The Economic Vulnerability and Potential for Adaptation of the Maltese Islands to Climate Change

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1. *Introduction*

The phenomenon of climate change is associated with potential wide-ranging effects, not least on human welfare. Increasing mean temperatures, rising sea-water levels, more pronounced temperature extremes, lower rainfall with nonetheless more intense precipitations accompanied by an increase in days of thunderstorms, increased atmospheric pollution and a reduction in daylight hours can be expected to have important economic influences as they affect production decisions and consumption patterns. The extent of economic vulnerability to climate change and the potential for adaptation depend on, amongst other things, the geographical and resource characteristics of the country or region involved, the structure of production and consumption and demographic and social considerations.

The aim of this paper is to explore the potential economic vulnerability and possibilities for adaptation to climate change of the Maltese Islands. It is a contribution to the output of Working Group III: Vulnerability and Adaptation involved in the preparation of the First National Communication by Malta to the United Nations Framework Convention on Climate Change. The climate change projections assumed in this paper are those developed for the purposes of the Communication, featuring overall a moderate impact of climate change including temperature increases ranging between 1 and 4 degrees Celsius and a rise in sea level of between half and 1 meter in a long term scenario.

Following this introduction, Section 2 presents an assessment of the current state of the Maltese Islands in terms of their demographic and economic characteristics, together with a discussion of their likely future long-term development. The baseline scenario through which the effects of future climate changes are to be assessed should as much as possible consider the future pattern of economic activities rather than the

present one. For instance, vulnerability to climate change would be high if the future development of the economy depends on the growth of a climate-sensitive sector, even though that sector may currently account for a relatively small share of economic activity.

Section 3 reviews the potential vulnerability and possibilities of adaptation to climate change of small islands states in general. This is interesting because smallness and insularity are perhaps among the most important characteristics defining the Maltese economy in its relation to climate change.

Section 4 brings together the findings of Sections 2 and 3 to focus the discussion of vulnerability and adaptation to climate change on Malta. From an analytical viewpoint, an assessment of the economic vulnerability to climate change can take place through two approaches. One is the evaluation of the loss of the economy's amenities, income and consumption welfare due to climate change. The other is based on adaptation costs associated with attempts to eliminate the negative effects of climate change, and would therefore focus on the costs of adaptation. Based on these considerations, this paper presents a qualitative assessment of the key long term climatic impacts and effects on the Maltese economy, discussing their potential severity and possibilities for adaptation. The approach used is based on the methodologies recommended by the United Nations Inter-governmental Panel on Climate Change (IPCC)[1]. This is followed by a discussion on the role of quantitative estimates in the context of this study.

2. *The Maltese Economy and Society*

An economy is viewed as a society of people engaged in producing, consuming, saving and thereby investing to permit their production possibilities to grow. This section assesses the main demographic characteristics of Maltese society, its production and consumption patterns and hence, the constraints and possibilities for

[1] Carter T R et al (1994).

future growth and development. This forms a baseline scenario against which the effects of climate change can be assessed.[2]

2.1 Demography of Maltese Society

Table 1 below summarises salient demographic trends in Malta over the past decade. The main characteristics of the Maltese population may be succinctly described as:

i. **one of the smallest national populations worldwide**, amounting to just over 391,000 in 2000 of which close to 9,000 were residents of foreign nationality – smallness often results in vulnerability in various respects, including climate change;

ii. **a very high population density rate**, amounting to over 1,200 inhabitants per km^2, making Malta one of the most densely populated countries in the world where land is a scarce and precious resource and its diminution or impoverishment arising out of climate change could have significant effects;

iii. **a high impact of visiting tourist population**, amounting to over 1.2 million visitors in 2000 with an average length of stay of 9.6 days which raises the effective population by over 31,000 (8%) on average during the year and by a peak of 44,000 (11%) during the summer months – tourism activity is especially susceptible to climate change;

iv. **demographic characteristics of a developed country** with the population growing at a slow 0.4% per annum, very low birth and death rates and a fertility rate at 1.8, which is below replacement;

v. **an ageing population**, with the proportion of population aged 60 and over rising from 14.7% in 1990 to 17.0% in 2000, consistent with a high and increasing life expectancy – a higher population average age may exacerbate the socio-demographic vulnerability to climate change and the costs of adaptation;

vi. **negligible migration**, with the sum of inward and outward annual flows averaging 0.1% of the population, consisting mainly of returned migrants;

[2] For a comprehensive description of the present state of the Maltese economy, society and environment see Ministry of Home Affairs and the Environment (2002).

vii. a **culturally homogenous population** albeit characterised by a dualism that is typical in post-colonial countries;

viii. a **stable democracy** with a bi-partisan political system operating from centrist platforms – this implies a degree of consensus on policy-making regarding issues of national importance such as climate change;

ix. a relatively **low incidence of social problems**, albeit these are on the increase, and virtually no poverty;

x. a United Nations **human development index** ranking that puts Malta within the top 30 countries of the world in terms of income, education and health.

