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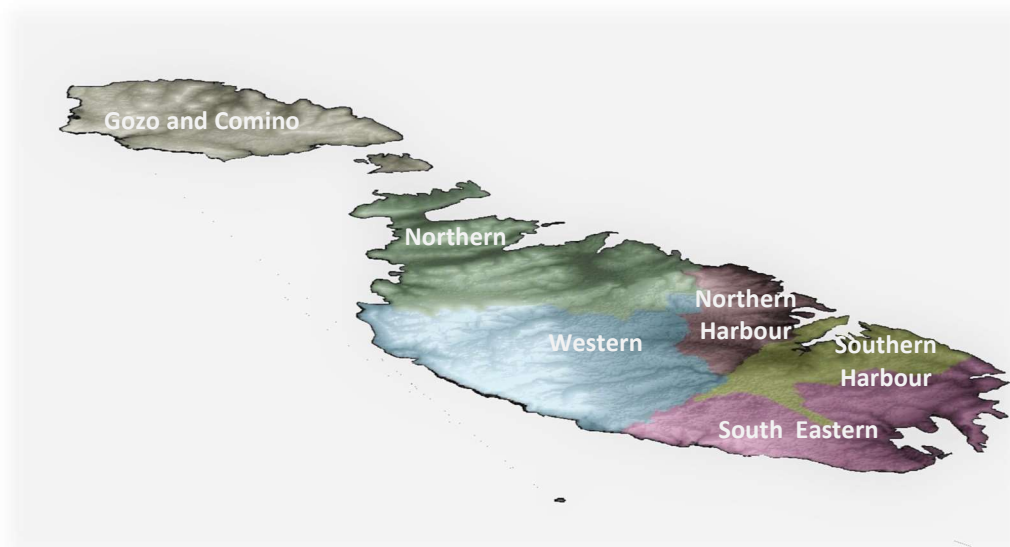
Action A.1: Deliverable 1

Assessment of the Sectoral Water Demand in Malta and Gozo



***“Tender for the assessment of the sectoral water demand
under the Life 16 IPE/MT/008 project”***

EWA/CFT/5/2018



**Analysis and Assessment of water demand
Deliverable 1**

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ABBREVIATIONS

Acronym	Definition
EC	European Commission
EWA	Energy and Water Agency
LAUs	Local administrative units (LAUs)
MS	Member State
NSO	National Statistics Office

1 INTRODUCTION

1.1 Background

In the absence of surface water that can be economically exploited (Maltese islands have the lowest natural freshwater availability in EU /ca/yr), water demand of the various sectors in the Maltese islands is increasingly being addressed through the conjunctive use of four main sources of freshwater, i.e. groundwater aquifer systems, harvesting of rainwater runoff, desalinated sea-water, and treated wastewater.

Water demand is estimated to reach around 62 million m³/year or around two times the volume of water which can be sustainably sourced from country's natural water resources. This highlights the need for effective and efficient use of freshwater resources in all sectors of the economy, in order to ensure that the available resources will sufficiently meet the national water demand requirements.

Furthermore, the European Commission (EC) assigns Water Demand Management as a primary priority in the list of measures that each Member State (MS) should implement, before considering water supply augmentation.

In this framework, in the 2nd Water Catchment Management Plan, nine measures were instituted under Water Demand Management Priority, aiming at addressing the efficient use of water resources in the Malta Water Catchment District and contributing to the achievement of the WFD's good status objectives for natural inland water systems. Among these measures, the development of a Water Demand Map representing the spatial variation of water demand in terms of quality and quantity and the establishment of benchmarks for efficient water use (PUB 1) is included.

Furthermore, the Energy and Water Agency (EWA), under the Life 16 IPE/MT/008 project¹, published, EWA/CFT/5/2018 Tender, for the assessment of the sectoral water demand. The overall objectives of the tender and this contract are:

- To characterise the key components of past, present and future national water demand by the most important water use sectors in the Maltese islands which are the domestic, agriculture industrial and tourism sectors.
- To analyse the water demand of each sector historically (last 50 years).
- To forecast future water demand variations and trends on a regional level, including spatial variations in water demand, and determine projected changes in water demand to which water production and distribution infrastructure will need to respond.

The results of this contract will provide water managers and policy-makers adequate knowledge and the necessary baseline data to manage current water management problems and plan for future water management scenarios.

EPSILON MALTA LIMITED has been awarded this contract, signed between EWA and EPSILON on 25th October 2018.

1

http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=6523

1.2 Scope of study

The present report, constitutes of the 1st Deliverable of the EWA/CFT/5/2018 CONTARCT and refers to the analysis and assessment of water demand for the past 50 years, in order to characterize (quantitatively/qualitatively) key components affecting water demand in the four (4) main water sectors (domestic, agricultural, industrial, tourism) at regional level for all local administrative unit (LAU) systems.

To meet this challenge a holistic approach has been adopted that identifies and analyses the complexities of inter-relationships between the various parameters affecting water demand in critical economic sectors

2 METHODOLOGY – DATA SOURCES

2.1 Factors affecting water demand analysis

It is widely acknowledged, that the total volume of water requested by people to satisfy their own needs, depends on a number of parameters, such as population distribution, household size, household income, water price, climate conditions, type of crops, nature of soil, type of irrigation systems, type and size of economic activities besides agriculture (e.g. manufacturing, tourism, etc.), and attitudinal and behavioural drivers (e.g. Nauges & Thomas, 2000; Arbués et al., 2003; Bithas & Chrysostomos, 2006; Domene & Saurí, 2006; Mazzanti & Montini, 2006; Grafton et al., 2011; Polycarpou & Zachariadis, 2013; Reynaud, 2015; Koutiva & Makropoulos, 2016). For instance, it is argued that high incomes are related to higher living standards, e.g. use of water-consuming appliances and presence of high-water demanding outdoor uses such as lawn gardens and swimming pools, etc. Further, changes in environmental factors can also influence water demand. Climate conditions (such precipitation, evapotranspiration, temperature) can significantly influence the amount and frequency of water-consumption activities such as garden watering, personal hygiene, etc. (Reynaud, 2015). For instance, increased precipitation or decreased evapotranspiration can lead to reduced demand in the agricultural sector². In fact, it is stated that extreme climatic events as extreme or prolonged drought can affect water demand and supply and therefore lead to greater competition among uses and users³. As regards Malta, Grech (2014) conducted a cross-sectional survey through the use of 432 self-completion questionnaire surveys and 30 time-use water diaries in order to identify the amounts and main uses of water in Maltese households and analyse the relationships between water consumption patterns and socio-economic and demographic characteristics of households. According to the findings of this study, domestic water consumed in households is influenced by household income, family size (e.g. the greater the number of people living permanently in a household, the greater the number of toilet flushes and the more showers taken by the family in a week), level of education (e.g. higher water conservation behaviours are recognised in those households whose members have a higher level of education), type of house respondents live in, rainwater tank ownership and the district respondents live in. In 2004, Delia (2004) performed an econometric analysis of residential water demand in Malta, based on annual data for the period of 1989 to 1999 (country-level time series) to estimate income and price elasticities of demand. Further, as many studies indicate, tourism is an important factor in freshwater consumption, given that tourists consume water when washing or using the toilet, when participating in recreational activities, when using wellness areas or swimming pools, etc. (Gössling et al., 2012). Freshwater is also needed to maintain the gardens and the landscaping of hotels, for food production etc. (e.g. Gössling, 2006; Chapagain & Hoekstra, 2008). Nevertheless, the prevailing factor as regards water consumption in tourist sector is the number of tourists visiting a tourist destination, provided that that the average tourist consumes more water compared to the local resident (e.g. Mangion, 2013). This fact is reflected on various studies that produce estimates of water use with respect to tourism, using as a main indicator the water volume consumed by tourist per day (Gössling et al., 2012).

² <https://www.nap.edu/read/6031/chapter/5#59>

³

https://www.drought.gov/drought/sites/drought.gov.drought/files/media/reports/Planning_and_Drought_Schwab_APA.pdf

Taking into consideration the above-mentioned remarks, datasets on land use, socio-economic (e.g. population and housing data, GDP, household income) and environmental factors (e.g. meteorological data, etc.), water demand data (e.g. water meters readings, billed consumption, etc.), and water supply data were sought for the period of the last 50 years at national and disaggregated regional levels for the local administrative units: MT011 - Southern Harbour, MT012 - Northern Harbour, MT013 - South Eastern, MT014 – Western, MT015 – Northern, MT026 - Gozo and Comino.

The data was sought from EWA and other reliable sources (e.g. technical reports and scientific publications, communication with local authorities as suggested by EWA). Also data obtained from National databases (e.g. National Statistics Office, Malta Resources Authority, etc.), European and international organizations and databases (e.g. FAO's AQUASTAT, Eurostat, World Bank, EEA, DGENV) (a detailed list of all sources is provided in Section 5) was contributed to the present analysis. The data collected were organised in a database that contains in total 138 variables.

2.2 Availability of data

Collecting the necessary for the analysis data proved to be a challenging task, due to lack of data in specific categories of water consumption and time periods, as well as due to discrepancies and inconsistencies, in some cases significant, between the various sources searched and gathered even between reports from the same organization (e.g. NSO), given that statistical authorities update and revise the data of previous years. For instance, the relationship between domestic water consumption and socio-economic and environmental factors derives mainly from cross-sectional surveys, since data on household water consumption are usually only available on aggregated level (National scale). For Malta, NSO and WSC figures provide the total domestic water consumption of all households in the Maltese Islands. Moreover, and most importantly, necessary socio-economic data, such as household income, household expenditure, housing characteristics, living conditions, etc., are only available for specific years (i.e. Household Budgetary Surveys have been conducted from the NSO in 2000, 2008 and 2015) creating a significant gap of missing information.

The inability to collect the necessary time series data for a period of 50 years at specific water sectors was clearly stated in the Inception Report submitted by EPSILON MALTA LIMITED to the EWA in early 2019. In view of those difficulties in collecting the necessary for the analysis data EPSILON MALTA LIMITED provided in the Inception Report a hierarchy list data that identifies the data that is mandatory especially for the historic analysis of 50 years per sector and administrative units. In order to overcome all these difficulties, EPSILON MALTA LIMITED in consultation with EWA made a series of contacts with national and local authorities to obtain water demand and other type of data necessary for the current tender. A detailed presentation of the contacts is given hereinafter.

Following the project meeting held on 26/8/2019 at EWA premises and the discussion on the availability and reliability of data, a list of additional stakeholder organizations who produce or process data directly or indirectly related to the management of water demand was provided by EWA. The list of the stakeholders to be contacted is provided in the Appendix 1.

After conducting the stakeholders, new information was collected, i.e. total water consumption (based on billed water) for Malta & Gozo from (1970 - 2018); tourism figures by Malta Tourism Industry such as: key Indicators (1959-2018), inbound tourists by country (1980-2018), inbound tourists by month (1989-July 2019), total inbound visitors (2011-July 2019), yearly guest nights by country (2005-2018), total yearly guest nights (1998-2018), average length of stay by month (2006-July 2019); and climatological data for the last 35 years

for monthly temperature (mean, max, min air temperature), wind speed, relative humidity, precipitation sum, sunshine hours and solar radiation for the last 11 years. Nevertheless, even after this new round of the contacts, some of the necessary data were still missing. Thus, an additional face-to-face meeting was organized between EWA officials and the consultants at the EWA premises, on December 17th, 2019, to discuss and mutually decide on the scientific methodology to be used for filling the gaps and create the final dataset. The methodology discussed during this meeting was formulated under certain assumptions and communicated to the EWA officials on January 23rd, 2020. The methodology is presented in Section 3.1. The final dataset is provided as a supplement to this report (Supplement 1: Complete dataset yearly.xlsx) and contains in total 20,145 records.

2.3 Area of interest: Profile information

2.3.1 Administrative units

The Maltese Islands are divided in 7 local administrative units. The LAUs and the localities are presented in Figure 1.

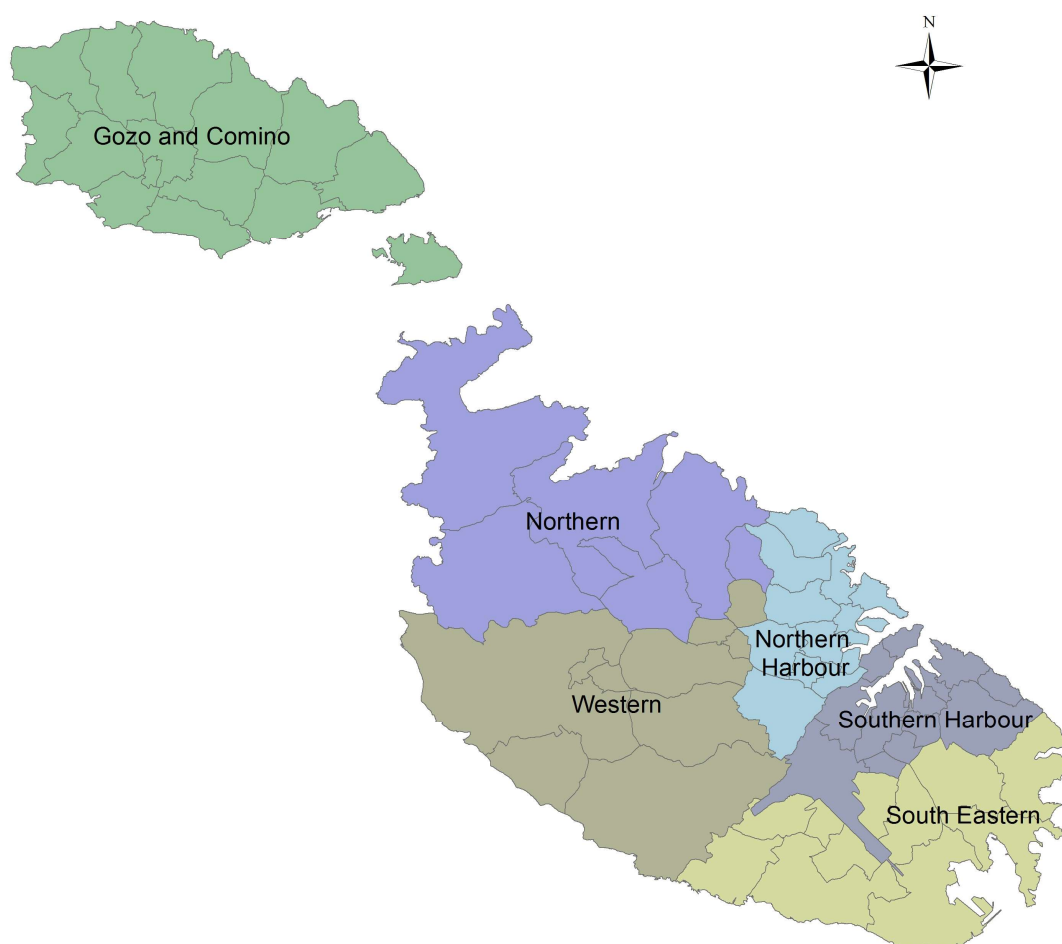


Figure 1: LAUs and localities in the Maltese Islands

Gozo and Comino

An area of 68.67 km², located in the islands Gozo and Comino. The localities found in the LAU are Rabat (victoria), Fontana, Xewkija, Ghajnsielem, Qala, Nadur, Xaghra, Zebbug (Ghawdex), Ghasri, Gharb, San lawrenz, Kercem, Munxar and Sannat.

Northern

An area of 73.66 km² located in the Northern part of Malta. The localities found in the LAU are Gharghur, Mosta, Naxxar, San Pawl Il-Bahar, Mellieha and Mgarr

Northern Harbour

An area of 24.02 km² located in the northeastern part of Malta. The localities found in the LAU are Qormi, Birkirkara, Hamrun, San Gwann, Santa Venera, Swieqi, Pembroke, Gzira, Sliema, Ta' Xbiex, Pieta, Msida and San Giljan

South Eastern

An area of 50.16 km² located in the South eastern part of Malta. The localities found in the LAU are Zejtun, Gudja, Ghaxaq, Kirkop, Mqabba, Safi, Qrendi, Zurrieq, Birzebbugia, Marsaxlokk and Marsascala

Southern Harbour

An area of 26.17 km² located in the eastern part of Malta. The localities found in the LAU are Fgura, Luqa, Santa Lucija, Tarxien, Valletta, Floriana, Marsa, Paola, Bormla, Isla, Birgu, Kalkara, Xghajra and Zabbar

Western

An area of 72.47 km² located in the Western part of Malta. The localities found in the LAU are Mdina, Zebbug (Malta), Attard, Balzan, Iklin, Lija, Dingli, Siggiewi, Mtarfa and Rabat (Malta)

2.3.2 Land use

Agricultural Land use is the most dominant in the Maltese Islands, covering around 52% of the territory. Urban areas, is the second land use factor, covering around 30%. Wetlands (salines) cover less than 1% and the rest of the Maltese territory is occupied by natural vegetated areas with dominant share (15,5%) sclerophyllous vegetation, followed by sparsely vegetated areas (~2,5%), while forests accounts for less than 1%.

Table 1 and Table 2 present Land use (area in km² and percentages) by region based on Corine Land cover data set (1990-2018).

Data is presented according to the 1st level of Corine Land cover data set classification where

- ARTIFICIAL SURFACES refer to urban fabric, Industrial, commercial and transport units, Mine, dump and construction sites and Artificial non-agricultural vegetated areas
- AGRICULTURAL AREAS refer to Arable land, Permanent crops and Heterogeneous agricultural areas
- FOREST AND SEMI NATURAL AREAS refer to forests, Scrub and/or herbaceous vegetation associations and open spaces with little or no vegetation and
- WETLANDS refer to Salines

Table 1: Land use in km2 by region over the past 30 years

		Agricultural areas	Artificial surfaces	Forest and semi natural areas	Wetlands	Grand Total
1990	Gozo and Comino	37,47	14,73	16,05		68,25
	Northern	39,82	12,38	20,88	0,23	73,31
	Northern Harbour	5,59	16,59	1,58		23,76
	South Eastern	30,37	14,63	4,53		49,53
	Southern Harbour	6,64	19,09	0,17		25,91
	Western	44,35	12,19	15,81		72,35
	Malta	164,25	89,61	59,02	0,23	313,11
2000	Gozo and Comino	37,47	15,19	15,58		68,24
	Northern	39,76	12,62	20,74	0,23	73,35
	Northern Harbour	4,8	17,38	1,58		23,76
	South Eastern	30,08	15,15	4,42		49,65
	Southern Harbour	6,64	19,09	0,17		25,9
	Western	44,3	12,63	15,42		72,35
	Malta	163,05	92,07	57,91	0,23	313,26
2006	Gozo and Comino	37,47	15,19	15,58		68,24
	Northern	39,76	12,69	20,67	0,23	73,35
	Northern Harbour	4,8	17,38	1,58		23,76
	South Eastern	30,07	15,15	4,42		49,64
	Southern Harbour	6,64	19,09	0,17		25,9
	Western	44,3	12,63	15,43		72,36
	Malta	163,04	92,13	57,85	0,23	313,25
2012	Gozo and Comino	37,43	15,24	15,58		68,25
	Northern	39,76	12,89	20,46	0,23	73,34
	Northern Harbour	4,8	17,38	1,58		23,76
	South Eastern	29,15	15,15	5,35		49,65
	Southern Harbour	6,64	19,09	0,17		25,9
	Western	44,3	12,63	15,43		72,36
	Malta	162,08	92,38	58,57	0,23	313,26
2018	Gozo and Comino	37,85	15,13	15,26		68,24
	Northern	39,88	13,42	19,82	0,23	73,35
	Northern Harbour	5,08	17,41	1,30		23,79
	South Eastern	29,01	15,30	5,41		49,72
	Southern Harbour	6,51	19,26	0,17		25,93
	Western	45,39	12,37	14,62		72,39
	Malta	163,72	92,88	56,59	0,23	313,41

Source: Adapted from Corine Land Cover for Malta data as reported on Eionet, Authors' own processing

Table 2: Land use percentage by region over the past 30 years

		Agricultural areas	Artificial surfaces	Forest and semi natural areas	Wetlands
1990	Gozo and Comino	54,89	21,59	23,51	
	Northern	54,31	16,88	28,49	0,31
	Northern Harbour	23,53	69,82	6,65	
	South Eastern	61,30	29,55	9,14	
	Southern Harbour	25,63	73,72	0,66	
	Western	61,28	16,86	21,86	
	Malta (Maltese Islands)	52,45	28,63	18,85	0,07
2000	Gozo and Comino	54,91	22,26	22,83	
	Northern	54,21	17,21	28,28	0,31
	Northern Harbour	20,20	73,15	6,65	
	South Eastern	60,58	30,51	8,90	
	Southern Harbour	25,64	73,71	0,66	
	Western	61,23	17,46	21,31	
	Malta (Maltese Islands)	52,05	29,39	18,49	0,07
2006	Gozo and Comino	54,91	22,26	22,83	
	Northern	54,21	17,30	28,18	0,31
	Northern Harbour	20,20	73,15	6,65	
	South Eastern	60,58	30,52	8,90	
	Southern Harbour	25,64	73,71	0,66	
	Western	61,22	17,45	21,32	
	Malta (Maltese Islands)	52,05	29,41	18,47	0,07
2012	Gozo and Comino	54,84	22,33	22,83	
	Northern	54,21	17,58	27,90	0,31
	Northern Harbour	20,20	73,15	6,65	
	South Eastern	58,71	30,51	10,78	
	Southern Harbour	25,64	73,71	0,66	
	Western	61,22	17,45	21,32	
	Malta (Maltese Islands)	51,74	29,49	18,70	0,07
2018	Gozo and Comino	55,47	22,17	22,36	
	Northern	54,37	18,29	27,02	0,31
	Northern Harbour	21,33	73,18	5,48	
	South Eastern	58,35	30,77	10,88	
	Southern Harbour	25,09	74,26	0,65	
	Western	62,71	17,09	20,20	
	Malta (Maltese Islands)	52,24	29,64	18,05	0,07

Historically, urban areas, are mostly concentrated in the Southern and Northern Harbours, while agricultural land is dominant in the other localities, and mostly concentrated in the Western District (Figure 2 to Figure 7).

