prize to the IPCC in 2007.

The Institute is also involved in COST Action ES1106 - Assessment of EUROpean AGRIculture WATer use and trade under climate change (EURO-AGRIWAT).

Institute for Sustainable Energy

The Institute for Sustainable Energy[82] aims to assist in the development of national energy plans through studies in the use of new and renewable energy sources and methods of energy conservation. Its interest in climate change is thus primarily from a mitigation perspective, looking at alternative means of sourcing energy.

Department of Geography - Faculty of Arts

The Department of Geography[83] is involved in research in a number of broad areas. Of particular interest to climate change is the research concerning Coastal Zone Management and sea level rise which has also seen the completion of a number of postgraduate dissertations in this field over the years.

Department of Economics – Faculty of Economics, Management and Accountancy

The Department of Economics[84] offers a number of study units related to environmental economics and policy. The current research interests of the Department include the determinants of environmental behaviour, behavioural change and research into incentives and communication for environmental policy.

Institute for European Studies

The Institute for European Studies[85] is a multi-disciplinary teaching and research institute which was awarded the Jean Monnet Centre of Excellence in 2004. The Institute is engaged in various research and publication activities in European integration studies and is a member of the Trans-European Policy Studies Association (TEPSA), the LISBOAN network, EPERN and the two Euro-Mediterranean Networks EuroMeSco and FEMISE.

[81] http://www.um.edu.mt/islands.
[82] http://www.um.edu.mt/iet.
[83] http://www.um.edu.mt/arts/geography.
[84] http://www.um.edu.mt/fema/economics.
[85] http://www.um.edu.mt/europeanstudies.

Current research programmes at PhD level within the Institute, in conjunction with the Department of Economics, include the area of climate change adaptation and international development, looking into how the EU is contributing to the enhancement of climate change adaptation in the least developing countries of Africa.

Department of Civil and Structural Engineering - Faculty of the Built Environment

The research interests of the Department of Civil and Structural Engineering[86] range across masonry materials and structures, reinforced and pre-stressed concrete structures, concrete technology, the utilization of building waste in the production of masonry units, or as replacement materials in concrete, composite structures, glass structures, tensegrity structures, structural cladding systems, structural repair interventions, rock material characterisation. On the basis of research in these areas, members of the department have participated in a number of European projects dealing with lifetime engineering, sustainability in construction and life cycle analysis. Research focuses primarily on life cycle assessment, materials and durability and energy efficiency and lifetime engineering. Recently it has also hosted an international conference and an international PhD training school on sustainability and the built environment.

Members of the Department have also assisted in setting up a new association dealing with sustainability in the built environment addressing, in particular, the effect of climate change, resource consumption and waste generated on the built environment. The association also acts as the Maltese chapter of an international organisation dealing with sustainability in the built environment. Given the major contribution of the construction industry and the built environment on global greenhouse gas emissions and the significant consumption of resources and generation of waste in the construction industry globally, the drive to address climate change issues with regard to this field is worthy of note.

Centre for Environmental Education and Research - Faculty of Education

The Centre for Environmental Education and Research[87] (CEER) offers opportunities for environmental education to empower citizens to actively participate in environmental decision-making fora and in initiatives that promote good quality of life for all. CEER provides a focal point for coordinating environmental education initiatives, increasing the opportunity for environmental education research, making scientific and technological research results more accessible and facilitating resource transfer and capacity building in Malta and the Euro-Med region.

The Centre is involved in research in the area of education for sustainability and climate change and academic staff of CEER have published on the subject, including articles in international journals on areas such as youth and environmental and climate change knowledge, attitudes and behaviour .

An online teaching module on climate change was also developed by the CEER under the EU funded project RADC (Raising Awareness for Development Cooperation). The CEER also coordinated a three-year EU funded project called Global Action Schools where Climate Change was one of the main themes that the project focussed upon. The project was aimed at exploring how small changes in the day-to-day running of schools can have a positive impact on life in developing countries, and to link learning to the role that students can play in creating a fairer and more sustainable world.

[86] http://www.um.edu.mt/ben/civileng.
[87] http://www.um.edu.mt/ceer.

Environmental and Resources Law Department - Faculty of Laws

The Environmental and Resources Law Department[88] was set up in 2010 and focuses on lecturing, tutoring and research at under graduate and post graduate level in:

- Environmental law;
- Law relating to sustainable development and sustainable resource management;
- Development Planning law;
- Climate change law;
- Occupational Health and Safety Law;
- Food Safety Law;
- Heritage law; and ,
- Aspects of policy making related thereto.