Table 1: Maltese Demography

Persons

	1990	1995	1996	1997	1998	1999	2000
Total Population*:	n.a.	378,404	381,405	384,176	386,397	388,296	391,400
Maltese	355,900	369,684	372,755	375,246	377,517	379,446	382,500
Foreign	n.a.	8720	8650	8930	8880	8850	8,900
Gender distribution:							
Males	49.4%	49.4%	49.4%	49.4%	49.5%	49.5%	49.6%
Females	50.6%	50.6%	50.6%	50.6%	50.5%	50.5%	50.4%
Age structure:							
0-14	23.3%	21.5%	21.4%	21.3%	20.8%	20.4%	20.0%
15-59	62.0%	62.8%	62.7%	62.4%	62.5%	62.8%	63.0%
60 and over	14.7%	15.7%	15.9%	16.3%	16.7%	16.8%	17.0%
Population growth	1.0%	0.9%	0.8%	0.7%	0.6%	0.5%	0.4%
Immigration	858	621	399	453	349	339	450
Emigration	160	107	94	73	121	67	50
Net Immigration	698	514	305	380	228	272	400
Fertility per 1000 population	15.1	12.5	13.3	12.9	11.9	11.4	11.2
Death rate per 1000 population	7.7	6.7	6.6	6.5	6.4	6.2	5.9
Life expectancy at birth:							
– Males	73.7	73.9	74.0	74.1	74.1	74.2	74.3
– Females	78.1	79.5	79.7	79.1	80.0	80.1	80.2

Source: National Statistics Office (2001a)

2.2 The Maltese Economy

The Maltese economy is small and very open, with strong trade ties to the EU. Malta has applied for EU membership and it is considered as a front-runner for accession in the upcoming enlargement. Malta has a labour force of just over 156,000. Its Gross Domestic Product currently stands at around 55% of the EU average on a per capita purchasing power parity basis, making Malta an Objective One country for the purposes of EU development funds. In view of the absence of natural resources and the smallness of the domestic markets, Malta's imports, exports and gross capital flows each amount to over 100% of its GDP, of which over one half are undertaken with the EU.

Following a period of rapid real GDP growth during the first half of the 1990s - when it averaged 6% per annum – in good part stimulated by fiscal expansion, the Maltese economy currently faces the twin problems of an excessively large fiscal deficit and a slowdown in economic growth, which at an average of 4% per annum over the past five years remains significant but insufficient for a country in Malta's state of development. A related problem is a persisting external deficit that is exacerbated by the fiscal imbalance. If persisting, these factors could jeopardise the process of economic growth convergence to the EU, in spite of Malta's low inflation and unemployment rates, standing at around 2% and 5% respectively. The Government plans to bring the fiscal deficit to 3% of GDP by 2004.

The macroeconomic restructuring necessary to improve the long term sustainability of the economy and assist in the EU membership process is to be accompanied by a microeconomic reform intended to improve the country's competitiveness. This will involve privatisation, industrial restructuring and the removal of protectionist mechanisms for domestic producers who will thus be to a greater extent exposed to international competition. It can therefore be argued that the policy-makers and the population in general perceive that there are at present economic challenges and threats that are more immediate, certain, and potentially costly than those associated with climate change.

2.2.1 Productive Activities

Malta is an advanced developing economy that during the past three decades transformed its productive base from one that was essentially dependent on expenditure by the British military services to one that is competing in the international market place through a mix of manufacturing and service activities, with the latter growing in importance over time. This in spite of the absence of natural resources except for the temperate climate, natural beauty and limestone which is quarried for use by the construction industry.

Table 2 details the contribution of different productive sectors to GDP in Malta in 1990 and 2000.

Table 2: The Composition of GDP in Malta

Percent

	1990	2000	Change
Agriculture and fishing	3.5	2.4	-1.1
Industry	30.5	28.4	-2.1
Distribution	14.4	11.1	-3.3
Transport & Communication	5.7	6.4	0.7
Financial	16.1	19.8	3.7
Private Services	9.0	11.1	2.1
Public Sector	20.8	20.8	0.0

Source: National Statistics Office (2001c)

The agriculture and fishing sector is relatively small and in long term decline. This reflects mainly the unattractiveness for younger people to pursue an agricultural career because of the unsuitability of Maltese land and sea territory to allow for relatively large undertakings where new technology can be competitively applied. Industry, comprising manufacturing for the most part, but also construction, quarrying and ship-building accounts for over a quarter of Maltese GDP, as it used to be the main engine of economic growth particularly during the 1970s. As a proportion of GDP, however, it is declining. Service activities, on the other hand, are expanding their share of GDP. These include financial services, private services and transport and communication, but the importance of the distribution sector is diminishing. Taken together, services activities accounted for almost one half of Malta's output in

2000. Permeating all these economic activities is the tourism industry, which, albeit not singled out in the statistics, is estimated to contribute around 20% of GDP through expenditure in various service and manufacturing activities, as well as on agricultural produce.

The public sector share of output remained constant at just over one-fifth of GDP, in spite of the privatization of various activities. Table 3 provides estimates of the composition of services provided by public sector activities. Chief amongst these is the provision of electricity, fuel and water utilities, which amounts to 6% of GDP. Education and health are other important aspects, as the public sector plays a leading role in the provision of these services without charging user costs in Malta. Somewhat neglected aspects are the transport and sanitation services, and there is a wide perception that these services are inadequate in Malta, in view of the pressures on the road network and sewage system posed by economic growth in general and the tourism sector in particular.

Table 3: Public Sector Output – 2000
(Percent of GDP)

Utilities	6.0
Administration	2.8
Law enforcement	1.8
Transport and Sanitation	0.6
Education	4.3
Health	4.1
Community services	1.2
Total	20.8

Source: National Statistics Office (2001c) and author's estimates

A more detailed insight into the nature of manufacturing activities in Malta, which accounted for some 23% of Maltese GDP in 2000, is warranted to obtain a better understanding of potential vulnerability to climate change. This can be obtained through an analysis of manufacturing sales data, as presented in Table 4.

The table reveals the predominance of hi-tech firms involved mainly in the production of semi-conductor chips and medical equipment. The production of food, beverages and tobacco occupies another substantial share of manufacturing sales. As will be

elaborated upon further, it is considered that these two major sectors are relatively vulnerable to climate change. Maltese manufacturing is well diversified, especially when considering the small size of the economy, into a number of other sectors, as shown in Table 4.