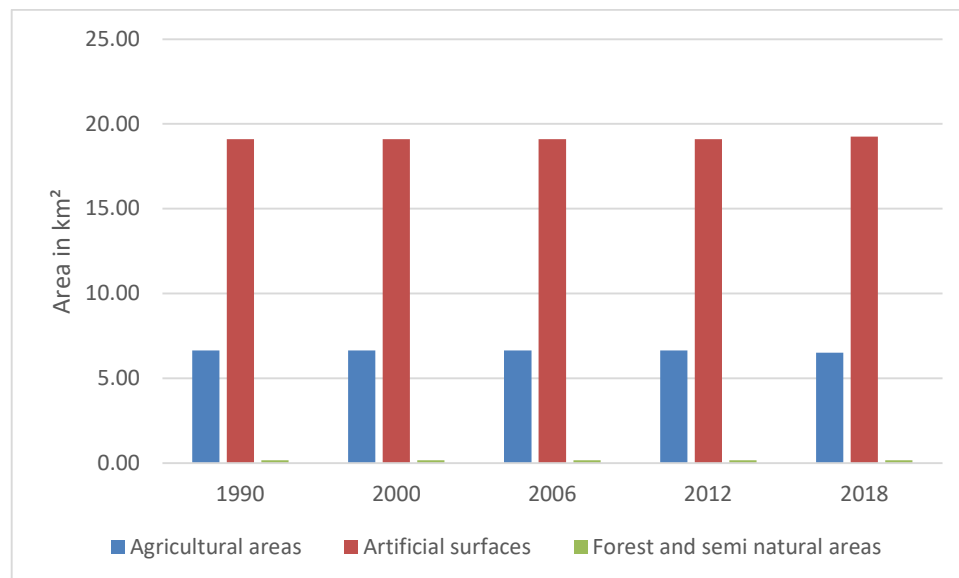


Figure 2: Land use (area in km²) in Southern Harbour region

Source: Adapted from Corine Land Cover for Malta data as reported on Eionet

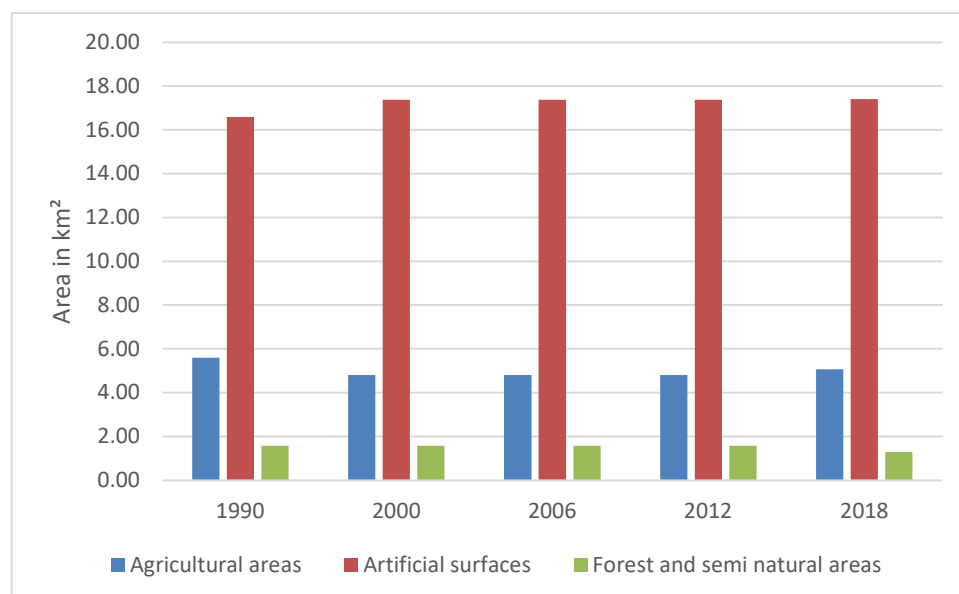


Figure 3: Land use (area in km²) in Northern Harbour region

Source: Adapted from Corine Land Cover for Malta data as reported on Eionet

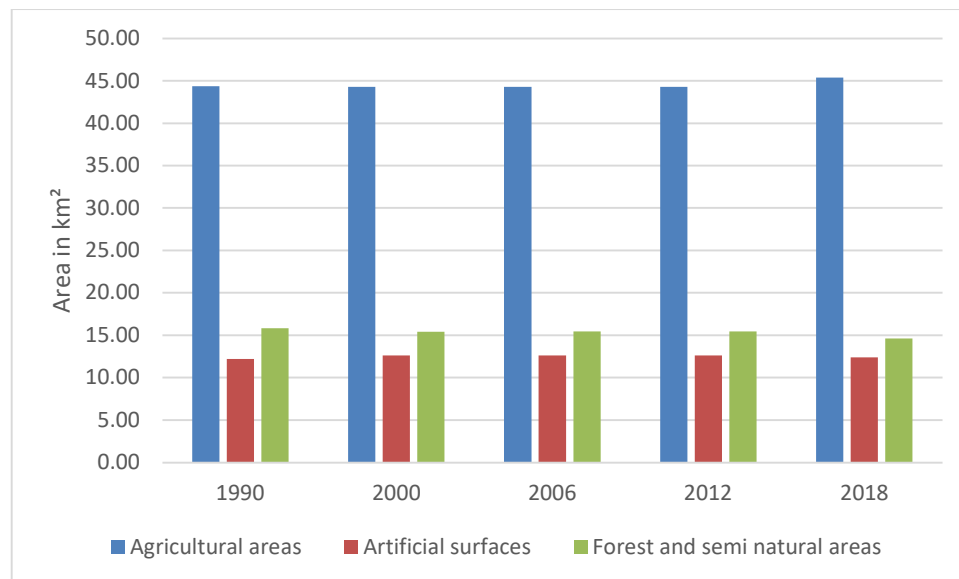


Figure 4: Land use (area in km²) in Western region

Source: Adapted from Corine Land Cover for Malta data as reported on Eionet

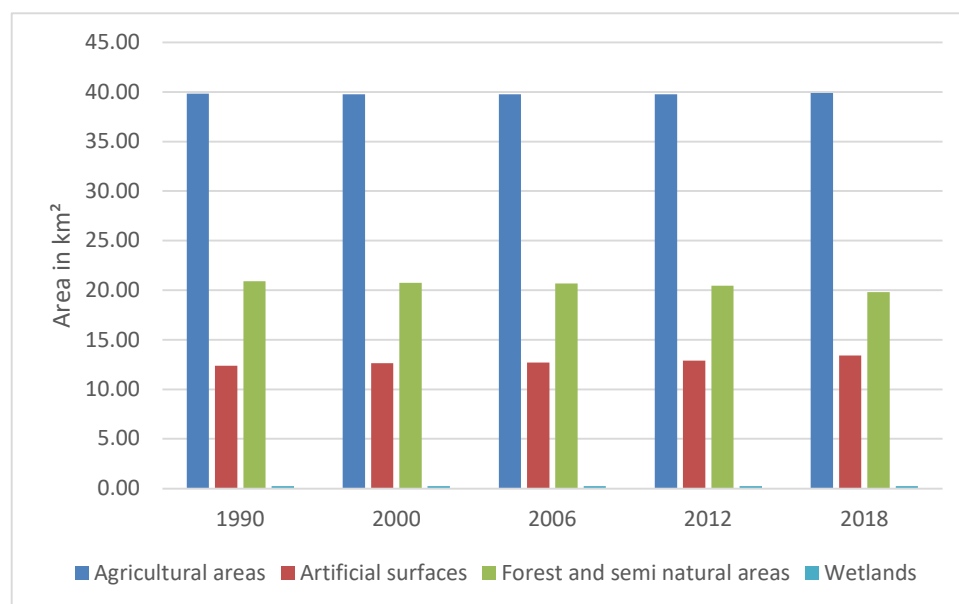


Figure 5: Land use (area in km²) in Northern region

Source: Adapted from Corine Land Cover for Malta data as reported on Eionet

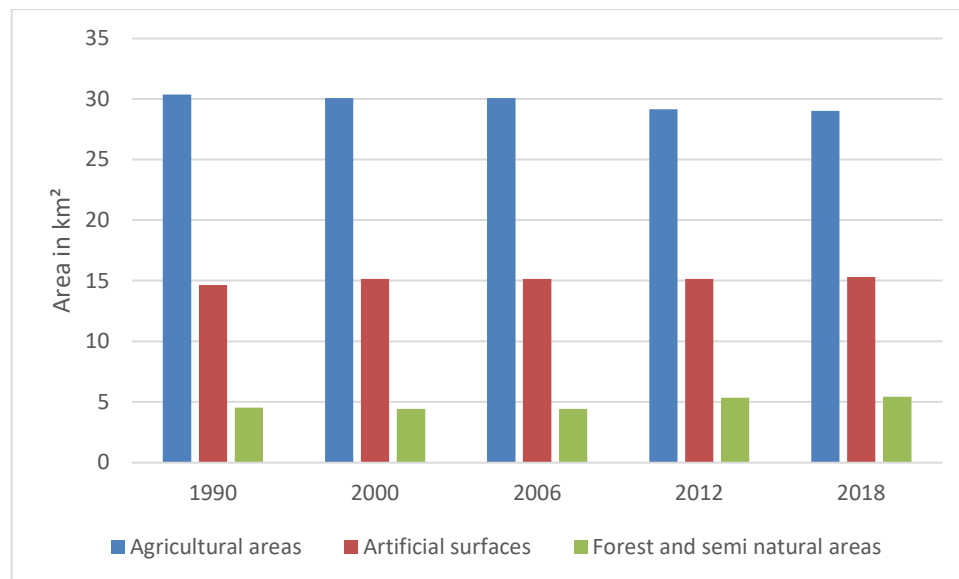


Figure 6: Land use (area in km²) in South Eastern region

Source: Adapted from Corine Land Cover for Malta data as reported on Eionet

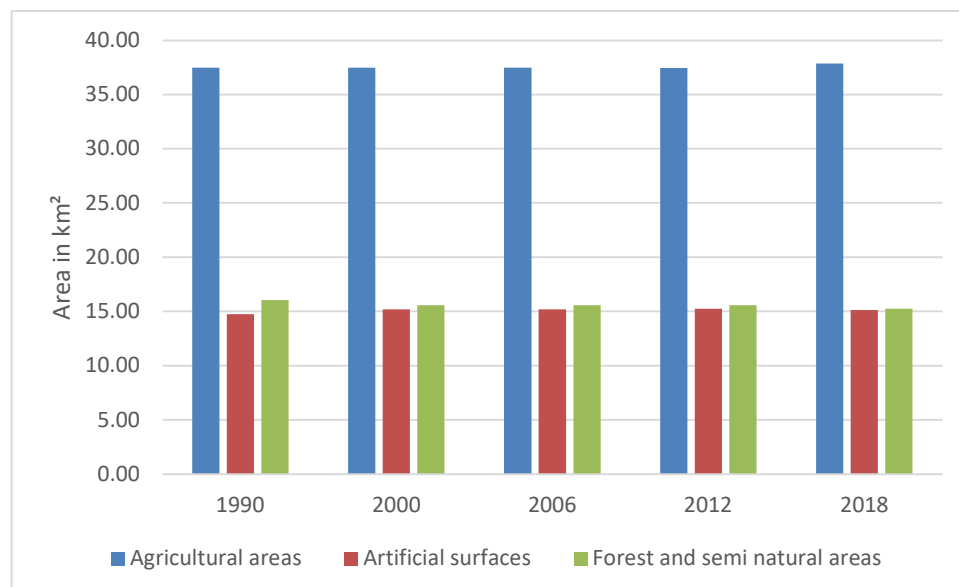


Figure 7: Land use (area in km²) in Gozo and Comino region

Source: Adapted from Corine Land Cover for Malta data as reported on Eionet

Since 1990, an increase in the urban areas (~1% in the total land are) and a decrease in the coverage of agricultural and natural vegetated areas is recorded (Figure 8).

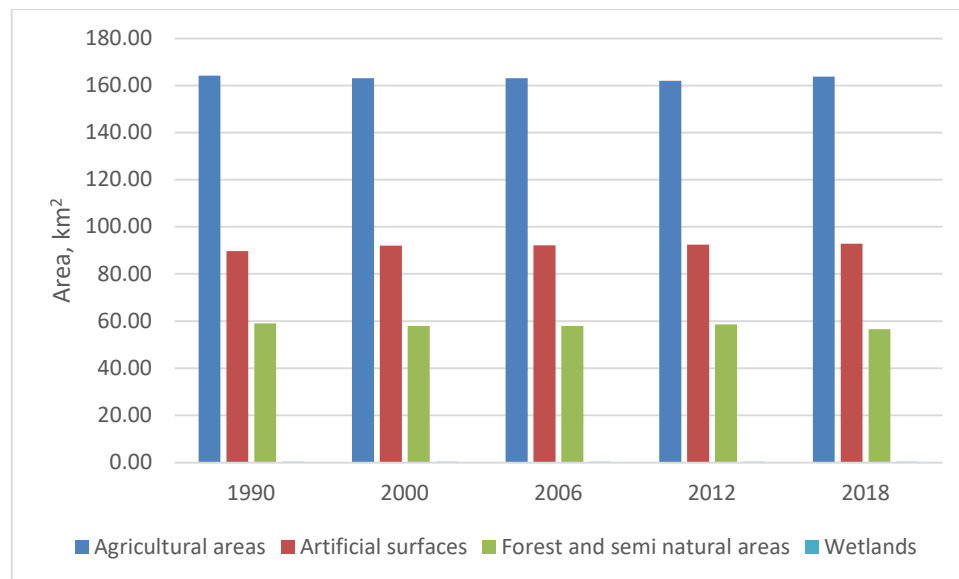


Figure 8: Land use (area in km²) in the Maltese Islands

Source: Adapted from Corine Land Cover for Malta data as reported on Eionet

In Malta the major change in land use was carried out before 1990. Based on the land use map, produced under a study carried out from the BRGM, there is a decrease in agricultural land of 42% in total land area and an increase of Natural areas and urban areas (Figure 9).

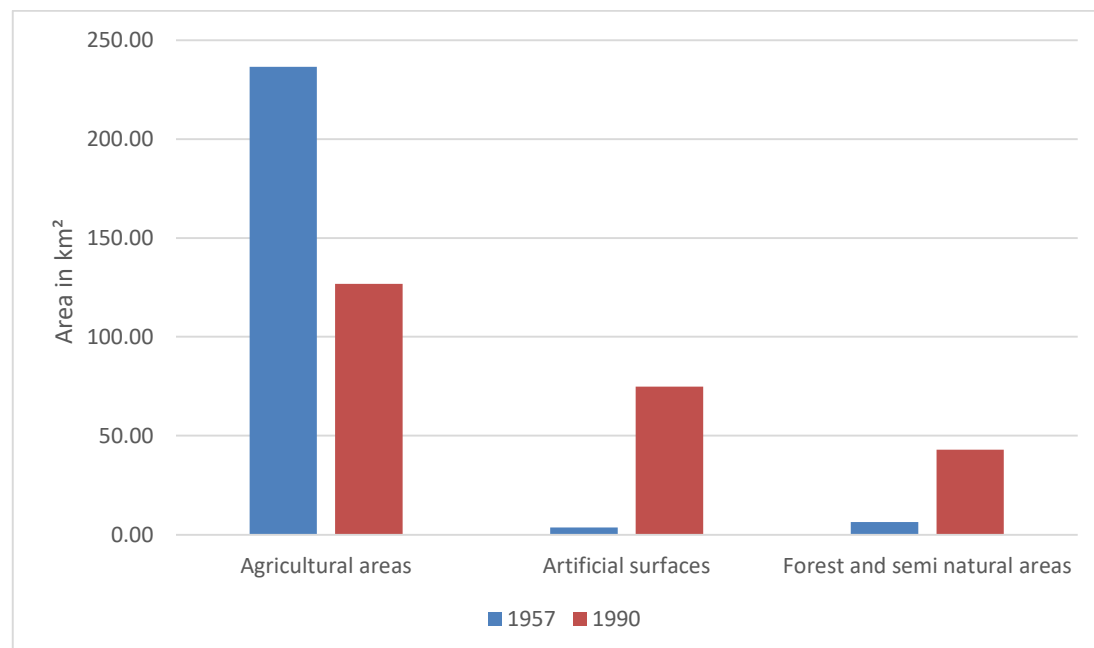


Figure 9: Land use (area in km²) in the Maltese Islands

Source: Adapted from map produced under land use development study from BRGM, Corine Land Cover 1990 for Malta data as reported on Eionet

2.3.3 Climate

Malta's climate is typically Mediterranean, with mild, rainy winters and hot, sunny summers. Luqa Airport meteorological station, operated by the Malta Airport MetOffice, offers Long-term observations for the key meteorological parameters. This analysis is mainly based on the Luqa Airport meteorological data published in "Environment statistics" for the period 1968-2005 (NSO, 2002, 2006) and the updated data up to 2018 provided by the Energy and Water Agency as well as by the Malta Airport MetOffice.

2.3.3.1 Temperature

Annual mean temperature in the Maltese Islands is around 19°C, ranging from 17.9°C in 1976 while to 20.1°C in 2016 (Figure 10).

Table 3 presents the mean annual temperature for a significant time period. Figure 11 presents the monthly variation of temperature for the period 1968-2018. Mean monthly temperatures are lower in January and February, while the highest ones are observed during the summer season (July and August), as shown in Figure 11.

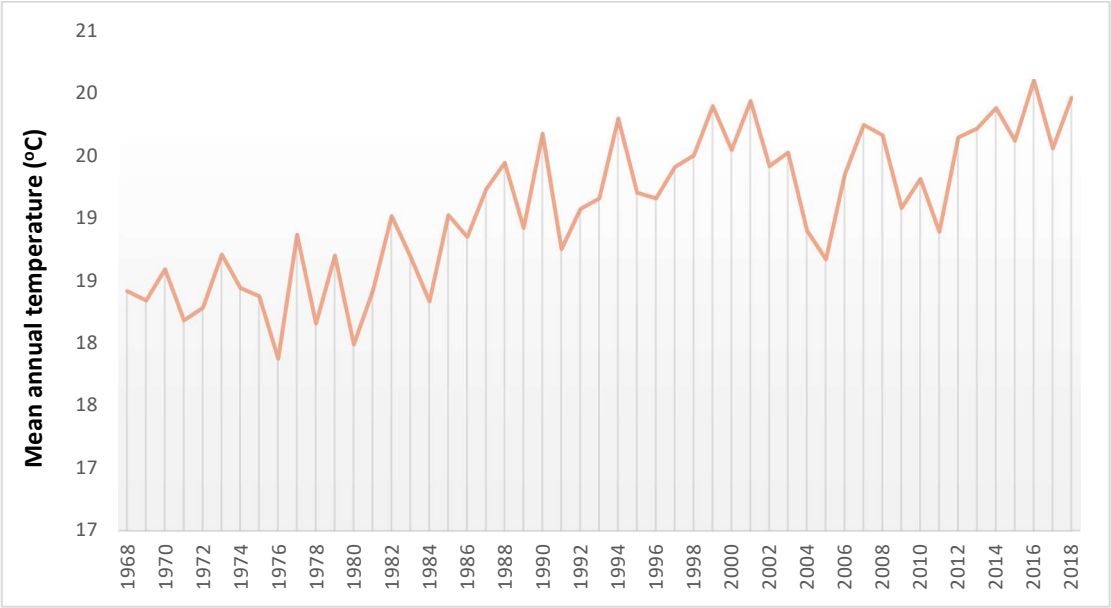
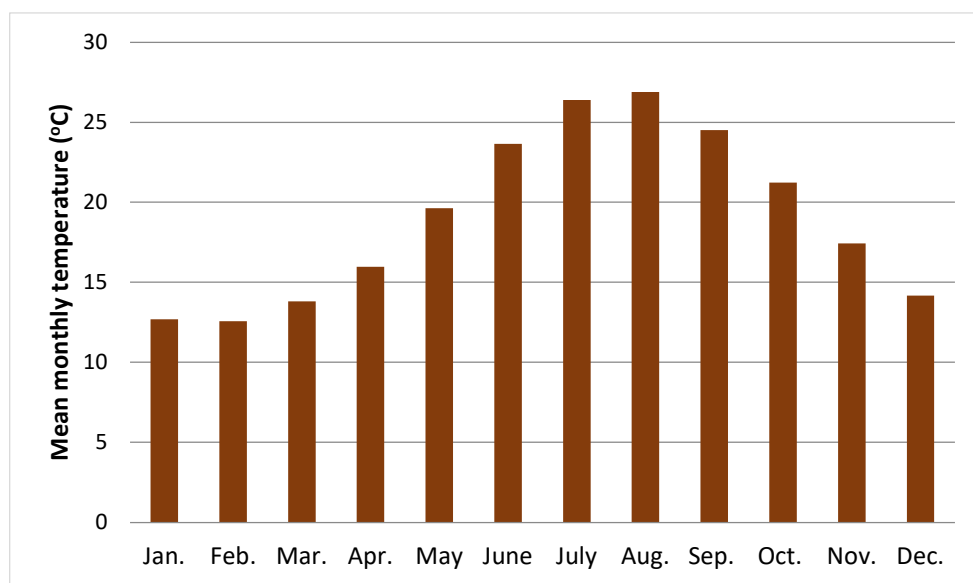


Figure 10: Annual mean temperature (°C) (1968-2018)
(Source: Malta Airport MetOffice)

Table 3: Annual mean temperatures (1969-2018)

Period	Mean annual temperature (°C)
1969-1973	18.4
1974-1978	18.3
1979-1983	18.6
1984-1988	19.0
1989-1993	19.1
1994-1998	19.4
1999-2003	19.7
2004-2008	19.3
2009-2013	19.3
2014-2018	19.8

Source: Adapted from Malta Airport MetOffice

**Figure 11: Monthly mean temperature (°C) (1968-2018)**

(Source: Adapted from Malta Airport MetOffice)

2.3.3.2 Precipitation

The average annual precipitation in Malta is 552.7 mm over the past 50 years (1968-2018). Figure 12 shows the monthly distribution of the annual precipitation during this period. Precipitation mainly occurs in winter, while in June, July and August is almost zero. In Figure 12, the annual precipitation over the past 50 years is presented, showing a downward trend. In order to confirm whether this trend is statistically significant, a Mann-Kendall Trend Test was performed using R software. The test statistic is -0.0906 and the corresponding two-sided p-value is 0.3575. As p-value is higher than 0.10 (confidence level of 90%), the downward trend of the time-series is not proved to be statistically significant.

Table 4 presents the 5-year averages regarding annual precipitation.

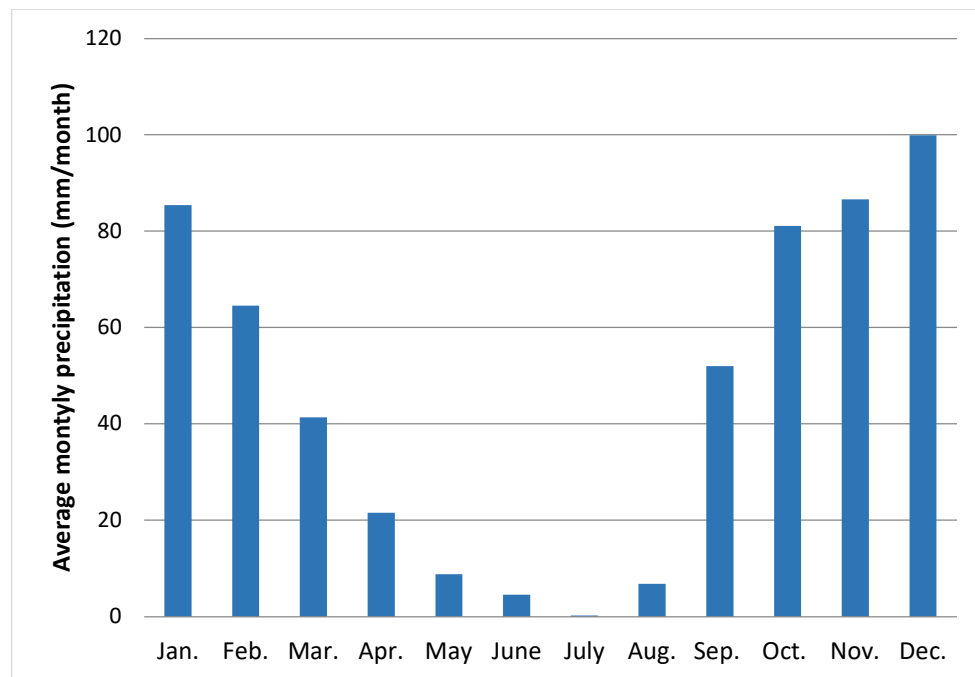


Figure 12: Average monthly precipitation over the past 50 years (1968-2018)

(Source: Adapted from Malta Airport MetOffice)

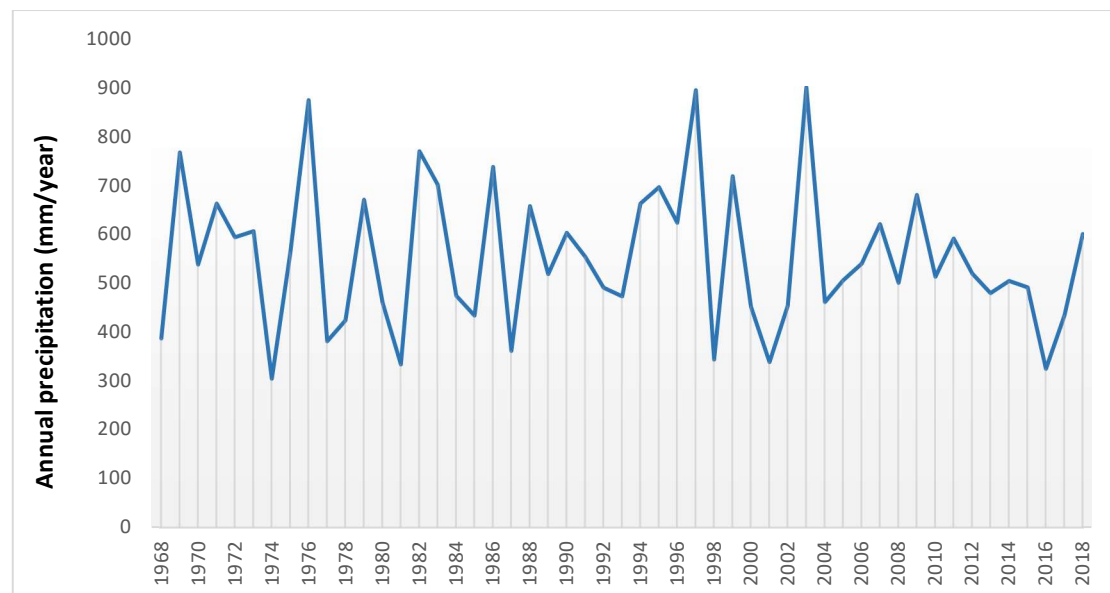


Figure 13: Annual precipitation over the past 50 years (1968-2018)

(Source: Malta Airport MetOffice)

Table 4: Annual precipitation 5-year averages over the past 50 years

Period	Annual precipitation (mm)
1969-1973	633.4
1974-1978	509.3
1979-1983	587.1
1984-1988	533.0
1989-1993	527.8
1994-1998	644.0
1999-2003	572.7
2004-2008	525.6
2009-2013	556.6
2014-2018	471.1

Source: Adapted from Malta Airport MetOffice

2.3.3.3 Evapotranspiration

In order to estimate potential evapotranspiration for the period of 1968-2018, FAO (Allen et., 1998) Penman-Monteith method has been selected. Specifically, FAO CROPWAT 8.0 software has been used to estimate PET, based on temperature, humidity, wind speed and solar radiation data series. Figure 14 shows the average monthly potential evapotranspiration. Higher values are observed during the summer period (Table 9). During the winter, potential evapotranspiration is significantly lower. The annual potential evapotranspiration for the period 1968-2018 is presented in Figure 15, with an average value of 1272.6 mm.