The decision to set up this new Department within the Faculty of Laws was prompted by the vast developments in the legal framework addressing these topics on a national, European and international level. The particular relevance for Malta of having an academic department dedicated particularly to environmental and resources law within the highest education institution in the country is borne out by the fact that the environmental (including climate change) *acquis communitaire* is the second largest chapter in the whole EU *acquis* to which Malta is bound as a member state of the Union; and this does not include other legal areas addressing topics that are closely related to environmental and climate change considerations, such as energy.

Forum on Legal Issues for Adaptation to Climate Change

An initiative of significant importance to which the University is contributing is the Forum on Legal Issues for Adaptation to Climate Change. This forum of European academic legal experts was jointly set up in 2010 by the University of Malta and the Catholic University of Leuven and is based at the University of Malta. Its mission statement is to serve as a place of discussion, continuing education and advice on developing a legal framework for adaptation to climate change in the EU and beyond. The Forum is committed to support the European Commission's Directorate General on Climate Action (DG CLIMA) in its work on adaptation to climate change.

Membership in this Forum includes academics from universities or academic institutions in five European Union states. The Forum which is co-chaired by Dr Simone Borg (University of Malta; Ambassador to Malta on Climate Change) and Prof Dr Kurt Deketelaere (University of Leuven) and has an advisory board made up of key people from the University of Malta and DG CLIMA that also includes Mr Michael Zammit Cutajar who has served as Executive Director of the UNFCCC Secretariat, Special Advisor on Climate Change to President of the European Commission Manuel Barroso and as Ambassador to Malta on Climate Change. The University of Malta offers the logistical set up and hosting of the Forum on its campus, including all conferences, as well as the contribution of its academics specialised in the field of adaptation to climate change. The University of Leuven as joint founder of the Forum contributes, through its Institute for Environmental and Energy Law, its expertise on climate change issues and its global legal network.

The Forum officially met for the first time in Autumn 2011. A second conference was then held in February 2012. Both conferences served as a general stock taking exercise and an evaluation of the present EU adaptation policy. They also provided a brainstorming session on how to climate-proof existing EU legislation that may be applicable to the various sectors that are most

[88] http://www.um.edu.mt/laws/env-resources.

vulnerable to climate change. The two conferences addressed aspects of sectoral EU environmental law, energy and other relevant legislation, thereby building up a group of participants and core key experts. A third conference was held in June 2012 and was attended by the Commissioner for Climate Change Connie Hedegaard. This meeting served *inter alia* to further elaborate upon work carried out in the previous conferences and the presentation of the proposal of the Forum to develop into a multi-disciplinary Centre of Excellence on Adaptation to Climate Change.

The fourth conference of the Forum held in October 2012 presented the work carried out by the members on certain tasks which DG CLIMA had requested the Forum to undertake, the finalisation of a draft legislation on climate change adaptation and further elaboration on the proposal for the Centre of Excellence.

8 EDUCATION, TRAINING AND PUBLIC AWARENESS

> "*All Parties [...] shall: Promote and cooperate in education, training and public awareness related to climate change and encourage the widest participation in this process, including that of non-governmental organizations*"[89]

8.1 Introduction

In highlighting the principles of Education for Sustainable Development (ESD), the UNECE stresses the need to shift "*the focus away from solely transmitting information towards facilitating participatory learning*"[90]. Consequently an educational process that promotes the adoption of sustainable lifestyles needs to have two intimately related dimensions:

- the inclusion, through a holistic approach, of key sustainable development themes into teaching and learning; and
- a participatory methodology that empowers learners to think critically, identify alternative scenarios and actively engage in decision making that promotes a change in behaviour.

The central role of education, training and public awareness has been identified and given due mention in national documents pertaining to the achievement of sustainability[91,92] and responding to climate change[93,94,95,96]. Nevertheless, efforts to promote education for climate change have, to some degree, failed to strike the desired balance between these two dimensions thus falling short in achieving the desired targets.

8.2 Examples of good practice

Most of the educational initiatives related to climate change were understandably conducted and, or, initiated within the formal education sector as it provides the advantage of having defined educational programmes, specific target audiences and dedicated structures that can be oriented to cater for emergent needs.