Table 4: The Composition of the Manufacturing Sales –2000

	Percent
Food, beverages and tobacco	14.7
Textiles and clothing	8.0
Wood and furniture	5.7
Paper and printing	4.1
Chemicals	3.6
Plastic	5.2
Metals	1.5
Machinery and transport equipment	6.6
Hi-tech	50.7

Source: National Statistics Office (2002).

The composition of Malta's gainfully occupied population broadly reflects that of output, with the share of public sector employment being somewhat higher reflecting the relatively low labour productivity.

2.2.2 Expenditure Patterns

The counterpart of the output in an economy is the expenditure that is devoted towards acquiring it. Expenditure patterns reveal the consumption activities taking place, from which an assessment of vulnerability to climate change can be obtained, as well as the resources being dedicated to investment, which provide a potential source from which adaptation measures can be effected. They also reveal the extent to which the economy's output is exported as opposed to being domestically used, and hence the extent of dependence on developments abroad.

Table 5 gives a breakdown of total final expenditure in Malta for 1990 and 2000. Private consumption accounts for one third of all expenditure in Malta and is on an increasing trend. The effects of climate change on this variable will therefore be of significance in future. Similar considerations can be made for government consumption, which occupies over 10% of expenditure in Malta.

Investment is on a strongly decreasing trend, possibly limiting the country's future growth prospects. On the other hand, it appears that the role of exports is increasing in the economy, rendering it more dependent on developments abroad. It is noted that although exports are significant and rising, Malta continues to suffer from a deficit on its external transactions, albeit to a diminishing extent compared to the early 1990s. There is an important role played in this respect by the tourism sector, as it generates an external surplus on its activities that contrasts deficits emanating from the rest of the economy.

Table 5: The Composition of Expenditure in Malta

Percent

	1990	2000	Change
Private Consumption	31.5	33.2	1.7
Government Consumption	8.8	10.5	1.7
Investment	16.8	10.6	-6.2
Exports	42.9	45.7	2.8
Total	100.0	100.0	0.0
Memorandum Item			
Net Exports	-6.9	-2.4	4.5
of which: Tourism	10.9	5.8	-5.1
Other	-17.8	-8.2	9.6

Source: National Statistics Office (2001c) and author's estimates

In order to assess the potential effects of climate change on the expenditure side of the economy, it is useful to analyse the composition of private consumption expenditure. This analysis is presented in Table 6. Changes in consumption patterns are typical of those of a developing economy with a rapidly decreasing share of expenditure devoted to basic needs such as food and clothing.

On the other hand, there is an increasing expenditure on housing, partly reflecting an increase in property values in a densely inhabited country. Moreover, this reflects an increased expenditure on consumer appliances, most notably air conditioners which have been acquired in significant quantities in recent years, not so much because of a climate warming phenomenon but due to a significant reduction in equipment prices. It is known that the use of air-conditioners in Malta is generating peak demands for electricity that are only with difficulty being met by the public sector monopolistic utility on the Island.

Table 6: The Composition of Private Consumption

Percent

	1990	2000	Change
Food, beverages and tobacco	39.1	34.7	-4.3
Clothing	9.2	8.2	-1.0
Fuel	2.5	2.5	0.0
Housing	15.5	15.8	0.4
Medical	4.4	4.6	0.2
Transport and Communication	20.3	24.0	3.6
Recreation	9.0	10.3	1.2
Total	100.0	100.0	0.0

Source: National Statistics Office (2001c) and author's estimates

Transport and communication and recreation have also occupied larger shares of consumption expenditure. The increase in the transport share reflects a strong increase in the use of private and commercial vehicles, which in 2000 amounted to over 250,000, or three vehicles for every two persons. This represents an inefficient and unsustainable use of transport resources, which is placing an excessive strain on road infrastructure. It is to be noted that the recreation enjoyed by the Maltese is probably larger than that revealed in consumption statistics, because the population enjoys the sun, sea and environment as free goods.

2.2.3 Long Term Economic Trends

Two major factors conditioning the long run development of the Maltese economy are:

i. **The demographic shift towards older populations.** This is expected to happen not only in Malta, where the proportion of population aged 60 and over is expected to rise from 17% in 2000 to almost one quarter by 2020, but also in Malta's trading partner countries.

ii. **The continuing process of globalisation.** Hence, the need for the Maltese economy to be increasingly competitive and attractive to foreign investment. This renders the debate on EU membership of interest only in

the short- to medium-run, because in the long run Malta would have no option but to align itself with international economic systems.

These considerations point to the likelihood of the following trends in Malta's future economic development:

i. **a shift away from manufacturing into service activities**, particularly in tourism and tourism-related areas such as retirement homes, international education and health services, as well as in financial and IT services;
ii. **a restructuring of manufacturing activities** away from the wide diversification of outputs currently being produced and towards the hi-tech area where Malta remains cost-competitive;
iii. **a reduction in the role of the public sector**;
iv. an **increase in investment expenditure** as Malta catches up with the infrastructure and income levels of the EU, later to be followed by **higher consumption** particularly on health and recreation, also in view of the ageing population.

3. *Economic Vulnerability and Adaptation to Climate Change of Small Island States*

Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change[3] (2001) focused on the special issues facing Small Island States in terms of their vulnerability and adaptation[4]. Small island states do not face an identical set of challenges with respect to climate change, yet they share a number of features that increase their vulnerability and reduce their adaptation capacity.