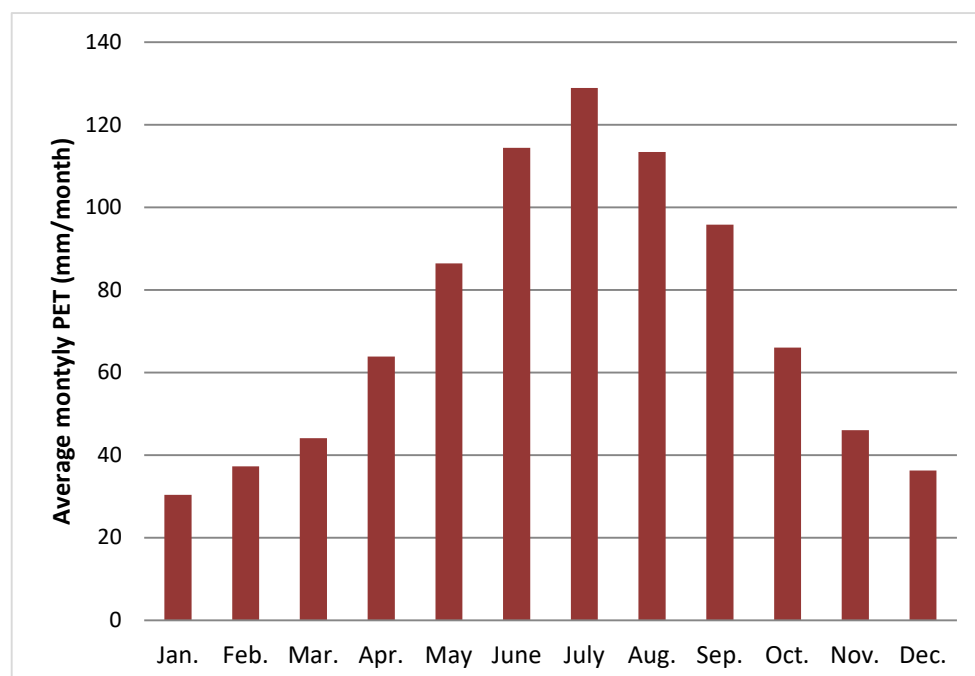


Figure 14: Monthly variation of potential evapotranspiration estimated based on FAO Penman-Monteith method (mm/month) (1968-2018)

(Source: Authors' own estimates)

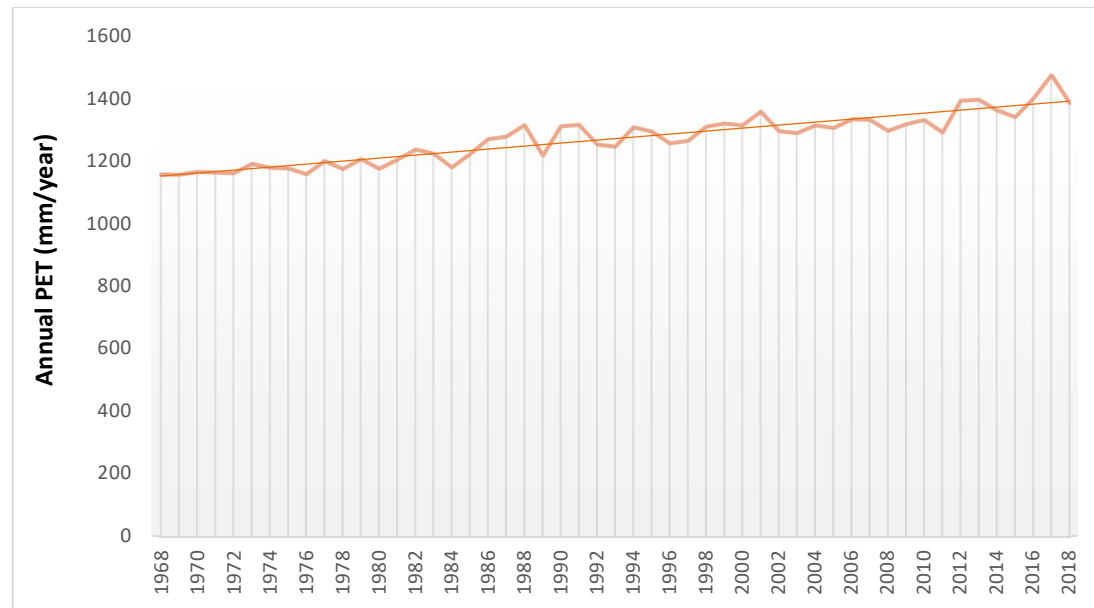


Figure 15: Annual potential evapotranspiration (mm/year)(1968-2018)

(Source: Authors' own estimates)

Table 5: Annual potential evapotranspiration 5-year averages over the past 50 years

Period	Annual potential evapotranspiration (mm/year)
1969-1973	1169
1974-1978	1179
1979-1983	1211
1984-1988	1255
1989-1993	1270
1994-1998	1288
1999-2003	1317
2004-2008	1318
2009-2013	1347
2014-2018	1394

Source: Authors' own estimates

To estimate actual evapotranspiration several widely used and easily applied empirical methods (e.g. Turc, Coutagne, Schrieber) have been reported in the literature. For the purposes of this analysis, Turc (1961) and Coutagne (1954) methods have been used mainly due to limited data required in order to be applied, leading to similar results (variance lower than 10%). In Figure 16 actual evapotranspiration based on Coutagne method is presented.

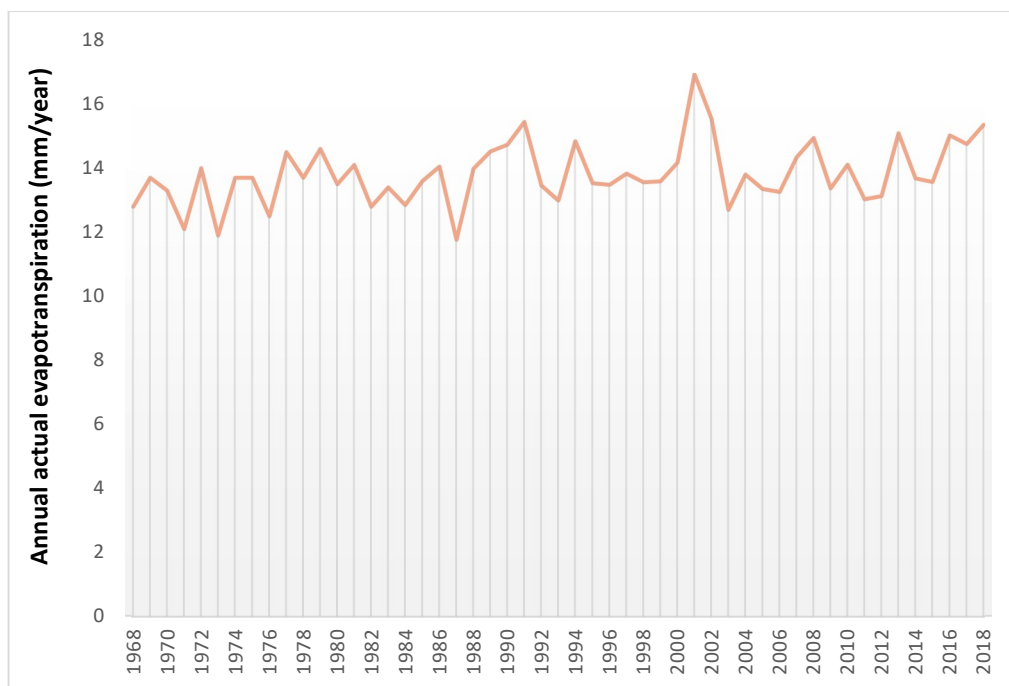


Figure 16: Actual evapotranspiration (mm/year) over the past 50 years (1968-2018)
(Source: Authors' own estimates)

2.3.3.4 Wind speed

The Maltese Islands are characterized by the intensity and the frequency of the winds (NSO, 2002). Figure 17 shows the average wind speed in knots, for the period 1968-2018. For the period of 1984-2018, data have been obtained by Malta Airport MetOffice, while for the period 1968-1983 average wind speed has been estimated based on the observed trend during the period 1984-2018, in a monthly base. In Figure 18, the average wind speed per month is presented.

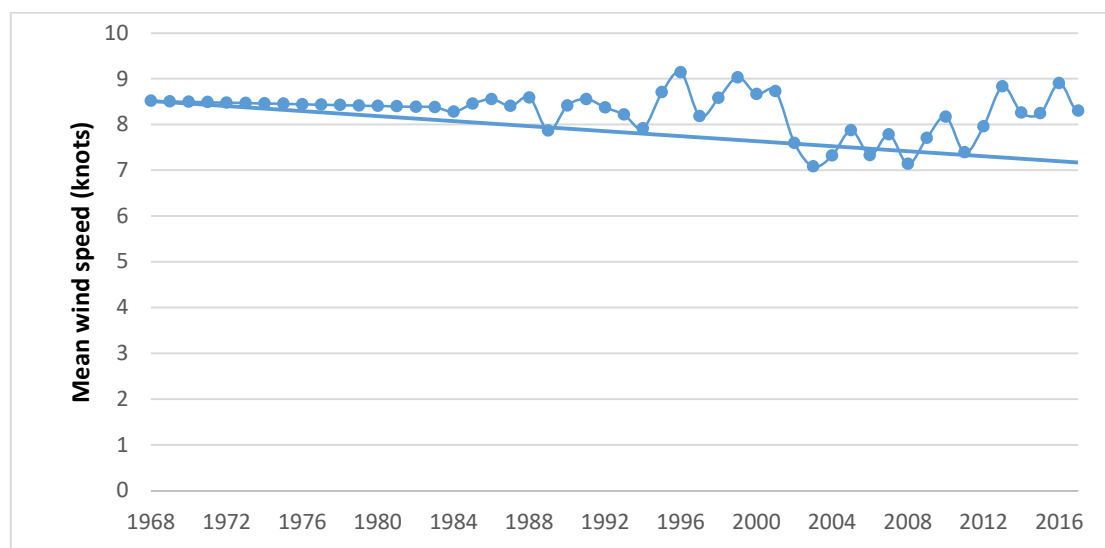


Figure 17: Average wind speed in knots over the past 50 years (1968-2018)

(Source: Adapted from Malta Airport MetOffice)

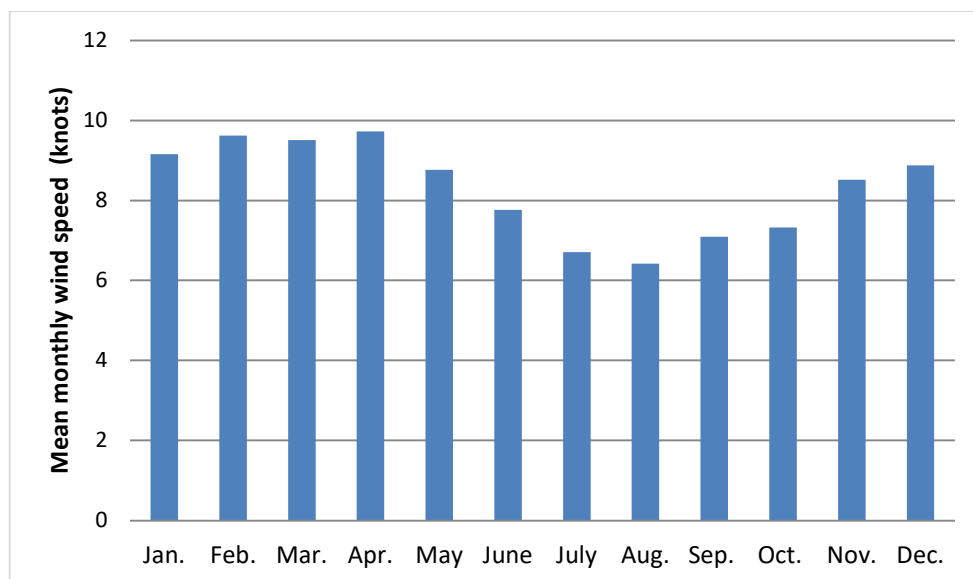


Figure 18: Mean monthly wind speed (1968-2018)

(Source: Adapted from Malta Airport MetOffice)

2.3.3.5 Relative humidity

The ratio of the partial pressure of water vapor to the equilibrium vapor pressure of water at a given temperature (i.e. the relative humidity) is constantly high in Malta. The annual mean relative humidity for the period of 1968-2018 is presented in Figure 19. For the period of 1984-2018, data have been obtained by Malta Airport MetOffice, while for the period 1968-1983, mean monthly humidity has been estimated based on the observed trend during the period 1984-2018. The average annual relative humidity 75.7%. However, the average monthly relative humidity ranges from 67.4% to 80% (Figure 20).

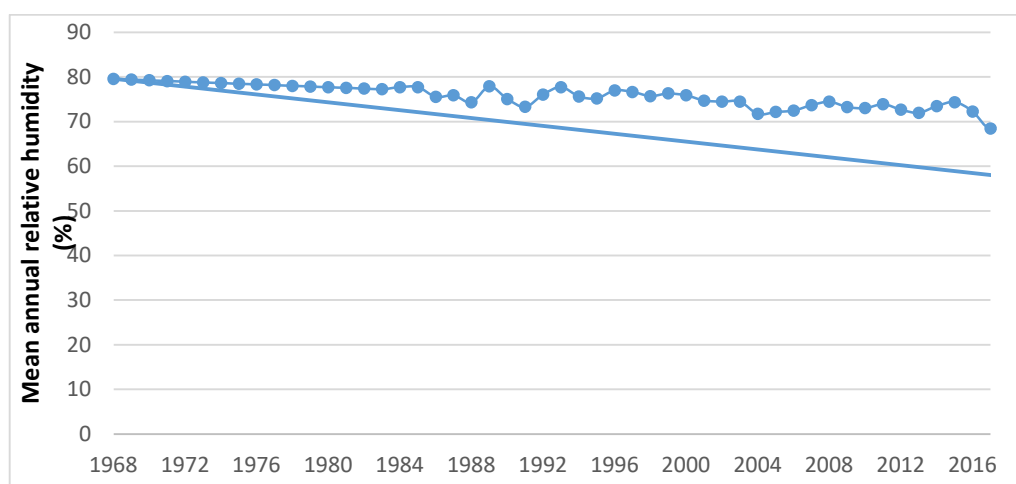


Figure 19: Mean annual relative humidity (%)

(Source: Adapted from Malta Airport MetOffice)

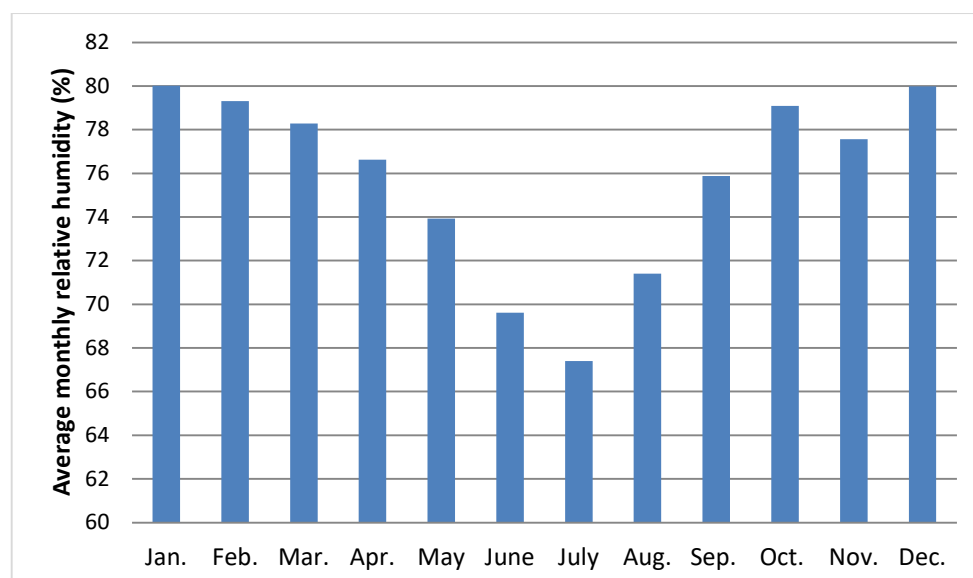


Figure 20: Average monthly relative humidity (%) (1968-2018)

(Source: Adapted from Malta Airport MetOffice)

2.3.3.6 Drought Indices

In order to assess and monitor drought, a set of indices has been estimated and included in the climate analysis. In the present report, the Aridity Index and the Standardised Precipitation-Evapotranspiration Index (SPEI) performance over the past 50 years is presented. The performance of additional drought indices will be evaluated by the authors during the progress of the analysis if necessary.

The aridity index (AI) introduced by UNEP (1992) is an indicator of the degree of dryness of the climate at a given location. AI is a simplified indicator expressed as the ratio of annual precipitation (P) to the annual potential evapotranspiration (PET) estimated based on the Penman-Monteith method. Using the AI, six subtypes of arid lands or drylands are classified: cold, hyper-arid, arid, semi-arid, dry subhumid and humid (Table 6). The estimated annual values of the UNEP AI in the Maltese islands for the period of 1968-2018, are presented in Figure 21. The mean AI for this period is 0.4 and therefore Malta's climate is characterized as semi-arid, according to Table 6.

Table 6: Climate classification and dryland subtypes based on the Aridity Index

Climate type	AI
Dryland Subtypes	
Hyper-arid	$AI < 0.05$
Arid	$0.05 \leq AI < 0.2$
Semi-arid	$0.2 \leq AI < 0.5$
Dry subhumid	$0.5 \leq AI < 0.65$
Non-Drylands	
Humid	$AI \geq 0.65$
Cold	$PET < 400 \text{ mm}$

Source: Middleton and Thomas, 1997

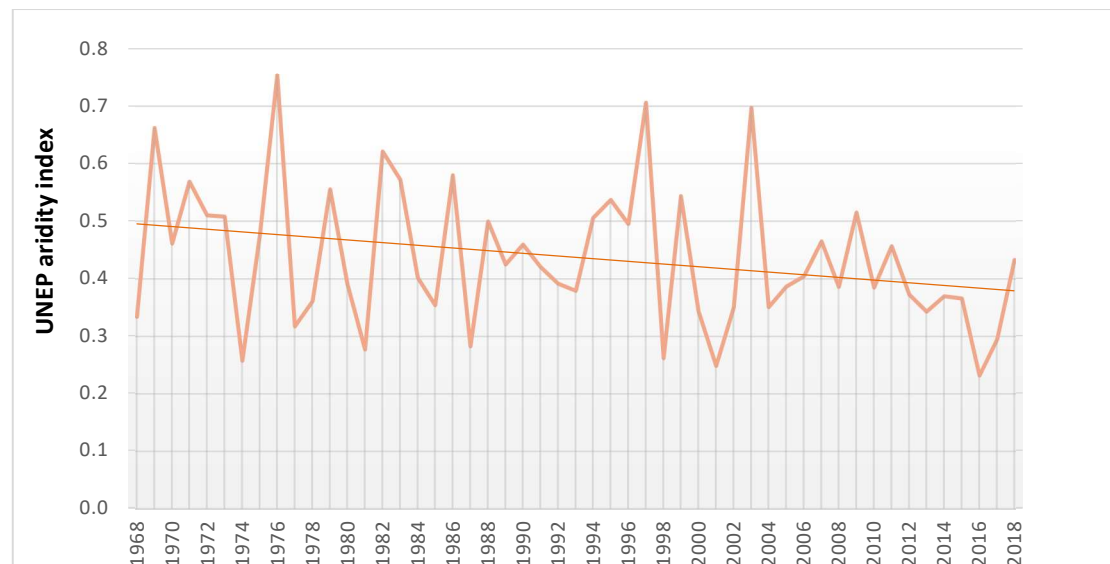


Figure 21: Annual evolution of the UNEP aridity index (1968-2018)

(Source: Authors' own estimates)

SPEI, the Standardised Precipitation-Evapotranspiration Index introduced in 2010, is a drought index based on climatic data that captures precipitation and temperature fluctuations and trends (Vicente-Serrano et al., 2010). The SPEI uses the difference between precipitation and potential evapotranspiration to represent a simple climatic water balance. Consequently, SPEI values lower than zero indicate dry periods. In Figure 22, SPEI-12 values -SPEI with 12 months' time step- for the period of 1968-2018 are presented, showing a downward trend.

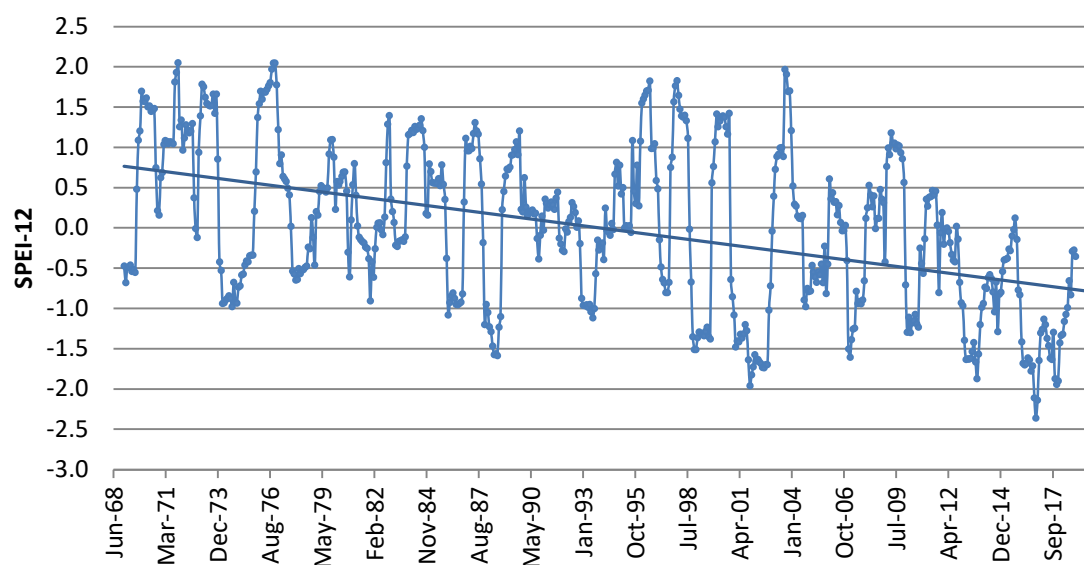


Figure 22: SPEI-12 evolution (1968-2018)

(Source: Authors' own estimates)

2.3.4 Permanent population

According to NSO statistical data, the population of Malta nearly doubled over the last century and reached 475,701 inhabitants in 2018 (note: population at the beginning of the year). The rate of change in the population varied along the years and was affected by several factors, such as world wars and migration flows (NSO, 2014a; NSO, 2018b; NSO, 2020). The total population in the Maltese Islands increased by almost 51% during the last 50 years (Figure 23). Nevertheless, the evolution of population presents notable differences among the regional units. As of today, the population in Malta Island grew by 53.7% and by 26% in Gozo and Comino islands over the same period. Furthermore, population in Northern, South Eastern, Western and Northern Harbour increased by 228.2%, 100.1%, 67.9% and 44.4%, respectively. On the contrary, population shrank by 7.2% in Southern Harbour.

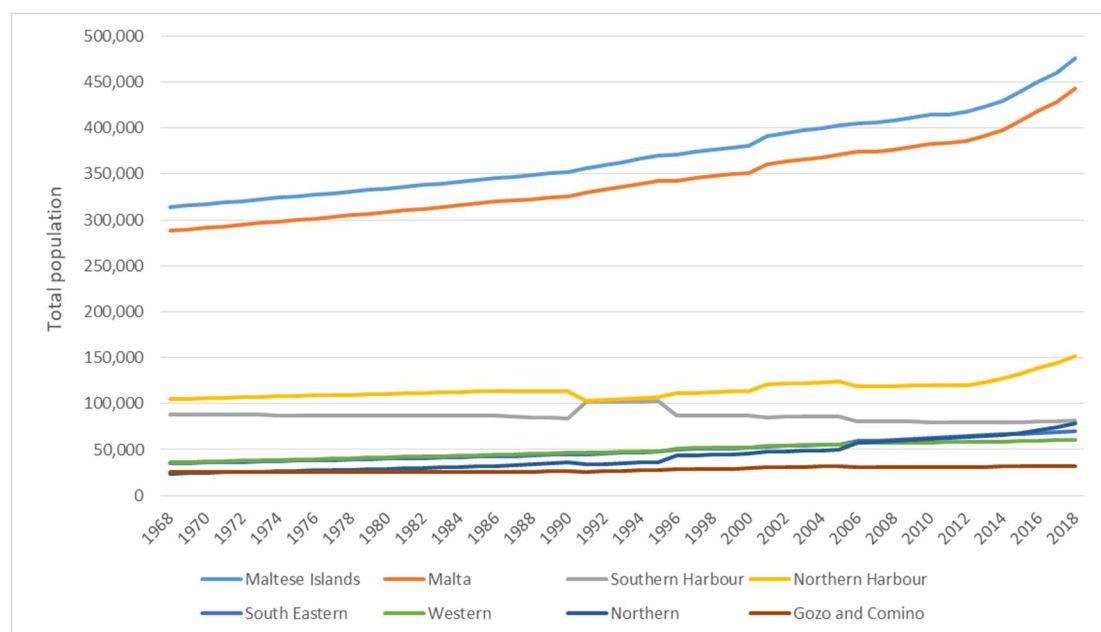


Figure 23: Total population in Malta and LAU districts over the past 50 years

Moreover, the population growth differs between the Maltese and the Non-Maltese population. According to NSO (2020), between 1986 and 2017, the Maltese population increased by 19.1% (i.e. from 340,907 to 405,976), while the Non-Maltese population increased over 1000% (i.e. from 4,798 to 54,321). As a result, the percentage of the foreigners to the total population increased from 1.4% in 1986 to 11.8% in 2017. The percentage change of foreigners to the total population differs per region. For instance, in 2018, foreigners accounted to more than 25% of total population in Msida, St. Paul's Bay, Gzira, Sliema and St. Julian's amongst others (Figure 24).

