UNIVERSITY OF MALTA
L-Università ta' Malta

Institute for Climate Change and Sustainable Development
University of Malta, Msida, Malta

T: +356 2340 3403
E: iccsd@um.edu.mt
W: www.um.edu.mt/iccsd

European Commission

Supported by the European Commission
Representation in Malta
254 St.Paul Street,
Valletta VLT 1215/Malta

T: +356 2342 5000
E: comm-rep-mt@ec.europa.eu
W: http://ec.europa.eu/malta/

THE EXTERNAL COSTS OF PASSENGER AND COMMERCIAL VEHICLES USE IN MALTA

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The External Costs of Passenger and Commercial Vehicles Use in Malta

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The External Costs of Passenger and Commercial Vehicles Use in Malta

AUTHORS
Maria Attard
Philip Von Brockdorff
Frank Bezzina

CONTACT
Professor Maria Attard
Director
Institute for Climate Change and Sustainable Development
University of Malta, Msida, Malta

T: +356 2340 3403
E: iccsd@um.edu.mt
W: www.um.edu.mt/iccsd

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EXECUTIVE SUMMARY

In 2013, the Council of Ministers addressed a country specific recommendation to Malta related to the energy mix and transport emissions in the Islands. The recommendation stated that Malta should (*CSR 4) Continue efforts to diversify the energy mix and energy sources, in particular through increasing the take up of renewable energy and the timely completion of the electricity link with Sicily. Maintain efforts to promote energy efficiency and reduce emissions from the transport sector* (European Commission, 2013a). This recommendation followed an analysis of the European Commission whereby peak hour congestion was observed to be a major problem in Malta, when compared to the EU average. The Institute for Climate Change and Sustainable Development within the University of Malta was commissioned by the European Commission Representation in Malta to carry out a study on the external cost of traffic and congestion in Malta.

Since the early 90s Malta started showing signs of high levels of motorization and car dependence. This car dependence was coupled with changes to the socio-demographic fabric of the islands' population, a lack of integration between land use and transport planning, a lack of investment in the public transport (bus) service, continued provision of road infrastructure and a relative dearth of policies aimed at promoting modal shift. Since 2006, subsequent governments have implemented a number of measures to tackle car dependence including Park and Ride schemes, pedestrianisation and road pricing. This policy direction, however, has been challenged over the years with the lack of support from land use planning agencies, enforcement and other stakeholders that influence the overall volume of traffic and congestion on Malta's roads. The European Commission's Joint Research Centre is currently working on measuring congestion across the Union and preliminary results for Malta estimated the average number of seconds of delay per km at 16.93 seconds (23.94 seconds for the two regions with the heaviest concentration of traffic) whereas the European average was 5.74 seconds in 2012. The results also suggest an ongoing deterioration in the congestion situation in Malta. An important issue that this study has identified is the significance of comparing Malta to other EU member states given Malta's unique geography and transport system. Of more relevance would be to compare with other major cities across the EU. In any event, the growth in car dependence has had impacts (positive and negative) on the Islands' environment and public health, the economy and overall business climate.

This study has for the first time attempted to collate all the necessary information to estimate the external costs of transport (for passenger and light duty commercial vehicles) in Malta. Data located from various sources was used to create a geographic database of the main road network (using GIS). Additionally, data on accidents, noise, air pollution, climate change and congestion was collated to estimate the external costs caused by passenger and light-duty commercial vehicles. The research team also identified challenges posed by data availability and their impact on the study. In some cases data was missing, and incomplete data sets hindered the estimation of costs.

In this study, the external costs of transport were estimated for accidents, air pollution, climate change, noise and congestion for the year 2012.

External Costs of Transport for 2012 (in millions)

Accidents	Air Pollution	Climate Change	Noise	Congestion	Total Cost
€83.9	€14.3	€46.8	€11	€117.9	**€274**

This study also tested a number of scenarios including a do-nothing scenario for 2020 and 2030.

External Costs of Transport for 2020 and 2030 (in millions) in a 'no policy change' scenario

	Accidents	Air Pollution	Climate Change	Noise	Congestion	Total Cost
2020	€89.6	€15.3	€51.2	€10.4	€151.1	**€317**
2030	€89.6	€15.5	€52.3	€10.6	€154.1	**€322**

For the purposes of estimating the cost of proposed measures aimed at reducing traffic and congestion, three policy actions were developed and their impact was projected in the future.

Policy Action 1: Increasing the efficiency and use of public transport, e.g. through further use of park and ride schemes; use and deployment of non-road modes; more efficient use of the road network, e.g. through intelligent transport services, market-based instruments including time differentiated congestion charging, or removal of infrastructural bottlenecks; and stimulating the use and making the road network more suitable for soft modes (walking/cycling).

The total external costs for 2020 and 2030 were estimated at €187.8 million and €189.5 million respectively. Compared to 2012 there is a noticeable reduction of costs. The savings are greater when compared to the 'no policy change' scenario. This shows that an effective and reasonably priced public transport supported by other related measures could help reduce external costs.

Policy Action 2: Reducing and making the car fleet more sustainable, e.g. through electric mobility and car sharing schemes.

The total external costs were estimated at €315 million for 2020 and €320 million for 2030, both much higher than those estimated for 2012. Although the reductions in external costs were marginal for 2020 and 2030, when compared to the 'no policy change' scenario, electric mobility could still have positive impacts on reducing emissions. The main challenge remains the short distances travelled by car on Maltese roads. Fiscal incentives and subsidies certainly help. However, further technological developments could make electric mobility more cost effective for relatively short distance travel.

Policy Action 3: Optimising work and school hours, and reducing education-related car trips.

Staggering work and school hours would potentially distribute the traffic in the network, reducing the peak but extending the hours of relatively high traffic. This would not directly contribute to a decline in the amount of traffic and related impacts on the network, but could potentially impact congestion (and its costs). Insofar as reducing education-related travel by car, the analyzed reductions of 20 per cent and 50 per cent noticeably reduced the costs compared to the 'no policy change' scenario. The total estimated external costs for 2020 and 2030 were €275 and €273 million respectively, which are only marginally different to 2012.

External Costs of Transport for 2020 and 2030 (in millions) following policy action

	Policy Action 1	Policy Action 2	Policy Action 3
2020	€188	€315	€275
2030	€190	€320	€273

Policy action 1 proves effective in reducing external costs. However, this policy action alone might not be enough and complementary policy actions may still be needed to successfully tackle congestion on Malta's roads. Also, demand management and supply side policies (e.g. improving road infrastructure) need to be explored in depth. The latter may help to ease temporarily congestion levels but given existing delays, supply side policies are unlikely to make any significant impacts of reducing congestion. Measures such as road pricing and restricting car use, through a series of coordinated transport demand management measures, would be more effective in containing the increase and further use of cars on the roads. In theory, by increasing the marginal private cost of car use to a level where the net benefits of car use become lower than for alternative options or modes would be deemed sufficient.

Road pricing and paid parking, aided by complementary educational, environmental and planning measures in specific areas, could be considered as policy options but their effectiveness and impacts need to be studied in depth. Also, the social impacts of the policy actions, notably the affordability of transport in low-income households cannot be overlooked.

1.0 INTRODUCTION

The Institute for Climate Change and Sustainable Development of the University of Malta was commissioned to carry out a study on the external costs of traffic and congestion in Malta by the European Commission Representation in Malta in May 2014. This report is the final requirement for the project as detailed in the work plan for the project described in Annex 1 (Terms of Reference) of the Service Contract.

This final report outlines the purpose, context and objectives of the study. It describes the approach and methodology used in the research and presents the findings of the study.

2.0 THE PURPOSE, CONTEXT AND OBJECTIVES OF THE STUDY

In 2013, the Council of Ministers addressed a country specific recommendation to Malta related to the energy mix and transport emissions in the islands. The recommendation stated that Malta should:

CSR 4 Continue efforts to diversify the energy mix and energy sources, in particular through increasing the take up of renewable energy and the timely completion of the electricity link with Sicily. Maintain efforts to promote energy efficiency and reduce emissions from the transport sector (European Commission, 2013a).

This recommendation followed an analysis of the European Commission whereby peak hour congestion was observed to be a major problem in Malta, when compared to other Member States. An upcoming report from the EU's Joint Research Centre (JRC) shows that congestion in the Islands is amongst the worst across the Member States. Additionally, it appears to be deteriorating and fast becoming a burden on the Maltese economy. The JRC results show that the average number of seconds of delay per km is estimated at 16.93 seconds when the European average is 5.74 seconds. It should be stressed however that Malta is largely an urban area with its Northern Harbour and Southern Harbour regions characterized by heavy traffic. The study has identified this issue of comparability with other countries in the EU and suggests comparing Malta with other metropolitan areas as is shown later in this study.

These preliminary results build upon a study published by the JRC in 2012 entitled *Measuring road congestion*, which did not contain as yet results for Malta (European Commission Joint Research Centre, 2012). These figures are also supported by other surveys which show that 74 per cent of the Maltese often encounter problems when travelling and rank road congestion (97%), noise pollution (92%) and air pollution (95%) as important challenges for the Islands' urban area (European Commission, 2013b).

Malta is an island state with an area of just 316km^2 and consists of three main islands (Figure 1), two of which are inhabited with a population of 417,432 (NSO, 2014a). Malta joined the European Union in 2004 and adopted the Euro in 2008. It developed economically at a stable rate of increase since the early 90s, and withstood the financial downturn of the first decade of this century mostly due to its high resilience as a small island state (Briguglio, 2014). This economic growth has also reflected on its demographic and land use patterns. The population growth has slowed down in the last two decades mostly because of a fall in the birth rate, and the mobility patterns of the population have changed significantly. Since the early 90s, Malta experienced a rapid growth in motorization and a decline in public transport use and in active mobility (walking and cycling). This is most evident in the comparison of the islands modal split as recorded in the last three National Household Travel Surveys (Figure 2).

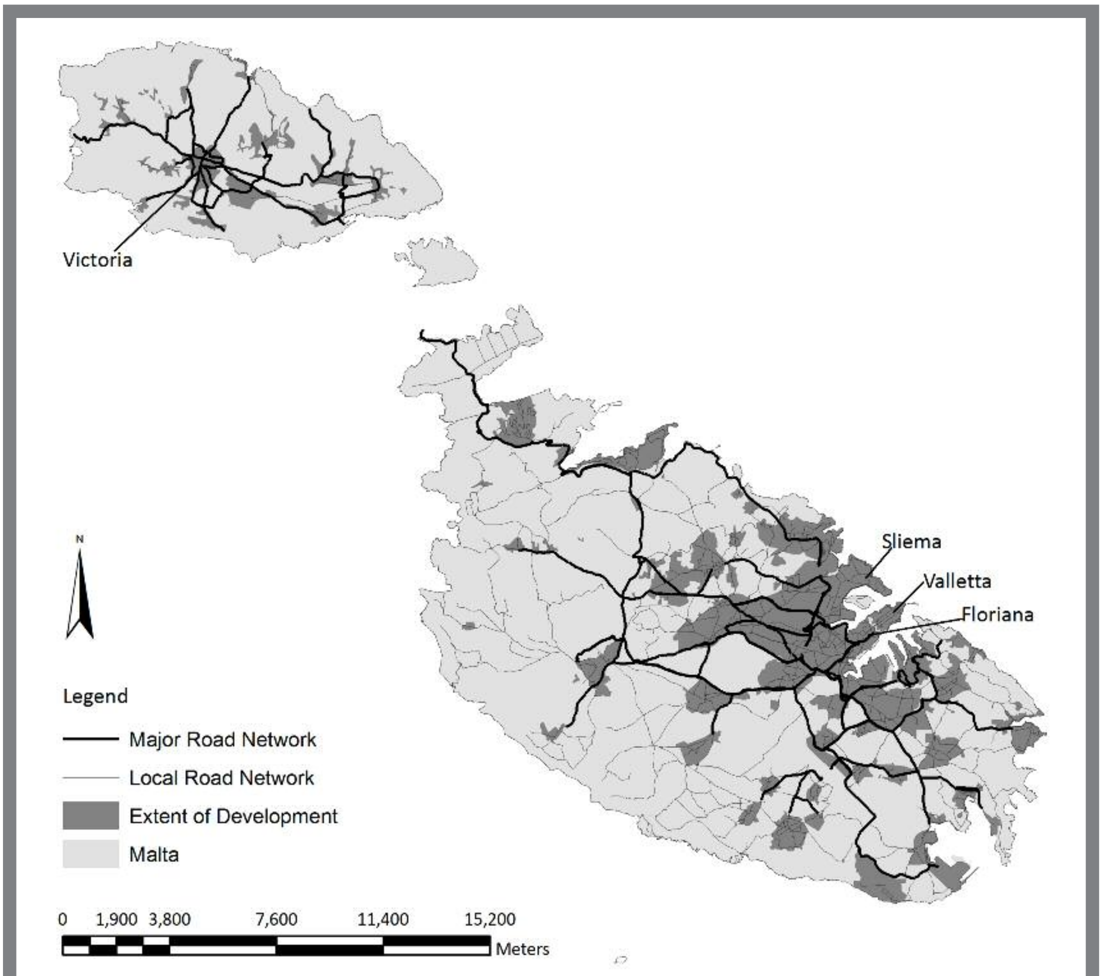


FIGURE 1. The islands of Malta. *Source: Attard and Ison (2015).*

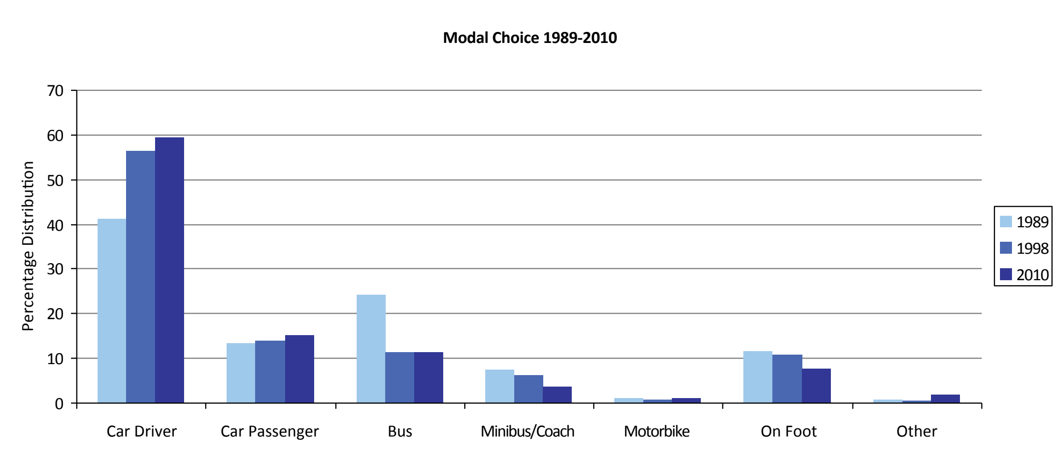


FIGURE 2. Modal Split for Malta 1989 – 1998 – 2010. *Source: Transport Malta (2011).*

Other factors have also contributed to the growth in motorization and car dependence (Attard, 2005). A discussion on some of these factors follows.

Household Income

Household income increased consistently over the years (Table 1). Consecutive surveys carried out by the National Statistics Office have confirmed the high overall expenditure on transport by households. In 2010 Maltese households spent up to 17.9 per cent of their budgets on transport. This is very high when compared with the EU average of 12.8 per cent (Eurostat, 2014a). In 2003, MEPA had already reported a high expenditure on transport. The availability and use of income for transport has supported overall the growth in car ownership.

TABLE 1. Household Income in € million in Malta. *Source: NSO (2012).*

1990	2000	2010
1,283	2,443	3,127

Car Ownership

The rapid increase in the rate of motorization in Malta happened over a relatively short period of time, following the economic boom of the early 90s (Table 2). This growth happened in parallel to increased standards of living (and income), increased rate of participation of women in paid employment and declining size of households.

TABLE 2. Rate of Motorization* in Malta. *Source: NSO (2013); Eurostat (2014b).*

1985	1995	2005	2012
230	376	508	592

* number of private cars per 1,000 inhabitants

Figure 3 shows Malta's growth in motorization and a comparison of the 2010 motorization rate with selected countries.

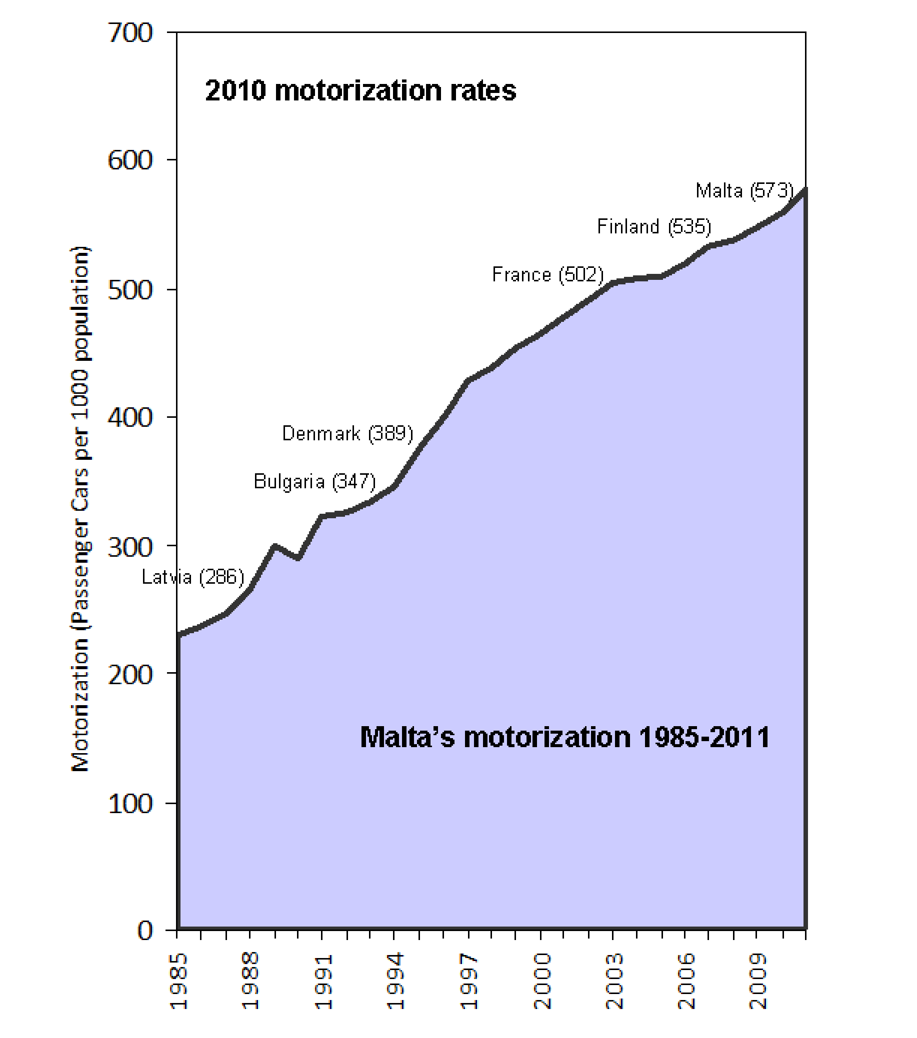


FIGURE 3. Malta's growth of motorization between 1985-2011 and a comparison of the 2010 motorization rate across countries. *Source: Attard and Ison (2015).*

Car use

In 2013, the European Union estimated passenger kilometers for the period 2000-2010 in its document entitled *EU Energy, Transport and GHG Emissions Trends for 2050. Reference Scenario 2013* (European Union, 2014). The passenger kilometers for private cars (and motorcycles) increased by over 20 per cent between the period 2000 and 2010 (Table 3).

TABLE 3. Gpkm* for Private Cars and Motorcycles in Malta. *Source: European Union (2014).*

2000	2005	2010
1.9	2.1	2.3

* Giga Passenger Kilometers

This growth in car use, traffic and congestion is confirmed by the JRC study referred to earlier. Further outputs of the study show the daily changes in travel time and speed over two main sections of the Trans-European Transport Network (TEN-T) Core Network, highlighting aspects of daily traffic behaviour (Figure 4). Figure 5 shows the geographic extent of congestion on the main road network.