8.2.1 Formal education

Although environmental themes have been part of school curricula since the mid-1800s, knowledge specific to climate change appeared in 2008 at secondary level and as far back as 2002 at post-secondary level. At university level, there are a good number of study units and courses that address climate change, the majority promoting a scientific/technological

[89] United Nations Framework Convention on Climate Change, Article 4 (1)(i).
[90] *The UNECE Strategy for Education for Sustainable Development*, United Nations Economic Commission for Europe, 2005.
[91] *National Environment Policy*, Ministry for Tourism, Environment and Culture, 2012.
[92] *A Sustainable development Strategy for the Maltese Islands 2007-2016, National Sustainable Commission for Sustainable Development, 2006.*
[93] *The First Communication of Malta to the United Nations Framework Convention on Climate Change*, Ministry for Rural Affairs and the Environment, 2004.
[94] *National Strategy for Policy and Abatement Measures Relating to the Reduction of Greenhouse Gas Emissions*, Ministry for resources and Rural Affairs, 2009.
[95] *The Second National Communication of Malta to the United Nations Framework Convention on Climate Change*, Ministry for Resources and Rural Affairs, 2010.
[96] *National Climate Change Adaptation Strategy*, Ministry for Resources and Rural Affairs, 2010.

perspective, closely followed by themes related to the economic and legal dimension of the phenomenon. Worth pointing out is the emergence of study units, albeit very limited in number, which approach climate change from a holistic perspective and adopt a learner centred methodology.

The University of Malta is also significantly involved in generating knowledge about climate change through local and international research projects. Once again, the predominant thrust of these research projects is scientific and technological in nature. Another emerging trend in university based research is the focus on ESD related issues (including themes related to climate change education).

The need to include ESD in the National Curriculum was repeatedly suggested by most of the national documents focusing on sustainable development and climate change. This target was achieved in 2012 with the publication of the National Curriculum Framework[97] that proposes ESD as a cross curricular theme. The next imminent step is the development of specific National Curriculum guidelines that would regulate ESD's integration within the various subject areas.

Another notable development in the formal education sector was the launch of EkoSkola – an international ESD programme – in 2002. Disseminated in the vast majority of local schools, EkoSkola empowers students to adopt an active role in environmental decision-making and action in their school and in their community. Climate change is a frequently recurrent theme in the activities carried out by schools participating in EkoSkola. In the June 2008 session of the EkoSkola Parliament, students urged members of parliament to treat climate change as a national priority.

The EkoSkola schools' commitment towards climate change issues was subsequently extended beyond the school confines through the School-Community Link Project Grant Scheme. The scheme was intended to financially support schools in their plans to initiate community-based sustainability projects targeting climate change. This was part of the Climate Initiative – a 3-Year project funded by HSBC International – that saw the implementation of 34 school-community projects spread all over the Maltese Islands and the organisation of two EkoSkola Parliament sessions (in 2010 and 2011) during which students reported to members of parliament about their projects.

8.2.2 Non-formal education

The non-formal education sector was also the stage of a successful campaign called 'Naqqas u Ffranka' (Save and Reduce) in 2011. The initiative, implemented by the Ministry for Gozo in collaboration with the University of Malta, targeted over 5,000 households and involved house-to-house visits during which eco-trainers provided families with free advice and an information booklet about water and energy conservation and proper waste management. The eco-trainers involved in the project received specific training on how to interact with families and how to respond to their needs during their visits (Ministry for Gozo, 2012).

8.3 Hurdles to education targeting climate change

It is important to highlight that the initiatives identified in the previous section were not part of any concerted national plan to address climate change or in response to the recommendations outlined by the national climate change documents. They were the result of the commitment of individuals and organisations towards climate change.

[97] *A National Curriculum Framework for All*, Ministry for Education and Employment, 2012.

In truth, although ESD's importance is unequivocally considered crucial in bringing about desired behavioural changes by national climate change documents, they still failed to formally acknowledge its importance to the extent of adequately exploring its remit to propose clear guidelines for its implementation. Consequently, most of the suggestions related to education tend to show a lack of basic knowledge about ESD and the local educational system, propose 'changes' that had already been implemented, and miss out on developments in the field.

The following is an attempt to identify and list the predominant misconceptions about ESD that have influenced how climate change education, training and public awareness campaigns were perceived. The major aim of this exercise is to propose an informed framework against which such educational initiatives could be developed in the future.

An in-depth analysis of the proposed plans for climate change education, training and public awareness campaigns reveals the following issues:

- an ingrained opinion that behavioural change can be obtained just by imparting knowledge about the required behaviour. Local and foreign research has shown that this is simply not the case. As highlighted in the introduction to this chapter, behavioural change is effectively achieved only if it is specifically targeted and planned for in the educational process.
- awareness is not a point of arrival, but a point of departure. Investing huge resources just in awareness raising, in a world where information is available at the touch of a button, is (to say the least) myopic. Awareness raising, i.e. acquiring a sensitivity towards an issue, should foster a need to know more about the issue. Learning more about the nature of the issue provides the foundations for the development of a set of values and feelings of concern that, in turn, develop the need to acquire skills conducive to its resolution. The final step is the engagement of the learner in the actual resolution of the issue – on a personal and a collective level.
- national campaigns promoted as "educational campaigns" may in fact be more appropriately referred to as "communication campaigns". The two are not synonyms. While an educational campaign goes through the whole process (outlined in the previous point), a communication campaign (at best) addresses the initial two steps.
- how knowledge is defined is also problematic. The knowledge imparted tends to be predominantly monodisciplinary and science/technology oriented, irrespective of the fact that a true understanding of the dynamics of climate change requires an interdisciplinary and systemic approach. This narrow interpretation of knowledge generates unattainable targets such as looking for and filling "gaps" in content at school and tertiary education in the futile attempt of developing a comprehensive and exhaustive course, as though knowledge about climate change is finite. Moreover, this stance is in direct conflict with the basic principles of lifelong learning.
- climate change documents rightly acknowledged that an effective education campaign should be developed over the formal, non-formal and informal sectors and should target both children and adults. Nevertheless, there is a tendency to treat the "public" as one homogeneous audience, thus failing to identify the diversity and complexity of roles within society.
- people experience different roles and different realities throughout their life. Consequently, different people have different and varying learning needs that are not addressed by a one-size-fits-all methodology. Effective educational campaigns are therefore characterised by a diversity of methods/techniques that can be used in conjunction with each other to address diverse needs and offer learners opportunities of engagement in the issue at different levels.

The issues highlighted above are symptomatic of a top-down approach to education characterised by the transmission of other people's priorities, knowledge, values and thinking to passive learners. Achieving the set educational objectives through this approach is a continuous struggle and course designers have to frequently resort to extrinsic motivation to achieve them, such as scaremongering about health issues or making the course a compulsory requirement for progression onto higher education. Educational research shows that both these options (which were actually suggested in the climate change documents) are ineffective. What is needed is a pedagogy that identifies the learners' needs and actively engages them in their learning. Learners are thus transformed into inquisitive, reflective, experienced and critical thinking individuals – the basic unit of a sustainable society.

Another essential aspect that is frequently disregarded is the need to evaluate whether educational campaigns achieved their intended objectives. Although a lot of resources have been invested in major energy conservation campaigns, no evaluation was carried out to identify the reasons why the "practical tips" communicated during the campaigns failed to be taken up by the majority of the targeted audience.

8.4 Looking forward

The problems highlighted above clearly indicate a need for involvement of professionals in ESD. Malta can make headway in climate change education, training and public awareness campaigns once the need for the expertise of such professionals in acknowledged and tapped.

Furthermore, rather than wasting resources (and duplicating efforts) on sporadic and disjoint educational campaigns, there is clearly a need to develop a holistic national ESD strategy that targets various environmental themes and different sectors of society. To illustrate the level of engagement that an effective educational strategy should look at, the following non-exhaustive list presents examples of sectors that should be engaged:

- Government organisations and authorities;
- Environmental/Development organisations;
- Influence groups (e.g. religious institutions, political parties);
- Mass media and the Arts;
- Education organisations and information networks;
- Business and professional groups;
- Civil society.

The success of the strategy depends on the level of public participation. Therefore, the strategy needs to be the result of an amalgamation of top-down and bottom-up approaches to decision making. By approaching various target groups, the strategy would identify their various educational needs, recognise and build upon existing initiatives and systematically propose the actions that need to be taken. People are thus actively involved in the drawing up of policies and will thus own the strategy, improving its chances of success.

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Acronyms and Abbreviations

2AR	Second Assessment Report of the IPCC
4AR	Fourth Assessment Report of the IPCC
CRF	Common Reporting Format
CRG	Climate Research Group
DHIR	Directorate for Health Information and Research
EEA	European Environment Agency
ESD	Effort-Sharing Decision
EU	European Union
EU ETS	European Union Emissions Trading Scheme
GDP	Gross Domestic Product
Gg	Giga grammes
GHG	Greenhouse Gas
GWP	Global Warming Potential
IPCC	InterGovernmental panel on Climate Change
LULUCF	Land Use, Land-Use Change and Forestry
MBB	Malta Business Bureau
MEPA	Malta Environment and Planning Authority
MERG	Marine Ecology Research Group
MRA	Malta Resources Authority
MRRA	Ministry for Resources and Rural Affairs
MSDEC	Ministry for Sustainable Development, Environment and Climate Change
MWh	Mega Watt hours
NACE	Nomenclature des Activités Économiques dans le Communauté Européenne
NAOI	North Atlantic Oscillation Index
NEEAP	National Energy Efficiency Action Plan
NREAP	National Renewable Energy Action Plan
NSO	National Statistics Office - Malta
RCP	Representative Concentration Pathway
SLP	Sea Level Pressure
SOA	Secondary Organic Aerosols
UNFCCC	United Nations Framework Convention on Climate Change
WAM	With Additional Measures
WEM	With Existing Measures
WHO	World Health Organization
WM	With Measures
WSC	Water Services Corporation