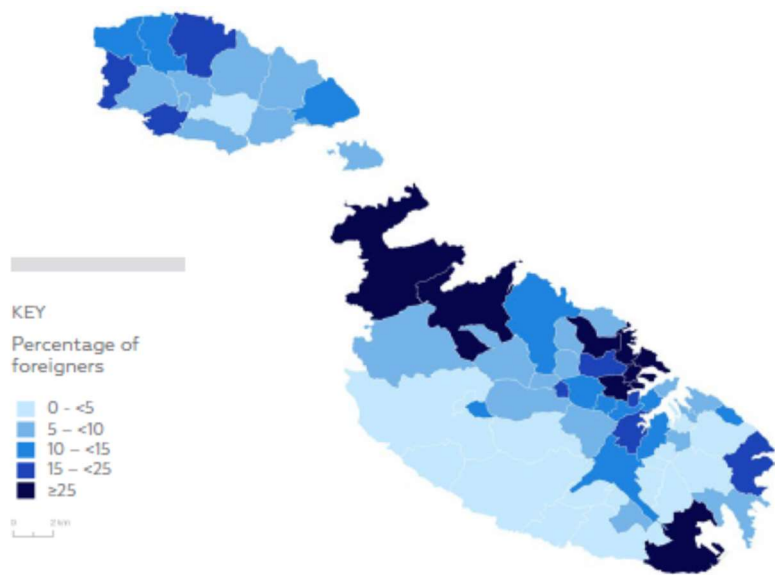


Figure 24: Percentage of foreigners to the total population of each locality, in 2018

(Source: NSO, 2020)

Table 7 and

Table 8 present the 5-year total population averages and population percentages by region, accordingly. In recent years, the most populated district of Malta is the Northern Harbour (almost one-third of the population resides in this area), followed by Southern Harbour (18.2%). South Eastern, Western and Northern districts host more or less the same percentage of population (approximately 15%). Finally, Gozo and Comino is the least populated district, with about 7%.

Table 7: Total population 5-year averages by region over the past 50 years

Period	Malta (Maltese Islands)	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	319,012	293,084	87,706	106,460	36,344	37,433	25,141	25,928
1974-1978	327,337	301,491	87,417	108,831	38,284	39,680	27,279	25,846
1979-1983	336,136	310,372	87,130	111,254	40,327	42,062	29,599	25,764
1984-1988	345,326	319,506	86,449	113,431	42,562	44,576	32,488	25,820
1989-1993	356,305	329,843	94,908	107,986	45,215	46,661	35,073	26,462
1994-1998	371,505	343,386	93,409	109,769	49,189	50,197	40,821	28,119
1999-2003	388,414	358,187	86,165	118,319	53,145	53,659	46,899	30,228
2004-2008	404,196	372,879	82,637	120,858	58,219	56,365	54,800	31,317
2009-2013	415,999	384,674	79,782	120,652	63,554	58,010	62,675	31,326
2014-2018	451,106	419,097	80,365	138,831	68,402	59,700	71,799	32,009

Source: Adapted from NSO Malta (2014, 2017 & 2020)

Table 8: Total population percentage by region over the past 50 years - 5-year averages

Period	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	91.9%	27.5%	33.4%	11.4%	11.7%	7.9%	8.1%
1974-1978	92.1%	26.7%	33.2%	11.7%	12.1%	8.3%	7.9%
1979-1983	92.3%	25.9%	33.1%	12.0%	12.5%	8.8%	7.7%
1984-1988	92.5%	25.0%	32.8%	12.3%	12.9%	9.4%	7.5%
1989-1993	92.6%	26.6%	30.3%	12.7%	13.1%	9.8%	7.4%
1994-1998	92.4%	25.1%	29.5%	13.2%	13.5%	11.0%	7.6%
1999-2003	92.2%	22.2%	30.5%	13.7%	13.8%	12.1%	7.8%
2004-2008	92.3%	20.4%	29.9%	14.4%	13.9%	13.6%	7.7%
2009-2013	92.5%	19.2%	29.0%	15.3%	13.9%	15.1%	7.5%
2014-2018	92.9%	17.8%	30.8%	15.2%	13.2%	15.9%	7.1%

Source: Adapted from NSO Malta (2014, 2017 & 2020)

Given the differences in the spatial distribution of population growth, the population densities vary significantly. In order to estimate the population density of Malta and its regional units, the following figures were used for the area of Malta and of the LAU1 districts (Table 9).

The results by region are presented in Figure 25. Northern Harbour is by far the most densely populated district (almost four times higher than Malta's average population density), followed by Southern Harbour, South Eastern, Northern, Western and Gozo and Comino.

Table 9: Area of Malta and LAU districts

	Area (km ²)
Malta (Maltese Islands)	315.15
Malta region	246.49
Southern Harbour	26.17
Northern Harbour	24.02
South Eastern	50.16
Western	72.47
Northern	73.66
Gozo and Comino	68.67

Source: NSO Malta, 2014

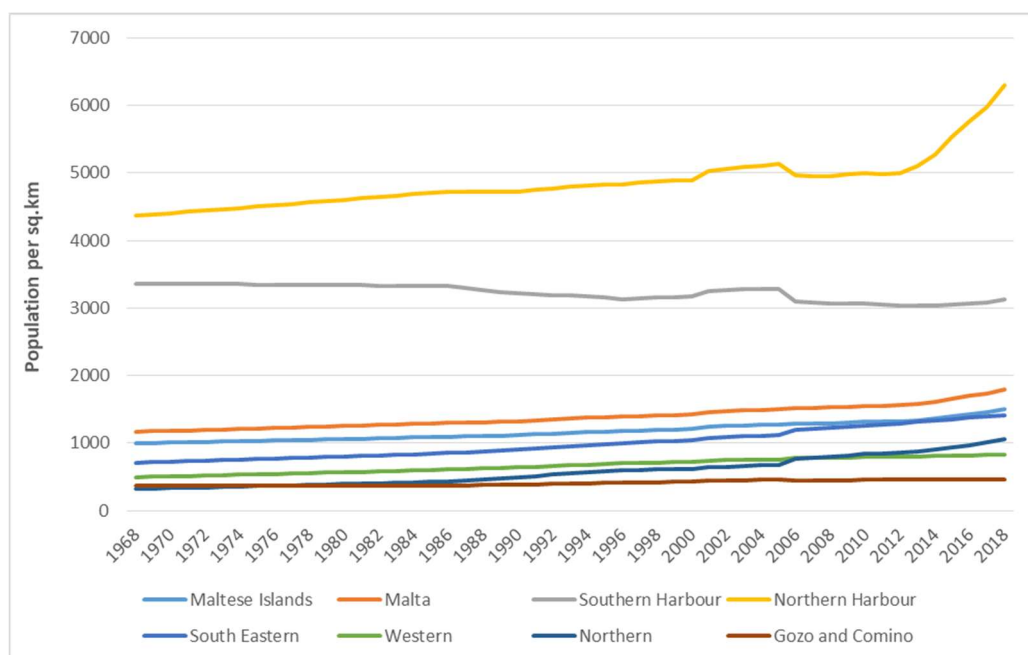


Figure 25: Population density by region over the past 50 years

(Source: Authors' own estimates)

Table 10 summarizes the 5-year averages of population density in Malta and in the six LAU1 districts. Overall, the population density in Malta increased by almost 40% between 1968 and 2017. In Northern district, the population density almost doubled (i.e. 180%) from 335.8 people/km² to 937.5 people/km². Increases in population density were also significant in all other districts (South Eastern: 87.3%, Western: 60.2%, Northern Harbour: 25.6% and Gozo and Comino: 22.4%) except Southern Harbour, where population density was decreased by 8.9%.

Table 10: Population density by locality over the past 50 years - 5-year averages

Period	Malta (Maltese Islands)	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	1,012.4	1,189.6	3,356.5	4,422.9	731.1	513.6	341.4	377.0
1974-1978	1,038.8	1,223.7	3,345.5	4,521.4	770.1	544.5	370.4	375.8
1979-1983	1,066.7	1,259.8	3,334.5	4,622.1	811.3	577.1	401.9	374.6
1984-1988	1,095.9	1,296.9	3,308.4	4,712.5	856.2	611.6	441.1	375.4
1989-1993	1,130.7	1,336.9	3,207.6	4,752.8	920.1	651.2	515.6	391.4
1994-1998	1,179.1	1,392.4	3,149.9	4,840.6	998.6	698.4	593.0	414.7
1999-2003	1,232.6	1,453.6	3,226.5	4,988.5	1,067.9	735.5	638.9	440.4
2004-2008	1,282.7	1,513.5	3,162.5	5,021.1	1,171.2	773.4	744.1	455.3
2009-2013	1,320.2	1,561.4	3,053.3	5,012.6	1,278.5	796.0	851.0	455.4
2014-2018	1,431.6	1,701.1	3,075.6	5,767.8	1,376.0	819.2	974.9	464.1

Source: Adapted from NSO Malta data (2014, 2017 & 2020)

2.3.5 Economic and social factors

2.3.5.1 Main economic indicators

Data on main economic indicators were obtained from the Central Bank of Malta (<https://www.centralbankmalta.org/real-economy-indicators>), which offers a complete time-series over the period 1968-2017. The 2018 figures were estimated using the percentage change in the nominal and real GDP announced by NSO (2019).

As illustrated in Figure 26, nominal GDP improved by almost 55 times during the last 50 years (from 217.7 million € to about 12,130 million €) and the Real GDP (in 2010 prices) by 13.5 times (from 754.4 million € to about 10,180 million €). Similarly, GDP per capita (Figure 27), which is a preferred measure of wellbeing (Grech, 2015), increased from about 720 € to 26,500 € (that is by almost 35 times) or, if one accounts for rising prices, by almost 8.5 times. Table 11 presents the 5-year averages for the above-mentioned indicators.

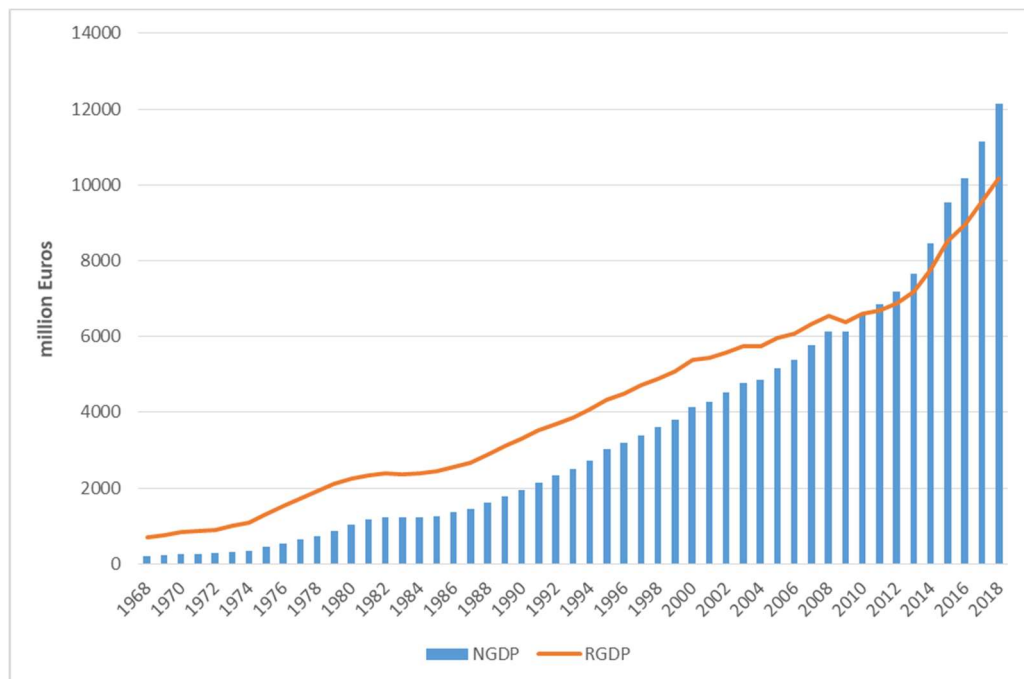


Figure 26: Nominal and Real GDP evolution over the past 50 years

(Source: Central Bank of Malta. Available from: <https://www.centralbankmalta.org/real-economy-indicators>)

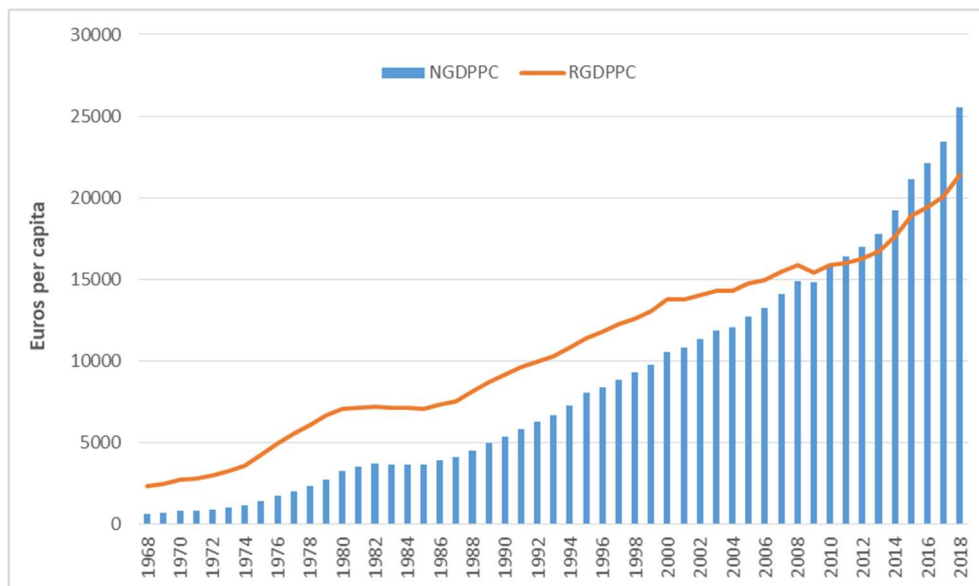


Figure 27: Nominal and Real GDP per capita evolution over the past 50 years

(Source: Central Bank of Malta. Available from: <https://www.centralbankmalta.org/real-economy-indicators>)

Table 11: Main economic indicators 5-year averages over the past 50 years

Period	GDP (million €)	Real GDP (million €)	GDP p.c. (€)	Real GDP p.c. (€)
1969-1973	261.5	868.2	864.7	2871.1
1974-1978	540.7	1512.1	1750.5	4898.8
1979-1983	1100.8	2291.8	3386.0	7059.0
1984-1988	1382.7	2587.5	3977.4	7447.3
1989-1993	2137.6	3495.5	5836.4	9550.1
1994-1998	3191.9	4494.7	8363.0	11779.8
1999-2003	4294.9	5440.6	10882.8	13790.8
2004-2008	5454.8	6132.7	13415.1	15086.0
2009-2013	6877.6	6742.7	16374.3	16060.0
2014-2018	10288.6	8994.9	22287.9	19503.2

Source: Adapted from Central Bank of Malta data (<https://www.centralbankmalta.org/real-economy-indicators>)

Figure 28 shows the share of each broad economic sector on Gross Value Added (GVA). As can be seen, Malta's economy was gradually oriented towards services (from 60% in 1970s to 85% during the last years). The industry's share has been reduced to 13.7%, in 2018, from 32.8%, in 1970. Similarly, the share of primary sector decreased from 7.4%, in 1970, to 1.0%, in 2018.

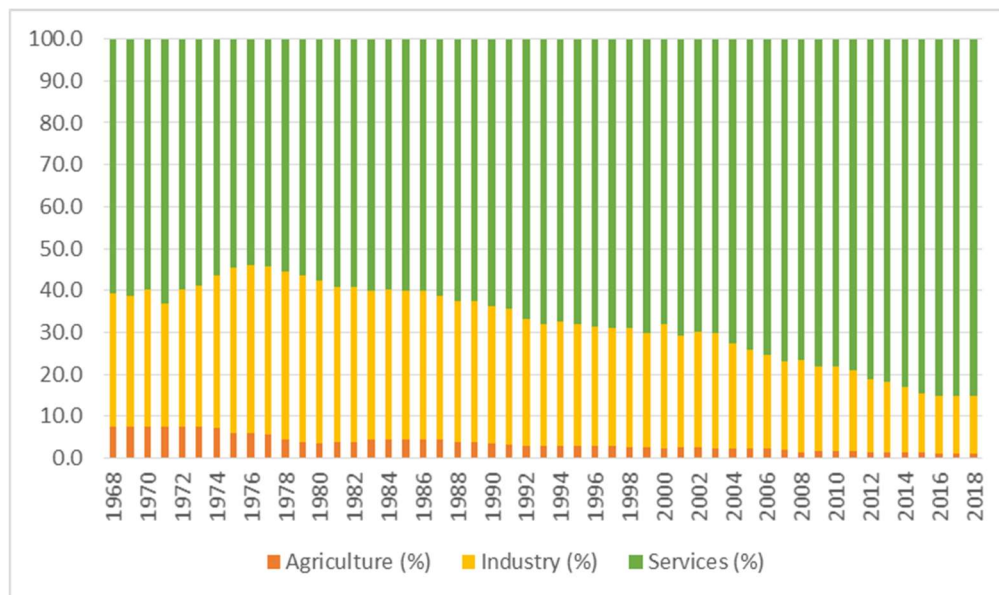


Figure 28: Share of GVA by broad economic sector over the past 50 years

(Source: Central Bank of Malta, Historical Annual Database. Available from: <https://www.centralbankmalta.org/en/historical-annual-database>)

It should be noted, however, that both the primary (agriculture and fishery) and the secondary (industry) sectors witnessed a considerable growth in terms of GVA, given the sharp increase in Malta's economy. More specifically, as displayed in Figure 29, total GVA grew more than fiftyfold between 1970 and 2018 at current prices (i.e. from 191 million € to 10,672 million €). During the same period, the GVA of primary, secondary, and tertiary sectors of the Maltese economy grew by 7.8, 23.3 and 79.6 times, respectively.

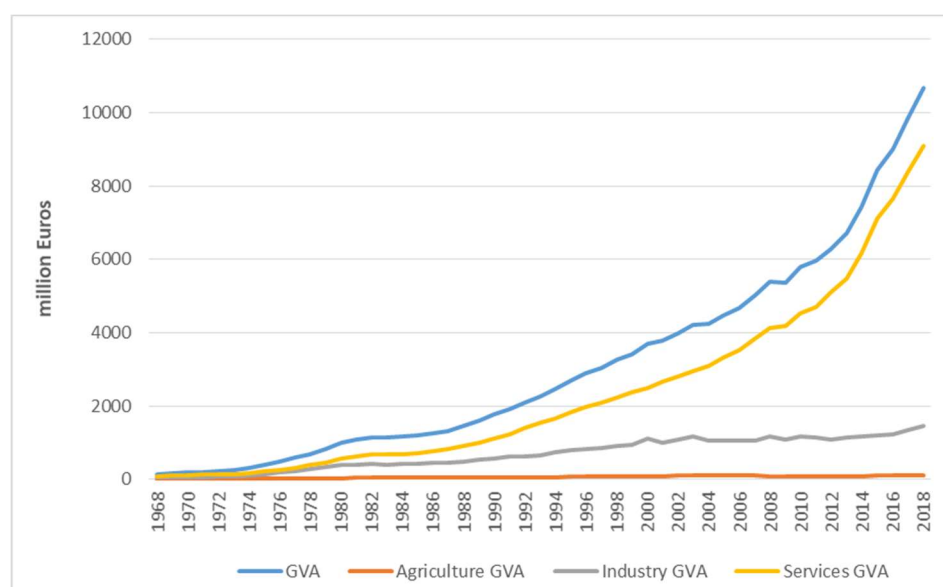


Figure 29: Total GVA and GVA by broad economic sectors at current prices over the past 50 years

(Source: Central Bank of Malta, Historical Annual Database. Available from: <https://www.centralbankmalta.org/en/historical-annual-database>)

2.3.5.2 Employment

The employment figures coincide with the evolution of the GDP and the other economic indicators, as showed in Figure 30. Total employed people rate was increased by more than 2.4 times during the last 50 years, based on the information retrieved from the Central Bank of Malta. Up to the start of the 1990s, there were significant cyclical movements in the unemployment rate. During the last years, the unemployment rate appears to have considerably declined owing to Malta's recovery after the 2008 recession, and the active labour market policies that have been implemented.

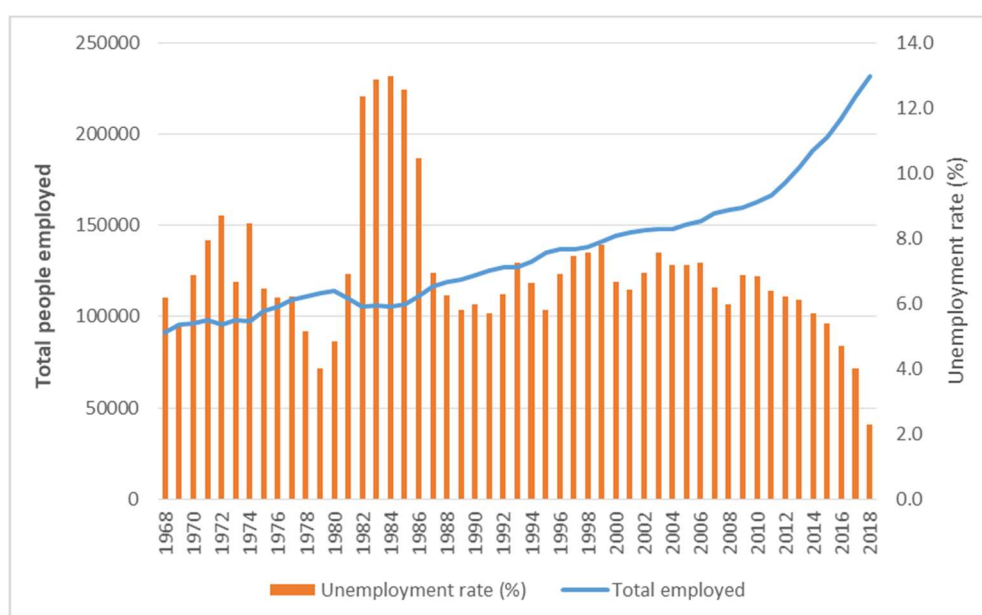


Figure 30: Total employed people and unemployment rate over the past 50 years

(Source: Central Bank of Malta, Historical Annual Database. Available from: <https://www.centralbankmalta.org/en/historical-annual-database>)

The most important sector in terms of employment is the Services sector. More specifically, this sector employs more than 80% of the total workforce in Malta during the last five years (Figure 31). The industrial sector follows with approximately 20%, while the primary sector employs just 1% of Malta's workforce (Table 12).

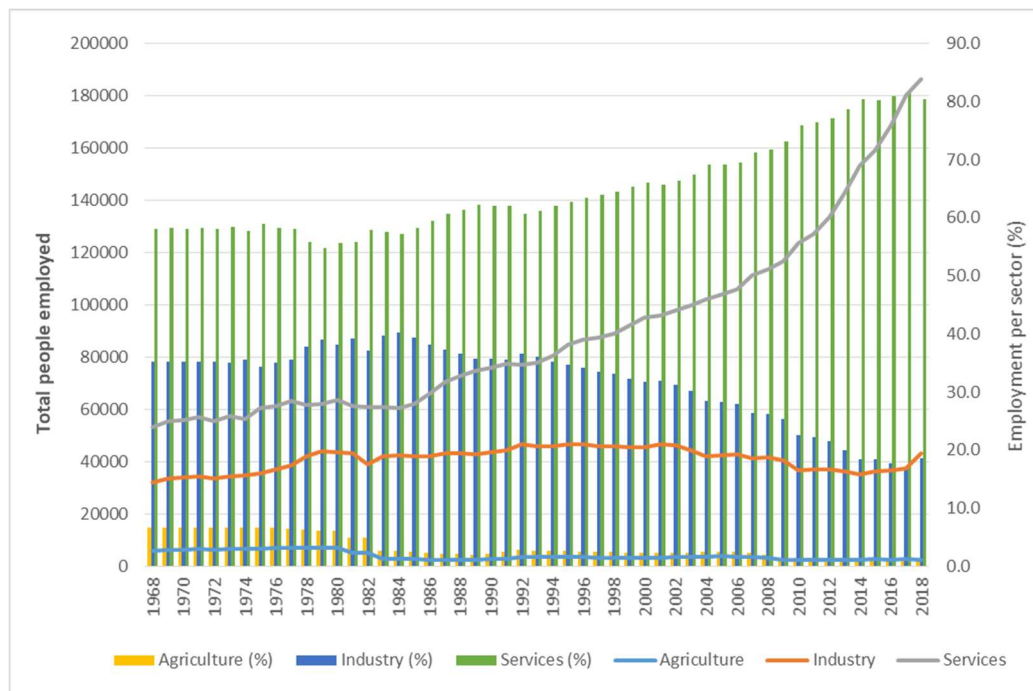


Figure 31: Total employed people and employment per sector over the past 50 years

(Source: Central Bank of Malta, Historical Annual Database. Available from: <https://www.centralbankmalta.org/en/historical-annual-database>)

Table 12: Employment in Malta by broad economic sectors, 5-year averages over the past 50 years

Period	Agriculture (%)	Industry (%)	Services (%)
1969-1973	6.7	35.2	58.2
1974-1978	6.5	35.7	57.8
1979-1983	4.9	38.7	56.4
1984-1988	2.3	38.3	59.4
1989-1993	2.4	35.9	61.6
1994-1998	2.5	34.2	63.3
1999-2003	2.3	31.5	66.2
2004-2008	2.3	27.5	70.2
2009-2013	1.4	22.3	76.3
2014-2018	1.2	18.0	80.8

Source: Adapted from Central Bank of Malta, Historical Annual Database (Available from: <https://www.centralbankmalta.org/en/historical-annual-database>)

Finally, based on the latest available data from NSO, the employment by sector in Malta and Gozo and Comino for the period 2010-2015 are presented in Table 13. In all economic sectors, as expected, except from “Agriculture, forestry and fishing”, more than 90% of the total workforce resides in Malta.