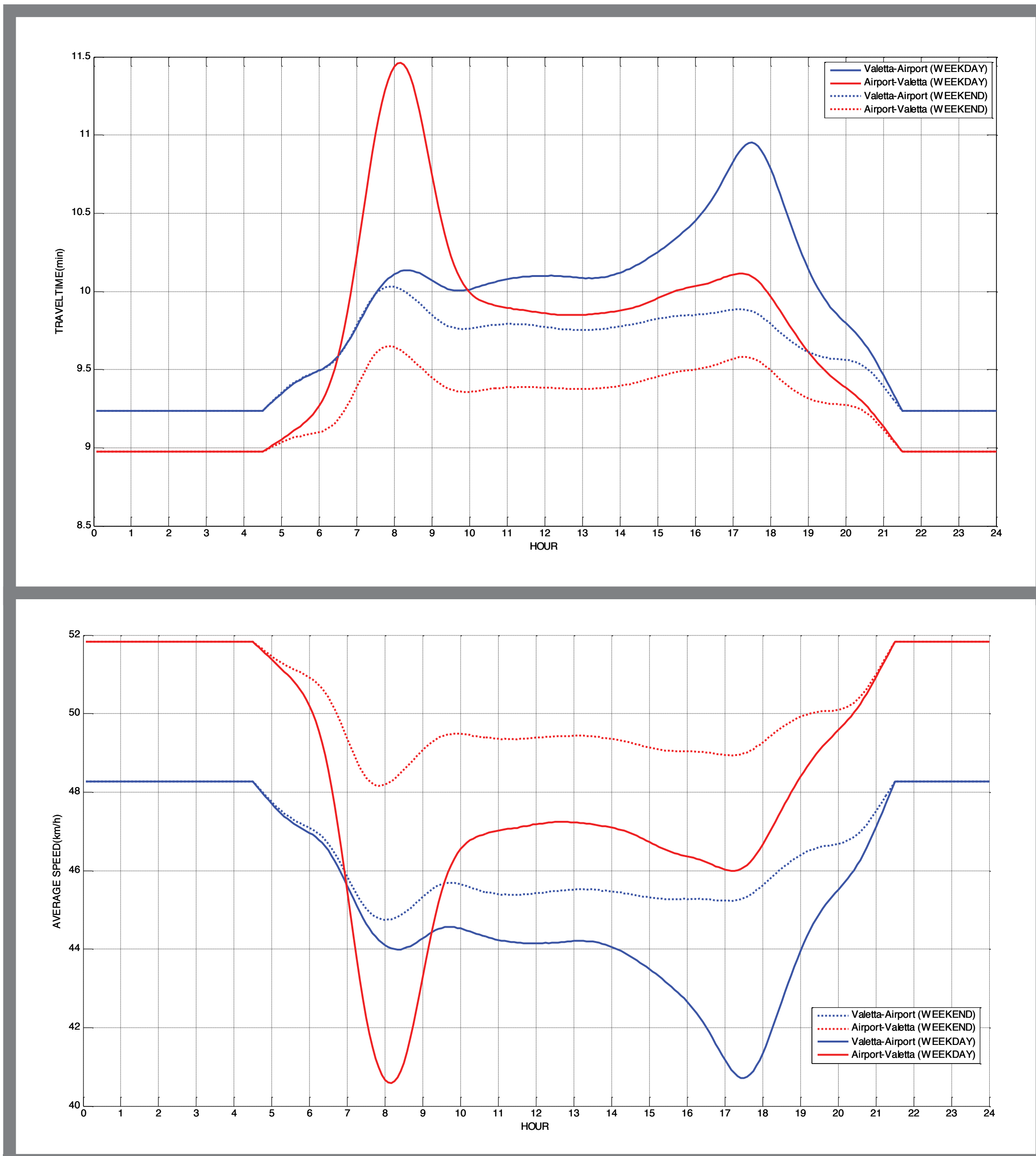


FIGURE 4. Travel time and speed over time for the Valletta-Airport link.
Source: JRC (forthcoming)

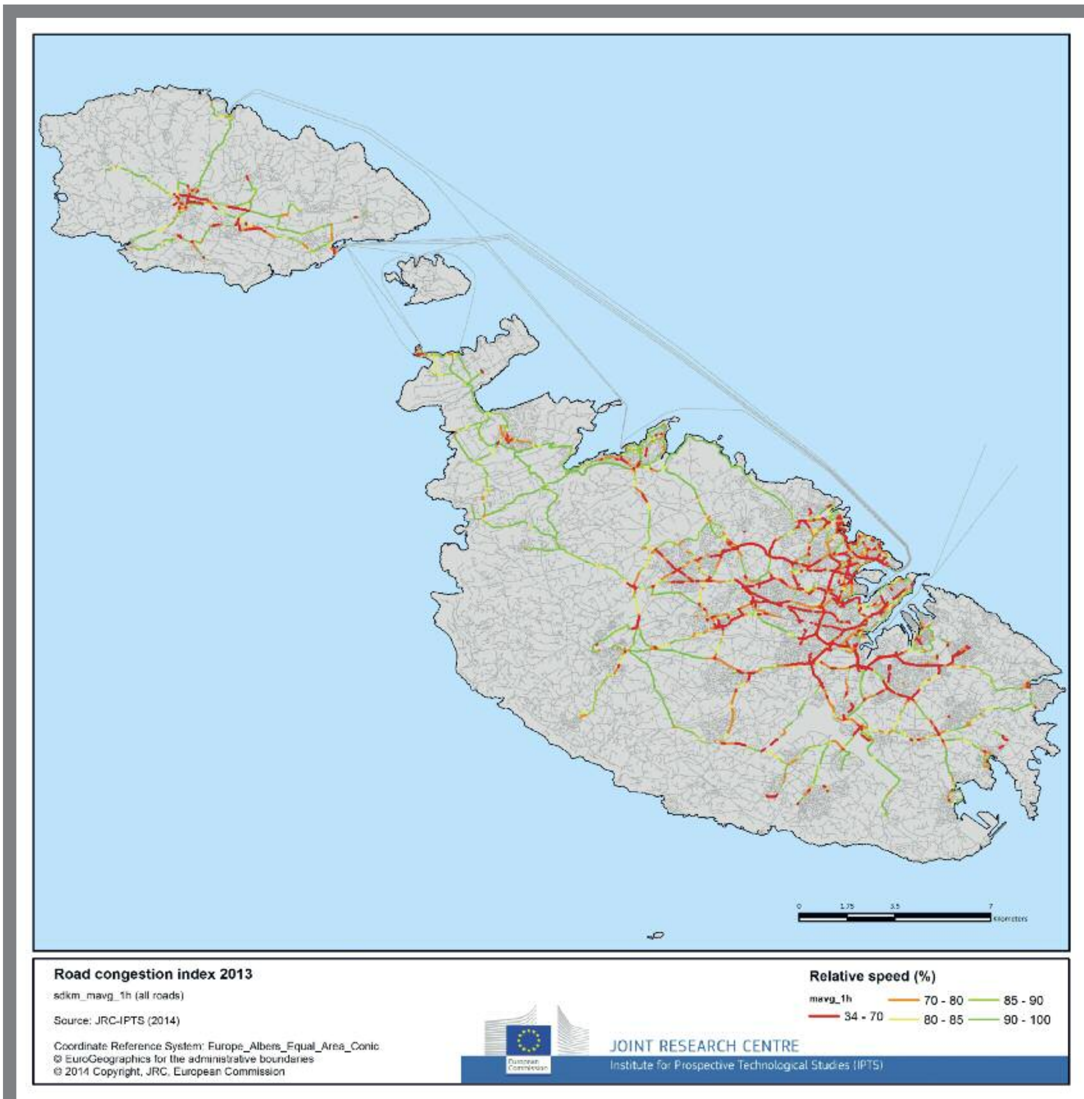


FIGURE 5. Road Congestion Index 2013 for Malta. *Source: JRC (forthcoming).*

Spatial Planning – The Coordination of Transport and Land use (Structure Plan Policies TRA2-TRA4)

The 1990 Structure Plan for the Maltese Islands sets out policies aimed at improving the coordination between transport decisions and land use decisions. The Structure Plan identified the close relationship between the location of (land use) activities and the subsequent transport needs (Planning Services Division, 1990). These policies however were not successfully implemented. The results of Traffic Impact Assessments for larger developments (a requirement under Policy TRA2) had little, if any impact on land use decisions, and the introduction of parking guidelines (Policy TRA4) and the provision of minimum parking standards for developments encouraged further car use. In both cases MEPA (2003) identified these two problematic policies which have "indirectly caused increases in car use and hence traffic flows".

Attard (2006) also reports this lack of coordination between transport and land use as one of the most critical factors to impact car use (and dependence), growth in motorization rates and subsequently congestion on the network.

Inadequacy of public transport services

Attard and Hall (2003) identified a number of issues that have led to the decline in public transport services in Malta. This decline was fuelled by (i) the then weak and ineffective administrative and institutional structures operating and regulating the bus services, (ii) the rather organic growth in public transport services developed over the years through lack of proper network planning, (iii) a monopoly of operators that resisted change and provided poor quality services with old and inaccessible buses. The poor quality services discouraged users to use the bus and served to shift to the car, which was by far more convenient. Over the years, as congestion increased, bus services suffered the same congestion, thus limiting the efficiency gains (if any) of using the bus.

In 2008, Childs and Sutton identified specific customer-oriented issues with the then public transport service. These included:

- reliable service operation but timetable departure time adherence can be poor, with early departures a particular issue;
- lack of intermediate timing points on routes meaning that intermediate passengers often have to wait considerable time on the stop;
- an unsustainable high number of supervisors, inspectors and bus inspectors which do not reflect in the operating standards;
- variable quality and standard of vehicle fleet with maintenance, cleanliness, customer care and driving standards being very variable;
- poor use of some 140 modern low floor buses purchased with government grants (25% utilisation) and no guarantee of a low floor accessible bus on particular corridors due to the rostering system whereby buses and drivers are shifted on a daily and route basis;
- information is not of high quality making current and even more new users uncertain of the services on offer;
- a fare system based on two zones with little difference in pricing making the longer journeys financially unsustainable even with substantial loadings;
- the 'tourist' pre-purchased multi-trip ticket represents very poor value; and
- the ad hoc irregular headways represent very bad practice in public transport bus operations.

Ultimately in 2008, the then Minister for Transport published a list of problems which were endemic to the network and operation. Attard (2012a) reproduced this list from MITC (2008). This document was the first of its kind to set out a policy direction to encourage modal shift, with public transport being seen as a critical infrastructure for sustainable mobility.

Government's investment in public transport was relatively low until the reform of 2011. Following the reform, in which competitive tendering was introduced and the service passed on to a new operator, several operational problems arose. Attard (2013) reports consistent problems related to punctuality and reliability before and after the reform was implemented. This significantly undermined the service and its appeal to non-bus users. Despite public transport patronage figures continue to date to show an increase (NSO, 2013a), this cannot be attributed to modal shift but more realistically to an overall increase in the mobility of all sectors of the Islands' population.

Road Infrastructure

For a number of years there was capacity to absorb more cars on the existing infrastructure and up until 1997 the Government of Malta was still increasing capacity with new and relatively large road infrastructure projects (the last being the Santa Venera – Marsa tunnels). This "predict and provide" approach led to a relative stable ratio of cars per km of road over the years (Attard, 2006). Table 4 shows the number of vehicles per km of road for Malta between 1985 and 2013.

TABLE 4. Number of vehicles per km of road for the Maltese Islands (1985 – 2013). *Compiled by authors.*

Year	Motor Vehicles per km of road	Year	Motor Vehicles per km of road
1985	74	2003	119
1987	70	2004	120
1988	76	2005	120
1989	82	2006	124
1990*	87	2007	127
1997	113	2008	131
1998	106	2009	133
1999	109	2010	135
2000	113	2011	138
2001	113	2012	140
2002**	116	2013	143

* Data on the number of kilometres of road for the period 1991-1996 was not available.

** Length of road network based on total in 2001. The National Statistics Office last published this figure in 2002.

Since the late 90s the increase in the vehicle fleet however was not reflected in new supply of infrastructure and the urban road network became embedded in a dense and compact urban fabric, which did not allow further growth. German

Consultants (GTZ) reported in 1998 that 88 per cent of the strategic network was over-designed, being too wide for the amount of traffic carried on them, whilst the remaining 12 per cent were under-designed with carriageways that were too narrow. The total land wasted in over-designing the main road network was calculated to amount to 0.896km^2, most of which were prime development areas (GTZ, 1998).

Cost of private transport

In 2005 Maltese households spent 16.6 per cent of their annual household budgets on transport when compared to the 11.9 per cent EU average. By 2010 the Maltese household expenditure on transport went up to 17.9 per cent (EU average at 12.8%) (Eurostat, 2014a). This shows a much higher burden on household income, primarily driven by the high cost of private transport.

Apart from actual purchase, maintenance and fuel costs, other costs associated with private mobility are related to car taxation (circulation and fuel taxes) and restrictions on use such as paid parking, which although not widespread, is available in a few localities around the island. The replacement of the V-licence with the Controlled Vehicular Access (CVA) system in Valletta, a road pricing scheme introduced in 2007, charges users for use of the road whilst in the centre of the City. The CVA system is based on a pay-per-use model whereby users entering the charging zone are charged for the amount of time spent in the zone. This is the major difference to other road pricing schemes implemented elsewhere, such as the London scheme where a daily fee is paid once. A detailed description of the scheme and its implementation is given in Attard and Ison (2010).

Despite all this, there has been an evident resistance to transfer to cheaper modes of transport over the years. One exception to the rule has been the observed modal shift for trips to Valletta over the period 1998-2010. The Household Travel Survey observed a 10 per cent shift from car to bus between 1998 and 2010 for trips ending in Valletta (Figure 6). Attard (2013) attributed this to a significant reduction in parking within the city due to the introduction of Park and Ride services outside the City (2006), pedestrianisation of the shopping centre and main squares (2007-2009), the introduction of road pricing (2007), and the relatively good public transport service towards the City.

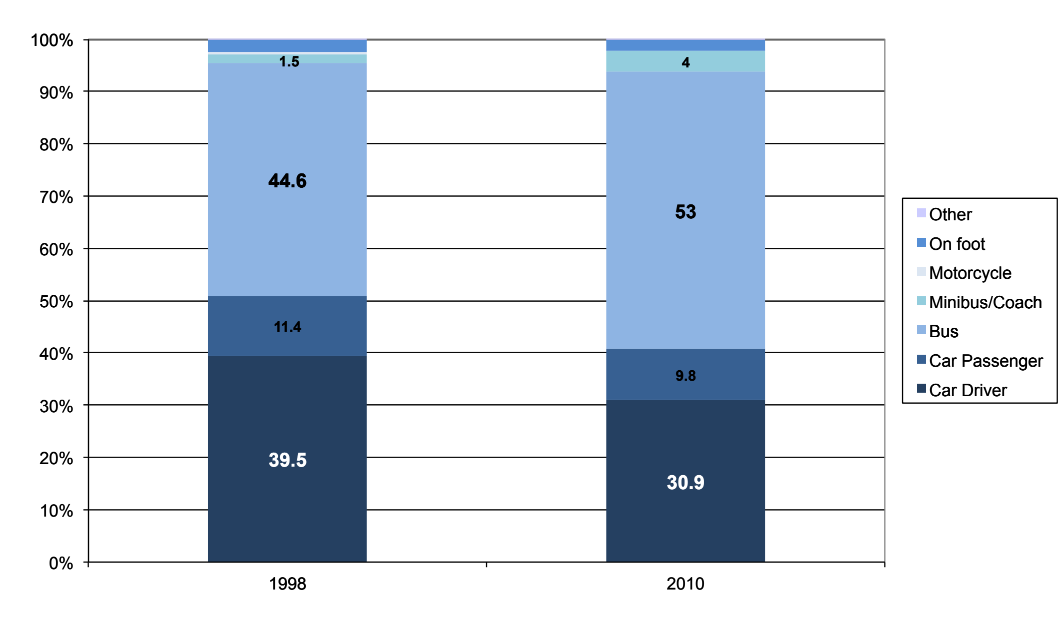


FIGURE 6. Modal Split for trips to Valletta 1998 and 2010. *Source: Transport Malta (2011).*

Changes in traffic flows towards Valletta (in St Anne Street) over the past decade can be traced in Figure 7 with traffic declining following the introduction of CVA in 2007. Following interventions such as the increase in parking capacity in Floriana, the traffic towards Valletta during the morning peak is seen to have increased to pre-2004 levels (between 8:30-9:00am).

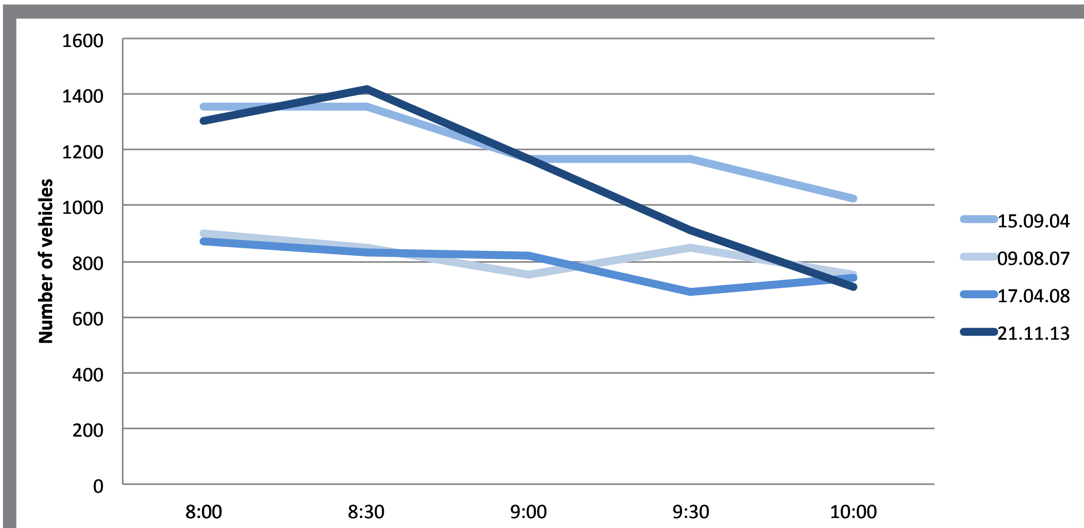


FIGURE 7. Peak hour traffic volumes towards Valletta in St Anne Street, Floriana 2004-2013. *Compiled by authors.*

Malta is not only densely populated but has also very important and strict limits of development to contain urban sprawl. Within this context, and with a steady growth in the population, a steep rise in the rate of motorization, a decline in the use of public transport and increased economic activities, Malta started experiencing congestion and pollution.

With respect to pollution, the urban areas have consistently reported high levels of pollution over the past decade which can, for a significant part be attributed to transport (Figure 8) and significantly correlate with the congestion pattern over time as reported in Figure 4. Malta's percentage distribution of CO_2 emission by energy sector highlights the contribution of transport (Figure 9). This has implications on public and environmental health and impinges on Malta's obligations on air quality and climate change targets. However, with respect to traffic, congestion and impacts, there has been very little research locally.

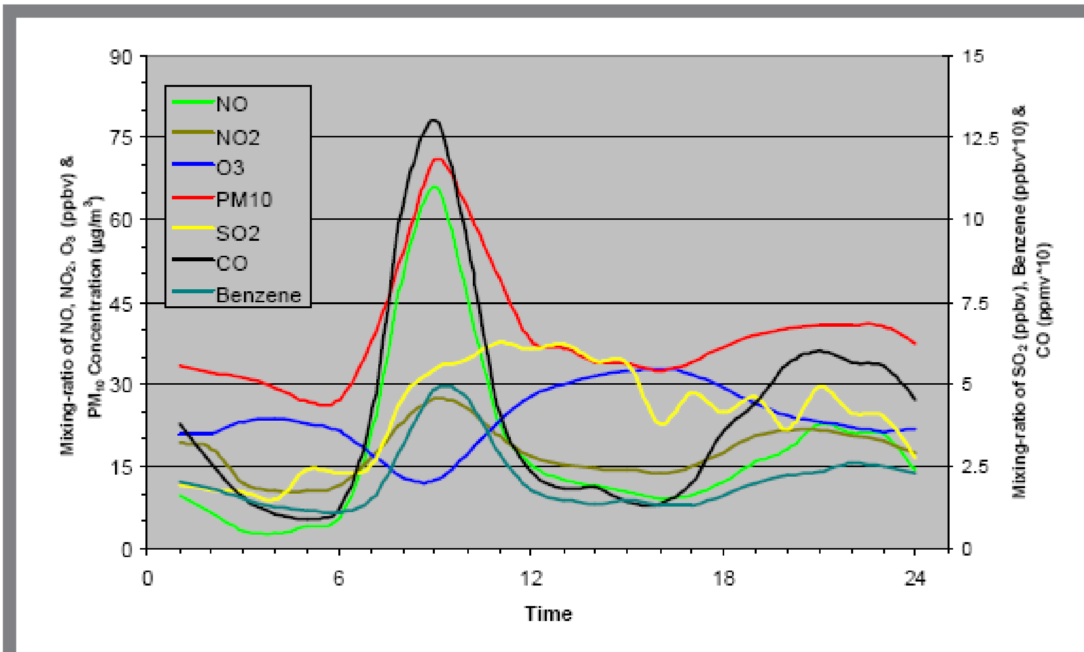


FIGURE 8. Diurnal variation of trace gases and PM_{10} measured in a traffic site within the agglomeration from mid-September to December 2004. *Source: Office of the Prime Minister (2010).*

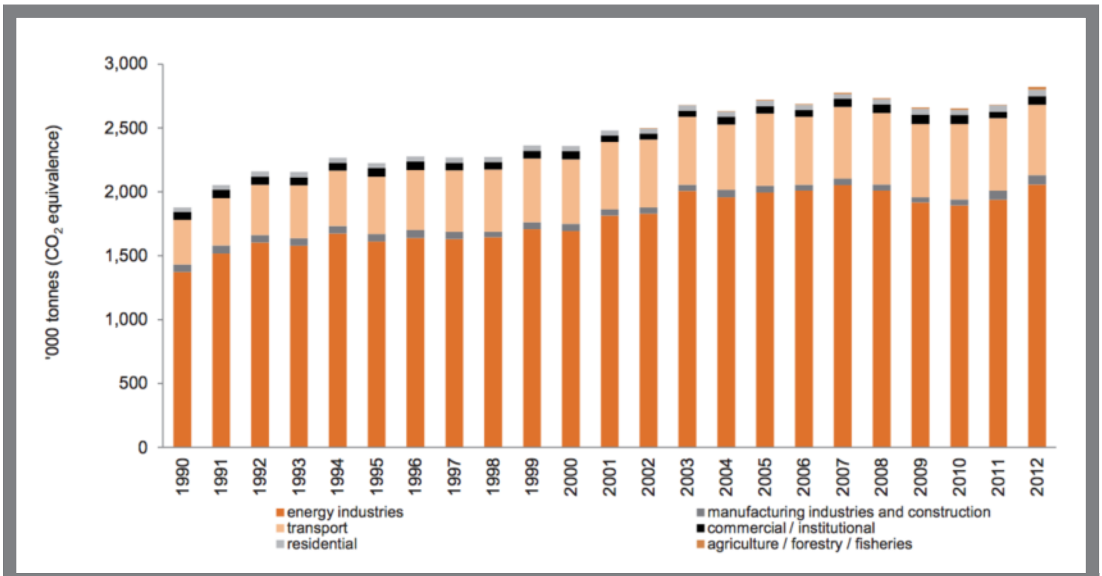


FIGURE 9. Emission sources for the energy sector. *Source: NSO (2014a).*

There is therefore very little support for policy and decision making because of the dearth of research in this area. This has been the rationale behind this study, commissioned specifically to assist the European Commission to analyse this particular aspect of the Maltese Islands and its conclusions within the European Semester.

The main objectives of the study are:

Objective 1

Analyse the road transport situation in Malta and its expected development.

Objective 2

Develop an analytic framework to determine the external costs of Malta's road transport system.

Objective 3

Analyse the impact on external costs of implemented and planned policies influencing road transport, and provide policy recommendations.

These objectives will be achieved through the following tasks (and as described in the Terms of Reference).

Task 1 Analyse the current situation of road transport and in particular road congestion in Malta, based on real traffic data, where possible disaggregated by road type, location and time.

Task 2 Develop an analytic framework to determine the external costs of road transport, and make a comprehensive assessment of the current situation and development of these costs. The methodology presented shall be transparent and reproducible, based on a review of relevant literature. In consultation with the Commission, this assessment could be supplemented by an indicator-based and EU comparable analysis of the Commission's Joint Research Centre on the congestion in Malta.