Among the factors that increase vulnerability to climate change are:

i. high **susceptibility to natural phenomena** and hazards, often as a result of the significant presence of socio-economic activities in coastal areas;

[3] The Intergovernmental Panel on Climate Change was set up in 1988 by the United Nations Environmental Programme and the World Metereological Organisation.
[4] See Nurse et al (2001)

ii. **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;
iii. the high economic **dependence on tourism**, a sector that is especially susceptible to climate change;
iv. **high population densities**, implying more extreme socio-economic effects over limited areas;
v. **poorly developed infrastructure**, which reduces the scope for mitigation and adaptation;
vi. relatively **thin water lenses** that are easily disturbed by changes in climatic conditions;

The areas of socio-economic activity where this vulnerability is most evident include tourism, coastal housing and related activities, water production and human health.

The major features of small island states that constrain their capacity for adaptation include[5]:

i. **limited physical size**, which reduces the scope for options such as retreat from sea level rise or relocation to areas with milder climatic conditions;
ii. **limited natural resources**, which would often be already heavily stressed by human activities;
iii. **relative isolation** and long distance from major markets and concentrations of human activity, precluding from enjoying fully any external benefits of adaptation put in place by other countries;
iv. **limited human and financial resources**, implying a reduced capability to adapt to climate change;
v. **more urgent economic growth and development targets** that would not only reduce the amount of resources that can be devoted to adaptation to climate change, but also increase the delay in taking the necessary measures.

[5] See Briguglio (1995)

Compared to other countries, small island states face heightened challenges from climate change in spite of the fact that they contribute relatively marginally to the phenomenon through pollution and other adverse by-products of economic activity, accounting for less than 1% of global greenhouse emissions. At the same time, they face the challenge of growth and development to converge to economic activity levels of larger trading partner countries. It is thus clear that climate change imposes an equity issue between those countries that are chiefly responsible for the phenomenon and yet less vulnerable and more easily adaptable to it, and those countries which are more vulnerable to its effects in spite of their marginal contribution to it, and whose state of development inhibits adaptation.

Other considerations of relevance to small islands states are the relatively high degree of uncertainty and risk associated with the effects of climate change together with the need for further research into their specific conditions. Climate change impacts are typically more difficult to predict for small regions due to a lack of geographical modeling detail. The use of downscaled models that incorporate analyses from empirical research and observation from small island states is advocated.

4. *Malta's Economic Vulnerability and Adaptation to Climate Change*

From a synthesis of the arguments presented in Sections 2 and 3, it is evident that the Maltese economy and society share a number of characteristics with other small island states with respect to the challenges they face from climate change. This section explores in further detail the areas of major vulnerability and possibilities for adaptation for Malta. It builds and extends on, *inter alia*, a 1996 study[6] that presented a description of a number of major impacts of climate change, analysed here through an approach that has been adapted from the IPCC technical guidelines for assessing climate change impacts[7].

[6] See Attard D J et al (1996).
[7] See Carter T R et al (1994). An example of a practical application of an approach based on this method is Klein and Nicholls (1999).

4.1 Vulnerability

The assessment of the vulnerability of the Maltese economy to climate change is based on the analysis of the economy presented in Section 2, thus distinguishing between the effects on the production sector and those on expenditure activities.

4.1.1 Vulnerability of the Production Sector

Table 7 details potential long-term impacts of climate change on the production activities of major sectors in the Maltese economy together with an assessment of their likely strength. It analyses the impacts on the supply side of production operations, as distinguished from the potential effects on the demand side that are presented under the discussion on expenditure activities.

The extent of the strength of the effects was derived on the basis of a qualitative evaluation involving export opinion considering:

i. the magnitude of the initial impact;
ii. the degree of certainty of the realization of the impact – in this respect, the precautionary principle giving a relatively large weight to the significant consequences of worst case scenarios is adopted[8];
iii. the extent to which such impact is already present in the baseline scenario, to assess the net effects of future global warming;
iv. the degree to which the impact can be easily mitigated or its effects reduced through substitute activities or autonomous adaptation (as opposed to planned or anticipated adaptation measures which are discussed in the next section).

The **agriculture and fisheries** sector in Malta is expected to be significantly impacted by climate change phenomena. It is currently in a state of long term decline, but this can be expected to be halted in the medium term through restructuring, improvement

[8] See Burton I et al (1999).

in quality and marketing efforts, and rural development measures aimed at diversifying agricultural activities and exploiting positive externalities.

Climate change is however expected to exert a number of negative impacts on the sector, among which an impoverishment and aridification of soil. Although a major consideration, this effect is already taking hold to a significant extent in Malta, such that the relative contribution of future global warming is in this respect deemed to be moderate. Warmer temperatures are also expected to engender an increase in the incidence of pests, an effect that can be relatively mitigated through the use of pesticides, albeit not without undesirable side effects. A sizeable proportion of agricultural land, which could be as much as 15%, is expected to be inundated due to the expected rise in sea level. Once again however, this effect is to be viewed within the context of the loss of agricultural land in the baseline scenario, such that its effect is judged to be moderate. On the other hand, any loss of land in Malta is bound to have significant costs in a country where it is such a scarce resource.

In the fisheries sector, the major impacts of climate change are likely to be related to the shifts in migratory patterns of the most-intensively fished species, such as tuna, as well as the erosion of posidonia meadows through the success of other species that are better suited to the new climate conditions. Fish migration is already being influenced to an extent by warmer sea temperatures, at present to the benefit of Maltese fishermen as migration routes are moving southwards. The continuation of this trend could however mean a loss of potential catches in future. Posidionia meadows are a feeding and breeding ground for a number of species, and their erosion could have some indirect effects on the fisheries sector and perhaps also on tourism. The notable degree of uncertainty of regarding the impact of these effects on final economic activity results in their strength being judged as moderate. A similar impact on the fisheries sector arising out of climate change is the disruption to fish farming activities due to the damage to equipment and gear.