Table 13: Employment in Malta by economic sector, place of residence and year

NACE REV 2		2010	2011	2012	2013	2014	2015	2016	2017	2018
Agriculture, forestry and fishing	MALTA	2 958	2 974	2 956	2 960	2 936	3 281	3 210	3 250	3 393
	Malta	2 337	2 353	2 333	2 339	2 315	2 664	2 601	2 624	2 748
	Gozo and Comino	621	621	623	621	621	617	609	626	645
Mining and quarrying; manufacturing; electricity, gas, steam and air conditioning supply; water supply; sewerage, waste management and remediation activities of which manufacturing	MALTA	25 562	25 358	25 173	25 264	24 108	24 237	24 645	25 286	25 809
	Malta	24 162	23 983	23 870	23 964	22 850	22 929	23 321	23 926	24 383
	Gozo and Comino	1 400	1 375	1 303	1 300	1 258	1 308	1 324	1 360	1 426
Construction	MALTA	13 272	13 226	12 972	9 924	10 102	11 082	11 688	12 240	13 189
	Malta	12 193	12 154	11 917	8 885	9 043	10 041	10 577	11 100	11 974
	Gozo and Comino	1 079	1 072	1 055	1 039	1 059	1 041	1 111	1 140	1 215
Wholesale and retail trade; repair of motor vehicles and motorcycles; transportation and storage; accommodation and food service activities	MALTA	52 443	54 053	55 573	56 128	58 015	60 591	62 238	64 274	66 716
	Malta	49 361	50 795	52 225	52 765	54 509	56 953	58 554	60 474	62 682
	Gozo and Comino	3 082	3 258	3 348	3 363	3 506	3 638	3 684	3 800	4 034
Information and communication	MALTA	5 439	5 585	5 949	6 158	6 817	7 311	7 745	8 175	8 557
	Malta	5 228	5 376	5 746	5 929	6 554	6 987	7 424	7 829	8 170
	Gozo and Comino	211	209	203	229	263	324	321	346	387
Financial and insurance activities	MALTA	7 388	7 635	7 946	8 421	8 909	9 470	9 849	10 799	11 741
	Malta	7 071	7 322	7 619	8 089	8 573	9 126	9 496	10 407	11 310
	Gozo and Comino	317	313	327	332	336	344	353	392	431
Real estate activities	MALTA	1 222	1 215	1 253	1 311	1 425	1 690	1 850	2 089	2 356
	Malta	1 100	1 094	1 134	1 196	1 307	1 562	1 706	1 919	2 167
	Gozo and Comino	122	121	119	115	118	128	144	170	189
Professional, scientific and technical activities; administrative and support service activities	MALTA	17 642	18 556	20 051	22 300	26 216	28 705	32 512	36 194	38 403
	Malta	17 033	17 916	19 347	21 555	25 309	27 662	31 088	34 369	2 144
	Gozo and Comino	609	640	704	745	907	1 043	1 424	1 825	55 456
Public administration and defence; compulsory social security; education; human health and social work activities	MALTA	40 326	41 613	42 882	48 136	50 238	49 508	51 212	53 280	49 915
	Malta	36 102	37 281	38 427	43 615	45 546	44 550	46 084	47 921	
	Gozo and Comino	4 224	4 332	4 455	4 521	4 692	4 958	5 128	5 359	5 541
Arts, entertainment and recreation, repair of household goods and other services	MALTA	8 523	8 994	9 588	9 987	10 781	12 207	14 731	16 690	18 219
	Malta	8 080	8 545	9 132	9 514	10 274	11 666	14 150	16 054	17 515
	Gozo and Comino	443	449	456	473	507	541	581	636	704
	MALTA	174 775	179 209	184 343	190 589	199 547	208 082	219 680	232 277	245 983
	Malta	162 666	166 818	171 751	177 851	186 279	194 139	205 002	216 622	229 267
	Gozo and Comino	12 109	12 391	12 592	12 738	13 268	13 943	14 678	15 655	16 716

Source: NSO, Malta Regional Statistics, 2017 & 2020

Note: Foreign workers are included in the dataset as Maltese residents who work on a full-time and part-time basis

2.3.5.3 Agriculture

Although the direct contribution of the agricultural sector to Malta's GDP is modest in extent, it plays significant role in water consumption. Therefore, a more detailed analysis of this sector was carried out, so as to gather and analyse data that could be of potential use for the econometric water demand model (Activity 2: Development of an econometric water demand model).

Specifically, the irrigated land has been estimated by crop category (Potatoes, Permanent cropping exc. Vineyards, Vineyards, Market gardening and Kitchen gardens) over the past 50 years in order to be embedded in the irrigation water consumption estimation (3.2 Water consumption). NSO reports (Agriculture and Fisheries 2000-2014; Census of Agriculture 2001 & 2010; and Malta in Figures: 2004- 2005, 2007-2014) were used as a base in order to produce the irrigated land dataset. However, data for a limited period (e.g. 1970-1983, 2000/01, 2010-2012) are provided in the specific reports (Table 14-Table 17). Additionally, inconsistencies have been observed between the various reports. Therefore, in order to proceed with a complete dataset, missing values were filled based on the assumptions described in Appendix 3. In Table 18, estimated irrigated land in 5-year averages over the past 50 years is presented. To proceed with irrigation water consumption estimation per LAU (3.2.2 Irrigation water consumption), the percentage distribution of irrigated land, for each crop category, among LAUs deriving from Census of Agriculture 2010 (Table 19) has been adopted.

Table 14: Land declared by farmers by year and type (in Ha)

Year	Total agricultural land area	of which	
		Irrigated land	Dry land
1970 / 71	13,203	625	12,578
1971 / 72	12,825	578	12,247
1972 / 73	12,657	620	12,037
1973 / 74	12,673	670	12,003
1974 / 75	12,564	683	11,881
1975 / 76	12,857	690	12,167
1976 / 77	13,006	715	12,291
1977 / 78	12,585	624	11,961
1978 / 79	12,353	604	11,749
1979 / 80	12,299	618	11,681
1980 / 81	11,617	586	11,031
1981 / 82	11,639	585	11,054
1982 / 83	11,491	580	10,911
2000 / 01	10,149	1,509	8,640

Source: NSO, Census of Agriculture 2001

Table 15: Agricultural land by district and type, year 2000 (in Ha)

District	Total Area	Irrigated Land	Dry Land
MALTA	10,738	1,143	8,240
Malta	8,956	1,055	6,735
Southern Harbour	524	121	360
Northern Harbour	350	79	242
South Eastern	1,961	140	1,580
Western	3,525	301	2,728
Northern	2,597	415	1,826
Gozo and Comino	1,782	88	1,505

Source: NSO, Agriculture and Fisheries 2000

Table 16: Land declared by farmers by district and type, years 2001-2004 (in Ha)

District	Total Area	Irrigated Land	Dry Land
MALTA	11,620	1,509	8,640
Malta	9,394	1,374	6,826
Southern Harbour	532	161	329
Northern Harbour	332	73	223
South Eastern	2,123	182	1,672
Western	3,684	385	2,822
Northern	2,722	572	1,779
Gozo and Comino	2,226	135	1,814

Source: NSO, Agriculture and Fisheries 2001-2004

Table 17: Land declared by farmers by district and type, years 2001-2012 (in Ha)

	2001-2006		2007-2009		2010-2012	
	Irrigated land	Dry land	Irrigated land	Dry land	Irrigated land	Dry land
Malta (Island)	1,374	6,826	2,886	5,148	3,003	5,837
Gozo	135	1,814	317	1,975	495	2,118
Total	1,509	8,640	3,203	7,123	3,498	7,954

Source: NSO, Malta in Figures 2004-2005, 2007-2014

Table 18: Irrigated land, 5-year averages over the past 50 years (in Ha)

Period	Irrigated land
1969-1973	664
1974-1978	676
1979-1983	686
1984-1988	1,159
1989-1993	1,284
1994-1998	1,409
1999-2003	1,469
2004-2008	2,742
2009-2013	3,732
2014-2018	3,810

Source: Authors' own estimates

Table 19: Irrigated land per crop and LAU (in Ha)

Crops	Irrigated land							
	Maltese Islands	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
Total	3,498.4	3,003.2	305.1	177.6	496	1,013.6	1,010.8	495.2
Potatoes	631.9	592.8	127	27.3	195.2	147.8	95.5	39.1
Flowers and seeds	65.5	63.9	6.8	13.2	7.7	19.9	16.3	1.6
Vegetables	1,357.1	1,143.5	58.3	46.9	76.4	385.3	576.6	213.7
Kitchen gardens	586.5	500.5	55.9	44	146.8	137.6	116.1	86.1
Fruit and berry plantations	228.1	212.6	6.3	8.9	6.6	122.7	68.1	15.5
Citrus plantations	103.5	49.7	5	5.5	2.4	30.3	6.4	53.8
Olive groves	93.6	76.7	6.6	15.1	12.9	20.7	21.5	16.9
Vineyards	432	363.4	39.3	16.8	48.1	149	110.2	68.6

Source: Census of Agriculture 2010 (NSO, 2012)

The estimated irrigated area (Table 18) reflects the following remarks:

- The total agricultural land area was reduced by 23% between 1970 and 2000 (Table 14). Nevertheless, the irrigated land, within the same period, increased by more than 140%, from 625 Ha to 1,509 Ha.
- Within a decade (from 2001 to 2010), the irrigated land increased sharply by another 130%, reaching almost 3,500 Ha. The main driver behind this increase in the irrigated land area was revenue generation, backed by liberalization in water use, declining costs of borehole construction, and improvements in irrigation technology.

As regards livestock breeding, the emphasis was given to the population of animals (e.g. cattle, poultry, etc.) using the “Agriculture and Fisheries” series reports of NSO. Given that the available data sets are limited in terms of spatial and temporal coverage, missing values were imputed with linear interpolation and moving averages approaches. The results are presented in Table 20 to

Table 25.

Table 20: Cattle, pig, sheep, goat and poultry population, 5-year averages over the past 50 years (number)

Period	Cattle	Pig	Sheep	Goat	Poultry
1969-1973	9405	24369	7235	2417	762217
1974-1978	12947	29105	6945	3011	951602
1979-1983	12835	35208	4657	3756	1195654
1984-1988	13956	58079	5717	4092	1233054
1989-1993	15893	65934	7381	4692	1485694
1994-1998	17830	73790	9045	5217	1738333
1999-2003	18700	78358	11770	5399	2534376
2004-2008	19120	73140	13220	6065	2308323
2009-2013	15421	55490	11956	5095	1932953
2014-2018	14744	43661	11076	4860	1822765

Source: Adapted from NSO, Agriculture and Fisheries 2001-2014

Table 21: Cattle population percentage by region over the past 50 years - 5-year averages

Period	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	69.5%	7.9%	12.8%	29.9%	12.1%	6.8%	30.5%
1974-1978	69.5%	7.9%	12.8%	29.9%	12.1%	6.8%	30.5%
1979-1983	69.5%	7.9%	12.8%	29.9%	12.1%	6.8%	30.5%
1984-1988	69.5%	7.9%	12.8%	29.9%	12.1%	6.8%	30.5%
1989-1993	69.5%	7.9%	12.8%	29.9%	12.1%	6.8%	30.5%
1994-1998	69.5%	7.9%	12.8%	29.9%	12.1%	6.8%	30.5%
1999-2003	69.0%	8.4%	12.5%	28.9%	12.1%	7.2%	31.0%
2004-2008	68.3%	9.7%	9.6%	26.8%	12.7%	9.5%	31.7%
2009-2013	66.8%	9.4%	8.3%	24.7%	14.6%	9.8%	33.2%
2014-2018	67.2%	9.2%	8.3%	23.3%	15.4%	11.0%	32.8%

Source: Adapted from NSO, Agriculture and Fisheries 2001-2014

Table 22: Pig population percentage by region over the past 50 years - 5-year averages

Period	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	93.1%	9.3%	12.2%	20.3%	33.5%	17.7%	6.9%
1974-1978	93.1%	9.3%	12.2%	20.3%	33.5%	17.7%	6.9%
1979-1983	93.1%	9.3%	12.2%	20.3%	33.5%	17.7%	6.9%
1984-1988	93.1%	9.3%	12.2%	20.3%	33.5%	17.7%	6.9%
1989-1993	93.1%	9.3%	12.2%	20.3%	33.5%	17.7%	6.9%
1994-1998	93.1%	9.3%	12.2%	20.3%	33.5%	17.7%	6.9%
1999-2003	93.5%	8.6%	14.5%	22.0%	31.2%	17.5%	6.5%

2004-2008	93.7%	8.1%	11.8%	20.1%	32.7%	21.0%	6.4%
2009-2013	92.7%	6.5%	8.5%	19.4%	36.2%	22.0%	7.3%
2014-2018	90.4%	5.4%	9.2%	18.5%	34.9%	22.3%	9.6%

Source: Adapted from NSO, Agriculture and Fisheries 2001-2014

Table 23: Sheep population percentage by region over the past 50 years - 5-year averages

Period	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	64.6%	4.7%	6.1%	18.7%	21.0%	14.1%	35.4%
1974-1978	64.6%	4.7%	6.1%	18.7%	21.0%	14.1%	35.4%
1979-1983	64.6%	4.7%	6.1%	18.7%	21.0%	14.1%	35.4%
1984-1988	64.6%	4.7%	6.1%	18.7%	21.0%	14.1%	35.4%
1989-1993	64.6%	4.7%	6.1%	18.7%	21.0%	14.1%	35.4%
1994-1998	64.6%	4.7%	6.1%	18.7%	21.0%	14.1%	35.4%
1999-2003	64.7%	4.2%	6.2%	17.4%	21.9%	14.9%	35.3%
2004-2008	65.8%	4.9%	7.3%	20.6%	20.0%	13.1%	34.2%
2009-2013	70.3%	6.1%	8.1%	22.7%	21.0%	12.4%	29.7%
2014-2018	72.1%	6.5%	7.5%	23.5%	22.5%	12.2%	27.9%

Source: Adapted from NSO, Agriculture and Fisheries 2001-2014

Table 24: Goat population percentage by region over the past 50 years - 5-year averages

Period	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	71.3%	8.7%	11.1%	29.5%	14.6%	7.3%	24.4%
1974-1978	71.3%	8.7%	11.1%	29.5%	14.6%	7.3%	24.4%
1979-1983	71.3%	8.7%	11.1%	29.5%	14.6%	7.3%	24.4%
1984-1988	71.3%	8.7%	11.1%	29.5%	14.6%	7.3%	24.4%
1989-1993	71.3%	8.7%	11.1%	29.5%	14.6%	7.3%	24.4%
1994-1998	71.3%	8.7%	11.1%	29.5%	14.6%	7.3%	24.4%
1999-2003	71.8%	9.4%	10.6%	29.5%	13.9%	8.4%	25.6%
2004-2008	75.7%	12.7%	11.8%	25.7%	17.5%	8.0%	24.3%
2009-2013	76.8%	15.1%	11.3%	23.7%	17.8%	8.9%	23.2%
2014-2018	75.4%	17.3%	8.6%	22.6%	19.0%	8.0%	24.6%

Source: Adapted from NSO, Agriculture and Fisheries 2001-2014

Table 25: Poultry population percentage by region over the past 50 years - 5-year averages

Period	Malta region	Gozo and Comino
1969-1973	77.9%	22.1%
1974-1978	77.9%	22.1%
1979-1983	77.9%	22.1%
1984-1988	77.9%	22.1%
1989-1993	77.9%	22.1%
1994-1998	77.9%	22.1%
1999-2003	77.8%	22.2%
2004-2008	79.5%	20.5%
2009-2013	78.8%	21.2%
2014-2018	77.4%	22.6%

Source: Adopted from NSO, Agriculture and Fisheries 2001-2014

In general, livestock population has increased in Malta during the last 50 years (from 55% in goats up to 140% in poultry). Nevertheless, this trend differs among the districts. For instance, as far as cattle population is concerned, the average increase in Malta is 57%, but exceeds 150% in Northern district. On the contrary, cattle population in Northern Harbour and South Eastern districts, increased at a rate of 2% and 2%, respectively. Similar findings are noticed in the cases of pigs, sheep and goats (Table 26).

Table 26: Change in livestock by district during the last 50 years

	Cattle	Pigs	Sheep	Goats	Poultry
MALTA	57.3%	73.3%	54.7%	101.9%	137.9%
Malta	52.1%	68.3%	73.7%	113.7%	137.9%
Southern Harbour	82.6%	1.1%	129.1%	302.2%	--
Northern Harbour	1.8%	30.1%	81.8%	56.4%	--
South Eastern	22.4%	58.1%	94.0%	54.7%	--
Western	101.5%	80.7%	65.7%	162.3%	--
Northern	154.8%	118.1%	36.8%	118.5%	--
Gozo and Comino	69.2%	140.5%	19.9%	102.8%	137.9%

Source: Adapted from NSO, Agriculture and Fisheries 2001-2014

As mentioned, in order to fill the missing data for livestock over the period of 50 years commonly used imputation techniques (e.g. linear interpolation) were used. The total livestock population was tested with statistical data obtained for Malta from the World Bank (<https://data.worldbank.org/country/malta>). More specifically, these data refer to the livestock production index (LVIPI), which includes meat and milk from all sources, dairy products such as cheese, and eggs, honey, raw silk, wool, and hides and skins and shows livestock production for each year relative to the base period 2004-2006.

The pattern of the two parameters is shown in Figure 32, and the 5-year averages are given in Table 27. The Spearman's rank correlation coefficient, which was used to evaluate the relationship between the estimated total livestock population and the LIVPI was statistically significant and high (i.e. 89%) indicating a robust imputation approach.

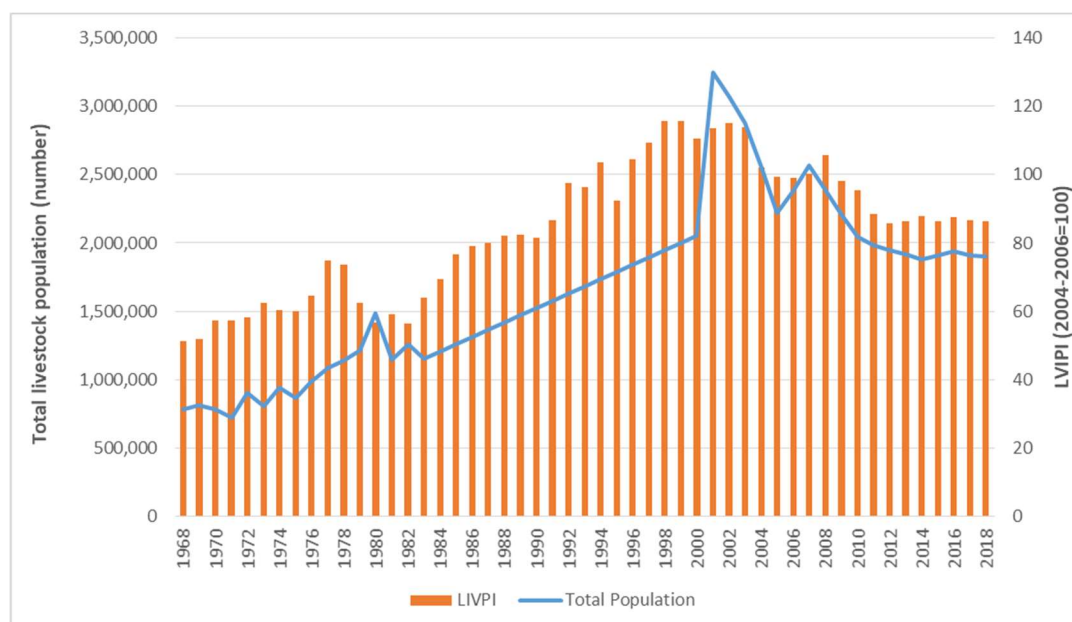


Figure 32: Total livestock population and LIVPI over the past 50 years (for LIVPI 2004-2006=100)

(Source: Adapted from World Bank. Available from: <https://data.worldbank.org/country/malta>)

Table 27: Total livestock population and LIVPI 5-year averages over the past 50 years

Period	Total livestock population	LIVPI
1969-1973	805,642	57.5
1974-1978	1,003,610	66.6
1979-1983	1,252,111	59.8
1984-1988	1,314,899	77.4
1989-1993	1,579,595	88.9
1994-1998	1,844,215	105.1
1999-2003	2,648,602	113.6
2004-2008	2,419,869	101.2
2009-2013	2,020,916	90.8
2014-2018	1,907,830	86.9

Source: Adapted from World Bank (Available from: <https://data.worldbank.org/country/malta>)

2.3.5.4 Industry

A detailed analysis of Industry for the period of interest based on NSO data is not feasible for two reasons. First, the available data cover only a short period of time, as presented in the following tables. Second, the reporting format changed after 2010 (i.e. the turnover index in

industry by main industrial grouping and flow is reported, instead of the total sales in manufacturing industry). Table 28 and Table 29 show the total sales in manufacturing industry for 2001-2002 and 2003-2008, respectively.

Table 28: Total sales in manufacturing industry, 2001-2002 (in '000 €)

Sector	2001	2002
Food and Beverages	263,554	276,424
Tobacco products	82,970	69,795
Textiles and textile products	23,249	41,050
Wearing apparel and clothes	136,967	142,399
Leather and leather products	38,188	32,250
Wood and wood products	1,239	1,099
Paper and paper products	17,039	17,000
Publishing and printing	76,904	99,758
Chemicals and chemical products	80,892	81,218
Rubber and plastic products	88,626	91,931
Other non-metallic mineral products	31,051	32,208
Basic metals products	1,274	913
Fabricated metal products	32,702	37,016
Machinery and equipment n.e.c.	30,382	25,176
Office machinery and computers	3,224	2,704
Electrical machinery and apparatus	104,381	94,295
Radio, TV and Communication equipment	1,106,952	1,069,733
Medical, precision and optical instruments	42,581	53,161
Motor vehicles, trailers and semi-trailers	2,462	1,654
Other transport equipment	13,026	16,988
Furniture and Manufacturing n.e.c.	129,837	123,147
Totals	2,307,500	2,309,920

Source: Adapted from NSO (2004). MTL converted to Euro: 1 MTL = 2.32937 EUR

In order to overcome these difficulties, data provided from the World Bank relating to the value added from manufacturing as percentage of GDP were used. As presented in Figure 33 and Table 30, which provides the 5-year averages of the above-mentioned parameters and the contribution of specific sectors in manufacturing, the contribution of industry (including construction) and manufacturing declines. As regards the impact of other sectors, "Food, beverages and tobacco" industry becomes less important in manufacturing and the same stands for "Textiles and clothing" industry, which presents a sharp decline. On the contrary, "Chemicals", "Machinery and transport equipment" and "Other manufacturing" appear to have a positive outlook.