Task 3 Undertake a comprehensive assessment of implemented, planned and other possible policy measures in Malta which may have a significant impact on road transport and assess their effectiveness, efficiency, coherence and potential fiscal implications. Based on this assessment, policy recommendations shall be provided. An indicative, non-comprehensive list of policies which influence road transport include:

- Increasing the efficiency and use of public transport, e.g. through further use of park and ride schemes, use and deployment of non-road modes
- More efficient use of the road network, e.g. through intelligent transport services, market-based instruments including time-differentiated congestion charging, or removal of infrastructural bottlenecks
- Stimulating the use and making the road network more suitable for soft modes (walking/cycling)
- Reducing and making the car fleet more sustainable, e.g. through electric mobility and car sharing schemes
- Optimizing work and school hours.

In order to fulfill the objectives of this study a work programme was established and presented in the inception report. A copy of the work plan is available in Annex 1.

3.0 DOCUMENTATION, DATA AND METHODOLOGY

The study was divided into three tasks. This section includes all the details pertaining to the documents, data and methodology applied to fulfill the objectives.

3.1 Current situation of road transport in Malta – Task 1

In order to establish a baseline for the study a process of literature review, data collection and collation was necessary. In the initial stages consultation with Transport Malta was necessary to establish the roads that are considered to form part of the main road network in the island. These roads extend further from Malta's TEN-T network as they are seen to contribute to the overall network connectivity (Figure 10). This process of road classification, which is currently under review by Transport Malta for the development of a national transport model, was necessary to build a data infrastructure for the purposes of this study, using Geographic Information Systems (GIS) and open source data, with attribute information about the characteristics of the network, traffic data, accidents, noise and air pollution, disaggregated by road type and location.

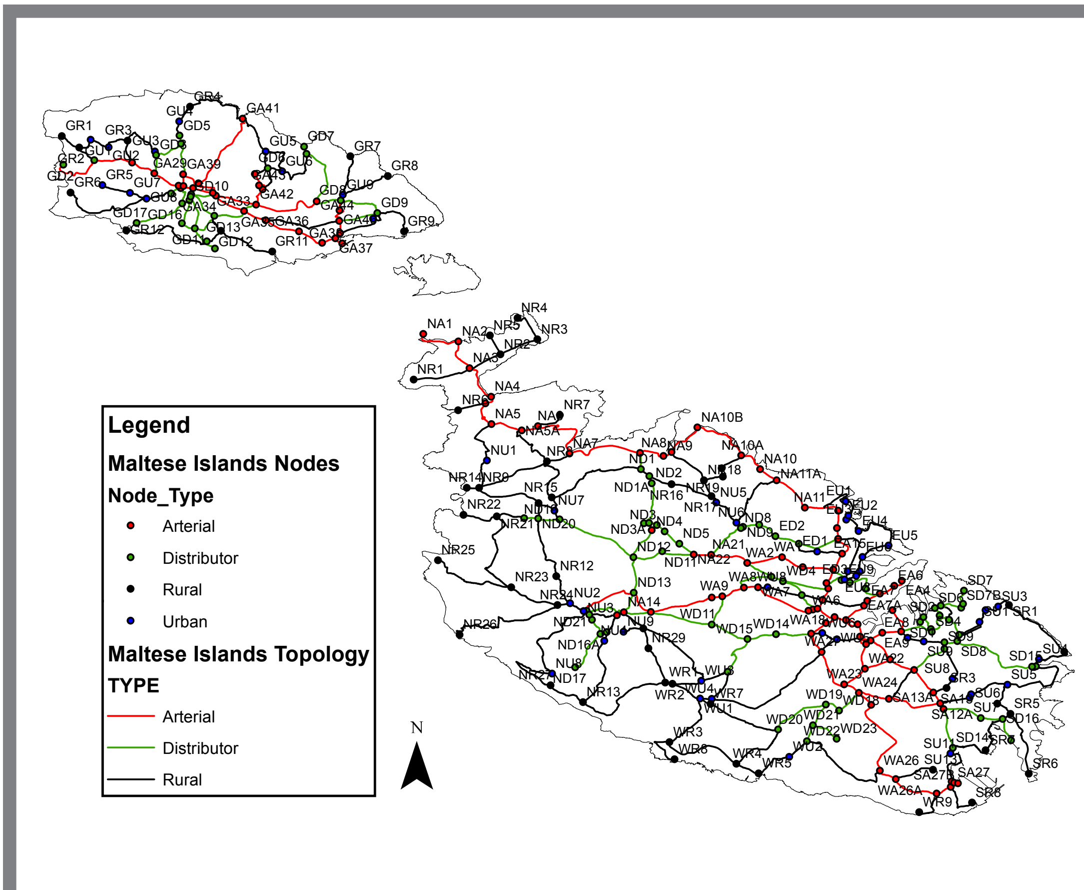


FIGURE 10. Main Road Network in Malta and Gozo by type (including nodes and node information). *Drawn by the Institute for Climate Change and Sustainable Development, University of Malta.*

Table 5 lists the attributes of the network data. More comprehensive metadata files for both links and nodes are being attached in Annex 2. This information in GIS format was also compiled in consultation with the Institute for Prospective Technological Studies (IPTS) at the EU Joint Research Centre, in order to supplement their EU-wide comparably analysis on road congestion which is currently being undertaken. This research includes Malta and the results on congestion levels have enabled us to include congestion as an important variable in the subsequent costing framework for the road network in Malta. In order to define congestion levels in the islands, the team at IPTS has applied the methodology defined by the JRC in their report *Measuring Congestion* (European Commission Joint Research Centre, 2012).

TABLE 5. Attribute data of the Road Network Map. *Compiled by the Institute for Climate Change and Sustainable Development, University of Malta.*

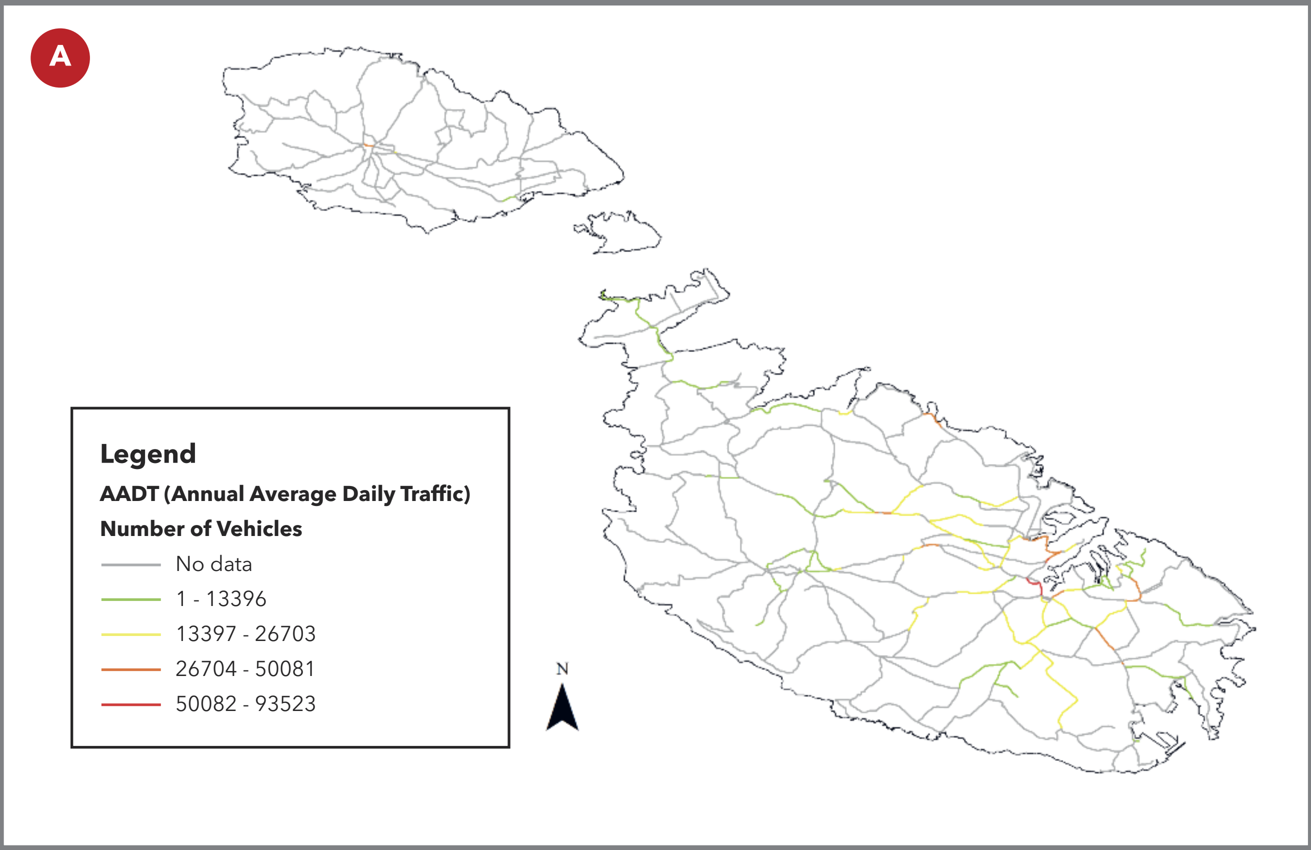
Feature	Attribute Information*
Links (roads)	Road Names
	Type
	Locality
	Nodes
	Road Classification
	Annual Average Daily Traffic (AADT)
	Mean Speed
	Accidents
	Percentage Heavy Goods Vehicles in traffic
	Speed Guideline Category
	Recommended Posted Speed Limit
	NO_2
	Noise
Nodes	Code
	Locality
	Type

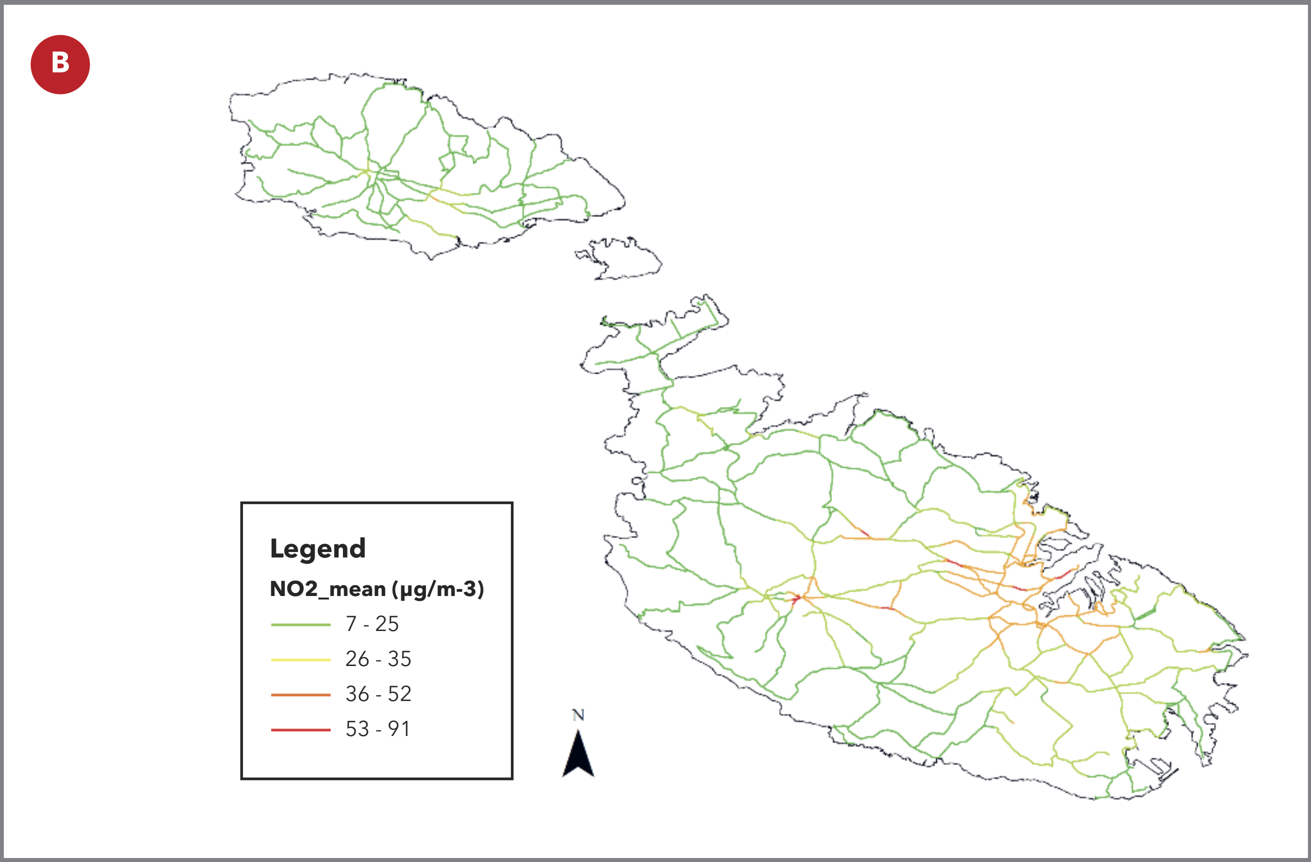
*See also Annex 2 for more detailed information about each attribute field.

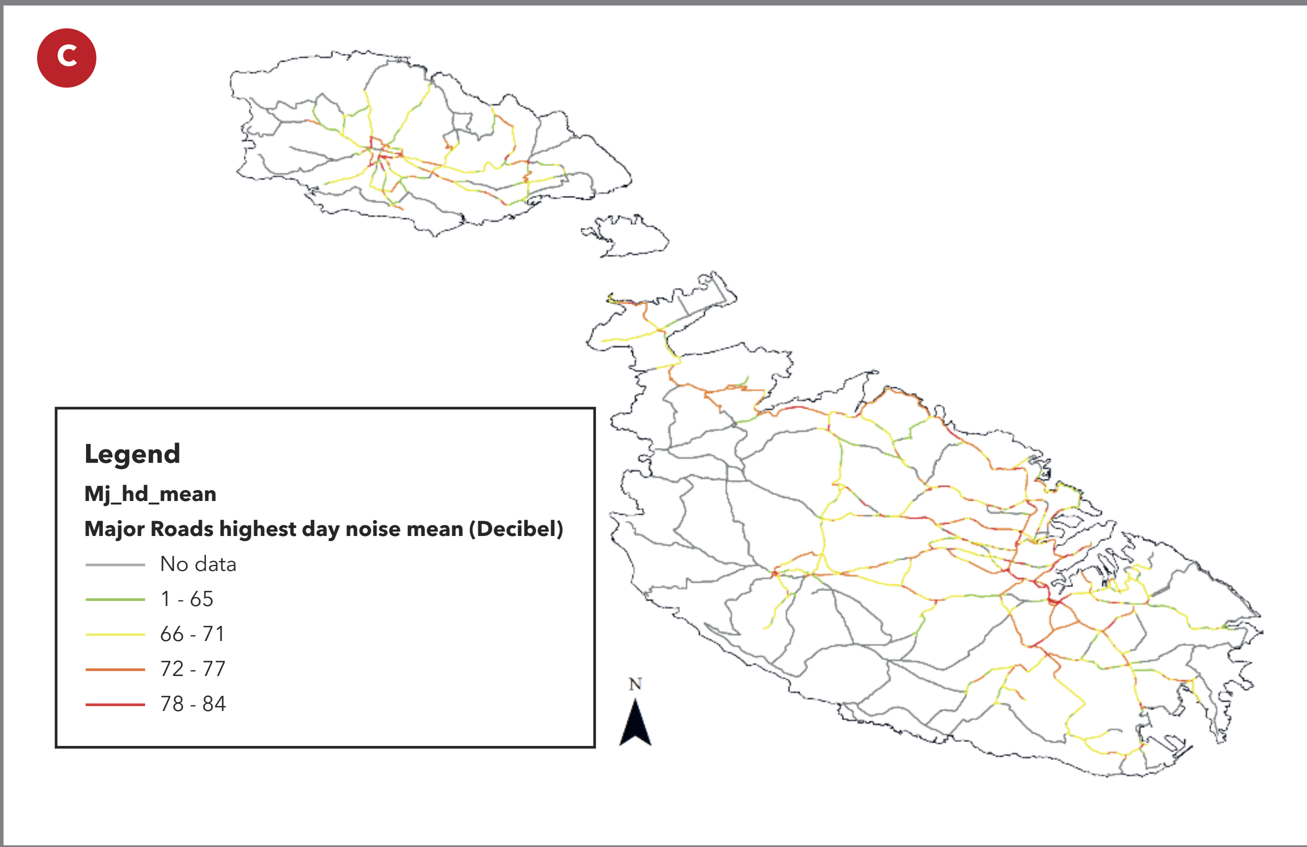
In addition to the mapping exercise to develop the road topology a number of secondary sources were used to extrapolate and compile the attribute information (Table 5). These documents included:

- The Ma-ze Street Atlas: Malta and Gozo (Attard, 2011)
- Malta SEIS GeoPortal (Malta Environment and Planning Authority, 2014a)
- Air Monitoring Data (Malta Environment and Planning Authority, 2010)
- MEPA Map Server (Malta Environment and Planning Authority, 2014b)
- Noise Action Plan (Malta Environment and Planning Authority, 2013)
- It-Toroq Arterji ta' Malta (Planning Authority, 1992)
- Speed Management on Maltese Roads Policy and Technical Guidance Manual: Consultation Document (Transport Malta, 2012)

The completion of the map data allowed the team to visualise the information and obtain a more realistic view of the network characteristics. Below are four outputs of the mapping exercise whereby it is possible to establish the AADT densities along the network (Figure 11a), mean NO_2 concentrations (Figure 11b), mean highest day noise levels (Figure 11c), and accident density on the network (Figure 11d).


A
Legend
AADT (Annual Average Daily Traffic)
Number of Vehicles
No data
1 - 13396
13397 - 26703
26704 - 50081
50082 - 93523
N


B
Legend
NO2_mean (µg/m-3)
7 - 25
26 - 35
36 - 52
53 - 91
N



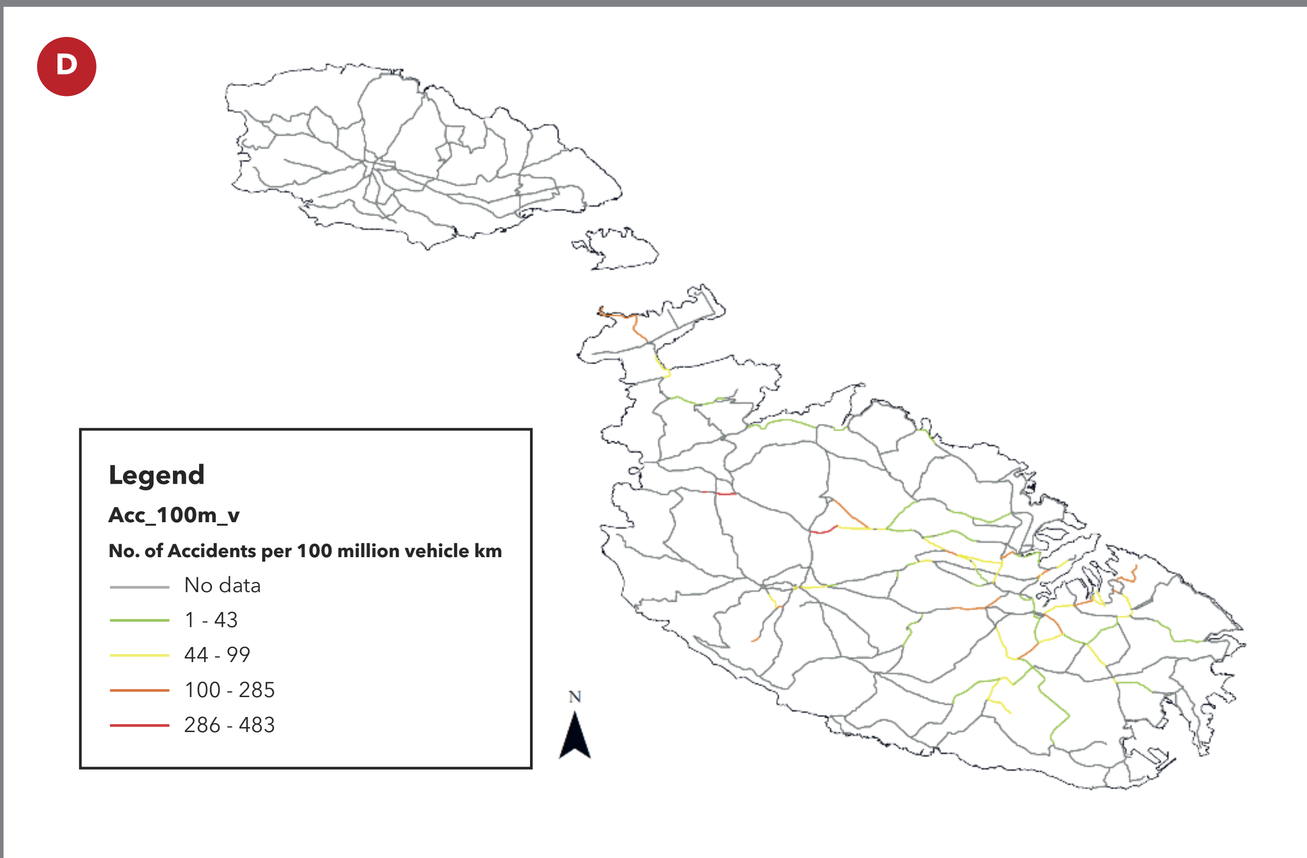


FIGURE 11. Examples of maps of the road network characteristics for traffic (a), NO_2 (b), noise (c) and accidents (d). *Drawn by the Institute for Climate Change and Sustainable Development, University of Malta.*

Following the successful completion of the map data and the transfer of information to the JRC-IPTS team (26 August 2014), efforts into the compilation of additional data required for the purposes of Tasks 1 and 2 were undertaken. AADT data was sourced from traffic count data collected by the Malta Environment Planning Authority and Transport Malta, with the full data set being available for 2010. This data is also reproduced in the Speed Management Policy and Guidance Manual (TM and MITC, 2012). The link attribute information was added to the road topology and represented in Figure 11(a).