In the **manufacturing** sector, the activities that are most likely to be impacted by climate change are those that require strict environmental control within their production processes. These would include hi-tech activities as well as food-processing. While production environment control already forms part of the operating

Table 7: Vulnerability of the Production Sector

Sector	Effects	Strength
Agriculture and fisheries	More arid, less fertile soil	Moderate (already relevant)
	Increase in pests	Moderate
	Land inundation	Moderate
	Change in fish migration	Moderate
	Erosion of posidonia meadows	Moderate
	Disruption to fish-farming	Strong
Industry	Higher costs of production environment control for hi-tech and food sectors	Strong
	Deteriorating working conditions in other sectors, especially in construction	Negligible
	Disruption due to flooding	Moderate
	Compliance to pollution standards	Moderate to strong
Transport and communication	Infrastructural damage	Indeterminate
	Road flooding	Moderate (already relevant)
	Increased discomfort	Strong (already relevant)
	Wind disruption to maritime transport	Moderate
	Thunderstorm disruption to air transport	Negligible
	Disruption to wireless communication	Negligible
	Compliance to pollution standards	Moderate to strong
Distribution	Higher costs due to transport disruption	Moderate
	Higher costs of storage and service environment control	Moderate
Service activities	Higher costs of service environment control	Moderate
Utilities	Acquifers affected by sea-water intrusion and lower precipitation	Moderate (already relevant)
	Disruption to sewerage sea outflow points	Strong
	Flooding of sewerage network	Strong
	Disruption to energy production due to high peak demands and higher investment costs	Strong (already relevant)
	Compliance to pollution standards	Moderate to strong
	Disruption to renewable energy production	Moderate

processes of these business, it is expected that changes in climate would contribute to significantly increase their production costs. Thus, the effect of climate change on these sectors is judged to be strong.

Another effect on the industrial sector is that climate change would cause a deterioration in working environment conditions for persons, especially in the relatively labour-intensive and exposed construction and quarrying sector. This effect is already being mitigated to a significant extent by increased mechanization and environment control measures such as air-conditioning, such that any increase in future costs in this respect arising out of climate change in judged to be negligible. Another potential effect is the flooding of industrial areas due to excessively concentrated rainfall with which drainage systems would be unable to cope. This phenomenon is already to an extent present and is judged to have a moderate impact on industry.

Due to Malta's economic openness and the dependence of its industry on developments abroad, it is very likely that Malta will have to increasingly comply with international pollution standards. This is a concern that extends to other sectors such as transport as well as the utilities. It is already expected that with the prospect of EU membership and the adoption of the environmental *acquis*, Malta will have to make significant adjustments in this respect, the costs of which will be partly borne by the EU. In this event, it is probable that further international restrictions on pollution emissions would have only a moderate effect on Maltese industry. The negative effects could be stronger should Malta opt to fully bear the costs of environmental compliance and the longer it postpones the adoption of the necessary measures.

Productive activity in the **transport and communication** sector in Malta is expected to be affected by climate change in various ways. An extent of infrastructural damage can be expected, depending on the prevalence of extreme meteorological conditions. Road flooding, which is already somewhat prevalent in Malta, can be expected to increase. The effect of climate change in this factor is judged to be moderate because it is expected that Malta will have in any case to effect significant investment to upgrade its road network in the short to medium term irrespective of climate change

considerations. Another important consideration is the increased discomfort in travel produced by climate change. It is expected that this is to have strong effects, in the form of costs to air-condition private and public means of transport. This, within the context of a relatively inefficient public transport system in Malta that is protected by state regulation, using obsolete vehicles and facing a significant trend decline in demand.

Other effects of climate change on the transport and communication sector in Malta include disruption to maritime activities due to wind force, problems to air transport due to increased thunderstorms, and interference in wireless communication. These effects can be relatively easily mitigated through technological means and logistical adjustments to transport systems. The disruption of maritime activities is however expected to have more important effects due to the dependence on sea transport in Malta, particularly for communication between the two main islands.

The **distribution** sector in the Maltese economy is expected to be influenced in two major ways by climate change. Firstly, it will have to bear higher costs due to the disruption of transport. Secondly, it will have to shoulder increased costs of environmental control for storage environments and service provision. The impacts of these effects as emanating from future climate change are judged to be moderate because the distribution sector is likely to an extent face these effects in a baseline scenario in any case. This is due to the poor state of the road network in Malta, as well as the need for business to upgrade their operations in view of competitive pressures. Similar considerations apply to all other **services** activities in Malta, which will have to bear the increased costs of environmental control of working and service activities.

The **utilities** sector involved in the production and provision of energy, fuel, water and sewerage services are expected to be influenced by climate changes in a number of important ways. Water production, which relies significantly on groundwater extraction, will be disrupted by sea water intrusion due to the rising sea-water levels together with the lower rain precipitation. This effect is judged to be moderate as it is already relevant in current conditions.

Sewerage services are expected to be strongly disrupted by a loss of servicability of sea outflows together with flooding of the systems. This impact is expected to have serious repercussions on the household sector and on tourism and the costs of rectification are likely to be significant.

Electricity production is expected to be disrupted by peak demands in extreme temperature conditions that are expected to be exacerbated by climate change. This will not only increase the frequency of power-outs with significant costs for the entire economy, but will cause an increase in operating costs and replacement investment for the electricity provider. Further additional costs to the energy sector will be imposed by the need to comply to international pollution standards in view of climate change, as discussed earlier on. Finally, climate change may impose difficulties for Malta to exploit renewable energy sources because of an increase in extreme meteorological conditions. At present, Malta makes only a minimal use of such sources, but it is believed that a potential for more profitable exploitation exists and is being actively explored.