Table 29: Total sales in manufacturing industry, 2003-2008 (in '000 €)

Sector	2003	2004	2005	2006	2007	2008
Food and Beverages; Tobacco	359,997	348,679	339,675	319,286	262,023	287,003
Textiles and textile products	36,084	62,180	56,429	44,788	44,526	42,822
Wearing apparel and clothes	124,165	88,692	64,464	52,479	38,275	31,164
Leather and leather products	25,392	18,335	12,634	6,620	5,012	2,222
Wood and wood products	1,158	1,398	1,864	1,620	1,620	3,018
Paper and paper products	17,335	17,474	15,746	17,004	15,640	16,055
Publishing and printing	114,903	113,195	122,694	121,783	139,798	147,440
Chemicals and chemical products	86,298	67,332	108,031	163,737	215,411	219,706
Rubber and plastic products	88,523	89,994	88,872	92,745	98,632	94,833
Other nonmetallic mineral products	33,228	34,207	47,634	50,432	49,192	62,531
Fabricated metal products	37,209	33,671	43,455	43,691	47,157	54,565
Machinery and equipment n.e.c.	30,105	28,342	33,887	33,598	35,015	33,032
Electrical machinery and apparatus	111,803	120,851	138,819	114,110	142,580	132,453
Radio, TV and Communication equipment	1,112,544	1,126,170	923,798	1,181,299	1,105,235	908,157
Medical, precision and optical instruments	46,674	43,827	43,891	49,612	45,526	46,738
Motor vehicles, trailers and semitrailers	1,654	1,485	1,408	1,301	1,017	535
Other transport equipment	37,391	30,403	29,696	25,909	23,572	28,025
Furniture and Manufacturing n.e.c.	117,936	104,795	103,434	111,722	113,950	97,363
Totals	2,382,400	2,331,030	2,176,431	2,431,736	2,384,181	2,207,662

Source: Adapted from NSO (2004 – 2009). 2003 MTL figures converted to Euro: 1 MTL = 2.32937 EUR

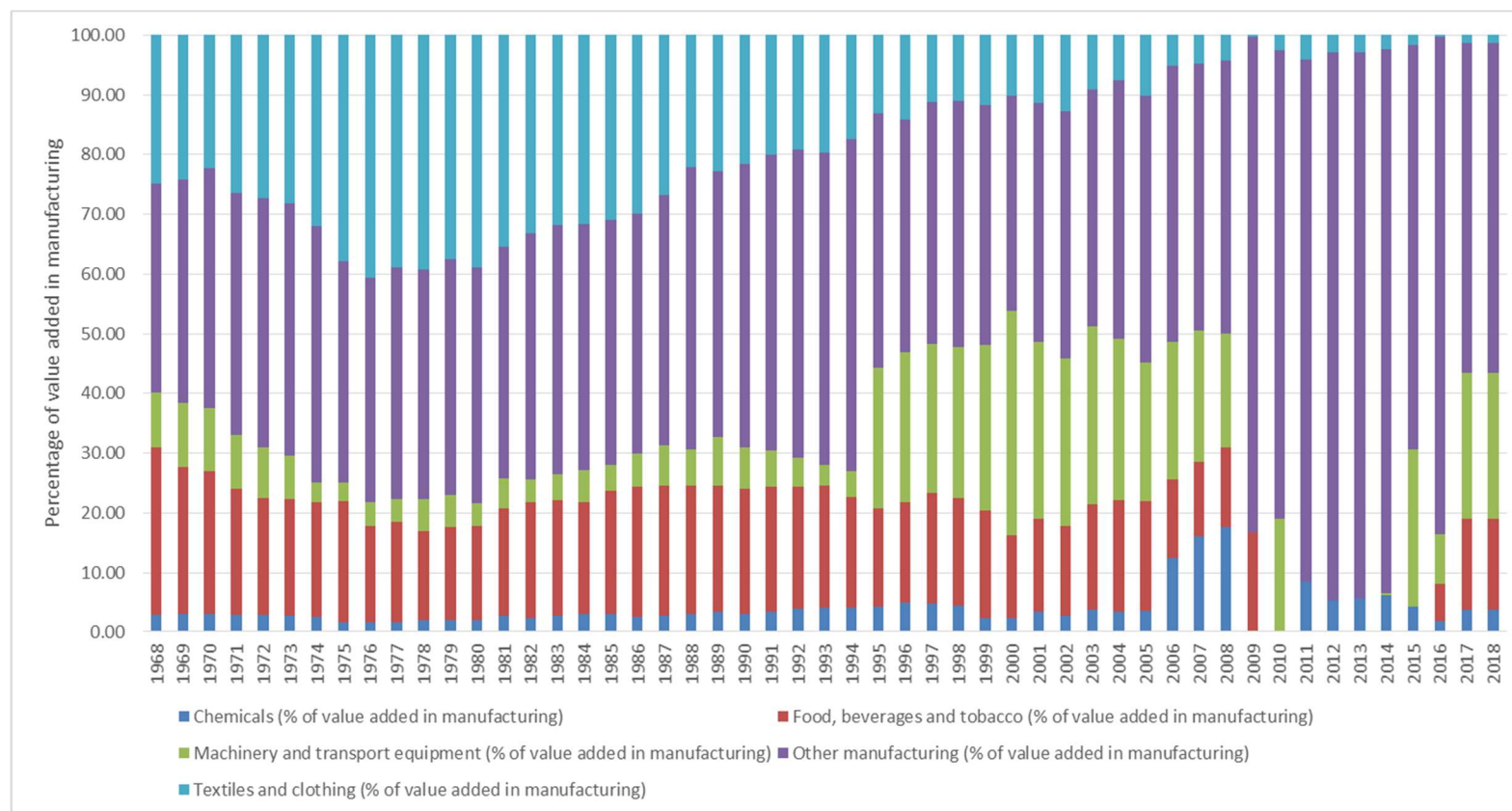


Figure 33: Contribution of Industry and Manufacturing in GDP over the past 50 years

(Source: World Bank. Available from: <https://data.worldbank.org/country/malta>)

Note: Other manufacturing covers wood and related products, paper and related products, petroleum and related products, basic metals and mineral products, fabricated metal products and professional goods, and other industries. Includes also unallocated data. When data for textiles, machinery, or chemicals are shown as not available, they are included in other manufacturing.

Table 30: Contribution of Manufacturing in GDP and specific sectors in Manufacturing, 5-year averages over the past 50 years

Period	Manufacturing, value added (% of GDP)	Chemicals (% of value added in manufacturing)	Food, beverages and tobacco (% of value added in manufacturing)	Machinery and transport equipment (% of value added in manufacturing)	Other manufacturing (% of value added in manufacturing)	Textiles and clothing (% of value added in manufacturing)
1969-1973	18.3	3.0	21.7	9.2	40.4	25.7
1974-1978	26.5	1.8	17.6	3.9	38.9	37.7
1979-1983	25.9	2.2	17.8	4.5	40.1	35.4
1984-1988	23.6	2.9	21.0	5.6	42.3	28.3
1989-1993	21.0	3.7	20.8	5.8	49.1	20.6
1994-1998	18.3	4.5	17.7	20.6	43.8	13.4
1999-2003	17.2	2.9	16.2	30.5	39.4	11.0
2004-2008	12.8	10.6	15.2	22.8	44.9	6.4
2009-2013	10.9	6.5	16.8	19.1	86.4*	2.6
2014-2018	7.6	4.0	12.2	16.8	70.5*	1.4

Source: Adapted from World Bank (<https://data.worldbank.org/country/malta>)

*: Between 2009 and 2014 “Other manufacturing” includes “Machinery and transport equipment” and “Chemicals”

2.3.5.5 Tourism

Inbound tourist data (i.e. inbound tourist departures by air and sea and cruise passengers) and supplementary information (e.g. average length of stay, nights spent at tourist accommodation establishments, etc.) was provided by the Malta Tourism Authority's Research Unit via email on September 11, 2019. The number of inbound tourists skyrocketed by 14 times during the past 50 years, i.e. from 186,080 to 2,598,690, breaking the one million mark in 1992 and the two millions in 2017 (Figure 34). Further, during the same period, cruise passengers increased by more than 10 times (from around 62,000 to 630,000). Figure 35 displays data on guest nights.

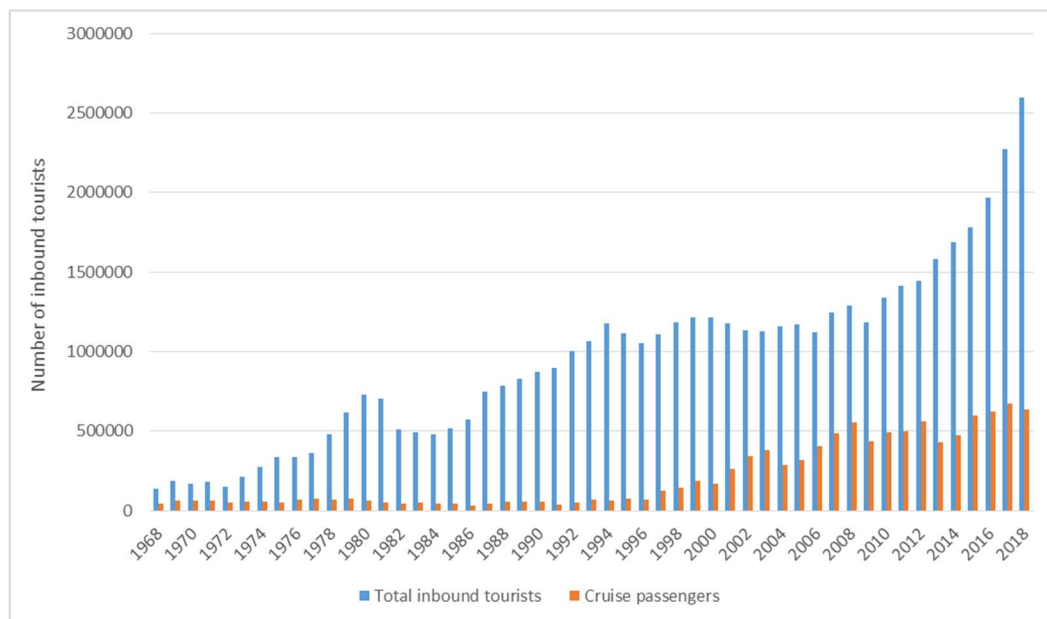


Figure 34: Annual number of inbound tourists and cruise passengers over the past 50 years

(Source: Malta Tourism Authority's Research Unit, personal communication)

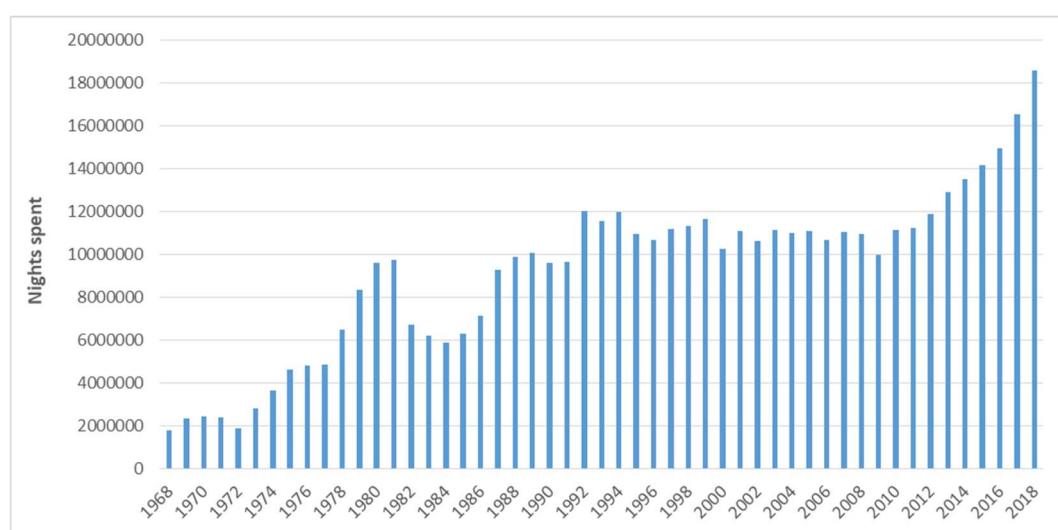


Figure 35: Nights spent at tourist accommodation establishments over the past 50 years

(Source: Malta Tourism Authority's Research Unit, personal communication)

Based on these figures, the equivalent population of tourists was estimated by dividing the number of nights spent by 365 days per year (Figure 36). The equivalent population increased by almost 8 times during the period under investigation (i.e. from around 6,400 to 50,900) and almost doubled since 2010.

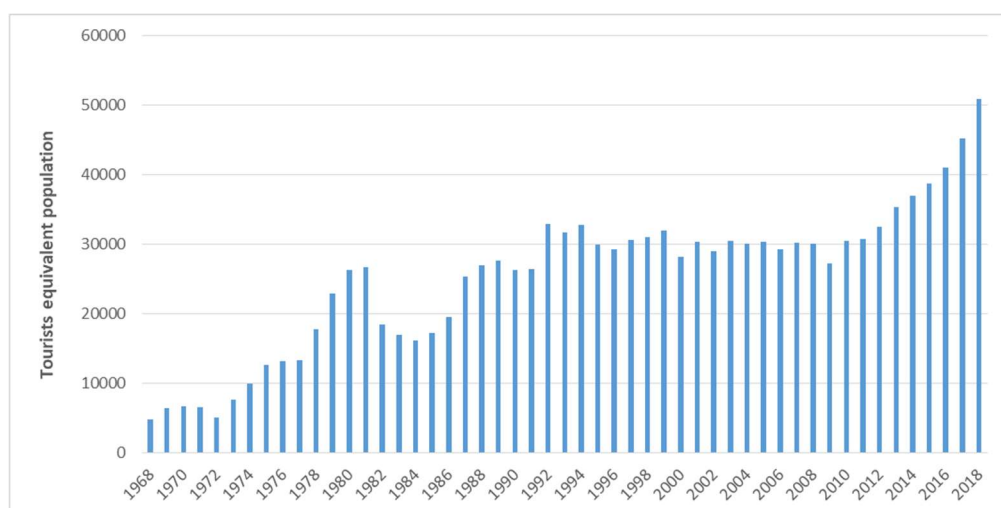


Figure 36: Equivalent population of tourists over the past 50 years

(Source: Adapted from Malta Tourism Authority's Research Unit)

Table 31 presents the 5-year averages regarding total annual inbound tourists and the tourist equivalent population. Further, Table 32 illustrates the estimated 5-year average tourist equivalent population by region taking into consideration the profile of the collective accommodation by region/district (NUTS 3 and LAU 1) and year provided by the NSO Regional Statistics reports (2017 & 2020). Finally, Table 33 and Table 34 and Figure 37 and Figure 38 illustrate the average inbound tourists and the tourist equivalent population per month for the 50-year period. The tourist season seems to start late April till late October, with high season being from July to September.

Table 31: Total annual inbound tourists and equivalent population of tourists, 5-year averages over the past 50 years

Period	Total annual inbound tourists	Tourist equivalent population
1969-1973	179,350	6,478
1974-1978	357,237	13,368
1979-1983	610,863	22,250
1984-1988	620,318	21,044
1989-1993	932,143	28,972
1994-1998	1,127,877	30,710
1999-2003	1,174,100	29,975
2004-2008	1,197,045	29,972
2009-2013	1,392,383	31,281
2014-2018	2,062,326	42,583

Source: Adapted from Malta Tourism Authority's Research Unit

Table 32: Equivalent population of tourists by region over the past 50 years - 5-year averages

Period	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	6,478	6,187	235	2,784	42	93	3,033
1974-1978	13,368	12,767	485	5,745	86	191	6,259
1979-1983	22,250	21,337	811	9,602	144	320	10,461
1984-1988	21,044	20,202	768	9,091	136	303	9,905
1989-1993	28,972	27,813	1,057	12,516	187	417	13,636
1994-1998	30,710	29,482	1,120	13,267	198	442	14,454
1999-2003	29,975	28,894	1,098	13,002	194	433	14,166
2004-2008	29,972	28,923	1,099	13,016	195	434	14,180
2009-2013	31,281	30,187	1,147	13,584	203	453	14,800
2014-2018	42,583	41,093	1,562	18,492	276	616	20,147

Source: Adapted from MTA Research Unit & NSO (2017 & 2020)

Table 33: Averaged inbound tourists per month over the past 50 years, 5-year averages

	January	February	March	April	May	June	July	August	September	October	November	December
1969-1973	6,236	6,792	11,906	15,430	16,116	15,940	24,146	26,774	18,548	15,598	10,520	11,348
1974-1978	12,302	14,448	22,838	27,466	32,704	35,720	48,868	49,718	38,438	32,426	21,728	20,588
1979-1983	23,188	26,984	40,122	46,176	59,548	63,842	81,558	83,930	71,050	53,974	32,344	28,146
1984-1988	18,734	23,686	36,814	42,946	59,192	63,550	80,948	92,278	75,408	62,120	33,764	30,874
1989-1993	32,093	40,973	59,247	74,696	91,373	94,349	114,182	125,851	107,008	90,697	56,869	44,806
1994-1998	39,493	54,260	83,863	103,577	110,271	106,948	138,033	146,681	121,104	105,482	64,167	53,997
1999-2003	42,328	55,933	83,518	104,841	112,035	116,779	148,217	153,710	127,614	110,001	64,581	54,542
2004-2008	53,699	50,142	72,680	96,983	112,216	116,929	139,823	174,932	133,693	128,332	73,003	44,950
2009-2013	59,359	58,645	83,438	115,837	131,235	140,086	163,158	195,365	154,975	148,770	84,203	57,312
2014-2018	91,492	89,365	124,520	179,656	200,585	206,889	233,921	266,726	218,446	219,061	138,817	92,849

Source: Central Bank of Malta data (<https://www.centralbankmalta.org/real-economy-indicators>) prior to 1989 and Malta Tourism Authority's Research Unit onwards, authors' own estimates

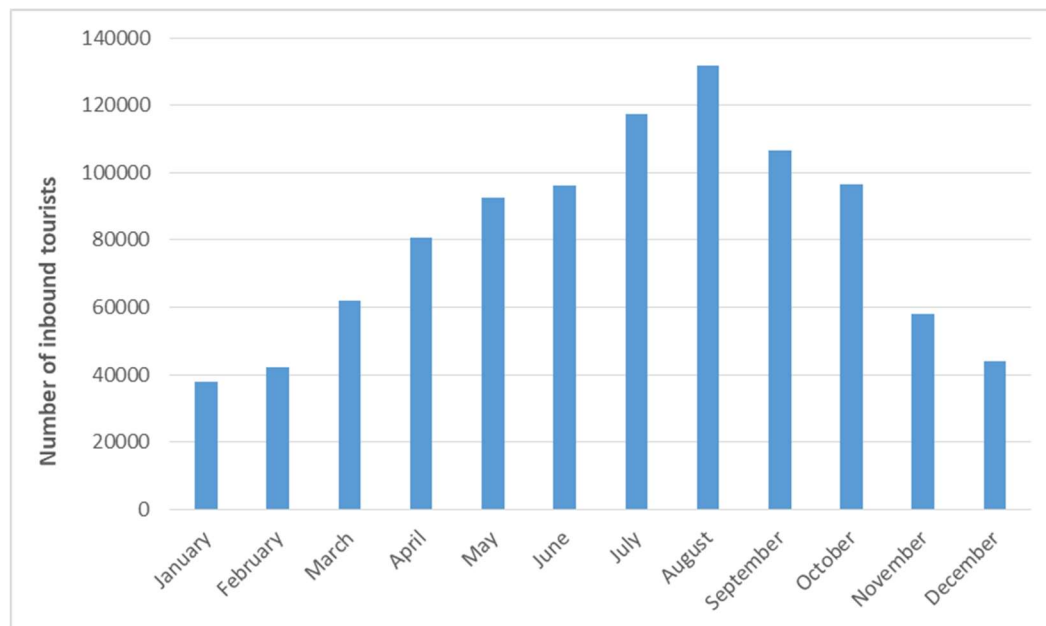


Figure 37: Averaged number of inbound tourists per month over the past 50 years

Source: Adapted from Central Bank of Malta data (<https://www.centralbankmalta.org/real-economy-indicators>) prior to 1989 and Malta Tourism Authority's Research Unit onwards

Table 34: Averaged equivalent population of tourists per month over the past 50 years, 5-year averages

	January	February	March	April	May	June	July	August	September	October	November	December
1969-1973	2,693	3,163	4,631	5,474	4,860	4,822	8,239	11,385	8,595	6,688	4,261	4,519
1974-1978	5,546	7,021	9,270	10,211	10,331	11,305	17,447	22,152	18,670	14,562	9,219	8,598
1979-1983	10,128	12,710	15,753	16,627	18,192	19,578	28,189	36,210	33,409	23,476	13,316	11,387
1984-1988	7,579	10,326	13,412	14,309	16,778	18,064	25,953	36,910	32,900	25,083	12,889	11,584
1989-1993	11,920	16,403	19,811	22,824	23,770	24,592	33,542	46,132	42,753	33,498	19,846	15,392
1994-1998	12,650	18,711	24,186	27,279	24,689	24,028	34,992	46,377	41,784	33,675	19,342	16,016
1999-2003	12,913	18,421	22,944	26,325	23,958	25,033	35,846	46,418	41,968	33,477	18,558	15,412
2004-2008	15,735	16,431	20,089	26,196	26,346	30,357	40,913	58,282	42,040	36,768	19,884	12,617
2009-2013	15,673	16,452	19,744	26,307	29,497	35,777	50,718	64,089	44,023	36,798	20,938	15,295
2014-2018	22,014	21,632	26,750	39,056	43,251	50,279	64,619	79,296	57,779	50,370	31,341	22,749

Source: Adapted from Central Bank of Malta data (<https://www.centralbankmalta.org/real-economy-indicators>) prior to 1989 and Malta Tourism Authority's Research Unit onwards

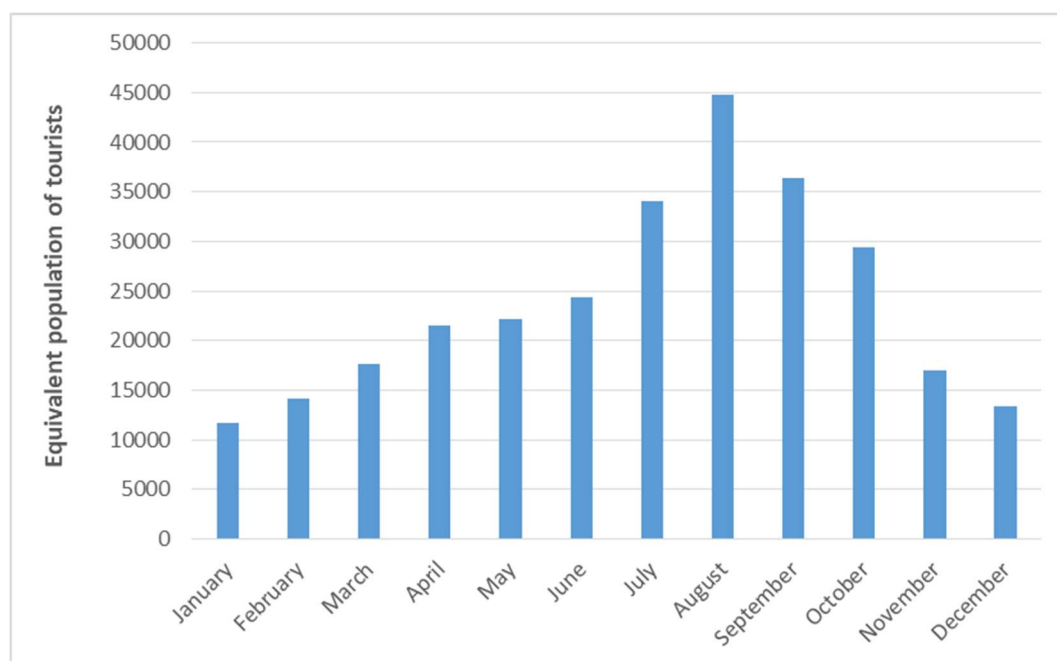


Figure 38: Averaged equivalent population of tourists per month over the past 50 years

Source: Adapted from Central Bank of Malta data (<https://www.centralbankmalta.org/real-economy-indicators>) prior to 1989 and Malta Tourism Authority's Research Unit onwards

The analysis of the total nights spent in all accommodations shows that there is a shift in preferences from collective accommodation⁴ towards stays in private accommodation establishments⁵. According to Attard (2018) and Ellul (2019), nights spent in collective accommodation increased from 7.8 million nights in 2008 to 10.1 million in 2018, while the nights spent at private accommodation rose from 3.1 million in 2008 to 8.5 million in 2018. This change in preference is mainly driven by technological advances and the ease in booking alternative accommodation on online platforms (Attard, 2018). As shown in Figure 39, in 2001, nights in private accommodation amounted to less than 20% of total nights, while, in 2017 the share of private accommodation increased to 43%. Based on the 2018 data (NSO, 2020), private accommodation share increased further to 45.5%. It should be mentioned, that the share of private accommodation is significantly higher in Gozo and Comino. According to NSO (2020), in 2011 the share of private accommodation was around 27% in Malta and 70% in Gozo and Comino, respectively. In 2018, the gap decreased significantly, i.e. the share of private accommodation was 43% in Malta and 74% in Gozo and Comino. Nevertheless, it should not be forgotten that the total nights spent in Gozo and Comino are less than 3.5% of the total nights spent in the Maltese Islands. The change in tourists' preferences, i.e. the growth in private accommodation, is a global phenomenon and not exclusive to Malta (Attard, 2018) and is definitely an issue that should also be taken into consideration from a water demand perspective (e.g. those who stay at private residences, with friends and at other private accommodations usually consume less water).