Data on NO_2 was extracted for 2009 and data on noise levels was collected in 2011. The air pollution monitoring network set up by the Malta Environment and Planning Authority provided the NO_2 data (MEPA, 2010). The minimum, maximum and mean amounts of NO_2 per road link were calculated from the average 2009 Passive Diffusion Tube Data. The SEIS GeoPortal on the other hand provided the noise data (MEPA, 2014a). In both cases spatial interpolation using Inverse Distance Weighting (IDW) in GIS was used to create pollution and noise surfaces from which data pertaining to specific road sections was extracted and mapped (Figure 11(b) and 11(c)). For the purposes of the study average air and noise pollution data was compiled for each region of the island. Table 6 represents the maximum NO_2 values, the maximum day noise levels and the maximum night noise levels.

TABLE 6. Air and noise pollution data by region.

Gozo		Localities	Northern Harbour		Localities
NO_2_max[1]	**19.04**	Fontana, Għarb	**NO_2_max[1]**	**37.22**	Birkirkara
Mj_hd_max[2]	**37.96**	Għajnsielem, Qala	**Mj_hd_max[2]**	**66.03**	Gżira, Ħamrun
Mj_hn_max[3]	**32.36**	Kercem, Għasri	**Mj_hn_max[3]**	**56.44**	Pembroke, Msida
		Munxar, Nadur			Pieta, Qormi
		San Lawrenz			St Julian's
		Sannat			San Ġwann
		Xagħra, Xewkija			Santa Venera
		Rabat, Zebbuġ			Sliema, Swieqi
					Ta' Xbiex

Northern		Localities	Western		Localities
NO_2_max[1]	**23.93**	Għargħur	**NO_2_max[1]**	**27.19**	Attard, Iklin, Lija
Mj_hd_max[2]	**40.73**	Mellieħa	**Mj_hd_max[2]**	**34.29**	Balzan, Mdina
Mj_hn_max[3]	**35.96**	Mġarr, Mosta	**Mj_hn_max[3]**	**29.07**	Dingli, Rabat
		St. Paul's Bay			Mtarfa
		Naxxar			Siġġiewi, Zebbuġ

TABLE 6. Air and noise pollution data by region. *(CONTINUED)*

Southern Harbour		Localities	South Eastern		Localities
NO_2_max[1]	36.59	Birgu, Bormla	NO_2_max[1]	25.68	Birzebbuġia
Mj_hd_max[2]	57.26	Fgura, Floriana	Mj_hd_max[2]	33.71	Għaxaq
Mj_hn_max[3]	49.33	Senglea, Kalkara	Mj_hn_max[3]	27.11	Kirkop
		Luqa, Marsa			Gudja
		Paola, Tarxien			Marsascala
		Santa Lucia			Mqabba
		Valletta, Xgħajra			Qrendi, Zurrieq
		Zabbar			Safi, Zejtun

[1]Nitrogen Dioxide Maximum. Source: Compiled from MEPA (2010). Data Units: µg/m-3

[2]Major Roads Highest Day Noise Max. Source: Compiled from MEPA (2014a). Data Units: Decibel

[3]Major Roads Highest Night Noise Max. Source: Compiled from MEPA (2014a). Data Unit: Decibel

Road accident data is compiled and published by the National Statistics Office. For the purposes of this study the number of injuries was computed for the period 2009-2014 (with the first two quarters represented in 2014). Table 7 shows the number of injuries by type of vehicle and severity of injury. Further computation was carried out to calculate the number of accidents and injuries per region (Table 8).

CO_2 data from transport is available from the National Greenhouse Gas (GHG) Inventory compiled by the Malta Resource Authority. The national emission data related to road transport has been compiled for the purposes of this study and is being reproduced here in Table 9.

TABLE 7. Road accident injuries (all injuries including pedestrians and passengers) by mode of transport and severity of injury 2009-2014. *Compiled from National Statistics Office (2014b).*

	Slight					
	2009	**2010**	**2011**	**2012**	**2013**	**2014***
Motorcycle	91	75	164	162	202	90
Passenger car	672	698	1024	995	968	550
Coach and bus	18	12	25	40	27	10
Goods vehicle	68	68	110	86	77	62
Unknown vehicle	0	0	2	7	25	4
	Grievous					
	2009	**2010**	**2011**	**2012**	**2013**	**2014***
Motorcycle	49	41	53	68	84	31
Passenger car	120	147	153	181	142	98
Coach and bus	4	1	7	20	11	5
Goods vehicle	26	22	22	19	19	10
Unknown vehicle	0	0	0	12	9	4
	Fatal					
	2009	**2010**	**2011**	**2012**	**2013**	**2014***
Motorcycle	5	4	5	2	6	1
Passenger car	16	8	9	5	9	4
Coach and bus	0	0	2	0	1	0
Goods vehicle	0	3	1	2	2	2
Unknown vehicle	0	0	0	0	0	0
	Total					
	2009	**2010**	**2011**	**2012**	**2013**	**2014***
Motorcycle	145	120	222	232	292	122
Passenger car	808	853	1186	1181	1119	652
Coach and bus	22	13	34	60	39	15
Goods vehicle	94	93	133	107	98	74
Unknown vehicle	0	0	2	19	34	8
	1069	**1079**	**1577**	**1599**	**1582**	**871**

*2014 data for the first 2 quarters only

TABLE 8. Number of accidents by type, by injury and by region. *Compiled from National Statistics Office (2014b).*

	Total Road Traffic Accidents				
	2010	**2011**	**2012**	**2013**	**2014***
Southern Harbour	3078	3209	3154	3036	1556
Northern Harbour	5182	5451	5481	5313	2621
South Eastern	1275	1286	1344	1264	675
Western	1530	1610	1633	1647	843
Northern	2003	2015	2210	2153	1027
Gozo	659	693	724	657	317
	Non-Injury Road Traffic Accidents				
	2010	**2011**	**2012**	**2013**	**2014***
Southern Harbour	2895	2953	2869	2757	1408
Northern Harbour	4966	5108	5071	4901	2396
South Eastern	1186	1112	1215	1127	592
Western	1431	1456	1472	1484	765
Northern	1814	1802	1985	1941	910
Gozo	605	633	655	584	279
	Total Injuries in Road Accidents				
	2010	**2011**	**2012**	**2013**	**2014***
Southern Harbour	249	336	377	353	178
Northern Harbour	254	447	471	473	263
South Eastern	126	216	155	174	106
Western	129	206	200	217	107
Northern	247	287	307	276	163
Gozo	74	85	89	89	54

*2014 data for the first 2 quarters only

TABLE 9. Malta CO_2 emissions from transport. *Adapted from EEA (2014b).*

	2008		2009	
	Implied Emission Factor	Emissions	Implied Emission Factor	Emissions
	CO_2 (t/TJ)	CO_2 (Gg)	CO_2 (t/TJ)	CO_2 (Gg)
Road Transport		**485.22**		**496.27**
Gasoline	69.30	215.75		225.06
Diesel Oil	74.10	269.47	69.30	271.21
Liquefied Petroleum Gases (LPG)	NO	NO	74.10	NO
Other Liquid Fuels		NA	NO	NA
Gaseous Fuels	NO	NO		NO
Biomass	70.80	1.96	NO	1.92
Other Fuels		NA	70.80	NA
Other Transport		**20.12**		**18.16**
Aircraft support vehicles				IE,NO
Liquid Fuels	IE	IE	IE	IE
Solid Fuels	NO	NO	NO	NO
Gaseous Fuels	NO	NO	NO	NO
Biomass	NO	NO	NO	NO
Other Fuels	NO	NO	NO	NO
Off-road vehicles and other machinery		**20.12**		**18.16**
Liquid Fuels	74.07	20.12	74.07	18.16
Solid Fuels	NO	NO	NO	NO
Gaseous Fuels	NO	NO	NO	NO
Biomass	NO	NO	NO	NO
Other Fuels	NO	NO	NO	NO
TOTAL SUM		**525.46**		**532.59**

Legend: NO (not occurring); NA (not applicable); IE (included elsewhere)

2010		2011		2012	
Implied Emission Factor	Emissions	Implied Emission Factor	Emissions	Implied Emission Factor	Emissions
CO_2 (t/TJ)	CO_2 (Gg)	CO_2 (t/TJ)	CO_2 (Gg)	CO_2 (t/TJ)	CO_2 (Gg)
	517.48		**503.69**		**491.40**
70.94	230.70	70.94	223.66	72.25	228.12
73.81	286.78	73.81	280.03	74.24	263.23
NO	NO	NO	NO	64.93	0.05
	NA		NA		NA
NO	NO	NO	NO	NO	NO
75.03	1.71	75.03	4.11	84.97	3.95
	NA		NA		NA
	16.76		**16.92**		**16.92**
	IE,NO		0.51		0.51
IE	IE	74.07	0.51	74.07	0.51
NO	NO	NO	NO	NO	NO
NO	NO	NO	NO	NO	NO
NO	NO	NO	NO	NO	NO
NO	NO	NO	NO	NO	NO
	16.76		**16.41**		**16.41**
74.07	16.76	74.07	16.41	74.07	16.41
NO	NO	NO	NO	NO	NO
NO	NO	NO	NO	NO	NO
NO	NO	NO	NO	NO	NO
NO	NO	NO	NO	NO	NO
	551.1		**537.02**		**524.73**

3.2 Analytical framework to determine the external costs of road transport – Task 2

The work undertaken for this task focused on the identification of the relevant and appropriate methodologies to be applied to the study of external costs of road transport, as well as the compilation of relevant data, over and above those developed under Task 1. The research team also identified challenges posed by data availability and their impact on the study. Above all Task 2 centered on the estimation of external costs for vehicles, specifically for passenger cars and light-duty commercial vehicles.

The main interest of this study is the larger environmental costs of car traffic (plus accident costs not covered by insurance). This means that infrastructural costs (construction, maintenance, demolition, administration of infrastructure) are not included. Congestion costs are at times included in studies of this nature. In view of the on-going lively scientific discussion regarding the nature and adequate quantification of congestion, and given that traffic is a major issue in Malta, an estimate of congestion costs was deemed highly relevant.

The following cost categories are therefore covered in this study:
(i) Accidents
(ii) Air Pollution
(iii) Climate Change
(iv) Noise Pollution
(v) Congestion Costs

In order to define the analytical framework for the estimation of external costs, reference was made to specific documentation published locally and in Europe in support of similar studies. The use of established methodologies in the conduct of this study was very important to ensure comparability of results, not only across the discipline but also with other countries[1].

A Guide for the estimation of external costs relevant to this study has been prepared and is available in Annex 3.

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[1] The main reference documents included:
IER, Germany (2006) Harmonised European Approaches for Transport Cost and Project Assessment (HEATCO) Study – Deliverable 5 Proposal for Harmonised Guidelines.
CE Delft, INFRAS, Fraunhofer ISI (2011) External Costs of Transport in Europe.
Planning and Priorities Co-ordination Division, Government of Malta (2013) Guidance Manual for Cost Benefit Analysis (CBAs) Appraisal in Malta. Parliamentary Secretary for the EU Presidency 2017 and EU Funds.

Accidents

Road traffic accidents cause social costs including material damages, administrative costs, medical costs, production losses and immaterial costs (lifetime shortening, suffering, pain, sorrow, etc.). Market prices are available for material costs and they are often insured. However, no market prices are available for any immaterial costs and many a times these costs are not covered sufficiently by private insurance systems. Other approaches in the literature (for example using willingness-to-pay surveys) have been used for the purposes of estimation.

Not all social accident costs are considered external accident costs. Motorists pay for all cost components in an accident covered by transfers from the insurance system. Consequently many of these components are already internalised. However, this does not apply to health costs covered by public health insurances which are funded by society in general.

The Value of a Statistical Life (VSL) is most commonly used in economics for the valuation of fatalities, grievous and slight injuries (the three categories of injuries commonly used in studies). The VSL can be defined as the value that an individual places on a marginal change in their likelihood of death. A more detailed definition however can be found in economic literature in de Blaeij et al. (2003), which states that:

Valuation of statistical life is concerned with valuation of changes in the level of risk exposure rather than the valuation of the life of a specific individual. Operationally, this translates into statements in terms of risk exposure. When the risk of involvement in a fatal accident is 1:100,000, the implication is that statistically there is 1 death per 100,000 people per year. Changes in the risk level imply changes in the number of statistical lives saved, and can be given an economic value. The economic value is essentially the marginal rate of substitution of wealth for risk of death, due to any specific cause. The statistical value of life is then merely the average of a series of observations on the marginal rate of substitution, where the latter is taken as an appropriate estimator of the underlying (unobserved) population mean.

Since there is no formal market to estimate VSL, the only way to measure this is through indirect methods. These are generally referred to as preference surveys, where the respondents are asked for their willingness to pay for a reduction of the accident risk. In economic terms, the VSL is the amount of money a person (or society) is willing to spend to save a life or reduce the risk of grievous or slight injury in the case of road transport. This study uses estimates for VSL derived from the updated estimates contained in the *Guidance Manual for Cost Benefit Appraisal in Malta*, May 2013 p.35. These figures represent updates from the HEATCO study (2006) which estimated VSL across all EU countries.

For 2012, the VSL values for road accident injuries in Malta are shown in Table 10 below. These values were adjusted to factor in prices for 2012.

TABLE 10. VSL values for road accident injuries in Malta based on the year 2012.

Type of Injury	Fatal	Grievous	Slight
Cost (€2012 prices)	€1,205,573	€153,918	€11,442

Based on the number of fatalities (9), grievous injuries (300), and slight injuries (1,290) for 2012, the total cost of injuries and fatalities was estimated at €71.8 million.

The human capital cost (the lost production or the lost value of our human capacities) resulting from road transport injuries was also estimated. This was done by considering the total production costs or value added, and was applied to cases of grievous injuries where it was assumed that the lost production or value added covers a one-year period. Slight injuries were also included. However, in this particular case, the duration of lost production was assumed to be two months.

The Malta GDP per capita, adjusted for purchasing power parity (PPP) was recorded at €22,100 in 2012, and the human capital cost was derived from the product of the number of grievous and slight injuries and the GDP per capita (adjusted in the case of slight injuries). The cost of human capital was estimated at €11.5 million.

In addition to the above, the medical costs related to slight and grievous injuries were also estimated. The cost estimates for grievous injuries, which require emergency services and further hospitalisation, were based on research undertaken internally by the Department of Economics at the University of Malta. These included amongst others information on length of stay in surgery and at emergency. The cost of ambulance use was derived from the fee set by a private hospital operating in Malta (Bugeja, 2014).

In most developed countries, the Diagnosis Related Group (DRG) Classification System is used to classify hospital cases into some 500 groups, which generally allow for the accurate estimation of medical care related to for example injuries from road accidents. Unfortunately this classification or data pertaining to the number of cases reported to hospital after road accidents is not available for Malta's state hospital, Mater Dei.

Nonetheless, we were able to estimate the cost of in-patient health services at Mater Dei Hospital. The cost of emergency services was based on the average cost per bed per day (€205) and an average stay of one day, whereas the cost of in-patient surgery services was based on an average length of stay of 4.8 bed days (patients are generally admitted to surgery after emergency services) with an average cost of €194. This resulted in a cost of €340,860. In the case of slight injuries it was assumed that only emergency services are required. Based on an average cost of €205, the cost for 1,290 slightly injured persons was estimated at €264,450. Ambulance services costing €86 per call, for 300 calls (grievous injuries), totalled €25,800. This information was derived from a private hospital since information on the cost of ambulance services run by government was not available.

The total cost for car accidents comprising value of injuries and fatalities, human capital and medical services was estimated at €83.9 million, or 1.2 per cent of GDP. It should be stressed that this total cost can never represent the true cost. Nonetheless, the objective of this estimation (road accidents and other external costs) is to state the magnitude of costs where no market price can be determined. As shown for road accidents (which also apply for other external costs) the estimations depend on the methodology adopted and the data used. The methodological choices made in this study were previously tested and have been used in important studies on the external costs of road transport (CE Delft, INFRAS, Fraunhofer ISI, 2011; IER Germany, 2006; Cebr, 2014; Planning and Priorities Co-ordination Division, Government of Malta, 2013).

Air Pollution

The estimation of external air pollution costs in car traffic is generally based on three data sources. Car transport demand, measured in annual vehicle kilometres (km per year), is multiplied by specific emission factors (g/km). Consequently, the results show the total emissions for a specific pollutant or cost category [tonnes per year]. Eventually, the product of the first two inputs is multiplied with the cost factor or damage factor per pollutant (€/tonne).

The more important transport related air pollutants include Particulate Matters ($PM_{2.5}$) and (PM_{10}), Nitrogen Oxide (NOx), Sulphur Dioxide (SO_2), Volatile Organic Compounds (VOC), Carbon Monoxide (CO), and Total Hydrocarbons (THC) (EEA, 2014a). Greenhouse gases (CO_2) that accumulate in the atmosphere and contribute to potential climate change are not included in the air pollution costs since they do not have any direct toxic effects. External air pollution costs generally consist of three cost components:

- health effects;
- building and material damage; and
- eco-systems and biodiversity effects.

Air pollutants affect the health of individuals through cardiovascular and respiratory diseases, chronic bronchitis and activity reduction. Yet they also damage buildings and affect the ecosystem and biodiversity. As a result, most studies on air pollution caused by road transport focus on the three cost components referred to above.

Road transport emissions for NOx in 2012 were derived from the estimated average annual emissions for passenger cars and light-duty or goods carrying commercial vehicles. The estimates are based on emission factors determined by the United States Environment Protection Agency (US EPA, 2008) and modified to account for average km per year (as referred to in this study) applicable for Maltese commuters (7,800 km). In our view using these emission factors is more appropriate given the above average age of our vehicle fleet. Even though EU emission standards are typically more stringent than the US, it should be stressed that the majority of new vehicle registrations in the Islands are second hand vehicles from Japan and UK. New cars with progressive EURO standards do not account for a large proportion of Malta's vehicle fleet.

The estimated emissions for NMVOC, NOx, and $PM_{2.5}$ were 5kg, 3.4kg and 0.2kg per vehicle per year. The emission factor for $PM_{2.5}$ was adjusted by a factor of 10 to account for Malta's ageing fleet of cars and light-duty vehicles and the heavy presence of old diesel-fuelled engines on Maltese roads. This level of emission is not unreasonable given that in Sydney, Australia, the level in 2003 was estimated at 0.44kg per vehicle (see http://woodsmoke.3sc.net/woodheater-car-comparison). Though more recent levels of $PM_{2.5}$ have fallen considerably in Sydney (almost equivalent levels described by US EPA, 2008), one needs to factor in Malta's aged fleet of cars and light-duty vehicles.

The total stock of vehicles in Malta in 2012 was 314,510 (NSO, 2013a). However, the figure referred to in this study is 291,975 comprising of petrol-driven (176,643) and diesel-driven engines (115,332). We have excluded road tractors, agriculture vehicles, route buses, coaches and private buses, motorcycles, and special purpose vehicles but included goods carrying vehicles and minibuses. The reason for this is that vehicles such as route buses, private buses and coaches are considered indispensable for public transport and the tourism sector, whereas agriculture vehicles are used exclusively in rural areas. Road tractors and special purpose vehicles are used for building and maintaining road infrastructure whereas increased use of motorcycles could help ease congestion.

The total emissions for passenger cars and light-duty (commercial) vehicles with respect to NMVOC was estimated at 1,456 tonnes; 990 tonnes for NOx; and 58 tonnes for $PM_{2.5}$. It should be noted that according to HEATCO D5, cost factors are restricted to the pollutants referred to in this paragraph and those shown in Table 11 below. These are considered to be the primary pollutants for transport and therefore our analysis follows the recommendation referred to in HEATCO D5, namely that the list of pollutants should cover primary $PM_{2.5}$ for transport emissions ($PM_{2.5}$ is required for emissions from power plants), NOx as precursor of nitrate aerosols and ozone, SO_2 direct effects and as precursor of sulphate aerosols, and NMVOC as precursor of ozone.

Table 11 shows the cost factors for road transport emissions (per tonne) of pollutant emitted in 2002 prices (Table 6.2 of the HEATCO D5 Study) and adjusted for €2012 prices by a factor of 1.2, as estimated using data from the *Guidance Manual for Cost Benefit Appraisal in Malta* (2013).

TABLE 11. Cost Factors for NOx, NMVOC, SO_2, and $PM_{2.5}$ in €.

Malta	NOx	NMVOC	SO_2	$PM_{2.5}$ Urban	$PM_{2.5}$ Non-Urban
€2002 factor price	500	1,100	500	170,000	16,000
€2012 factor price	600	1,320	600	204,000	19,200

The values for estimating the external cost of NOx, NMVOC, SO_2, and $PM_{2.5}$ were therefore derived by the product of the adjusted cost factors and the tonnes of emissions for each of the pollutants caused by road transport. In the case of SO_2 since the emissions are negligible, there is no estimate for SO_2. As for $PM_{2.5}$, given the very heavy traffic on urban roads, it was assumed that all traffic is considered urban traffic and therefore the cost factor for non-urban traffic was not applied. Also, it is implausible to assume an even distribution between urban and non-urban traffic. The costs are shown in Table 12.

TABLE 12. Estimated Costs for NOx, NMVOC, SO_2, and $PM_{2.5}$ in € for 2012.

NOx	NMVOC	SO_2	$PM_{2.5}$ Urban	$PM_{2.5}$ Non-Urban
€594,000	€1,921,920	€0	€11,832,000	€0

The total estimated cost of air pollution (which covers human health, crop losses and material damages as detailed in Table 6.2 HEATCO D5 p.97) adds up to €14.3 million, or 0.2 per cent of GDP. Given that this estimate is based on an established methodology, one can safely conclude that air pollution and its effects on health, residuals on crops (again this affects health of local consumers) and material damages cannot be ignored. Put differently, if the ecosystem is to be protected the economic value equivalent to the external cost of air pollution should be determined and taken into account in the respective policy measures.

Climate Change

Global warming has a variety of effects, both mid-term and long-term. Key effects include higher average temperatures, extended dry seasons in the Southern Mediterranean (a region which has long and hot summers), a rise in sea level and further acidification of oceans, as well as an increase in the occurrence of extreme weather. These effects will have severe impacts on the use of energy in agriculture, water supply and public health, as well as in ecosystems and biodiversity. With more extreme weather conditions, more frequent and intensive use of climate control in vehicles will be required, and with more cars on the road, the impact will be greater.