This qualitative appraisal of the vulnerability of the Maltese economy to climate change can be summarized by means of a numerical evaluation exercise of the strength of effects on the individual major production sectors with the aim of deriving a **vulnerability score for productive activities** for the economy. This analysis is presented in Table 8.

The derivation of the vulnerability score depends on the production of the vulnerability score of individual sectors with the weight that the sectors occupy in the economy. Table 8 details the vulnerability scores and economic weights as they apply at present and as they would be perceived to be in a future long-term steady state scenario. Current economic weights relate to the share contributed by each sector of activity to GDP in 2000. Future economic weights were derived on the basis of the discussion presented in section 2.2.3, broadly featuring declining shares of activity in the primary, secondary and distribution sectors and an increase in service activities with the exception of the public sector. Within the manufacturing sector, high tech industries are expected to increase their share significantly, while utilities are expected to increase in importance in public sector operations.

Table 8: A Qualitative Assessment of Climate Change Vulnerability of Production Activities

	Current		Future	
	Economic weight (%)	Sector Vulnerability*	Economic weight (%)	Sector Vulnerability*
Agriculture and fishing	2.4	2.4	1.0	2.3
Industry	28.4	1.8	23.0	2.7
Distribution	11.1	2.3	9.0	2.3
Transport & Communication	6.4	2.5	10.0	2.5
Financial	19.8	1.4	25.0	1.4
Private Services	11.1	1.4	15.0	1.4
Public Sector (incl. Utilities)	20.8	2.4	17.0	2.7
Overall Production Vulnerability	100.0	1.9	100.0	2.2

* Index of Sector Vulnerability:
0 = None
1 = Negligible
2 = Moderate
3 = Strong

Sector vulnerability scores are derived as a weighted average of the different impacts and effects presented in Table 7, with the magnitude of effects being given a score ranging from 0 to 3, as indicated in Table 8. Changes in sector vulnerability scores from the present to the future scenario reflect structural shifts that would be expected to autonomously take place within those sectors. In the agriculture and fishing sector, the relatively high vulnerability at present would be expected to decline marginally due to the diversification of activities that is expected to take place. In the manufacturing sector, the increased dependence on hi-tech activities in expected to increase vulnerability. In the public sector, the increased share of the utilities as a result of the scaling down of other areas of public sector intervention is expected to increase the average vulnerability score in the future scenario.

Based on these considerations, the overall production vulnerability to climate change of the Maltese economy is estimated at 1.9 in the current scenario and expected to increase to 2.2 in the future scenario. Thus, in qualitative terms, the vulnerability is expected to range from just under moderate to moderate-high.

4.1.2 Vulnerability of Expenditure Activities

An analysis with regards to the vulnerability to climate change similar to that presented in the previous section is here undertaken for the expenditure activities in the Maltese economy. The results are presented in Table 9.

Private consumption activities are expected to be influenced through a greater share of resources being diverted towards meeting the effects of climate change. These include expenditures on climate control in houses and cars, with an attendant increase in expenditure on energy. Moreover, the amount of consumption resources devoted towards acquiring water of good quality can be expected to increase. The strength of these effects is judged to be moderate, mainly because they are already present irrespective of the effects of climate change.

Climate change can be expected to have a number of health effects that are to be met by resources being defrayed from consumption activities. Adverse health effects will emanate from disruptions to the sewage system, the reduced quality of potable water, temperature extremes, and a greater incidence of tropical diseases together with those associated with skin, eyes and the immune system. It is expected that there will be a strong response of consumption expenditure to these factors, not only via private consumption but also on public consumption, as government is a major provider of health services in Malta. This especially since population ageing will tend to exacerbate the adverse effects of climate change on health.

Inundations through sea-water rise can be expected to affect residential areas in coastal areas. This effect is expected to be strong, affecting around 5% of the population and an equivalent proportion of units of housing stock. This is also bound to be a chief consideration in Malta, given the scarcity of land. Residents in inundation-risk areas could also be expected to experience a significant drop in wealth levels over time, as the value of property in these areas would be expected to diminish. There could also be equity considerations involved in this issue, because the

more socio-economically disadvantaged groups in Malta tend to live closer to the harbour regions.[9]

A similar consideration is the risk of flooding through excessively concentrated precipitation. Inundations and similar climate change phenomena are also expected to aversely affect entertainment and transport and communication activities, especially when considering the extent of entertainment obtained through activities on the coast including summer residences.

Table 9: Vulnerability of Expenditure Activities

Activity	Effects	Strength
Private consumption	Increased expenditure on environmental control in houses and cars, and consequently on energy, crowding out other consumption	Moderate (already relevant)
	Increased expenditure on water of good quality	Moderate (already relevant)
	Increased expenditure on health	Strong
	Disruption to housing in coastal areas	Strong
	Disruption to housing due to rainwater flooding	Moderate
	Disruption to entertainment associated with natural amenities	Moderate
	Disruption to transport and communication	Moderate
Public consumption	Increased expenditure on health services	Strong
Investment	Resources diverted to climate change adaptation crowd out other activities	Moderate
Tourism exports	Lower demand due to: - disruption to coastal activities and environment - warmer climate in home countries - health hazards	Strong
Other exports	Reduction in competitiveness due to increased costs to adapt to climate change	Moderate

[9] See National Statistics Office (2001b).