⁴ Collective accommodation includes include hotels, guesthouses, hostels, tourist villages, holiday complexes, bed & breakfasts, and campsites

⁵ Private accommodation includes rented accommodation, own private residence, staying with friends and other private accommodations

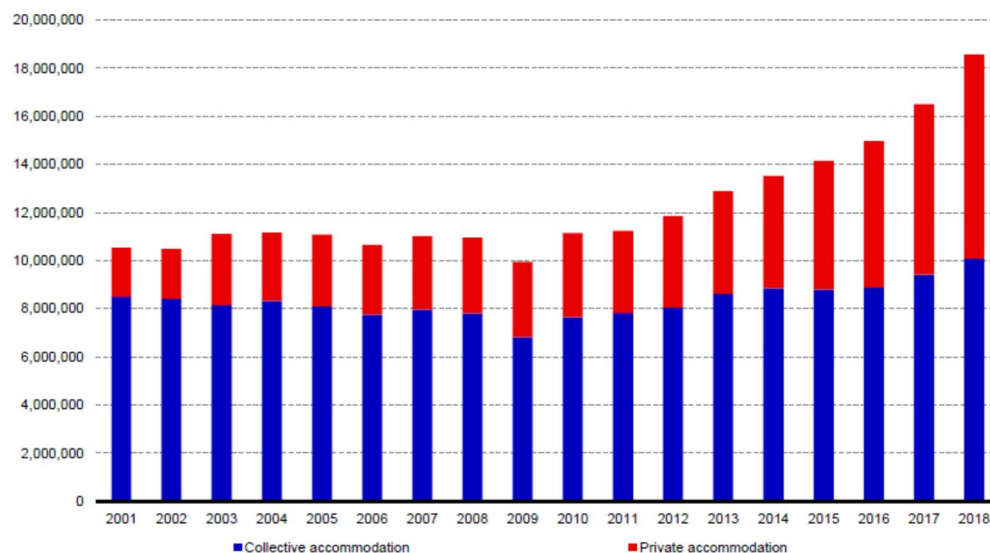


Figure 39: Nights spent in collective and private accommodation (in millions)

(Source: Ellul, 2019)

Based on the above-mentioned information, the number of tourists residing in collective and private accommodation was estimated over the time period under consideration, across all regions (Figure 40, Figure 41). The results of the analysis are presented hereinafter (Table 35, Table 36) in terms of 5-year averages. The complete time series data is available in the dataset (Supplement 1 to this report).

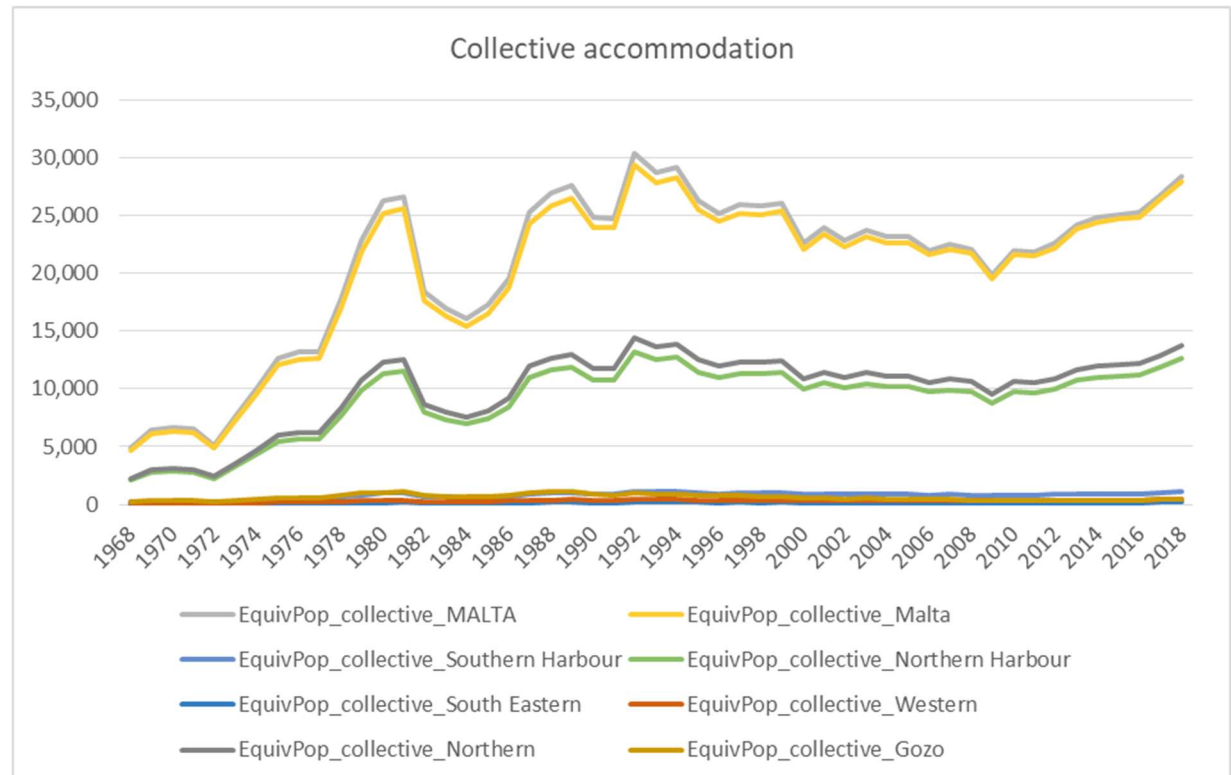


Figure 40: Equivalent population of tourists residing in collective accommodation

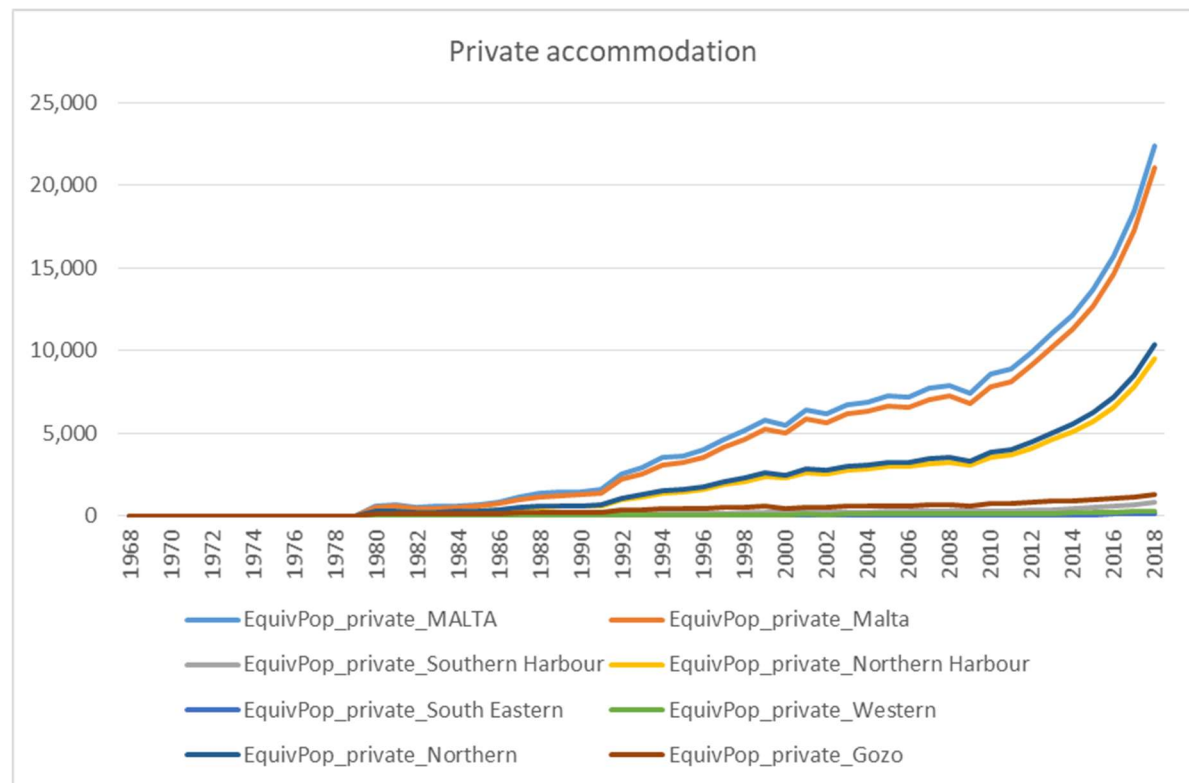


Figure 41: Equivalent population of tourists residing in private accommodation

Table 35: Equivalent population of tourists residing in collective accommodation by region over the past 50 years - 5-year averages

Period	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	6,478	6,187	235	2,784	42	93	3,033
1974-1978	13,368	12,767	485	5,745	86	191	6,259
1979-1983	22,250	21,337	811	9,602	144	320	10,461
1984-1988	21,044	20,202	768	9,091	136	303	9,905
1989-1993	27,261	26,332	1,001	11,849	177	395	12,910
1994-1998	26,507	25,730	978	11,579	173	386	12,615
1999-2003	23,849	23,302	885	10,486	157	350	11,424
2004-2008	22,585	22,156	842	9,970	149	332	10,862
2009-2013	22,110	21,768	827	9,796	146	327	10,672
2014-2018	26,084	25,688	976	11,560	173	385	12,594

Source: Adapted from MTA Research Unit & NSO (2017 & 2020); Attard (2018); and Ellul (2019)

Table 36: Equivalent population of tourists residing in private accommodation by region over the past 50 years - 5-year averages

Period	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	0	0	0	0	0	0	0
1974-1978	0	0	0	0	0	0	0
1979-1983	485	405	15	182	3	6	199
1984-1988	922	785	30	353	5	12	385
1989-1993	2,001	1,730	66	778	12	26	848
1994-1998	4,203	3,751	143	1,688	25	56	1,839
1999-2003	6,126	5,592	213	2,516	38	84	2,742
2004-2008	7,388	6,768	257	3,045	46	102	3,318
2009-2013	9,171	8,419	320	3,788	57	126	4,127
2014-2018	16,499	15,405	585	6,932	104	231	7,552

Source: Adapted from MTA Research Unit & NSO (2017 & 2020); Attard (2018); and Ellul (2019)

2.3.5.6 Domestic sector

For reasons previously mentioned, it's not possible to analyse socio-economic data, such as household income, household expenditure, housing characteristics, living conditions, etc., and identify trends or relationships with water consumption over the time period and for all districts examined. However, some key features are given hereinafter, based on the most recent data of NSO and Eurostat.

According to the NSO Household Budgetary Surveys of 2000, 2008 and 2015 and the NSO Regional Statistics reports (NSO, 2003, 2010, 2017, 2018a & 2020), the distribution of households by district is presented in the following Table 37. The distribution of households, with the exception of Northern district, remains practically stable across districts. Further, the average size of households shows a slight decrease in all districts (

Table 38).

Table 37: Distribution of households by district: 2000, 2008, and 2010-2018

District	2000	2008	2010	2011	2012	2013	2014	2015	2016	2017	2018
Southern Harbour	22.5%	19.9%	19.4%	19.2%	19.0%	18.7%	18.2%	17.8%	17.4%	17.0%	16.6%
Northern Harbour	32.2%	30.8%	30.3%	30.3%	30.2%	30.6%	31.1%	31.9%	32.4%	32.8%	33.5%
South Eastern	13.0%	14.2%	14.5%	14.5%	14.6%	14.7%	14.8%	14.7%	14.6%	14.5%	14.2%
Western	12.8%	12.9%	12.9%	12.9%	12.8%	12.7%	12.5%	12.2%	12.0%	11.8%	11.5%
Northern	11.9%	14.5%	15.2%	15.5%	15.7%	15.8%	15.9%	16.1%	16.5%	16.9%	17.3%
Gozo and Comino	7.6%	7.7%	7.6%	7.6%	7.6%	7.5%	7.4%	7.2%	7.1%	7.0%	6.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Adapted from NSO (2003, 2017, 2018 & 2020)

Table 38: Average size of households by district: 2000, 2008, 2015

District	2000	2008	2010	2011	2012	2013	2014	2015	2016	2017	2018
Southern Harbour	2.9	2.8	2.8	2.8	2.7	2.7	2.7	2.6	2.6	2.6	2.5
Northern Harbour	2.9	2.7	2.8	2.8	2.7	2.7	2.7	2.7	2.6	2.6	2.6
South Eastern	3.1	3.0	2.7	2.6	2.6	2.6	2.5	2.5	2.4	2.4	2.4
Western	3.2	3.1	2.9	2.9	2.9	2.8	2.8	2.7	2.7	2.7	2.6
Northern	3.0	2.9	3.0	3.0	3.0	2.9	2.9	2.9	2.8	2.8	2.8
Gozo and Comino	3.0	2.9	2.7	2.7	2.7	2.6	2.6	2.5	2.5	2.4	2.4
Total	3.0	2.9	2.8	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.5

Source: Adapted from NSO (2003, 2017, 2018 & 2020)

The distribution of households by type and period of construction of main dwelling in Malta is given in Table 39.

Table 39: Distribution of households by type and period of construction of main dwelling

Period of construction	Terraced house			Semi/Fully detached house			Tenement/ Maisonette			Flat/ Penthouse			Other		Total	
	Number	%	% of total houses in the period	Number	%	% of total houses in the period	Number	%	% of total houses in the period	Number	%	% of total houses in the period	Number	%	Number	%
1918 or earlier	11,499	18.2	70.2	:	:	:	2,835	6.0	17.3	:	:	:	:	:	16,371	9.9
1919-1945	7,700	12.2	60.9	:	:	:	3,675	7.7	29.1	:	:	:	:	:	12,649	7.7
1946-1960	5,260	8.3	37.3	:	:	:	5,585	11.8	39.6	3,002	6.6	21.3	:	:	14,092	8.6
1961-1970	4,762	7.5	33.3	[1,242]	[17.0]		3,678	7.8	25.7	4,615	10.1	32.3	:	:	14,297	8.7
1971-1980	9,487	15.0	37.9	1,903	26.1		6,298	13.3	25.2	7,185	15.8	28.7	:	:	25,017	15.2
1981-1990	15,002	23.8	50.1	1,845	25.3		7,528	15.9	25.1	5,498	12.1	18.4	:	:	29,955	18.2
1991-2000	7,231	11.5	25.0	[1,230]	[16.9]		11,055	23.3	38.2	9,249	20.3	31.9	:	:	28,958	17.6
2001-2005	[1,259]	[2.0]	[8.6]	:	:	:	4,561	9.6	31.2	8,502	18.7	58.2	:	:	14,597	8.9
2006+	:	:		:	:	:	2,231	4.7	25.1	5,625	12.3	63.4	:	:	8,879	5.4
Total	63,081	100.0		7,294	100.0		47,447	100.0		45,577	100.0		1,417	100,0	164,815	100.0

Source: NSO (2018); Notes: [] Figures to be used with caution; (:) Data not available due to unreliable survey estimates

According to the 2000 Household Budgetary Survey, the declared total annual net household income was, on average, €19,100 per household. The distribution of households by household net income and district is given in Table 40.

Table 40: Distribution of households by household net income and district, in 2000

	Less than €7,000	€7,001- €14,000	€14,001- €21,000	€21,001- €28,000	€28,001+	Total
Southern Harbour	20.5	32.2	22.3	13.7	11.3	100.0
Northern Harbour	13.5	32.4	24.4	11.8	17.9	100.0
South Eastern	11.9	29.0	32.1	15.1	11.9	100.0
Western	9.4	26.0	28.6	14.6	21.4	100.0
Northern	10.7	26.9	26.2	15.8	20.4	100.0
Gozo and Comino	12.5	34.5	23.2	15.1	14.7	100.0
Total	13.9	30.6	25.6	13.7	16.2	100.0

Source: NSO, 2003

The declared total annual net household income, in the 2008 Household Budgetary Survey was estimated at €2.9 billion, with an average of €20,695 per household. The distribution of households by household net income and district is given in Table 41. Further, in Table 42, the average household disposable income by region and year, for the period 2010 – 2018 is provided, based on the Regional Statistics reports of NSO (NSO, 2017 & 2020). After 2014, the income gap between Malta and Gozo and Comino is growing significantly (i.e. from €1,700 in 2013 to more than €3,300 in 2014 and about €5,000 in 2017). On average, the poorest region of Malta (but still richer than Gozo and Comino) is Southern Harbour and the richer one is Western. The rest regions rank in the middle.

Table 41: Distribution of households by household net income and district, in 2008

	Less than €7,500	€7,501- €14,000	€14,001- €22,000	€22,001- €27,000	€27,001+	Total
Southern Harbour	15.4	29.3	23.8	11.4	20.1	100.0
Northern Harbour	12.0	28.2	22.5	11.3	26.0	100.0
South Eastern	9.8	22.7	26.9	10.7	29.9	100.0
Western	9.5	20.2	23.4	15.1	31.8	100.0
Northern	9.3	23.5	26.9	12.6	27.7	100.0
Gozo and Comino	21.0	[25.3]	[20.5]	13.2	[20.0]	100.0
Total	12.4	25.6	24.0	12.1	25.9	100.0

Source: NSO, 2010

Table 42: Average household disposable income by region and year

	2010	2011	2012	2013	2014	2015	2016	2017	2018
MALTA	21,149	21,527	22,379	23,498	24,730	25,960	26,189	27,466	27,830
Malta	21,299	21,639	22,525	23,627	24,978	26,274	26,542	27,810	28,131
Southern Harbour	19,057	19,603	19,986	20,986	21,176	22,253	22,438	23,835	25,183
Northern Harbour	21,512	21,066	22,296	23,319	25,211	26,974	26,359	27,091	27,173
South Eastern	21,264	22,412	24,239	24,481	25,776	27,020	27,224	29,548	30,419
Western	24,504	25,144	24,834	26,326	27,801	29,029	29,801	32,754	32,964
Northern	21,056	21,655	22,566	24,400	26,002	26,709	28,260	28,271	27,724
Gozo and Comino	19,335	20,169	20,618	21,917	21,660	22,053	21,567	22,867	23,741

Source: NSO, 2017 & 2020

Finally, in Table 43, the mean equivalent net income in Malta between 2005 and 2017, by broad age categories, based on Eurostat data in nominal and real values is presented. The latter were converted using the Harmonised Index of Consumer Prices (HICP, 2015=100). The real income for ages 16 to 64 increase by almost 36% and that of people of 65 by 32%, respectively. In all years, the average income of elder people is, on average, approximately 30% lower than that of younger people.

Table 43: Distribution of mean equivalent household net income by age category, 2005-2017

Year	From 16 to 64 years		65 years or over	
	<i>Nominal</i>	<i>Real</i>	<i>Nominal</i>	<i>Real</i>
2005	10,336	12,653	7,805	9,554
2006	10,795	12,883	8,391	10,014
2007	10,844	12,851	8,313	9,852
2008	11,983	13,566	8,596	9,732
2009	12,701	14,120	9,664	10,744
2010	12,555	13,678	9,893	10,778
2011	12,898	13,707	10,049	10,679
2012	13,513	13,912	10,787	11,106
2013	14,294	14,574	11,450	11,674
2014	15,153	15,331	11,967	12,107
2015	16,129	16,129	12,440	12,440
2016	16,508	16,361	12,173	12,064
2017	17,575	17,200	12,857	12,583

Source: Eurostat

The total annual household expenditure of Maltese private households in 2015 was estimated at €3.7 billion, which corresponds to an annual average of €22,346 per household. The average annual expenditure increased across all districts by 14.2% compared to 2008 (national average). The largest increase was recorded in the Western district (average increase of €4,336) and the smallest one in the Southern Harbour district (average increase of €1,126). The Northern and Western districts have the highest expenditure, with annual averages exceeding the national average by €2,180 and €3,419, respectively, while the Southern Harbour and Gozo and Comino districts have the lowest average expenditure (€3,462 and €2,995 below the national average, accordingly). Similar to average household disposable income, households in the Northern Harbour and South Eastern districts spent about the same as the national average (NSO, 2018a).

Focusing on “Housing, water, electricity, gas and other fuels” (expenditure to water services only were unavailable), in 2015, households allocated about 8.4% of their expenditure to this category, at a national level (2008: 8.4%; 2000: 9.0%). Households residing in the Southern Harbour and Northern districts allocated almost the same share as the national average of their expenditure to “Housing, water, electricity, gas and other fuels”, i.e. 8.2% (Southern Harbour - 2008: 8.9% and 2000: 8.2%; Northern - 2008: 9.1% and 2000: 8.6%). Northern Harbour is the only district that spent more than the national average on this category, i.e. 9.8% (2008: 8.4%; 2000: 9.5%). South Eastern, Western and Gozo and Comino allocated a smaller proportion than the national average that is 7.6%, 7.2% and 6.8%, respectively (Southern Eastern - 2008: 7.1% and 2000: 7.8%; Western - 2008: 8.4% and 2000: 9.1%; Gozo and Comino - 2008: 7.7% and 2000: 10.9%).

2.3.5.7 Water tariffs

Malta water authority used to follow a policy of supporting water consumption by households and of maintaining such water tariffs stable for several years (FAO, 2006). Before 1994, tariff structures were made up of a fixed meter household charge and a set of marginal block prices, and the first block used to be given free as a means of guaranteeing access to a minimum threshold of water (Sammut, unknown). The old (i.e. pre 1994) tariff was introduced in 1981 when groundwater accounted for 85% of water production (Birdi, 1997). The domestic water tariff was heavily subsidised since water was very expensive to produce. For every Lm1.00 paid by the customer, the Government paid Lm9.00. The lowest water tariff was the industrial and the highest, for the use of first class water, was that of tourist sector. Further, that tariff of boathouses, gardens and files was relatively high to discourage the use of first class water for these uses (ibid.). In 1994, a new pricing regime was introduced, incorporating a 90% and 75% subsidy scheme on the first and second block of consumption of 5.5 m³ per person for every four-month cycle (Sammut, unknown). Attempting to recover the full cost of water, tariffs were again changed in 1997 (there was a basic structure for all consumers including a fixed charge of Lm 24 per year plus a charge of Lm 1.10/m³ of water). These changes were never actually implemented, and the new government introduced additional rebates where water consumption was less than 12 m³ per person for every four-month cycle. The subsidies were being smoothed out over a three-year period and in the year 2000-2001, rebates only applied to households having more than four members (ibid.).

Table 44 summarises the changes that have taken place in the tariff structure in this period.

Table 44: Tariff structures in Malta, pre 1994 and post 1998

Pre 1994		1994 -1998		Post 1998	
Meter Charge	Lm 1,20	Meter Charge	Lm 1,20	Service Charge	Lm 8,00
Consumption Charge		Consumption Charge (incl. of Govt. subsidy)		Consumption Charge (incl. of Govt. subsidy)	
First 27 m ³	Free	First 5,5 m ³ /person	7c.5/ m ³	First 8,6 m ³ /person	11c/ m ³
27 -42 m ³	12c.0/ m ³	5,5-11 m ³ /person	18c. 8/ m ³	8,6 to 9,0 m ³ /person	22c/ m ³
42 -57 m ³	16c.5/ m ³	Above m ³ /person	75c.0/ m ³	Above 9,0 m ³ /person	Lm 1,10/ m ³
Above 57 m ³	25c.0/ m ³			Rebate	Lm 1,40

Source: Sammut, Unknown

Nowadays a rising-block water-tariff system has been adopted to encourage more sustainable water use, where successive blocks of water are sold at a higher price (Delia, 2014). An annual service charge is paid independently of the amount of water actually consumed. Between 1987 and 1999, prices were changed four times. There were no price changes between 1987 and 1990 or between 1994 and 1996.

Table 45 lists the different water tariffs and service charges paid (in LM) by the various economic sectors, in Malta, at January 2005 (FAO, 2006).

Table 45: Water tariffs as at January 2005

Type of consumer	Service rent	Consumption charge	Tariff per m ³ (LM)
Domestic	LM12	0-33 m ³ /person	0.165
		> 33 m ³ /person	1.100
Social assistance	Free	0-16.5 m ³ /person	Free
		16.5-33 m ³ /person	0.165
		> 33 m ³ /person	1.100
Agriculture & agrofood	LM24	0-6810 m ³	0.165
		> 6810 m ³	0.350
Personal health use in field	LM24	0-15 m ³	0.225
		> 15 m ³	0.600
Industrial	LM18		0.850
Food & beverage	LM24		0.600
Tourist flats	LM24	0-252 m ³	0.750
		> 252 m ³	1.100
Hotels	LM24	0-42 m ³ /bed	0.900
		> 42 m ³ /bed	1.100
Laundry	LM24	0-6810 m ³	0.750
		> 6810 m ³	1.100
Sea craft	LM24		1.100
Government	LM24		1.100
Boat house, garden & garages	LM24		1.100
Non-commercial	LM12	0-171 m ³	Free
		> 171 m ³	0.350
Commercial & other	LM12	0-33 m ³	0.165
		> 33 m ³	1.100

Source: FAO, 2006

Table 46 presents the water tariffs from 2009 up to date, based on Watkins and Pantzar (2016) and the REWS⁶. It is noted that self-abstraction, although frequently metered (in the case of boreholes), is not subject to water supply tariffs or extraction quotas (Watkins and Pantzar, 2016). Yet, it carries a substantial operating cost of around 0.20-0.25 €/m³. The WSC may, on demand, supply non-potable water which shall be charged for agricultural and industrial uses at a rate of 0.093 €/m³, and for building or other purposes at a rate of 0.932 €/m³ (Government of Malta, 2015).