The identification of damage cost figures would also be very useful for estimating climate change cost effects. However, such cost estimation is fraught with difficulties, due to complex, global impact variations, uncertainties in the quantification of effects, and long timescales involved. For these reasons, external cost calculations are often based on estimated avoidance costs rather than damage costs (CE Delft, 2011).

Avoidance costs follow a very different methodological approach. They describe costs which are linked to a reduction of the specific amount of CO_2 compared to a reference technology or reference point in time. From a scientific perspective, the calculation of damage costs would be the theoretically preferred way, because the external effects and the related costs are quantified directly. However, as previously described, the complex impact variations and uncertainties related to the physical impacts, as well as a number of specific methodological issues prevent us from choosing this approach. On the other hand, the calculation of external costs based on the avoidance cost approach does not necessarily stand in conflict with economic theory.

The cost of climate change can be interpreted as the cost of implementing policy targets and it can be assumed that these targets correctly represent people's preferences towards a socially optimal emission level. The cost factors used in the report are therefore based on the avoidance cost approach, which in practical terms can only be mitigated by reducing the number of cars on the road. Other measures such as restrictions on car size and intensity of use, as well as a switch to alternative sources of automotive power such as electricity and bio-fuel could also help to reduce emissions. However, it should be noted that the rate of replacement of the local fleet is not at the same level as in the UK or Germany, and perhaps an effective way to dissuade Maltese drivers from using their car regularly would be through fiscal disincentives such as an extension of road pricing and charging for parking.

It should be stressed that road transport in Malta dominates CO_2 emissions and is only second to energy generation. CO_2 car emissions are therefore very relevant for estimating climate change effects. The emissions for 2012 were again derived from the estimated average annual emissions for passenger cars and light-duty commercial vehicles (US EPA, 2008) and modified to account for average km per year, applicable for Maltese commuters (7,800km). As stated earlier, this was considered appropriate given the above average age of the vehicle fleet, and using emission factors based on a European source with higher standards for emissions would have underestimated the cost of CO_2 car emissions. The average emissions were estimated at 1,785 kg per year and based on the total number of vehicles (291,975), the total kg for all cars per year was derived.

Climate change effects are an important component of external costs of road transport and the cost per kg can be represented by referring to the shadow price or economic cost. A shadow price of €0.025 per kg, as shown in the *Guidance Manual for Cost Benefit Appraisal in Malta* (2013) may be applied to determine the total cost of climate change for petrol and diesel-engine vehicles. The shadow price is based on a theoretical concept in Economics and may be applied either in cases where price does not reflect the actual value of a good or commodity, or where no market value for a good or commodity exists. Shadow pricing can also mean a proxy value of a good, often defined by what an individual must give up to gain an extra unit of the good. In this case, it represents the impact or economic cost resulting from climate which affects individuals' daily lives as well as economic prosperity and social welfare. Put differently, the shadow price represents the damage cost of climate change.

In this study, however, we have opted to use the alternative method which is based on the abatement cost of approach. The rate applied is the central value of €90 per tonne as derived from the *Handbook on External Costs of Transport* (2014). Abatement represents the total reduction in emissions whereas marginal abatement cost reflects the cost of one additional unit or tonne of emission that is abated, or not emitted. The main objective insofar as climate change is concerned, is abatement. Therefore it was necessary to estimate the abatement costs. Such cost was estimated at €46.8 million as compared with €13 million (damage costs) based on the *Guidance Manual for Cost Benefit Appraisal in Malta*. Considering that the abatement approach also comprises avoidance costs, it is considered more relevant for comparison purposes.

Climate change effects cannot be downplayed and the United Nations Intergovernmental Panel on Climate Change (IPCC) 2014 report concludes that "greenhouse gases will cause further warming and long-lasting changes in all components of the climate system" (IPCC, 2014). Despite the small size of the Maltese Islands, the recently agreed greenhouse gas reduction targets for Europe (40% reduction by 2030 compared to 1990 values) will also have an impact on Malta's road transport policy.

The total cost of climate change in 2012, which represents the abatement cost of climate change, was estimated at €46.8 million, or 0.7 per cent of GDP.

Noise Pollution

Noise can be defined as any unwanted or harmful outdoor sound which may also be harmful to human health due to its quality and characteristic. The literature distinguishes two types of negative impacts (European Commission, 2014).

Costs of annoyance: transport noise imposes undesired social disturbances, which result in social and economic costs such as restrictions on enjoyment of desired leisure activities, discomfort or inconvenience.

Health costs: The literature determines that noise from transport causes physical health damage. Noise levels above 55 to 65 dBA (depending on day/night and on country characteristics) may result in nervous stress reactions, such as change of heart beat frequency, increase of blood pressure and hormonal changes. In addition, noise exposure increases as a co-factor the risk of cardiovascular diseases (heart and blood circulation) and decreases subjective sleep quality. The negative impacts of noise on human health result in various types of costs, such as medical costs, costs of productivity loss, and the costs of increased mortality (IER Germany, 2006).

According to an analysis on the road network using MEPA (2014a) only two regions (defined as such for statistical purposes) in Malta exceeded the 55 dBA levels, i.e. the Northern Harbour and Southern Harbour regions. These regions had a population of 114,818 and 80,078 persons respectively in 2010 (NSO, 2011). In view of the small size of these regions, one can safely assume that noise exposure affects all residents (especially those residing along major roads). The central values for noise exposure, as contained in HEATCO D5, were applied to estimate cost of noise pollution. These values were adjusted to 2012 factor costs. Table 6.9 in HEATCO D5 refers to factor costs per year per person exposed.

In 2011 noise levels during the day in the Northern Harbour and Southern Harbour regions reached an average maximum of 66.03 dBA and 57.26 dBA respectively, whereas at night noise levels fell to an average maximum of 56.44 dBA and 49.33 dBA respectively. Though these represent the average maximum not the average levels and may overestimate the external cost of noise pollution, in the absence of average values, we still went ahead with applying the available levels. This is not unreasonable given that the Maltese Islands are in fact one of the noisiest places to live in the EU with noisy areas extending to around 90 per cent of Malta compared to some 50 per cent in most other EU Member States. In its report *Noise in Europe 2014*, the EEA concludes that metropolitan areas housing more than 250,000 people generally have a larger share of the population exposed to levels above the legal guidelines (EEA, 2014c).

A weighting based on 17 hours 'day' traffic and 7 hours 'night' traffic was assumed, as shown in Table 13.

TABLE 13. Weightings for Day and Night Noise Pollution, 2011.

Affected Region	Day Noise Pollution (17 hours)	Night Noise Pollution (7 hours)
Northern Harbour	66.03 dBA	56.44 dBA
Southern Harbour	57.26 dBA	49.33 dBA

The central values for noise exposure per person per year adjusted for 2012 factor cost and applicable to the above noise levels are shown in Table 14.

TABLE 14. 2012 Cost Factor by Region.

Affected Region	€	€
Northern Harbour	79.2	30.0
Southern Harbour	34.8	4.8

The central values were set a weighting of 71 per cent during the day and 29 per cent during the night. From a total of 8,760 hours per year, 6,205 hours had noise levels at 66.03 dBA and 57.26 dBA for the Northern Harbour and Southern Harbour regions respectively. Night time noise pollution totalled 2,555 hours a year with noise levels of 56.44 and 49.33 dBA respectively. Given a population of 114,818, the total cost for noise pollution in the Northern Harbour was estimated at €7.5 million. The Southern Harbour registered a population of 80,078 and the total cost of noise pollution was estimated at €2 million. Overall, the cost adds up to €9.5 million.

In addition to this, we have added the cost of annoyance, estimated through costs of installing double-glazed windows to provide sound insulation. The cost is restricted to residences along major roads in both regions and not all the residences found in these two regions. The 2007 electoral register was used to estimate the number of residences. It was assumed that in 2011 the number of residences along major roads (those with the heaviest traffic) did not change considerably and therefore totalled 3,939 and 1,955 in the Northern Harbour and Southern Harbour regions respectively. Each of these residences would be required to replace at least two double-glazed windows to insulate noise pollution for road transport. For the purposes of this study, the change to double-glazed windows is considered a one-time cost. Quotes for two sizes (here described as A and B and considered as standard sizes for Maltese residences) were derived from a specialist contractor. The estimated costs are shown in Table 15.

TABLE 15. Residences and Cost of Noise Insulation by region.

Residences (Major Roads) Northern Harbour	Cost of Installation	Total
3,938	€140 (Size A)	€551,320
3,938	€120 (Size B)	€472,560

Residences (Major Roads) Southern Harbour	Cost of Installation	Total
1,955	€140 (Size A)	€273,700
1,955	€120 (Size B)	€234,600

The total external cost for noise pollution adds up to €11 million, or 0.2 per cent of GDP. As previously stated this includes the one-time cost of noise insulation. However, as in the case of aircraft noise for residents close to UK's Heathrow airport, developing noise insulation schemes to provide practical assistance to those local residents experiencing the highest levels of noise, cannot be excluded. There is both a day noise and a night noise scheme for residents in Heathrow and air authorities refund 50 per cent of the cost of replacement windows, free secondary-glazing as well as free loft insulation and ventilation. A similar scheme could be considered for residents affected by noise pollution. Of course, this comes at a cost to tax payers and may be difficult to administer.

Congestion Costs

Traffic congestion in Maltese roads has become a real concern for motorists (see for example Dalli, 2014). The level of congestion in Maltese roads depends on a range of supply and demand factors. On the supply side, traffic congestion depends on the size and capacity of our roads, and given the restricted capacity and dimensions of the Maltese Islands, the option for widening roads is virtually non-existent. As far as demand is concerned, the major causes are the amount of trips undertaken by the population, the modal share of the private car and the population density. The concentration of economic activity in towns such as Valletta and Sliema is another factor influencing congestion and delay.

Malta's real economic growth rate is more robust than in several other European countries. As previously stated this has resulted in more disposable income and greater mobility. It should be noted that in Malta, the demand for cars increased irrespective of higher fuel prices. The enhanced competition resulting from the thriving second hand car market has counteracted the effects of either increasing fuel prices or excise duties. Motoring costs such as licences, insurance, servicing and repairs have also increased.

In spite of this the number of cars has continued to rise. This increase in vehicles ownership is also explained by the status associated with driving a car (rather then using the bus) and a shift in lifestyle to include more activities and trips in a day. In fact, rates of car ownership among younger aged cohorts in Malta have continued to rise in contrast with falling rates in the USA and UK (Cebr, 2014). Unsurprisingly, therefore, traffic congestion on our road network has become the norm.

There is of course an economic cost to traffic congestion. Two sources of direct costs have been considered and include (i) the opportunity cost of the time wasted whilst delayed in congested traffic; and (ii) the cost of the fuel wasted whilst delayed in congested traffic. The social cost associated with the negative impact of traffic congestion on the environment is not included in this estimate. However, it is a consideration that cannot be overlooked given Malta's economic reliance on tourism.

People affected by traffic congestion cannot ignore the value of time spent in traffic or the opportunity cost of that time, which varies by trip purpose. As one would expect, people travelling for work purposes have a higher opportunity cost. This is defined in this study as the increased cost of doing business. This is likely to be passed on to households in the form of higher prices for consumer goods and services, and this is another impact of congestion affecting in this case, expenditure by households.

In estimating congestion costs, the average annual hours wasted in congested traffic were factored in with its impact on two considerations: direct costs relating to the value of fuel wasted; and indirect costs resulting from the increased cost of doing business and the value of time lost by commuters. It was therefore necessary to estimate the fuel wasted in litres per vehicle in 2012 caused by congestion when vehicle engine is idling. The average number of seconds of delay per km was estimated at 16.93 seconds when the European average is 5.74 seconds (excluding Bulgaria, Cyprus, Croatia and Romania) (JRC, *forthcoming*). However, this study opted to use the average seconds delay per km of the two most densely populated regions (Northern Harbour and Southern Harbour) in the Maltese Islands. As shown in Figure 5 of this study, these two regions also have the heaviest traffic flow in Malta (also derived from the forthcoming JRC study). The average is 23.94 seconds and will enable comparisons (with caution, of course) to be made with other European cities such as Greater London and Brussels.

Based on a total number of 624 commuting trips per car owner per year or 1.7 trips per day of 25 minutes each, we have estimated the number of hours of commuting by car. This works out to 260 hours per year. With an assumed average speed of 30 km per hour, which is not unreasonable given the heavy extent of urban driving on Maltese roads, the total number of kilometres is estimated at 7,800. This is well below the European average kilometres (10,818) for traditional internal combustion-powered vehicles (as derived from http://www. automotiveworld.com) but again it is not unreasonable given the short distances travelled. It should also be noted that this study includes vehicles, other than passenger cars, but excludes coaches and private buses, route buses, agriculture vehicles, road tractors, special purpose vehicles, and motorcycles. Since commercial vehicles have been included (as well as minibuses), the average kilometres travelled have been increased. If commercial vehicles were excluded, the average would be lower than 7,800 kilometres.

Using the average seconds delay per km for the Northern Harbour and Southern Harbour regions (23.94 seconds) where there is the highest levels of traffic (and which is comparable with Greater London and Brussels, European cities with major congestion problems), we have estimated the lost hours per commuter per year. This is estimated at 52 hours. This is lower than the lost hours per commuter per year (almost 82 hours) for Greater London (the second highest in the EU after Brussels) as derived in the INRIX-based report by Cebr (2014), but is to be expected given the shorter distances travelled in Malta. Greater Manchester ranks 16th place in the list of cities with a total of 46 lost hours per commuter per year. If we take national figures for the UK, the average motorist spends 30 hours in gridlock every year.

The next step was to factor in the value of fuel used during hours wasted in congested traffic as well as the number of licensed vehicles. The estimated amount of fuel wasted resulting from congestion was based on the assumption that the car owners used their licensed vehicles regularly and that none of the vehicles had a start/stop system that cuts engine power during congestion. The fuel wasted during idling is dependent especially on the engine capacity though the age of the motor vehicle as well as heavy use of air conditioning (practically all second-hand cars imported from Japan or the UK have climate control facilities) are also important. According to the *Office of Energy Efficiency in Canada* (2003), which carried out a series of tests on a wide range of vehicles, the fuel wasted from idling per litre of engine displacement is shown in Annex 3. Though the majority of cars on Maltese roads are less than two litres engine displacement, given the spread of vehicles as defined in this study, we have opted to apply 1.2 litres as the fuel wasted per hour during idling. As noted above, one needs to factor in the age of the vehicles on Maltese roads which as indicated earlier is above average, and also take into consideration the heavy use of climate control during the hot months between June and September.

With diesel and petrol-powered vehicles totalling 115,332 and 176,643 respectively, the 2012 value of fuel wasted for a total of 52 hours (€1.38 for diesel and €1.44 per litre for unleaded fuel) for petrol and diesel engines, estimated separately, adds up to €25.8 million. It should be noted that fuel and lubricants accounted for 44.2 per cent of total merchandise imports in 2012, equivalent to €2.8 billion (Central Bank of Malta, 2013).

There is of course time wasted for commuters and drivers/owners of commercial vehicles resulting from congestion, and it is assumed that at least during peak hours, the majority of commuters would be travelling to and from work. However, different values for time have been applied depending on the type of vehicle used. The increased cost of doing business resulting from congestion has a negative impact upon competitiveness and business outcomes, particularly profitability. This cost is over and above the fuel wasted by commercial vehicles (numbering 41,386) and represents the value of time lost by the employed or self-employed drivers of these vehicles. Based on the number of hours lost (already estimated), the indirect cost or the increased cost of doing business (or the productivity lost during the time spent in gridlock) was estimated by factoring in the value of time (or work in €) for 2012. This was derived from the *Guidance Manual for Cost Benefit Appraisal in Malta* (2013 p.34) with the value of time €2012 per hour at factor cost shown as €15.07. The total indirect cost is the result of the product of the hours lost due to congestion, the factor cost representing value of time, and the number of commercial vehicles. The increased cost of doing business was estimated at €32.4 million.

If we now factor in the time wasted during gridlock by commuters (249,232) using their car for a variety of reasons other than for commercial purposes (including travelling to and from work), the cost of congestion would increase further. It is not possible to determine the reason for travelling and therefore the value of non-working time was applied to determine the value of time lost as a result of congestion. Again the value of non-working time was derived from the *Guidance Manual for Cost Benefit Appraisal in Malta* (2013 p.34) with the value at factor cost being €4.61 per hour. It should be noted that the value of working time is typically two and half times higher than that for non-working time. With a value for non-working time set at €4.61, the value of non-working time lost because of congestion in 2012 was estimated at €59.7 million. The total cost of congestion comprising of fuel wasted and lost values of working and non-working time adds up to €117.9 million, or 1.7 per cent of GDP.

The cost of congestion can be defined as an economy-wide cost given that so-called second-order costs have also been estimated. This second-order analysis could have been extended to account for other negative effects such as job growth, even though job growth does not appear to be a major economic concern at present. What appears to be more of concern for us is the impact of congestion on sectors such as tourism, which is especially important for Malta's economy.

It is assumed that the increasing levels of congestion reflect current levels of economic growth (in 2012 the economic growth rate was 0.6%, in 2013 it was 2.4% and currently it is around 3%). Put differently, congestion is also the result of Malta's above-average euro zone job growth rates. One also needs to keep in mind that distances are very short and this compensates for delays in travel time. However, as congestion levels continue to rise with road traffic growing faster than road capacity, congestion is expected to become a drag on growth, with higher costs for businesses and higher levels of inconvenience (due to longer waiting time) for tourists using either rented vehicles or public transport. This could put job growth at risk in the future.

The rise in car ownership implies higher levels of car imports, auto parts and fuel thus affecting the balance of trade. Today, second-hand cars account for around 58 per cent of the imported cars (NSO, 2015) and this is mainly due to the less expensive prices of imported cars especially from Japan as compared with prices for new cars. The rise in sales of second hand cars and higher excise duties on fuel has resulted in an increase in tax revenues in the period January to February 2014 as compared with the previous time period (NSO, 2014b). There was also an increase in revenue from VAT. This suggests that from a fiscal perspective, the increased use of passenger cars and light duty commercial vehicles results in higher revenues for government. This is especially important given that budget deficit targets for 2015 are heavily reliant on projected tax revenues.

4.0 TOTAL EXTERNAL COST AND PREDICTIONS FOR THE FUTURE – TASK 3

The study identified a number of data sources and methodologies to establish the economic impact of heavy traffic on Malta's roads but the team encountered challenges with specific local data and missing sources of information. Despite this, we have been able to estimate the external cost of transport.

The total cost taking into consideration costs for accidents, air pollution, climate change, noise pollution and congestion was estimated at €274 million in 2012 including the one-time cost of noise insulation (Table 16). This represents around 4 per cent of GDP at market prices in 2012 (€6,755.9 million).

TABLE 16. External Costs of Transport for 2012 (in millions).

Accidents	Air Pollution	Climate Change	Noise	Congestion	Total Cost
€83.9	€14.3	€46.8	€11.0	€117.9	**€274**

Based on the findings of this study it is safe to conclude that the level of car use in the Islands is not sustainable and results in considerable cost to society, caused mainly by congestion. Put differently, the effects of air and noise pollution, greenhouse gas emissions, congestion and road accidents (shown as an external cost) may have negative economic impacts that would need to be addressed.

4.1 Predicting costs in a 'no policy change' scenario

The findings of this study suggest that policy direction is needed to address (i) the time lost in congestion, and (ii) air pollution and climate change effects. This need for policy direction also emerges from the attempted predictions of the number of vehicles on Maltese roads (2014-2030). These predictions are based on a business as usual ('no policy change') scenario.

It is not unreasonable to assume that with an improving economic situation (economic growth in Malta is currently well above the euro zone average), congestion and delay can be expected to increase. With more economic activity (together with population growth and migratory flows) we expect higher employment and an increase in car ownership with an increase in congestion on our roads, especially at peak times.

Car ownership certainly impacts on the amount of cars on Maltese roads and the levels of car ownership are also affected by the overall cost of motoring (price of fuel inclusive of excise duties, licences, insurance, etc.). However, as has been observed, car ownership in Malta has continued to rise despite higher costs of motoring. Unlike say the UK, which since 2008 has experienced weaker growth in road usage due to tougher economic conditions and higher fuel prices, the total motor traffic vehicle kilometres on Maltese roads have risen sharply.

Predicting the growth in the vehicle fleet

A scatterplot showing by way of predictions the number of vehicles on Maltese roads between 1987[2] and 2013 is shown in Figure 12 (and reproduced alongside workings in Annex 4). It is clear in Figure 12 that a trend is present – as time passes by, the number of vehicles on the Maltese roads increases consistently. However, it is also evident that the number of cars on the road will be reaching saturation in the coming years.

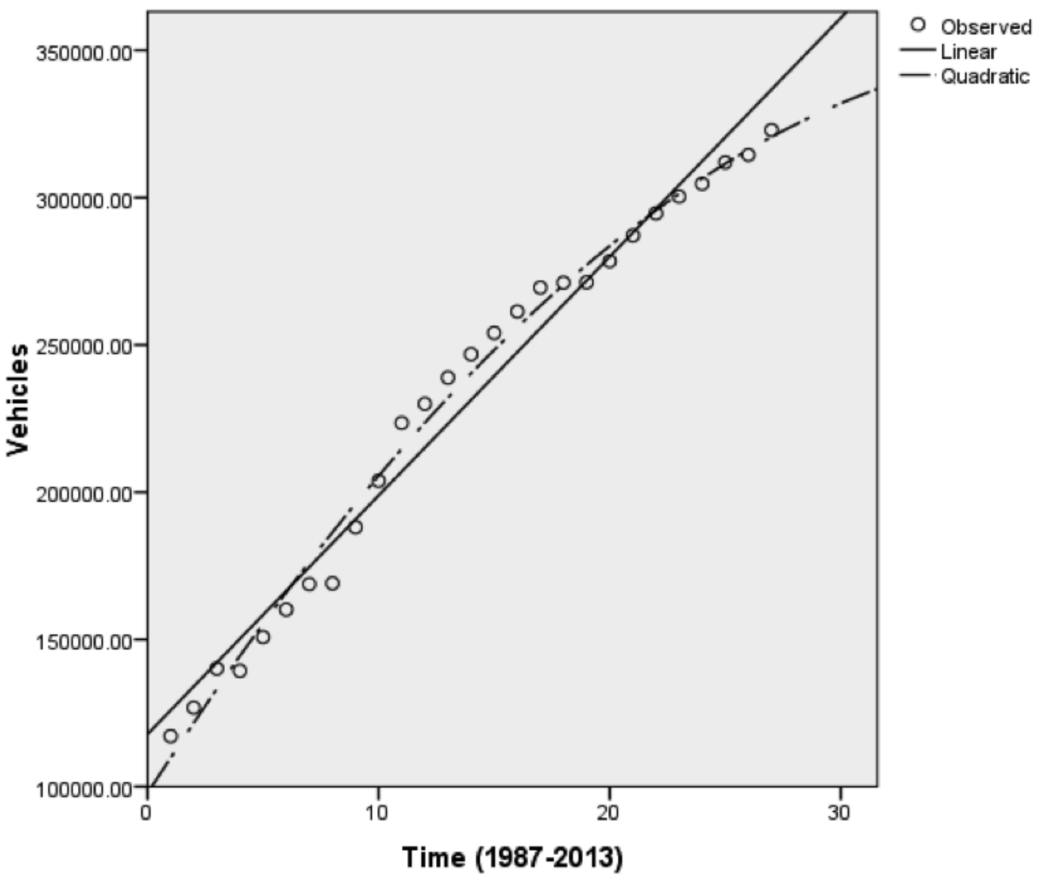

FIGURE 12. Time series of vehicle fleet growth in Malta (1987-2013). *Authors' own workings.*

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2 In 1987, Government adopted a strict policy of containment with respect to development. The Building Permits (Temporary Provisions) Act became the Government's instrument to control building and it provided for two years for the drafting of the Structure Plan and the establishment of a national land use planning agency. The legislation was approved by Parliament in 1992 with the first members of the Planning Authority Board appointed in October of that same year. Transport planning fell under the responsibility of the Planning Authority.