A measure of disruption to **investment expenditure** in Malta can be expected to take place due to climate change, mainly as resources are diverted towards adaptation and mitigation measures. The negative effects of this factor are expected to be compounded by the ageing population and a consequent drop in the saving rate, together with the fact that Malta needs to invest relatively more in order to catch up with economic activity levels of its major trading partners, and particularly the EU.

A strong effect of climate change on **tourism export** activity in Malta is expected. This would result from a lower demand for Malta as a resort, due mainly to:

- the disruption in coastal activity and environment, including effects on beaches, hotels and yacht marinas;
- the harsher temperature extremes in Malta;
- the warmer climate in tourist source countries;
- the increased incidence of health hazards in Malta;
- the disruption to transport as well as to power and sewage systems.

The effects of climate change in **other exports** is judged to be more moderate, arising mainly from a reduction in competitiveness due to the increased costs associated with climate adaptation. It is expected that the ensuing negative effects on competitiveness would be moderated by the fact that Malta's competitor countries would face similar cost increases, although larger economies may be in a better position to absorb them. Malta's weaknesses in this respect emanate out of the indivisibilities of infrastructural expenditure as well as the relatively high proportion of activities in coastal areas.

A climate change **vulnerability score for expenditure activities** for Malta is derived on through the same approach adopted for analyzing the vulnerability of productive activities, and is presented in Table 10. Current economic weights reflect year 2000 data, and are in future projected to change in line with the notion of a higher role for private consumption, due mainly to population ageing, a reduced role for public sector expenditure, the need for more investment to converge to international economic standards, a stronger reliance on tourism exports and allied activities, and a reduced share of expenditure on other exports.

The vulnerability score of consumption expenditure is bound to increase in the future scenario, because economic development will bring an increasing share of expenditure on activities that are more vulnerable to climate change effects, such as entertainment, transport and health. Other items of expenditure have unchanged vulnerability coefficients, reflecting the considerations made earlier on.

The **overall expenditure vulnerability** to climate change score of the Maltese economy is found at 1.8 at present, rising to 2.1 in the future scenario. It is comparable to, if somewhat lower than, the production vulnerability score. This reinforces the qualitative evaluation that the vulnerability of the Maltese economy to climate change is expected to range from just under moderate to moderate-high.

Table 10: A Qualitative Assessment of Climate Change Vulnerability of Expenditure Activities

	Current		Future	
	Economic weight (%)	Sector Vulnerability*	Economic weight (%)	Sector Vulnerability*
Private Consumption	33.2	1.7	35.0	2.2
Public Consumption	10.5	1.5	7.0	1.5
Investment	10.6	2.0	12.0	2.0
Tourism Exports	11.4	3.0	17.0	3.0
Other Exports	34.3	1.5	29.0	1.5
Overall Expenditure Vulnerability	100.0	1.8	100.0	2.1

* Index of Expenditure Vulnerability:
0 = None
1 = Negligible
2 = Moderate
3 = Strong

4.2 Potential for Adaptation

In line with Smith et al (1996), the potential for adaptation of the Maltese economy is viewed in terms of the required "adjustments in behaviour or economic structure that reduce the vulnerability of society to changes in the climate system." The issues that arise in this context include the degree to which such adaptation is possible, its costs, and whether it is autonomous (spontaneous) or planned given the degree of foresight required to forestall the effects of climate change. The extent to which technological

advances are required in order to implement adaptation measures and their impacts on the relative costs is another important consideration.

Autonomous reactions, mainly to climate variability, are already taking place in Malta, for example in the form of air-conditioning, water collection on roofs and retaining walls in agricultural land. In line with Klein and Nicholls (1998), it is argued that while these spontaneous measures are important, they are likely to be insufficient in meeting future challenges. The need for planned adaptation measures in Malta is thus discussed next.

Following Klein and Tol (1997), it is argued that planned adaptation aimed at reducing the vulnerability to climate change can have four objectives:

- **increasing robustness of vulnerable activities and infrastructure** to changes in climatic conditions, by for example, increasing the range of temperature or precipitation a system can withstand;
- **increasing the flexibility of vulnerable activities and infrastructure** to be able to better respond to changes in climatic conditions by, for example, developing industry with shorter economic lifetimes or that can be more easily relocated;
- **enhancing adaptability of vulnerable systems** by removing other stressors, such as excessive traffic pressures on the road network which accelerates its deterioration and potential vulnerability to flooding;
- **reversing trends that increase vulnerability** by, for example, halting further development in coastal areas.

Adaptation measures on these fronts involve a mix of instruments, including economic, legal, institutional and technological. Technological measures can be "hard", involving the construction of infrastructure and physical capital or "soft", relying mainly on a better use of available knowledge. Technological measures are particularly relevant in the context of the first two of the above goals.

A number of adaptation measures relevant to reduce the vulnerability of the Maltese economy to climate change are here considered out of the plethora of measures listed

in the literature[10]. This discussion is however by no means intended to be exhaustive or comprehensive but merely illustrative of the type of measures likely to be required in Malta and indicative of the relative costs. Relevant adaptation measures for Malta include:

- **Increased reliance on airconditioning systems** across the productive sectors and households. This measure is already being autonomously implemented to a significant extent. It would however increase energy demand and release heat in the urban environment. The latter effect would be relevant given the high population density in Malta.
- **Improved energy production and more reliance on renewable sources**. This is necessary to reduce the vulnerability of the energy sector itself and sustain adaptation by other sectors. The Government of Malta is expected to publish an Energy Policy document in the coming months, and a committee is currently studying the potential use of renewable energy sources. These measures are likely to entail significant investment costs for Malta.
- **Tree planting in urban areas** entailing a more careful management of such amenities than that carried out in Malta to date.
- **Constructing and converting buildings to improve energy efficiency and climate control.** A number of changes to current construction practices towards this end have been identified in Malta[11], which are likely to be costly but provide a positive net financial return in the long run, apart from reducing vulnerability to climate change.
- **Improving early warning systems of extreme meteorological conditions and upgrading disaster preparedness.** Given Malta's smallness and geographical characteristics, improved collaboration with other Mediterranean countries would be desirable.
- **Constructing flood defense systems** of the low-lying coastal areas with highest socio-economic concentration of activity by means of hard and soft structural engineering options.
- **Retreat** from coastal areas that are most vulnerable to inundation. This option is however difficult to implement in Malta given the scarcity of land.