The scatterplot also indicates that the relationship between the number of vehicles on the road and time during the period 1987-2013 (coded 1-27) would have greater predictive capacity if a non-linear component is added to linear regression. In this regard, we sought to examine the impact of non-linear effects (namely, a quadratic function) via hierarchical multiple regression. To counteract the problem of multicollinearity in polynomial regression due to the squared term, we used the mean-centering data method such that transformed independent variable Centered Time = 'Time – Mean Time', where mean time was 14 (the average of the digits from 1 to 27).

In the hierarchical regression analysis, mean-centered Time was included in the first step (linear term), and 'mean-centered Time squared' in the second step (the quadratic term). Model 1 which includes the linear effect produced an R^2 of 97.5 per cent which was statistically significant ($F_{1, 25}$ = 971.33, p <0.01). In Model 2, the quadratic effect produced an R^2 change of 0.016 per cent which was statistically significant ($\Delta F_{1, 24}$ =41.05, p = 0.02). The model combining the linear and non-linear effects (quadratic) - Model 2 - produced an R^2 of 99.1 per cent that was statistically significant ($F_{2, 26}$ = 1284.19, p <0.01). The VIF statistics for Model 2 also indicate that multicollinearity is not an issue in our case. Thus, the model used to predict number of vehicles is:

$Y = 240{,}316.33 + 8107.18X - 148.62\,X^2$, where X is mean-centered time and X^2 is mean-centered time squared.

This produces the following predictions for the number of cars in 2020 and 2030 under a 'no policy change' scenario: 343,011 and 349,774 respectively (see Figure 13). The table showing predictions between 2014 and 2030 is shown in Annex 4, which also shows the model summary and ANOVA results. GDP was not included as an additional predictor in multiple regression analysis due the problem of multicollinearity (GDP was highly correlated with time) while continuous transport activity data between 1987 and 2013 was not available.

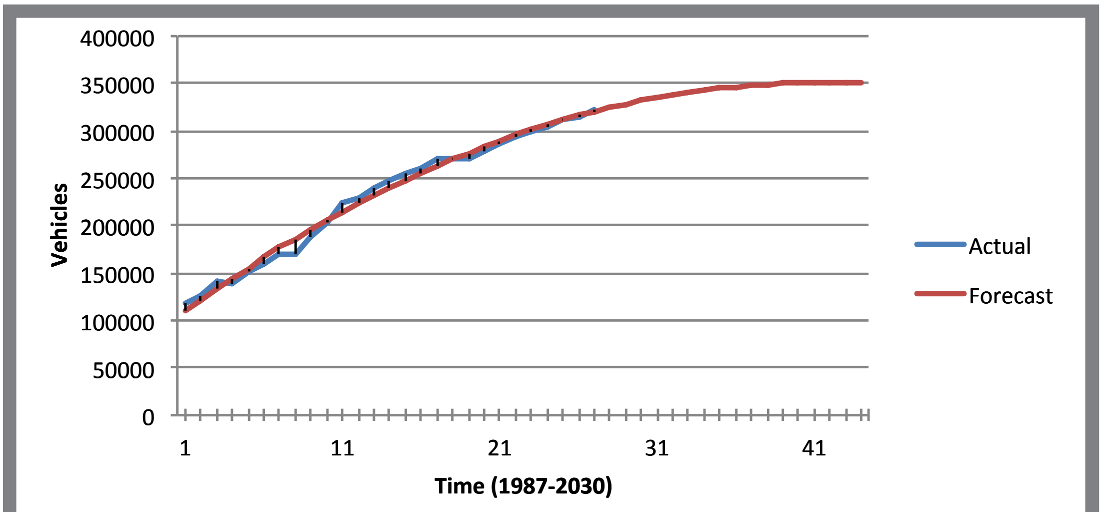

FIGURE 13. Number of Vehicles - Actual (1987-2013) and estimated (1987-2030).

Predicting the number of road accident injuries

We have also attempted to predict the number of road accident injuries in Malta (Annex 5). The road accident injury data for the period 2001-2013 show that 78.82 per cent of the injuries were slight, 20.0 per cent were grievous, while the remaining 1.18 per cent were fatal (Table 17). These proportions were relatively stable over time (see Annex 5).

TABLE 17. The road accident injuries by type for the period 2001-2013.

Year	Slight	Grievous	Fatal	Total
2001	853	262	16	**1,231**
2002	982	314	16	**1,312**
2003	923	248	17	**1,188**
2004	1,003	265	13	**1,281**
2005	883	257	16	**1,156**
2006	907	279	10	**1,196**
2007	949	246	14	**1,209**
2008	909	248	15	**1,172**
2009	849	199	21	**1,069**
2010	853	211	15	**1,079**
2011	1,325	235	17	**1,577**
2012	1,290	300	9	**1,599**
2013	1,299	265	18	**1,582**
Total	**13,125**	**3,329**	**197**	**16,651**
%	78.82	20.00	1.18	100.00

While the number of injuries was generally on the decline between 2000-2010 (see scatterplot in Annex 5), there was a drastic increase in the total number of injuries in 2011. Attempts to predict the number of injuries on Maltese roads with the present data resulted in forecasts that were not very realistic. This is because as from 2011, the injuries increased significantly and this may be attributed to a change in reporting methodology. In this regard, given that no trend was present during these 3 years, we have decided to use the average of the last three years (2011-2013) in our calculations i.e. 1,586 injuries.

Predicting external costs under a 'no policy change' scenario for 2020 and 2030

Based on the predictions for the vehicle fleet as well as accident injuries, the total external costs for 2020 and 2030 have been estimated. This is of course based on a 'no policy change' scenario which appears unrealistic given the effects of the external costs and the increasing pressures on authorities to take effective, and perhaps unpopular, political actions in the transport sector.

Table 18 shows the cost for road accident injuries (2012 prices). The number of predicted accident injuries in 2020 and 2030 were estimated at 1,586 in each of both years. The same proportions as in 2012 were applied: fatal (1%), grievous (18%) and slight injuries (81%). The cost for both 2020 and 2030 was estimated at €78 million.

TABLE 18. Cost for road accident injuries (2012 prices) 2020 and 2030 (in millions).

Type of Injury	Fatal	Grievous	Slight
2020	€19.3	€44	€14.7
2030	€19.3	€44	€14.7

We also estimated the human capital cost for 2020 and 2030 caused by car accidents. Again, we have taken lost production as the measure for human capital cost. The same GDP per capita, adjusted for purchasing power parity was used to estimate lost production for grievous and slight injuries based on the proportions applied for road accidents. The costs for 2020 and 2030 were each estimated at €11 million.

The next step was to estimate the cost of medical services using the costs referred to earlier in this study. Costs will inevitably rise in the future. However, it is near impossible to predict the rise in the cost of say in-patient surgery services given that the various components of such services could not be determined. The estimated cost of medical services for both slight and serious injuries in 2020 and 2030 (inclusive of ambulance services) was each estimated at €0.6 million.

Predicting air pollution costs

The air pollution cost estimates for 2020 and 2030 were based on the same average emissions for passenger cars and light-duty commercial vehicles as in 2012. This would imply that the composition of the vehicle fleet remains the same, and assumes no replacement of vehicles. As newer vehicles typically have lower fuel use and emissions, this means that the costs of air pollution, climate change, and idling fuel consumption are likely overestimated. However, within the scope of this study it is not possible to estimate the development of the vehicle fleet, and given that the average yearly distance travelled on Maltese roads is well short of the EU average, might also contribute to a higher than average age and lower replacement rate of the Maltese vehicle fleet.

The predicted number of vehicles shown earlier was adjusted downwards to take into account that not all vehicles are defined as either passenger or goods carrying vehicles (those not classified as such accounted for 7 per cent in 2012). The number of passenger and goods carrying vehicles for 2020 and 2030 should therefore read 319,000 and 325,290 respectively. For 2020, the total predicted costs were estimated at €15.3 million whereas in 2030, air pollution costs were estimated at €15.5 million. It should be noted that the cost factor used for the estimated air pollution costs was the 2012 factor cost. One would expect this cost to change both in 2020 and 2030 implying an even higher cost for air pollution.

Predicting climate change costs

We also estimated the climate change effects for 2020 and 2030 under a 'no policy change' scenario. These too were based on the methodology referred to earlier in this study and which in the view of the authors represents a far more reliable representation of car emissions than total figures for road transport. Again, the central value of €90 per tonne was applied to determine the abatement cost of climate change for passenger and goods carrying vehicles. In 2020 and 2030, the estimated climate change costs were €51.2 million and €52.3 million respectively.

Predicting noise pollution costs

With regard to noise pollution, it was necessary to determine the average proportions of the Northern Harbour and Southern Harbour regions' populations from 2006 to 2011 to predict their population in 2020 and 2030. Again, and as explained earlier in the study the applicable cost factor for the Northern Harbour and Southern Harbour regions were taken and the same weightings were applied for day and night time.

The Eurostat (2014c) *EUROPOP 2013* (Malta population) projections for 2020 and 2030 were used to determine population growth. Projections show a growth in population to 440,437 in 2020 and to 447,295 in 2030. The estimated costs for noise pollution for the Northern Harbour and Southern Harbour regions in 2020 and 2030 were calculated at €10.4 million and €10.6 million respectively.

Predicting congestion costs

As far as congestion costs are concerned, the assumption for lost hours per commuter remained at 52 hours, as estimated for 2012. However, further increases in the number of hours lost cannot be ruled out if the congestion problem is not addressed. The value of fuel used during hours wasted in congestion is again based on the standard of 1.2 litres per hour with the number of cars as predicted for 2020 and 2030 (see Annex 4). The proportion of diesel and unleaded fuel was retained at 2012 proportions (40% diesel and 60% petrol). The price of fuel for 2020 and 2030 is practically impossible to predict and we have assumed 2012 prices for diesel and unleaded fuel as the prices applicable for the predicted cost. As we are assuming a 'no policy change' scenario the assumption of 2012 prices would not appear unreasonable. The cost for fuel wasted in 2020 and 2030 was estimated at €49.3 million and €50.3 million respectively.

The increased cost of doing business resulting from congestion was also estimated. Again, the value of time lost by employed or self-employed drivers of light-duty commercial vehicles was applied. When taking the number of hours lost per year, the 2012 € value of time per hour, and 2012 percentage (14.6%) of light-duty commercial vehicles relative to total vehicles as defined in this study, the increased cost of doing business in 2020 and 2030 was estimated at €36 million and €37.2 million respectively. As for the lost non-working time this amounted to €65.3 and €66.6 million respectively.

The total estimated congestion costs for 2020 and 2030 add up to €151.1 million and €154.1 million respectively. It is again evident that congestion costs are considerable, resulting in inefficient use of both time and fuel. The extraordinary high level of congestion on Malta's roads is clearly unsustainable and the economic cost will continue to rise unless political action is taken to address the problem. The longer it takes to implement effective decisions, the more severe and expensive the policy response will be.

Table 19 summarises the results of a 'no policy change' scenario for 2020 and 2030. The total external costs of transport for a 'no policy change' scenario for 2020 and 2030 are estimated at €317.6 and €322.1 million respectively.

TABLE 19. Estimated external costs of transport for 2012, 2020 and 2030 in a 'no policy change' scenario (in millions).

	2012	2020	2030
Accidents	€83.9	€89.6	€89.6
Air pollution	€14.3	€15.3	€15.7
Climate change	€46.8	€51.2	€52.3
Noise	€11	€10.4	€10.6
Congestion	€117.9	€151.1	€154.1
Total	**€274**	**€317**	**€322**

4.2 Addressing congestion and reducing external costs

In order to address the problem of congestion, a concerted effort needs to be made to reduce the number of vehicles on the road and provide a more reliable and efficient alternative. Due primarily to its size and population, cost-effective public transport solutions for Malta revolve around the bus service. Other public transport modes cannot be excluded but these would require both very high levels of investment as well as very long timeframes.

Other complementary measures to reduce congestion look at increasing the price of using private modes of transport, which would in effect mean internalising the external costs. Financial disincentives, though effective, could also be considered though they are likely to prove very unpopular.

For the purposes of this study, three policy actions have been selected to target congestion and predict impact on the external costs of transport.

Policy Action 1: Increasing the efficiency and use of public transport, e.g. through further use of park and ride schemes; use and deployment of non-road modes; more efficient use of the road network, e.g. through intelligent transport services, market-based instruments including time differentiated congestion charging, or removal of infrastructural bottlenecks; and stimulating the use and making the road network more suitable for soft modes (walking/cycling).

Over the past five years Government has invested considerable energy in a reform of the public transport (bus) service in Malta. Given that the reform has not as yet achieved one of its main objectives (a recognizable shift to public transport by commuters) the efforts of the current Government to improve public transport will continue with a new operator taking over the service in 2015. It is still not yet clear whether the three Park and Ride infrastructures at Floriana, Pembroke and Marsa will be part of the concession to operate the public transport service (as previously done with ARRIVA Malta). However, every effort should be made to increase the use of Park and Ride services, in parallel with the use of public transport. Government has also recently re-launched the ferry service in Marsamxett Harbour in an effort to reduce the dependence on the road infrastructure.

These efforts and initiatives have so far been deployed independently from each other instead of adopting an integrated approach to the various public transport offers. Government should encourage better integration between services through integrated ticketing, scheduling and marketing.

The recent figures for public transport usage show an increase in overall mobility using the bus (see Figure 14). However, this does not reflect a recognizable modal shift as yet, since the number of cars on the road continues to increase (JRC, *forthcoming*). Figure 15 on the other hand shows the number of tickets sold to residents (excluding tourists). The peaks observed throughout the year reflect the start of each school term in October with lower peaks experienced during the summer months.

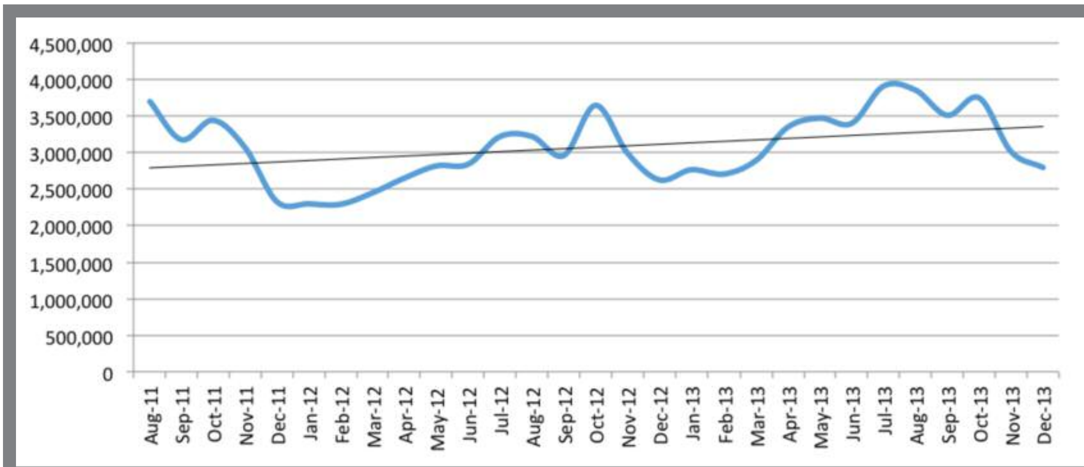

FIGURE 14. Number of passengers on public transport between August 2011 and December 2013. *Source: NSO (2013a; 2014b).*

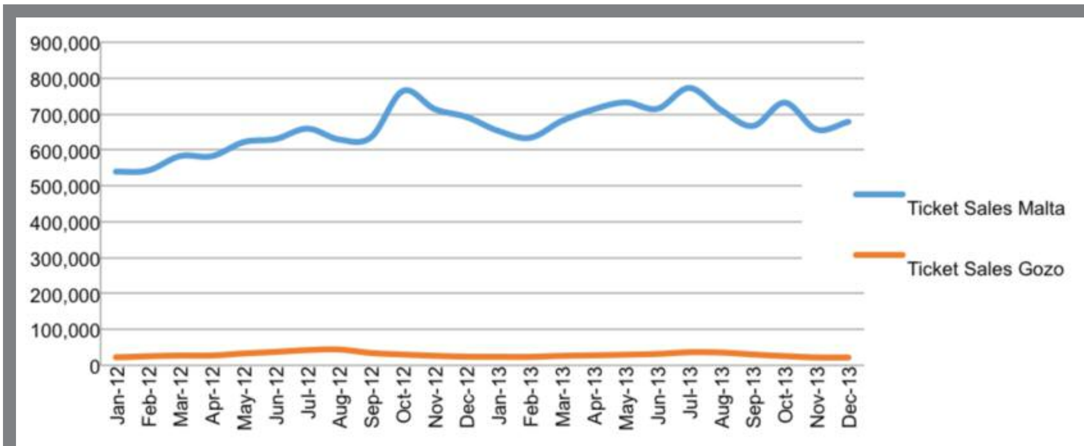

FIGURE 15. Number of "resident" public transport tickets sold in 2012 and 2013. *Source: NSO (2013a; 2014b).*

For the purposes of this study and in order to estimate the potential impact of improved public transport services and park and ride infrastructures, the Household Travel Survey data for 2010 was used to quantify the amount of trips shifted from one mode to the other. A further shift to soft modes was also estimated, assuming efforts by Government to incentivize the use of walking and cycling through measures such as bicycle lanes, pedestrian priority areas, pedestrianisation, shared spaces and car restrictions in old village centres (parking charges, road pricing and timed access).

The 2010 Household Travel Survey collected information on 41,771 trips per day, out of which 75 per cent were done by private modes, 15 per cent were done by public modes and 9 per cent were done by other non-motorised modes. In shifting 20 per cent of car trips to bus and other non-motorised modes, a sizeable amount of trips would be eliminated from the road network. Ten per cent of car trips would be transferred to bus assuming a 10 per cent shift from car to bus for trips going to Valletta. This is similar to the 1998-2010 trend for car trips to Valletta, which during the same period increased by 20 per cent. The 10 per cent shift to non-motorised modes is based on the fact that the 2010 NHTS found that 13.7 per cent of all trips are short trips carried out within the same locality. Given the proper disincentives to drive short trips, such as charging for parking, limiting access to town/village centres through pedestrianisation and reduced parking and road pricing, the shift to non-motorised modes for short trips would be easier (and cheaper). Assuming a direct relationship between the number of trips and the average seconds of delay per km (estimated by JRC, *forthcoming*) on the 2012 network, the average second of delay per km would decrease on a national level from 16.93 seconds to 13.50 seconds (see Table 20).

TABLE 20. Estimated average seconds of delay per km with a 20% modal shift from car, using NHTS (2010) data and JRC (forthcoming). *Authors' own calculations.*

District	2010 Car Trips	Average seconds of delay per km in seconds	Car trips incl. 20% shift to bus and non-motorized modes	20% reduction in delay from reduced trips	Estimated average seconds of delay per km
Southern Harbour	16,404	22.08	13,124	4.42	17.66
Northern Harbour	16,172	25.79	12,938	5.16	20.63
South Eastern	24,432	12.61	19,545	2.52	10.09
Western	36,225	14.44	28,980	2.89	11.55
Northern	29,869	10.72	23,895	2.14	8.58
Gozo	46,986	15.63	37,589	3.13	12.50
MT	**170,088**	**16.93**	**136,070**	**3.38**	**13.50**
EU24 (EXCL. BG, CY, HR, RO)		**5.74**			

Based on this policy change scenario, and using the same methodology applied previously for predicting external costs in 2020 and 2030, costs based on a reduced number of passenger car trips per day (34,018) were re-estimated. It should be noted that this policy change impacts air pollution and climate change effects but has also some impact on noise pollution. The number of car accidents for 2020 and 2030 were based on the predicted values as derived in this study.

Earlier in the study the number of car trips per year was assumed to be 624. A 20 per cent reduction in car trips means 124 fewer trips per commuter per year and is the equivalent of 63,800 and 65,058 fewer passenger cars on the road in 2020 and 2030 respectively. With regard to congestion, fewer trips per commuter per year (500) result in a reduction in the number of hours lost per commuter per year. Fewer trips also result in a reduction in the number of kilometres travelled per commuter per year (6,240). Since delay is assumed to fall to 13.50 seconds per km on a national level, the number of hours lost per commuter per km would be on average 23 hours. However, if we compare with the baseline, that is the Northern Harbour and Southern Harbour regions, the hours lost based on the 19.1 seconds per km delay would be 33 hours when compared to the 52 hours referred to earlier in this study.

Given that the average number of kilometres travelled is now set at 6,240km, the level of emissions for NMVOC, NOx, and $PM_{2.5}$ are 4kg, 2.7kg and 0.15kg respectively (the latter was also adjusted to account for the heavy presence of old diesel-fuelled engines and above-average age of the fleet, as done earlier in the study). These levels of emissions are applicable for 2020 and 2030. As for climate change, the level of emissions with fewer vehicles (255,200 in 2020 and 260,232 in 2030) and therefore a reduced number of kilograms per commuter was estimated at 1,428kg. Again, this applies for both 2020 and 2030.

The same costs derived for 2020 and 2030 predictions under a 'no policy change' scenario apply for car accidents and noise pollution. This is not unreasonable since in the case of accidents, the causes of accidents are not necessarily related to the number of cars on the road, and in the case of noise pollution, though the reduced number of trips and its equivalent in terms of number of cars for 2020 and 2030 may have some positive impact, the size restrictions of the Maltese Islands limit the effectiveness of measures aimed at reducing noise pollution. However, it should be noted that the replacement of old cars with new cars, also fitted with new tyres, should help reduce further the noise levels.

The total external costs for 2020 and 2030 were estimated at €187.8 million and €189.5 million respectively (Table 21). This is a significant reduction over 2012. Compared to the 'no policy change' scenario and previous 2020 and 2030 estimates there is an even greater reduction of costs. This policy action helps to reduce the external costs but would need to be explored in more depth to further assess its general effectiveness.

TABLE 21. Estimated external costs of transport for 2020 and 2030 for Policy Action 1 (in millions).

	2012	2020	2030
Accidents	€83.9	€89.6	€89.6
Air pollution	€14.3	€9.57	€9.67
Climate change	€46.8	€32.2	€33.3
Noise	€11	€10.4	€10.6
Congestion	€117.9	€46	€46.3
Total	**€274**	**€187.8**	**€189.5**

Policy Action 2: Reducing and making the car fleet more sustainable, e.g. through electric mobility and car sharing schemes.

In 2012 the vehicle fleet amounted to 314,510 with 242,149 (77%) being classified as passenger cars. In 2012, 175,286 passenger cars had petrol engines (70%) whilst 73,946 had diesel engines (30%). Thirty-two were electric, 272 hybrid, 1 LPG, 1 gas, 55 paraffin, 6 battery operated, 11 combined fuel, and 2 unknown.

Figure 16 shows progress so far, with the percentage of electric cars increasing to 0.015 per cent in 2012. The increase in the number of electric vehicles in 2013 was fuelled by Government's involvement in a LIFE+ project which saw the installation of a 100 charging stations in strategic locations around the islands and the purchase of 24 electric vehicles to use and monitor performance. In comparison, hybrid vehicles have been more popular making up 0.2 per cent of the fleet in 2012.

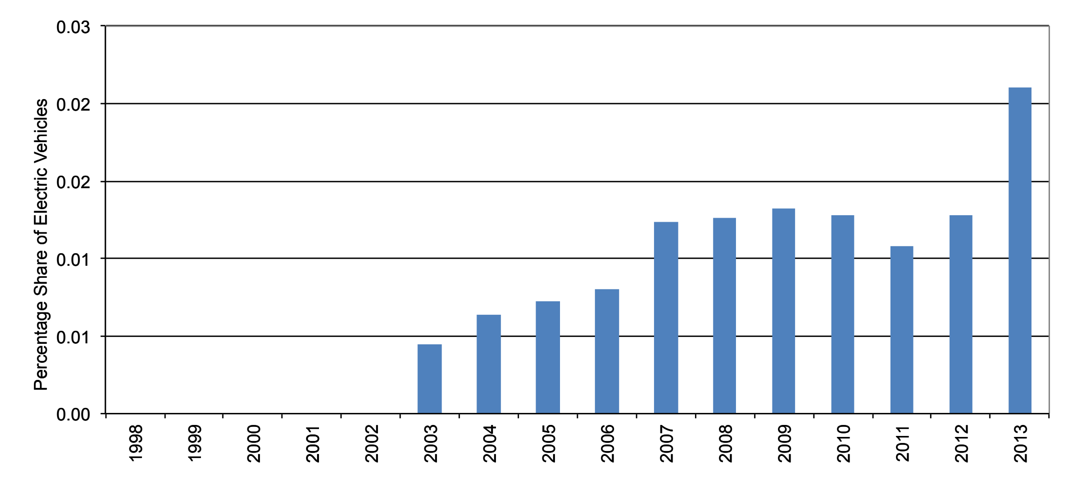

FIGURE 16. Percentage electric vehicles in the private vehicle fleet in Malta. *Source: Attard, (2012b); NSO (2014b).*

In 2010 the Government set up a committee to draft a national strategy for electric mobility in the Islands. The aim was to have 5,000 electric vehicles by 2020 as part of Malta's emission reduction plans. Despite the investment in the infrastructure and other incentives, it is evident from the data that the adoption of electric mobility has been much slower than expected.

Measures aimed at encouraging people to shift to electric mobility could include an effective replacement policy for older vehicles. Malta has a relatively high average age of vehicles, with the average for private vehicles standing at 13 years in 2012 and 2013. Over 60 per cent of vehicles are over ten years of age, and more financially attractive schemes to encourage replacement could make individuals consider buying electric cars. In addition, a proposal to introduce a staggered fleet replacement plan over a number of years could also be considered. This would offer opportunities to reduce the average fleet age and also encourage replacement with more efficient fuels or electric vehicles (See Annex 6 for workings).

The impact of such a plan can be simulated if a replacement effort for vehicles over 15 years of age until 2020 and ten years of age until 2030 is systematically implemented with a financial incentive to support replacement. An initial investment of €1.5 million a year until 2020 would provide a replacement fund of €3,000 for 500 vehicles. A subsequent investment of €3 million a year until 2030 would provide a replacement fund of €3,000 for 1,000 vehicles. Table 22 projects these estimates based on the predicted increase in the vehicle fleet in Malta. The number of electric vehicles in 2020 and 2030 following the implementation of a systematic fleet replacement scheme were estimated at 3,496 and 13,512 respectively.

TABLE 22. Estimated number of electric vehicles for 2020 and 2030 following the implementation of a systematic fleet replacement scheme. *Authors' own calculations.*

2013	Petrol	Diesel	Electric	Hybrid	Other	Total
Total fleet	196,452	125,822	130	322	261	
Passenger Cars	178,144	77,379	54	316	203	256,096
% Share of PCs	69.56	30.21	0.02	0.12	0.08	
2020	**Petrol**	**Diesel**	**Electric**	**Hybrid**	**Other**	**Total**
Passenger Cars	184,997	81,863	3,496	352	217	270,979
% Share of PCs	68.27	30.21	1.29	0.13	0.08	
2030	**Petrol**	**Diesel**	**Electric**	**Hybrid**	**Other**	**Total**
Passenger Cars	186,337	80,506	13,512	359	221	276,321
% Share of PCs	67.44	29.14	4.89	0.13	0.08	

Thus with the financial incentive aimed at encouraging fleet replacement and uptake of electric vehicles, the number of electric vehicles in 2020 would increase to 1.29 per cent of the private vehicle fleet (passenger cars only) and 4.89 per cent of the private vehicle fleet (again passenger cars only) in 2030. If we include light duty commercial vehicles, as previously referred to, the percentages would be smaller (1.1% in 2020 and 4.2% in 2030). The number of petrol or diesel-powered vehicles would now total 315,504 in 2020 and 311,778 in 2030. The estimated total external costs in 2020 were significantly more than 2012 and only marginally lower than those estimated for the 'no policy change' scenario (€315 million). In 2030 the external costs continue to increase over the 2012 costs with even more electric cars on the road. The total external costs were estimated at €320 million, only slightly below the "no policy change" scenario for 2030 (Table 23).

TABLE 23. Estimated external costs of transport for 2020 and 2030 for Policy Action 2 (in millions).

	2012	2020	2030
Accidents	€83.9	€89.6	€89.6
Air pollution	€14.3	€15.1	€15.5
Climate change	€46.8	€50.6	€51.7
Noise	€11	€10.4	€10.6
Congestion	€117.9	€149	€152.2
Total	**€274**	**€315**	**€320**

It is evident that more electric cars would be needed to have significant impact on external costs, in particular on air pollution, noise and climate change effects (with no impact on congestion given that electric cars are replacing conventional-powered vehicles). As pointed earlier in this study the major limiting factor in the effectiveness of this policy is the short distance travelled on Maltese roads which distorts efficiency relative to outlay for such vehicles. However, assuming further technological developments and a lowering of cost to commuters as prices fall, one would expect more electric cars on our roads.

Policy Action 3: Optimising work and school hours, and reducing education-related trips.

Figure 4 clearly demonstrated the problems encountered on the network with respect to peak hour traffic. The high peak of the morning reflects the current and almost simultaneous start of work, shop and school hours. The afternoon peak, around the time offices finish work (1700 to 1800 hours), causes lower congestion than the morning peak, with traffic being distributed between schools that close between 1300 and 1500 hours, and shops closing at 1900 hours.

School runs primarily drive the difference between the morning and evening peak. The increasing dependence of education trips on private vehicles, rather than school transport is already evident in the 1998 NHTS where 42 per cent of all education trips were carried out by private car, 47 per cent by public transport and only 10 per cent of trips were carried out on foot. The 2010 NHTS shows an increase in the number of education trips being carried out by private car (49%), a decline in the number of education trips being done using public transport (44%) and a reduction also in the number of trips being done on foot (6%) (see Table 24). This reliance on private vehicles is a cause of increased traffic on the road at a time when the network is already at capacity. A number of policies in this respect could be implemented to reduce this impact as shown hereunder.

TABLE 24. Percentage Modal Split for Malta by Purpose 1998, 2010. Data source: MEPA and Transport Malta. *Authors' own calculations.*

HTS Planning Authority, 1998 %							
Trip Purpose	Motor Car	Bus	On Foot	Motorcycle	Bicycle	Other	
Work place	79.56	12.92	6.07	1.17	0.06	0.21	100
Shop	62.29	16.97	20.05	0.32	0.29	0.08	100
Education	**42.24**	**47.16**	**9.91**	0.18	0.21	0.31	100
Other	71.81	15.53	11.19	0.66	0.39	0.43	100

HTS Transport Malta, 2010 %							
Trip Purpose	Motor Car	Bus	On Foot	Motorcycle	Bicycle	Other	
Work place	84.16	9.07	4.01	1.69	0.31	0.76	100
Shop	67.95	17.77	13.33	0.66	0.17	0.10	100
Education	**49.06**	**44.35**	**5.87**	0.45	0.18	0.09	100
Other	75.08	13.90	7.90	1.03	0.27	1.82	100

(i) Upgrade substantially the quality of school transport services and extend the free service to church and private schools (currently free school transport is only provided to public schools), and implement a national school transport system to coordinate the transport of children to reduce redundancy and increase efficiency in the use of the service.

(ii) Stagger school opening hours, even though this will be considerably harder to implement unless supporting mechanisms are in place to allow for parents and school transport to cover the new opening hours.

(iii) Introduce accountability and stricter procedures to successfully optimise working hours with the introduction of flexi-hours and telework. Teleworking policies in the public service have been in place in Malta since February 2008. Previous surveys held in 2004 and 2005 showed low uptake (Employer's Resources Centre, *undated*) and a report in January 2008 showed no formal policy (Formosa, 2008). In February 2008, the Government introduced teleworking procedures for the public service (http://pahro.gov.mt/chapter-5) and institutions like the University of Malta has put in place teleworking as part of its 2011 Collective Agreement (http://www.um.edu.mt/isd/greentravel/news_and_events/flexibility_and_teleworking_policy). There is however very little by way of research into the uptake and effects of teleworking. Informal communications with public service heads and directors at the University of Malta suggest the practice is not as successful, with events in the media highlighting the uncertainties about teleworking practices in various workplaces (Xuereb, 2013).

In an attempt to simulate the potential impact of these measures on the network, the 2010 Household Travel Survey was used to estimate the percentage contribution of education and work trips to the morning traffic. A reduction of traffic was estimated and the impact on the network was assessed.

The 2010 NHTS indicates the proportion of education-related trips done by car out of all education-related trips at 49 per cent. Based on the number of students attending pre-primary, primary, special schools, secondary and post-secondary schools (NSO, 2014d), but excluding vocational and tertiary education (the total of which is 62,662 students), we have used the proportion of education-related trips by car to determine the number of students driven to educational institutions per year (30,704). Assuming two trips per school day (in Malta this totals 170 days) and assuming that the number of parents driving their child to school is equivalent to the number of students[3], and taking 30,704 as the number of cars on the road for education-related travel per day, the number of trips per year would amount to 10.5 million trips per year. This is 6.8 per cent of all commuter trips totalling 154.6 million per year (excluding light duty commercial vehicles).

Now if we assume a 20 per cent shift of education-related trips from car to bus or walking, this would translate in a reduction of 2.1 million trips per year. If we assume a 50 per cent reduction however, the reduction would be of 5.25 million trips per year. Even though education-related trips as a proportion of total commuter trips is small (and is smaller once light duty commercial vehicles are factored in), this policy in combination with other effective policy actions could help ease congestion. It would be particularly effective during the morning peak hour when education-related trips occur. Moreover reducing education-related car trips should have some positive impact on air pollution, climate change and to some extent on noise pollution. Though the possible reduction in delays per second per kilometre has not been factored in this study, it should not be overlooked.

It is a recommendation of this study to further investigate impacts from such measures using network analysis through simulation and modelling, to capture the effects of gridlock or otherwise on Malta's road network. The transport model being currently developed by Transport Malta will provide the opportunity to assess and quantify the positive outcomes of policy actions that would aim, amongst other things to reduce education-related travel by car on Maltese roads.

Based on the above assumptions, the external costs, once light duty commercial vehicles are factored in (following a reduction in car-related education trips by 50%), were estimated at €275 and €273 million in 2020 and 2030 respectively (Table 25). This represents only a marginal reduction in 2030 when compared to

[3] This may be a slight overestimation since it does not consider parents with more than one child attending the same school or educational institution.

the 2012 external costs, but there is a noticeable decrease in external costs from the "no policy change" scenario for both 2020 and 2030.

TABLE 25. Estimated external costs of transport for 2020 and 2030 for Policy Action 3 (in millions).

	2012	2020	2030
Accidents	€83.9	€89.6	€89.6
Air pollution	€14.3	€13.5	€13.4
Climate change	€46.8	€46	€45.3
Noise	€11	€10.4	€10.6
Congestion	€117.9	€115.5	€114.4
Total	**€274**	**€275**	**€273**

Other policy options, such as staggering working hours would potentially distribute the traffic in the network, reducing the peak but extending the hours of relatively high traffic. However, this would not contribute to a decline in the amount of traffic and related impacts on the network, but could potentially impact congestion (and its costs).

The 2010 NHTS showed that work trips make up 22 per cent of all car trips on the network. According to Figure 4, the morning peak towards Valletta extends from 0700 to 1000 hours, with an evident peak at 0800 hours. A staggering of the working hours in Valletta by an hour would reduce the 0800 hours peak potentially by 11 per cent (assuming a 50% distribution of work starting time between 0800 to 0900 hours) and extend the morning traffic to 1100 hours. This would extend the longer travel time and slower speeds into the late morning.

Staggering working times might be one of a number of measures to smoothen traffic flow. It may also help reduce congestion but it cannot be implemented on its own since the benefits of such policy would be minimal without other, more restrictive policies to control car use, and therefore reduce or at best contain congestion costs (as well as other external costs). As explained in this study, congestion costs increase with the addition of more vehicles on our roads. This reduces the speed and increases the average time it takes to complete a trip.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Whereas the results derived in this study conform to the standard conclusions of transport economics, namely the "Iron Law of Congestion" as posited by Anthony Downs (1992) (Mogridge, 1990), it should be noted that under a 'no policy change' scenario, external costs would rise in 2020 and 2030 when compared to 2012. The mitigating factor being, that the number of cars is not expected to increase in the future at the same levels as the recent past. This study has determined that a modal shift to public transport would have a significant positive impact on reducing transport external costs.

However, the study has also shown that one single policy action would not be enough to significantly reduce external costs and a range of effective measures would be required. This study has therefore considered a range of policy actions with, as stated, the modal shift to public transport being an effective action for reducing external costs. It is also evident from this study that the other proposed policy actions, as referred to in this study, would need to be explored further and in more detail to better estimate their impact on external costs. For example, electric mobility may in the future prove to be a more viable option for car owners, and effective policy measures aimed at reducing education-related trips by car from the network during peak hours would contribute to a more significant reduction in external costs.

5.1 Recommendations

Based on the findings of this study, it may also be relevant to analyse further both demand management and supply side policies (e.g. improving road infrastructure). Measures such as road pricing and restricting car use, through a series of coordinated transport demand management measures, could prove effective in containing the increase and further use of cars on the roads.

It is pertinent to point out that in terms of the structure of private costs incurred by car owners in Malta (made up of variable and fixed costs), car ownership costs tend to be largely fixed (e.g. licence, insurance and depreciation). This motivates car owners to maximise the use of their car so as to amortise fixed costs over a larger number of trips whereas the variable costs incurred when using a car, including road tax, are not steep enough to discourage car use. Increasing the variable costs of car usage through road pricing or paid parking could therefore help to achieve a better balance between demand and supply side policies, and thereby allocate road capacity more efficiently. It could also result in sizeable shifts in commuter travel behaviour.

Effective road pricing, for example, helps to allocate road network capacity more efficiently leading to a reduction in congestion. Predicting or simulating the effects of road pricing on congestion is, of course, complex and would require the development and use of a transport model of the Islands. This is currently being developed by Transport Malta and detailed studies using simulation and modelling approaches would significantly improve the predictions of policy actions on traffic and congestion, amongst other things. Further studies would therefore be required to quantify the potential impact of various road pricing options, including a change to the current Valletta (CVA) scheme and extension to other areas or a new scheme for road pricing on the main road network. It is also important to keep in view other, equally effective pricing policies implemented across many cities, such as paid on-street and off-street parking which increase the cost of private vehicle use and act as a deterrent to car users, particularly in commercial centres. Malta to date still has a free parking policy for its on-street and public off-street parking areas, and it may be relevant to explore whether paid parking could serve as a second best option for road pricing which tends to be politically unpopular.

Viewed in this context, road pricing and/or paid parking could be viewed as efficiency maximising taxes to relieve congestion, and could provide funds for further upgrading of roads and improvements in public transport. However, one would need an estimate of demand elasticities to determine the sensitivity of demand to pricing. There are other considerations that need to be factored in including equity (e.g. the impact on low income households) and effects on business competitiveness. Additionally, as for the introduction of the CVA in Valletta in 2007, a number of studies have to be carried out to ascertain the costs and benefits, the implementation framework and complementary measures to support the introduction of a new or revised road pricing scheme.

Road pricing and paid parking, supported by complementary educational, environmental and planning measures in specific areas, may appear to be the more effective options to reduce the external costs of road transport and reduce congestion. However, an in-depth analysis of their impact is strongly recommended and the authors of this study are by no way implying that road pricing is being advocated as the main policy action to combat congestion. Any recommendation on road pricing would be premature without any detailed insight on the technical issues, such as the cost of implementation and how to charge prices, as well as on the effectiveness of taxes levied on vehicle ownership and use (which could shed further light on why ownership has grown so impressively over the years).

Also, one cannot ignore the positive impact an improved public transport service might have and Policy Action 1 shows that if successfully implemented it would help reduce the external costs of road transport. Experience from the EU also seems to suggest that an effective and affordable public transport system may be a prerequisite for road pricing and paid parking. The experience of public transport reform in Malta has so far failed to live up to expectations. This may yet prove otherwise with the correct pricing of fares, regular monitoring of the performance of the new public transport operator, and the potential for public transport to substitute for many cars on the road. Furthermore, studies are needed to investigate the policy on land use and how this affects transport patterns and what policy action can be taken to improve land use development.

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ANNEX 1

Work Programme

	1				2				3			
	1	2	3	4	5	6	7	8	9	10	11	12
Inception Report												
Task 1												
Task 2												
Intermediate Report												
Task 3												
Final Report												

Note: WEEK 1 – 19 MAY 2014, WEEK 32 – 29 DECEMBER 2014

4				5				6				7				8			
13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32

ANNEX 2

<table>
<tr><td colspan="4">Name of Layer: A_D_R_Links</td></tr>
<tr><td colspan="3">Geometry Shape: Polyline
Coordinate System: Geographic Coordinate System WGS_1984
Description: Arterial, distributor and rural roads of the Maltese Islands</td><td></td></tr>
<tr><td>Field Name</td><td>Main Characteristics</td><td>Definition of Inputted Data</td><td>Methodology</td></tr>
<tr><td>Prefix</td><td>Full Name: Prefix of Road Names
Data Type: String
Width: 50
Description: This describes the article (prefix) for road names
Units: N/A
Source: Adapted from MEPA Map Server (MEPA, 2014b), OpenStreetMap, Google Maps and Attard (2011)</td><td></td><td></td></tr>
<tr><td>Name</td><td>Full Name: Name of Road
Data Type: String
Width: 50
Description: This describes the names of the roads
Units: N/A
Source: Adapted from MEPA Map Server (MEPA, 2014b), OpenStreetMap, Google Maps and Attard (2011)</td><td></td><td></td></tr>
<tr><td>TYPE</td><td>Full Name: Type of the Road
Data Type: String
Width: 21
Description: Three types of roads are listed: Arterial, Distributor, Rural
Units: N/A
Source: Transport Malta</td><td>Arterial Roads – Allow throughput of inter-urban traffic. They should not have development direct access
Distributor Roads – Roads with a distributor function – allow drivers to enter and exit towns and villages. More frequent intersections and at-grade.
Rural – Roads which provide important links between neighbouring local council areas (TM and MITC, 2012)</td><td></td></tr>
</table>

Locality	Full Name: The locality that the road lies within Data Type: String Width: 50 Description: This describes the localities that each link in the topology lies within. Units: N/A Source: Adapted from MEPA Map Server (MEPA, 2014b), OpenStreetMap, Google Maps and Attard (2011)	In some circumstances more than one locality is listed. This is due to a road link crossing between two localities	
From_Node	Full Name: The nodes that the link starts from Data Type: String Width: 20 Description: The node that the corresponding link starts from Units: N/A Source: Transport Malta		
To_Node	Full Name: The nodes that the link finishes to Data Type: String Width: 20 Description: The node that the corresponding link starts from Units: N/A Source: Transport Malta		
Link_Name	Full Name: The name of the link Data Type: String Width: 50 Description: This describes the link name of the road Units: N/A Source: Planning Authority (1992)	In most cases the link name is the same as the road name	

ONEWAY	Full Name: One way Data Type: String Width: 12 Description: This shows whether the road is one way or two way Units: N/A Source:	This data is not available yet	
LANES	Full Name: Lanes Data Type: Double Width: 11 Description: This shows the number of lanes per road Units: N/A Source: N/A	This data is not available yet	
Road_Class	Full Name: Road Classification Data Type: String Width: 50 Description: This classifies roads according to their characteristics, namely the number of carriageways and lanes Units: N/A Source: TM and MITC (2012)	D1 – Dual Carriageway with one lane each way D1H - Dual Carriageway with one lane each way, equipped with hard shoulders D2 - Dual Carriageway with two lanes each way D2H - Dual Carriageway with two lanes each way, equipped with hard shoulders D3 - Dual Carriageway with three lanes each way D4 - Dual Carriageway with four lanes each way S1 – Single Carriageway S2 – Single two-Lane Carriageway S2H – Single Two-Lane Carriageway, equipped with hard shoulders S4 – Single four-lane carriageway WS2 – Wider than standard single two-lane Carriageway WS2H - Wider than standard single two-lane Carriageway, equipped with hard shoulders WS4 - Wider than standard single four-lane Carriageway 1-WAY-1-LANE – equivalent to S1	

AADT	Full Name: Annual Average Daily Traffic Data Type: Double Width: 19 Description: This describes the annual average daily traffic per road link Units: Number of vehicles Source: TM and MITC (2012)		
Mean_Speed	Full Name: Mean Speed Data Type: Small Integer Width: 4 Description: This describes the average speed per road link Units: km/hr Source: TM and MITC (2012)		
Acc_100m_v	Full Name: Accidents per 100 million vehicle km Data Type: Double Width: 19 Description: This represent the number of accidents per 100 million vehicle kilometres Units: N/A Source: TM and MITC (2012)		
HGV_Mornin	Full Name: Heavy Goods Vehicles Morning Peak Data Type: Double Width: 19 Description: This describes the percentage of heavy vehicles during the morning peak per road link Units: Percentage Source: TM and MITC (2012)	Heavy Goods Vehicles are all types of vehicles having the maximum permissible mass exceeding 3.5 tonnes, used for the carriage of goods.	