[10] see, for example, MacIver (1998) and Bijlsma et al (1996).
[11] see Pace (1999)

- **Improved transport systems and infrastructure** so as to have better mobility for the eventuality of evacuation. The road network in Malta calls for particular attention.
- **Improved water run-off facilities** so as to reduce possibilities of flooding.
- **Directing more resources to primary health care and health surveillance** in the areas where climate change is imposing the more severe threats to human health.
- **Improved water production and distribution systems**, possibly with an increased emphasis on desalination., which is however very costly to invest in and operate.
- **Improved farming methods and infrastructure**, including the use of brackish water, dormant season irrigation, crop rotation, etc.
- **Preventing further development of coastal areas**, which in Malta are in any case probably already over-utilised.
- **Implementing afforestation, wetland creation and beach nourishment programmes.**
- **Fostering an economic environment necessary for the further development of the less vulnerable sectors of activity.** This, in an attempt to accommodate the effects of climate change by adjusting human activities to changing circumstances.

In general, it can be argued that "soft" adaptation measures would in Malta be less costly to implement and more effective than "hard" ones, not only in monetary terms but also from an environmental perspective. This in view of the smallness of the island, the high population density and indivisibilities in infrastructural investments. This would also be in line with a more flexible strategic approach given the high degree of uncertainty regarding the impacts and effects of climate change. Perhaps even more importantly, it is important to focus on "win-win" measures that are in any case bound to produce positive results for society and would protect from the effects of climate change if and when these take hold. Examples of such "win-win" strategies include efficiency in energy production with an emphasis on renewable sources, promoting energy-efficient buildings, upgrading the road network, improving farming methods, afforestation, wetland creation, beach nourishment and preventing further over-development of coastal activities. It is also argued that if these measures are undertaken in sufficiently timely manner, the need for more costly "hard" measures would be reduced or averted.

4.3 The Role of Quantitative Estimation

Quantitative assessments of the impacts of climate change is typically based on approaches aimed at estimating:

- **direct costs** of impacts through the cost of amenities or output lost or of adaptation measures[12], and;
- **equivalent variations**, which take into account secondary welfare losses arising out of direct costs[13].

The undertaking of a quantitative analysis of the effects of climate change and of the costs of adaptation, though desirable, is beset by a number of difficulties[14]. The principal ones that are relevant within the context of this study are:

- **An insufficient period of observation of past trends**, given that climate change occurs over a relatively long span of time.
- The way in which **economic behaviour** is likely to develop in future with respect to climate change will differ from the relative neglect observed in past, even if climatic variables were to continue to develop along a simple linear time trend. This is typical of the lagged, non-linear and often unpredictable nature of economic behaviour - which occurs even in the wake of relatively stable, linear phenomena - reflecting the intricacies of human psychology and the workings of the political decision-making system.
- The already **considerable margins of error** inherent in economic quantitative forecasting would be widened further by those present in the forecasts of variables depicting climate change.
- Applicable quantitative models of climate change are available mainly for the sea level rise phenomenon and are thus **too narrow for the scope of the present study**.
- Applicable quantitative models of climate change relate mainly to regions and large countries, such that the **cost co-efficients would be unsuitable** for use in a densely populated small island context.

[12] see, for example, Tol (1995) and Tol (1996).
[13] see Darwin et el (1999).
[14] See, for example, Feenstra et al (1998).

5. *Conclusions and Recommendations*

It is thus to be appreciated that this study represents merely an overview of the principal considerations involved in the vulnerability of the Malta to climate change and the required adaptation measures. Each of the sources of vulnerability requires more detailed study in terms of its magnitude, certainty, likely impact and economic cost. Similarly, more detailed investigation in each adaptation measure, on a cost-benefit basis, is required to identify the best mix of measures to undertake within the context of the socio-economic fabric of the Maltese Islands.

From an economic perspective, climate change is akin to a negative supply shock that disturbs productive activities and absorbs resources away from alternative consumption and investment activities. Subject to the uncertainties and incomplete information inherent in this type of study, this paper finds that there are bound to be important effects of climate change on the Maltese economy and society. These are similar to those applicable for other small island states characterized by exposure to coastal activities and suffering from the effects of indivisibilities in infrastructural investment, but are in the case of Malta compounded by a high population density and an ageing population. The future development of the economy is likely to increase the Island's vulnerability to climate change.

A number of adaptation measures to climate change that are more relevant for Malta are identified. Some of these, which are of a "hard" nature, could be expected to impinge significant costs on the economy. "Soft" adaptation measures implemented in a timely fashion are more likely to create "win-win" situations imposing lower costs and catering for the uncertainty associated with climate change phenomena. They would however include some re-direction of the present pattern of socio-economic development away from coastal activities.

The country's ability to effectively implement these adaptation measures is likely to be hampered by the scarcity of natural, physical and human resources, its relative isolation together with the existence of more urgent socio-economic development

goals. It is thus expected that Malta and countries in a similar condition would benefit from international assistance in averting the threats of climate change for which other countries that are less vulnerable are chiefly responsible for creating.

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