HGV_Mid_Da	Full Name Meaning: Heavy Goods Vehicles Mid-day Peak Data Type: Double Width: 19 Description: This describes the percentage of heavy vehicles during the mid-day peak per road link Units: Percentage Source: TM and MITC (2012)		
Speed_Guid	Full Name: Speed Limit Guideline Category Data Type: String Width: 50 Description: This describes the speed limit guidance per road type Units: N/A Source: TM and MITC (2012)	RURAL 1 - Arterial and distributor single or dual carriageway roads with adequate street lighting and few bends, junctions and accesses in rural roads (maximum posted speed – 80km/hr) RURAL 2 - Arterial and Distributor single or dual carriageway roads with adequate street lighting and a relatively high number of bends, junctions and accesses or concealed accesses but with little roadside development usually in rural areas (maximum posted speed – 70km/hr) RURAL 3 - Arterial and Distributor single or dual carriageway roads with inadequate street lighting levels and/or high number of bends, junctions and accesses in rural areas (maximum posted speed – 60km/hr) RURAL 4 - Low quality rural roads (maximum posted speed – 50km/hr) URBAN 1 - Arterial and distributor single or dual carriageway roads with roadside development but with few di-	

		rect accesses and with formal crossing places for pedestrians in urban areas (maximum posted speed – 60km/hr) URBAN 2 - Arterial and distributor roads single or dual carriageway roads with roadside development, with many direct accesses and informal pedestrian crossings (zebra crossings and refuges) in urban areas (maximum posted speed – 50km/hr) URBAN 3 - Spine roads in villages where the through traffic is essential but adequate facilities for vulnerable road users and cyclists are provided such as pedestrian crossings, footways and cycle lanes (maximum posted speed – 40km/hr) URBAN 4 - Shopping Areas and town centres with access to public transport, schools and commercial outlets. Pedestrians and cyclists have priority over traffic (maximum posted speed – 40km/hr)	
Rec_Speed	Full Name: Recommended Posted Speed Limit Data Type: String Width: 50 Description: This describes the recommended speed limit per road link or in specific points within the road link Units: km/hr Source: TM and MITC (2012)		

NO_2_min	Full Name: Nitrogen Dioxide Minimum Data Type: Double Width: 19 Description: The minimum amount of Nitrogen Dioxide per road link in 2009 Units: µg/m-3 Source: MEPA (2010)	The data used is the average 2009 Passive Diffusion Tube Data from Malta Environment Planning Authority (MEPA). The diffusion tube network is used by MEPA to review and assess air quality in the Maltese Islands. These highlight hot spots by long-term measurements. About three tubes (depending on the area) are installed in each locality in near-road, intermediate and urban background sites respectively. This helps to analyse how pollution diffuses throughout the locality.	The coordinates of the Nitrogen Dioxide Diffusion points were used to overlay the data on the road topology. An interpolation (Inverse Distance Weighting) in GIS based on such points was carried out to produce a raster surface visualising Nitrogen Dioxide Diffusion data in the Maltese Islands. Using geostatistical analysis, raster data was extracted to the polyline shapefile working out the minimum, maximum and mean values.
NO_2_max	Full Name: Nitrogen Dioxide Maximum Data Type: Double Width: 19 Description: The maximum amount of Nitrogen Dioxide per road link in 2009 Units: µg/m-3 Source: MEPA (2010)		
NO_2_mean	Full Name: Nitrogen Dioxide Mean Data Type: Double Width: 19 Description: The mean amount of Nitrogen Dioxide per road link in 2009 Units: µg/m-3 Source: MEPA (2010)		
Mj_ld_max	Full Name: Major Roads lowest day maximum noise Data Type: Double Width: 19 Description: The lowest day maximum noise in major roads in 2011 Units: Decibel Source: Malta SEIS GeoPortal (MEPA, 2014a)	Major Roads are those with more than six million vehicles per year (MEPA, 2013)	Noise data in major roads was extracted and downloaded from Malta SEIS GeoPortal (MEPA, 2014a). After it was overlayed on the road topology, the highest and lowest values per day and night were extracted. An interpo-

Mj_ld_min	Full Name: Major Roads lowest day minimum noise Data Type: Double Width: 19 Description: The lowest day minimum noise in major roads in 2011 Units: Decibel Source: Malta SEIS GeoPortal (MEPA, 2014a)		lation (Inverse Distance Weighting) in GIS was carried out to produce a raster surface visualising the lowest and highest noise for day and night in the Maltese Islands' major roads. Using geostatistical analysis, raster data was extracted to the polyline shapefile working out the highest and lowest noise maximum, minimum and mean values per day and night respectively.
Mj_ld_mean	Full Name: Major Roads lowest day mean noise Data Type: Double Width: 19 Description: The lowest day mean noise in major roads in 2011 Units: Decibel Source: Malta SEIS GeoPortal (MEPA, 2014a)		
Mj_hd_max	Full Name: Major Roads highest day maximum noise Data Type: Double Width: 19 Description: The highest day maximum noise in major roads in 2011 Units: Decibel Source: Malta SEIS GeoPortal (MEPA, 2014a)		
Mj_hd_min	Full Name: Major Roads highest day noise minimum Data Type: Double Width: 19 Description: The highest day minimum noise in major roads in 2011 Units: Decibel Source: Malta SEIS GeoPortal (MEPA, 2014a)		

Mj_hd_mean	Full Name: Major Roads highest day noise mean Data Type: Double Width: 19 Description: The highest day mean noise in major roads in 2011 Units: Decibel Source: Malta SEIS GeoPortal (MEPA, 2014a)		
Mj_ln_max	Full Name: Major Roads lowest night maximum Data Type: Double Width: 19 Description: The lowest night maximum noise in major roads in 2011 Units: Decibel Source: Malta SEIS Geo-Portal (MEPA, 2014a)		
Mj_ln_min	Full Name: Major Roads lowest night minimum Data Type: Double Width: 19 Description: The lowest night minimum noise in major roads in 2011 Units: Decibel Source: Malta SEIS Geo-Portal (MEPA, 2014a)		
Mj_ln_mean	Full Name: Major Roads lowest night mean Data Type: Double Width: 19 Description: The lowest night mean noise in major roads in 2011 Units: Decibel Source: Malta SEIS Geo-Portal (MEPA, 2014a)		

Mj_hn_max	Full Name: Major Roads highest night maximum Data Type: Double Width: 19 Description: The highest night maximum noise in major roads in 2011 Units: Decibel Source: Malta SEIS Geo-Portal (MEPA, 2014a)		
Mj_hn_min	Full Name: Major Roads highest night minimum Data Type: Double Width: 19 Description: The highest night minimum noise in major roads in 2011 Units: Decibel Source: Malta SEIS Geo-Portal (MEPA, 2014a)		
Mj_hn_mean	Full Name: Major Roads highest night mean Data Type: Double Width: 19 Description: The highest night mean noise in major roads in 2011 Units: Decibel Source: Malta SEIS Geo-Portal (MEPA, 2014a)		

Source:

Attard, F.A., 2011. *The Ma-ze Street Atlas: Malta and Gozo*. Gutenberg Press, Malta.

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MEPA (Malta Environment and Planning Authority), 2013. *Noise Action Plan*. Floriana, Malta.

Planning Authority, 1992. *It-Toroq Arterji ta' Malta*. Floriana, Malta.

TM (Transport Malta) and MITC (Ministry for Infrastructure, Transport and Communications), 2012. *Speed Management on Maltese Roads Policy and Technical Guidance Manual : Consultation Document*. Version 1.06c. Available at: http://www.transport.gov.mt/admin/uploads/media-library/files/1_Speed%20Management%20on%20Roads%20-%20Policy%20and%20Guidance.pdf

Transport Malta, 2014. Personal Communication.

Name of Layer: A_D_R_U_Nodes	
Geometry Shape: Point Coordinate System: Geographic Coordinate System WGS_1984 Description: The Arterial, distributor, urban and rural nodes of the Maltese Islands	
Field Name	**Main Characteristics**
Node_Code	Full Name: The code of the Node Data Type: String Width: 10 Description: This describes the codename per each node in Malta Units: N/A Source: Transport Malta
Locality	Full Name: Locality of the Node Data Type: String Width: 30 Description: This describes the locality that the nodes lies within Units: N/A Source: Transport Malta
Node_Type	Full Name: Type of the Node Data Type: String Width: 50 Description: This describes the type of nodes. Four types are listed: arterial, distributor, urban and rural Units: N/A Source: Transport Malta

Source:

Transport Malta, 2014.

ANNEX 3

Guide for Estimating the External Costs of Transport in Malta

Air pollution based on the average emissions shown below:

Non-methane volatile organic compounds (NMVOC)
7,800km or 4,846 miles per year

(1.034g/mi) * (4,846mi/year) * (1lb/454g) = 5,010/454 = 11.04lb or 5kg

where g/mi = grams per mile
lb = pound
g = gram(s)

Oxides of nitrogen (NOx)
7,800km or 4,846 miles per year
(0.69g/mi) * (4,846mi/year) * (1lb/454g) = 3,344/454 = 7.36lb or 3.4 kg

Fine particles ($PM_{2.5}$)
7,800km or 4,846 miles per year
(0.0041g/mi) * (4,846mi/year) * (1lb/454g) = 20/454 = 0.04 or 0.02kg
Multiply 0.02kg by 10 = 0.2kg (adjusted due to above average age of fleet)

Cost factors per tonne for above emissions

Cost Factors for NOx, NMVOC, $PM_{2.5}$ in €

	NOx	**NMVOC**	**$PM_{2.5}$ Urban**	**$PM_{2.5}$ Non-Urban**
€2002 factor price	500	1,100	170,000	16,000
€2012 factor price	600	1,320	204,000	19,200

Climate change

Carbon dioxide (CO_2)
368.4g * (4,846 mi/year) = 1,785 kg
Central value of €90 per tonne as derived from the Handbook on External Costs of Transport (2014).

Congestion

Fuel use per hour of idling is dependent on engine capacity as show hereunder:
1.5L = 0.9 litres
2L = 1.2 litres
4L = 2.4 litres
5L = 3.2 litres
6.8L = 3.8 litres
The majority of vehicles in Malta are below 2L and given the spread of engine capacities on Maltese roads, this study opted to take 1.2 litres as the fuel wasted per hour during idling.

Fuel wasted 1.2 litres per hour * 52 hours based on €1.44 per litre unleaded fuel and €1.38 per litre diesel.

Average speed flow is taken as 30 km per hour under urban conditions. Number of trips: 624 trips (covering both commuting and commercial purposes) per year per 25 minutes each trip (this is equivalent to 1.7 trips per day which is below that recorded for larger EU countries according to Eurofound (2010)).

25 minutes * 624 = 15,600 minutes/60 = 260 hours per year
Based on an average speed flow of 30 km per hour (slightly higher than the London wide average speed flow between 0700 and 1900 hours and recorded as 19.33 mph or just under 30km per hour (Transport for London, 2013). The number of km travelled per year is 7,800.

Delay is estimated at 23.94 seconds per km (average of Northern Harbour and Southern Harbour regions as estimated by JRC) or 52 hours lost per commuter per year based on 7,800 km.

Increased cost of doing business based on all vehicles defined as light duty commercial vehicles:

Value of time at factor cost = €15.07

Value of non-working time at factor cost = €4.61

Car accidents

Value of statistical life (VSL) for road accidents injuries, 2012 prices

Type of Injury	**Fatal**	**Serious**	**Slight**
Cost	€1,205,573	€153, 918	€11,442

Human capital cost (or lost production or value added) estimated as product of GDP per capita and VSL for serious and slight injuries

Serious injuries: one year period lost production
Slight injuries: two months lost production

Noise pollution

Weightings for day and night noise pollution, 2012

Affected region	day noise pollution (17 hours)	night noise pollution (7 hours)
Northern Harbour	66.03 dBA	56.44 dBA
Southern Harbour	57.26 dBA	49.33 dBA

2012 Cost factor by region

Affected regio		
Northern Harbour	€79.2	€30
Southern Harbour	€34.8	€4.8

Residences and cost of noise insulation by region

Residences (major roads)	cost of Installation	total
Northern Harbour		
3,938	€140 (Size A)	€551,320
3,938	€120 (Size B)	€472,560
Residences (Major Roads)		
Southern Harbour		
1,955	€140 (Size A)	€273,700
1,955	€120 (Size B)	€234,600

ANNEX 4

Predicting Number of Vehicles on Maltese Roads (2014-2030)

TABLE 1. Predicting number of vehicles on Maltese roads (2014-2030)

Year	No of Vehicles (Prediction)
2014	324687
2015	328484
2016	331984
2017	335187
2018	338092
2019	340700
2020	343011
2021	345025
2022	346742
2023	348161
2024	349283
2025	350108
2026	350635
2027	350866
2028	350799
2029	350435
2030	349774

SPSS Output

VARIABLES ENTERED/REMOVED[a]

Model	Variables Entered	Variables Removed	Method
1	Tc[b]	.	Enter
2	Tc_sq[b]	.	Enter

a. Dependent Variable: Vehicles

b. All requested variables entered (Tc = mean-centered time, Tc_sq = mean-centered time squared).

MODEL SUMMARY

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.987[a]	.975	.974	10527.92806	.975	971.332	1	25	.000
2	.995[b]	.991	.990	6526.72777	.016	41.048	1	24	.000

a. Predictors: (Constant), Tc
b. Predictors: (Constant), Tc, Tc_sq

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	107659808859.490	1	107659808859.490	971.332	.000[b]
	Residual	2770931732.807	25	110837269.312		
	Total	110430740592.296	26			
2	Regression	109408384383.215	2	54704192191.608	1284.191	.000[c]
	Residual	1022356209.081	24	42598175.378		
	Total	110430740592.296	26			

a. Dependent Variable: Vehicles
b. Predictors: (Constant), Tc
c. Predictors: (Constant), Tc, Tc_sq

COEFFICIENTS[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	231300.370	2026.101		114.160	.000		
	Tc	8107.181	260.127	.987	31.166	.000	1.000	1.000
2	(Constant)	240316.331	1886.268		127.403	.000		
	Tc	8107.181	161.264	.987	50.273	.000	1.000	1.000
	Tc_sq	-148.615	23.196	-.126	-6.407	.000	1.000	1.000

a. Dependent Variable: Vehicles

ANNEX 5

Predicting the number of road accident injuries in Malta

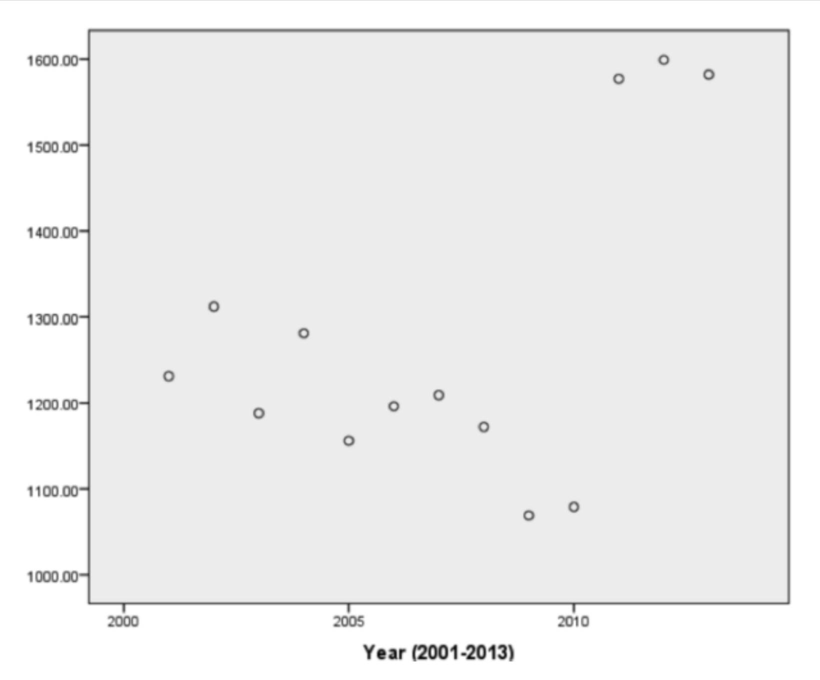

FIGURE 1. Number of road accident injuries per year (2001-2013).

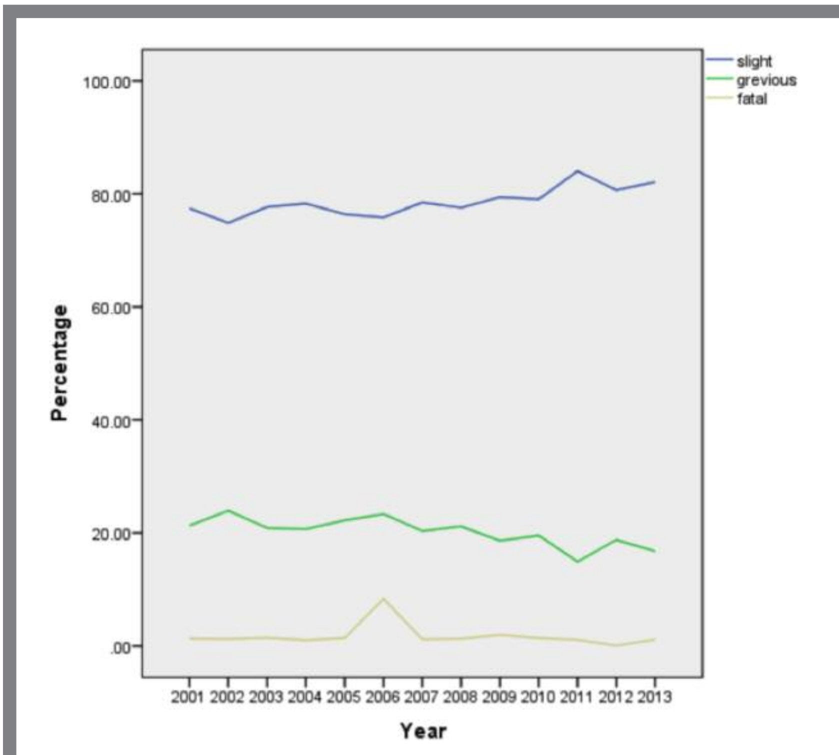

FIGURE 2. Percentage distribution of the type of road accident injuries (2001-2013).

ANNEX 6

Current and predicted vehicle fleet				Replacement Scheme (1)		Replacement Scheme (2)	
Year	No of Vehicles (prediction)	Percentage Private Vehicles (2014 %)	Number of Private Vehicles (prediction)	Number of Electric Vehicles	Percentage of Vehicle Electric	Number of Electric Vehicles	Percentage of Vehicle Electric
2014	324,687	79	256,503	500	0.19		
2015	328,484	79	259,502	1000	0.39		
2016	331,984	79	262,267	1500	0.57		
2017	335,187	79	264,798	2000	0.76		
2018	338,092	79	267,093	2500	0.94		
2019	340,700	79	269,153	3000	1.11		
2020	**343,011**	**79**	**270,979**	**3500**	**1.29**		
2021	345,025	79	272,570			4500	1.65
2022	346,742	79	273,926			5500	2.01
2023	348,161	79	275,047			6500	2.36
2024	349,283	79	275,934			7500	2.72
2025	350,108	79	276,585			8500	3.07
2026	350,635	79	277,002			9500	3.43
2027	350,866	79	277,184			10500	3.79
2028	350,799	79	277,131			11500	4.15
2029	350,435	79	276,844			12500	4.52
2030	**349,774**	**79**	**276,321**			**13500**	**4.89**

(1) The budget for the replacement scheme would be **EUR1.5m** a year until 2020, with a financial incentive for replacement to an electric vehicle of EUR3,000 per vehicle. Preference will be given to vehicles over the age of 15.
(2) The budget for the replacement scheme would be doubled to **EUR3m** a year until 2030, with a financial incentive for replacement to an electric vehicle of EUR3,000 per vehicle. Preference will be given to vehicles over the age of 10.

CURRENT AGE STRUCTURE OF THE MALTA VEHICLE FLEET

2013	<2 years	2-5 years	5-10 years	>10 years	Total
Total fleet	12,486	24,697	72,469	213,308	310,474
Passenger Cars	10,109	21,022	61,826	163,139	245,987

2012	<2 years	2-5 years	5-10 years	>10 years	Total
Total fleet	13,027	26,480	66,875	208,128	314,510
Passenger Cars	10,829	22,326	57,571	158,886	249,612