Table 46: Water supply tariffs in Malta (2009-today), € per m³

		Residential	Domestic	Non-residential
Annual service charge	To 31/12/09	59	59	59
	From 1/1/10	59	59	59
	From 31/3/14*	59	59	130
1st tier consumption	To 31/12/09	1.4	2.0	1.75
	From 1/1/10	1.47	2.30	2.10
	From 31/3/14*	1.3965	2.185	1.995
2nd tier consumption	To 31/12/09	5.15	5.15	2.15
	From 1/1/10	5.1	5.41	2.50
	From 31/3/14*	5.1395	5.1395	2.375
3rd tier consumption	To 31/12/09			1.4
	From 1/1/10	n/a	n/a	1.75
	From 31/3/14*			1.6625

Source: Watkins and Pantzar, 2016; REWS (2019)

Note: Approved Non-residential Water Tariffs are applicable as from 31st March 2015

Given the absence of data on water price for the entire reference period (i.e. 1968-2018), the Harmonised Index of Consumer Prices (HICP, 2015 = 100) for the water supply is used to capture water price evolution for the period 1996-2018 (Table 47). During 1996-2009, a significant increase in HICP of water supply is observed. From 2009 to 2017, the HICP is almost stable (~100.00).

⁶ Regulator for Energy and Water Services. <https://www.rews.org.mt/#/en/a/14-regulated-water-tariffs>

Table 47: Harmonised Index of Consumer Prices for water supply, 1996-2017

	Annual average index	Annual average rate of change
1996	28.69	:
1997	31.28	9.0
1998	44.23	41.4
1999	44.23	0.0
2000	44.23	0.0
2001	44.23	0.0
2002	44.23	0.0
2003	44.23	0.0
2004	44.23	0.0
2005	52.94	19.7
2006	67.53	27.6
2007	62.80	-7.0
2008	76.96	22.5
2009	100.17	30.2
2010	103.76	3.6
2011	103.76	0.0
2012	103.76	0.0
2013	103.76	0.0
2014	100.94	-2.7
2015	100.00	-0.9
2016	100.00	0.0
2017	100.00	0.0
2018	100.00	0.0

Source: Eurostat

(http://appsso.eurostat.ec.europa.eu/nui/show.do?lang=en&dataset=prc_hicp_aind)

3 DEMAND PATTERS/VARIATIONS

In Section 2, water-demand related factors were presented and analysed. This section aims at conducting an assessment of the sectoral water demand in Malta and its administrative units. As already discussed, there is lack of data in specific variables and years. For this reason, in certain cases, assumptions are adopted and a bottom-up estimation methodology is implemented to overcome this problem and fill out the missing values. The analysis in the present deliverable is conducted by means of univariate and bivariate techniques. Multivariate data analysis will be implemented during the development of the econometric water demand model. Hence, Section 3 is structured, as follows: first, Malta's water production and consumption in the main water sectors is presented, based on the best available data. Then, the sectoral water demand in Malta and its administrative units is given for the last 50 years using a combination of existing and estimated data by means of the above-mentioned bottom-up methodology.

3.1 Water production

Malta's water production main sources are groundwater and desalinated seawater.

Up to 1960's, water supply was principally based on groundwater (Figure 42), that was provided through boreholes, springs and pumping stations as these methods were sufficient for sustaining the population. The high population growth and the rapid economic growth and living standards, in the 1960's led to the increased groundwater abstraction and the deterioration of the status of the aquifers. Thus in 1963 a multi- stage flash (MSF) distillation plant was built, following another three plants built the following years. These plants were sparingly operated, due to high operating cost (mainly fuel).

In 1972, further groundwater exploitation was decided, and an intensive drilling campaign was commissioned, which resulted in a substantial decrease of water quality and an enormous increase of water salinity. As a result of high chloride concentrations, a number of boreholes and pumping stations in the sea-level aquifers have been discontinued, mainly in the northern and southeastern regions of Malta. The pumping stations consist of horizontal radiating galleries dug in the rock slightly above sea level in order to skim freshwater from the top of the freshwater lenses that constitute the sea-level aquifers. Thus, Government decided to diversify to more artificial ways to cover the water demand.

During the late seventy's new desalination technologies have been considered such as reverse osmosis (RO) and a plant of 20000 m³/day has been installed in SW part of the island in Ghar Lapsi. Further on, a brackish RO plant was also commissioned in 1983 at Marsa. Since 2003 the WSC operates three seawater RO plants at Lapsi, Cirkewwa and Pembroke, while a new plant in Gozo is planned.

Besides the desalination technologies, small reservoirs (with estimated capacity of 250,000m³) have been constructed across the drainage lines, aiming to collect storm runoff water for storage and reuse mainly for agriculture and recharging the sea-level aquifers.

Springs water production is only used for irrigation purposes lately (ERA, 2015). According to the Environment Statistics report (NSO, 2002), spring water production during the period 1995-2000 consists almost 1.7% of total groundwater production. Private boreholes and rain water harvesting systems for agricultural, commercial use or for leisure-related activities such as filling swimming pools are also used and in some cases, small RO plants are being used to desalinate the pumped groundwater.

Following the inauguration of the North (Malta) polishing plant in June 2017, and the Gozo and the South (Malta) polishing plants in 2018, treated sewage from the WSC sewage treatment plants that was formerly discharged to sea is pumped to new tertiary treatment polishing plants and very high-quality water for agriculture, industry, landscaping, and other sectors where drinking water quality levels are not required is provided.

Pumping stations contribute in the highest proportion on groundwater production, showing however a downward trend (Figure 43). By the 1990s, when reverse osmosis technologies started to be widely used in seawater desalination, desalination water became the main water source (Figure 42). Nowadays, Malta's public water supply is produced by boreholes, pumping stations and three reverse osmosis plants.

Table 48 presents the annual water production 5-year averages for Malta and Gozo and Comino, for all sources, i.e. pumping stations, boreholes and RO units. Water production was greater in the 1990s, but a significant reduction is observed over the past 10 years. Specifically, total water production in 2015 is 39% lower than in 1995 as a result of the efforts to reduce leakages in the distribution network.

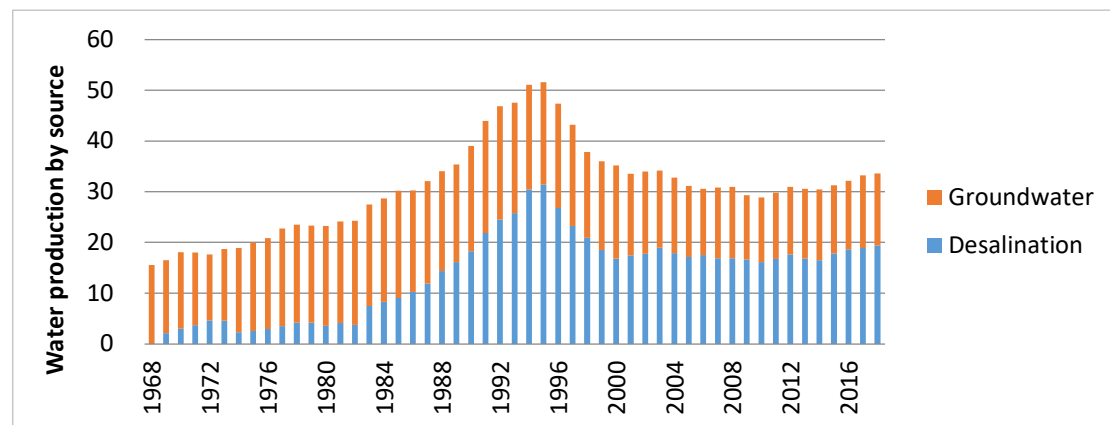


Figure 42: Water production (mcm/year) by source (1968-2018)

(Source: Energy and Water Agency)

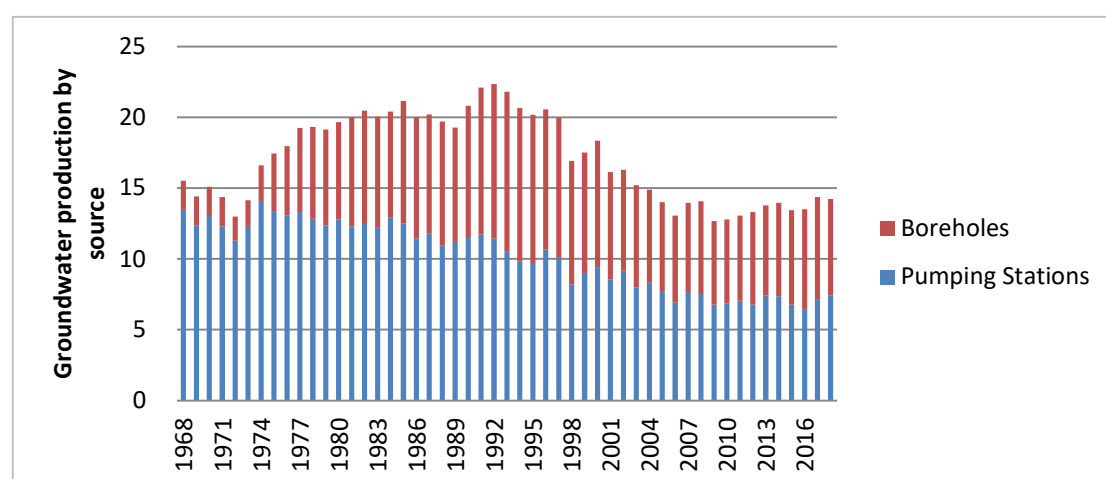


Figure 43: Groundwater production (mcm/year) by source (1968-2018)

(Source: Energy and Water Agency)

Table 48: Annual water production 5-year averages by source over the past 50 years (m³/year)

Period	MALTAPS	MALTABH	MALTAGW	GOZOPS	GOZOBH	GOZOGW	RODIS	WSCTOT
1969-1973	11,951,136	1,395,828	13,346,964	296,372	556,695	853,067	3,571,032	17,771,063
1974-1978	13,081,281	3,856,880	16,938,161	252,453	924,134	1,176,588	3,073,119	21,187,868
1979-1983	12,168,862	6,041,078	18,209,940	268,526	1,383,630	1,652,156	4,621,226	24,483,322
1984-1988	11,686,772	6,361,058	18,047,829	239,114	1,996,469	2,235,584	10,763,349	31,046,762
1989-1993	10,957,174	7,513,650	18,470,824	307,004	2,484,820	2,791,825	21,299,285	42,561,933
1994-1998	9,470,460	7,551,496	17,021,956	216,863	2,416,823	2,633,686	26,563,552	46,219,194
1999-2003	8,627,792	5,775,129	14,402,922	196,464	2,090,507	2,286,971	17,896,174	34,586,066
2004-2008	7,465,151	4,241,356	11,706,507	152,196	2,136,143	2,288,338	17,250,036	31,244,882
2009-2013	6,768,841	4,174,871	10,943,711	196,390	1,981,681	2,178,071	16,782,030	29,903,812
2014-2018	6,853,223	4,770,487	11,623,710	184,547	2,092,975	2,277,522	18,240,570	30,858,760

Source: Adapted from Energy and Water Agency; Notes: PS: groundwater production from pumping stations, BH: groundwater production from boreholes, GW: total groundwater production, RODIS: water production from reverse osmosis and distillers

The region of Malta produced more than 92% of the total public-supply water in the Maltese Islands (Table 49). It is noted that total production for Gozo includes groundwater production plus the transferred water from Malta less the polishing plant reject. The total production for Malta includes groundwater production and reverse osmosis production less the transferred water to Gozo.

Table 49: Public water production by region and year, 2010-2015 (m³)

	2010	2011	2012	2013	2014	2015
MALTA						
Groundwater Production	12,784,120	13,060,554	13,298,978	13,788,433	13,963,037	13,438,345
Pumping Stations	6,830,271	7,053,880	6,765,131	7,395,918	7,362,043	6,783,757
Boreholes	5,953,849	6,006,674	6,533,846	6,392,516	6,600,994	6,654,588
Annual reverse osmosis production	16,109,456	16,722,082	17,646,924	16,791,994	16,508,928	17,804,425
Gozo water polishing plant reject	131,318	132,757	115,947	96,775	103,780	86,585
Total Production	28,762,258	29,649,879	30,829,955	30,483,652	30,368,185	31,156,185
Malta						
Groundwater Production	10,588,199	10,981,344	11,229,648	11,530,549	11,623,791	11,151,834
Pumping Stations	6,596,522	6,852,960	6,640,984	7,242,080	7,184,032	6,573,614
Boreholes	3,991,677	4,128,384	4,588,664	4,288,470	4,439,759	4,578,220
Reverse Osmosis	16,109,456	16,722,082	17,646,924	16,791,994	16,508,928	17,804,425
Transferred from Malta to Gozo and Comino	-	-	-	-	-	-
Transferred from Malta to Gozo and Comino	488,360	515,280	660,100	581,640	481,190	481,150
Total Production	26,209,295	27,188,146	28,216,472	27,740,903	27,651,529	28,475,109
Gozo and Comino						
Groundwater Production	2,195,921	2,079,210	2,069,329	2,257,884	2,339,246	2,286,511
Pumping Station	233,749	200,920	124,147	153,838	178,011	210,144
Boreholes	1,962,172	1,878,290	1,945,182	2,104,046	2,161,235	2,076,368
Polishing plant reject	131,318	132,757	115,947	96,775	103,780	86,585

Transferred from Malta to Gozo and Comino	488,360	515,280	660,100	581,640	481,190	481,150
Transferred from Gozo and Comino to Malta	-	-	-	-	-	-
Total Production	2,552,963	2,461,733	2,613,482	2,742,749	2,716,656	2,681,076

Source: NSO, 2017

Apart from public water supply, all sectors and especially agriculture as discussed in previous section, cover a part of their needs through self-supply water from rain water harvesting systems, private boreholes and private RO production. The estimates for self-supply water quantities are either non-existent or vary widely (NSO, 2010b). For instance, the 2nd Water Catchment Management Plan for the Malta Water Catchment District 2015 – 2021 is based, for the purpose of the water balance calculation, on the highest water demand estimate from three models (i.e. Borehole Metering Model, FAO's CROPWAT model and the Crop Production model), an irrigation water demand of 18 million m³ (ERA, 2015). Similar estimates are provided by FAO (2006). The second largest user of freshwater resources is households (NSO, 2015a). Specifically in 2014, as reported in the 2nd Water Catchment Management Plan for the Malta Water Catchment District 2015 – 2021 (ERA, 2015), 49% of total abstracted groundwater is used in the agricultural sector and 37% is abstracted by WSC.

3.2 Water Consumption

In order to estimate the water consumption by district and sector, data from various sources (reports, databases, new releases and publications) were retrieved, as detailed below:

- Environment and Resources Authority - ERA (2011). The Water Catchment Management Plan for the Maltese Islands, Environment and Resources Authority, Malta.
- Environment and Resources Authority - ERA (2015). The 2nd Water Catchment Management Plan for the Malta Water Catchment District 2015 – 2021, Environment and Resources Authority, Malta.
- Eurostat Water Statistics database – Water uses (Available from: <https://ec.europa.eu/eurostat/web/environment/water/database>)
- FAO (2006). Malta water resources review. FAO, Rome.
- Mangion, E. (2013). Tourism impact on water consumption in Malta. Bank of Valletta Review, No. 47, 61-85.
- National Statistics Office – NSO (2002). Environment Statistics. Valletta: Malta.
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Nevertheless, neither complete time series data over the requested period of analysis, i.e. the past 50 years, nor detailed spatial data sets were retrieved regarding the water consumption in Malta (the available data are presented in Appendix 2). For this reason, and according to the Tender, EPSILON developed an alternative yet robust methodology for the estimation of water consumption (and later on of water demand) for the main sectors and per LAU, which is briefly described hereinafter.

The methodology is based on a “bottom-up” approach, i.e. the water consumption (that is billed and unbilled water) is estimated separately by sector and LAU and then these figures are added in order to estimate total water demand. To this end, unit water consumption coefficients from the literature are combined with expert judgment elicitation to establish the assumptions required.

More specifically, for each of the main water sectors the methodology was based on the following inputs and the water consumption was estimated according to the following equations:

A. Domestic water

Inputs:

- Total population (Maltese population and foreigners residing in Malta)
- Equivalent population of tourists in private accommodation
- Per capita water consumption (estimated by scientific papers, reports, and expert judgment)

$\text{Domestic water consumption} = \text{Population} * \text{per capita consumption}$

B. Irrigation water

Inputs:

- Irrigated area per crop category - in ha (based on reports and expert judgment)
- Irrigation needs estimated through the use of CROPWAT model (climate data: Malta Airport MetOffice, crop data: EWA communication and FAO, soil: FAO)

$\text{Irrigation water consumption} = \sum (\text{Irrigation needs} * \text{irrigated area})$
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C. Livestock water

Inputs:

- (a) Total number of livestock (cattle, pigs, sheep, goats and poultry)
- (b) Water consumption per animal (based on FAO, 2006)

$$\text{Livestock water consumption} = \text{Population} * \text{per animal consumption (for cattle, pigs, sheep, goats and poultry)}$$

D. Tourism water

Inputs:

- (a) Total equivalent population of tourists in collective accommodation
- (b) Water consumption per tourist (based on scientific papers, reports, and expert judgment)

$$\text{Tourism water consumption} = \text{Equivalent population of tourists} * \text{per capita consumption}$$

Note: Tourism water for those staying at private accommodation is estimated at domestic water

E. Other services water

Inputs:

- (a) Tourism water consumption
- (b) Ratio of 'Other services water' to 'Tourism water' (based on reports, own estimates, and expert judgment)

$$\text{Other services water consumption} = \text{Tourism water} * \text{Ratio of 'Other services water' to 'Tourism water'}$$

F. Industrial water

Inputs:

- (a) Total water consumption for all other uses
- (b) Ratio of 'Industrial water' to 'Total water consumption for all other uses' (based on reports, own estimates and expert judgment)

$$\text{Industrial water consumption} = \text{Total water consumption for all other uses} * \text{Ratio of 'Industrial water' to 'Total water consumption for all other uses'}$$

G. Total water consumption (billed and unbilled public and self-supply water)

Inputs:

- (a) Domestic water consumption
- (b) Irrigation water consumption
- (c) Livestock water consumption
- (d) Tourism water consumption
- (e) Other services water consumption

(f) Industrial water consumption

$$\text{Total water consumption} = \text{Domestic water} + \text{Irrigation water} + \text{Livestock water} + \text{Tourism water} + \text{Other services water} + \text{Industrial water}$$

The above-mentioned process was followed per LAU, so as to estimate water consumption for the Maltese Islands, Malta, Southern Harbour, Northern Harbour, South Eastern, Western, Northern and Gozo and Comino areas. The specific assumptions used per water sector (e.g. consumption per capita), are given in Appendix 3 As regards the 'Other services' and the Industrial water calculations, stochastic simulations were conducted and the annual averages of these simulations were used to account for the variability of the ratios implemented.

3.2.1 Domestic water consumption

The domestic water consumption was estimated taking into consideration the population of Malta (both Maltese and foreigners) and the tourists who reside in private accommodation. The detailed time series for the 'raw data' (i.e. population and tourists) and the estimated water consumption are included in the dataset (Supplement 1 to this report). For conciseness reasons only the 5-year averages are presented hereinafter.

Table 50: Domestic water consumption (in m³) by region over the past 50 years - 5-year averages, Maltese population and foreigners residing in Malta

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	9,570,367	8,792,514	2,631,166	3,193,792	1,090,325	1,123,002	754,229	777,853
1974-1978	9,820,110	9,044,729	2,622,512	3,264,921	1,148,518	1,190,402	818,375	775,381
1979-1983	10,084,080	9,311,163	2,613,888	3,337,634	1,209,817	1,261,848	887,976	772,917
1984-1988	10,359,795	9,585,195	2,593,483	3,402,929	1,276,867	1,337,286	974,629	774,600
1989-1993	12,470,666	11,544,494	3,321,791	3,779,494	1,582,515	1,633,150	1,227,544	926,173
1994-1998	13,002,682	12,018,503	3,269,322	3,841,915	1,721,608	1,756,909	1,428,749	984,179
1999-2003	15,536,568	14,327,462	3,446,581	4,732,749	2,125,811	2,146,370	1,875,952	1,209,106
2004-2008	16,167,856	14,915,160	3,305,480	4,834,336	2,328,752	2,254,592	2,192,000	1,252,696
2009-2013	17,471,975	16,156,291	3,350,827	5,067,401	2,669,276	2,436,437	2,632,350	1,315,684
2014-2018	20,299,752	18,859,365	3,616,416	6,247,404	3,078,090	2,686,500	3,230,955	1,440,387

Source: Own estimates

Table 51: Domestic water consumption (in m³) by region over the past 50 years - 5-year averages, tourists residing in private accommodation

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	0	0	0	0	0	0	0	0
1974-1978	0	0	0	0	0	0	0	0
1979-1983	14,553	12,157	462	5,471	82	182	5,960	2,395
1984-1988	27,658	23,546	895	10,596	158	353	11,544	4,112
1989-1993	70,052	60,549	2,301	27,247	407	908	29,685	9,502
1994-1998	147,100	131,299	4,989	59,085	883	1,969	64,372	15,801
1999-2003	245,027	223,689	8,500	100,660	1,505	3,355	109,668	21,338
2004-2008	295,513	270,711	10,287	121,820	1,822	4,061	132,722	24,802
2009-2013	385,188	353,586	13,436	159,114	2,379	5,304	173,353	31,601
2014-2018	742,438	693,208	26,342	311,944	4,664	10,398	339,860	49,230

Source: Own estimates

Table 52: Domestic water consumption (in m³) by region over the past 50 years - 5-year averages, population and tourists residing in private accommodation

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	9,570,367	8,792,514	2,631,166	3,193,792	1,090,325	1,123,002	754,229	777,853
1974-1978	9,820,110	9,044,729	2,622,512	3,264,921	1,148,518	1,190,402	818,375	775,381
1979-1983	10,098,632	9,323,320	2,614,350	3,343,105	1,209,899	1,262,030	893,937	775,312
1984-1988	10,387,453	9,608,741	2,594,378	3,413,525	1,277,025	1,337,640	986,173	778,712
1989-1993	12,540,718	11,605,043	3,324,092	3,806,741	1,582,922	1,634,059	1,257,229	935,675
1994-1998	13,149,782	12,149,802	3,274,311	3,901,000	1,722,491	1,758,878	1,493,121	999,980
1999-2003	15,781,595	14,551,151	3,455,081	4,833,409	2,127,316	2,149,725	1,985,620	1,230,444
2004-2008	16,463,369	15,185,871	3,315,767	4,956,156	2,330,574	2,258,653	2,324,722	1,277,498
2009-2013	17,857,163	16,509,878	3,364,263	5,226,515	2,671,656	2,441,741	2,805,703	1,347,285
2014-2018	21,042,190	19,552,573	3,642,758	6,559,348	3,082,754	2,696,898	3,570,815	1,489,617

Source: Own estimates

The domestic water consumption in the Maltese islands has increased by around 120% in the last 50 years. The Northern region saw the highest increase (around 370%), followed by the South Eastern region (180%) and the Western region (140%). The lowest increase is recorded in the Southern Harbour region (less than 40%).

On average, more than 92% of domestic water is consumed in Malta region and 8% in Gozo and Comino. More specifically, about 30% of domestic water is consumed in the Northern Harbour region, 23.5% in the Southern Harbour region, 13% in the South Eastern and the same percentage in the Western regions, and 11.5% in the Northern region. The domestic water consumed by tourists residing in private accommodation, during the last 5 years, is around 3.5% of the total domestic water in both Maltese Islands, but with an increasing trend. Since the '80s, the consumption of tourism water in private accommodation increased by more than 5000%, and nowadays it is estimated that it exceeds the amount of 1 million m³ per year.

Further, the proportion of the domestic water consumed by tourists in private accommodation is unevenly distributed among the LAUs. The highest percentage is noticed in the Northern region (around 9.5% on average during the last 5 years), followed by the Northern Harbour region (around 5%). In the rest of the LAUs, the share of tourism water is less than 1%.

3.2.2 Irrigation water consumption

The estimated irrigated water consumption by region and crop category is presented in the following tables.

Table 53: Irrigation water consumption (in m³) by region over the past 50 years - 5-year averages

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	3,374,704	2,967,386	390,989	166,142	616,341	931,180	862,733	407,319
1974-1978	3,572,569	3,142,276	416,627	176,518	657,519	986,122	905,490	430,293
1979-1983	3,657,064	3,208,623	413,717	180,994	653,849	1,013,801	946,260	448,441
1984-1988	6,423,664	5,615,554	695,977	320,162	1,105,768	1,791,622	1,702,027	808,110
1989-1993	7,162,937	6,261,079	775,240	356,961	1,230,165	2,000,101	1,898,613	901,858
1994-1998	7,746,803	6,772,819	834,726	384,009	1,324,819	2,155,228	2,074,036	973,984
1999-2003	9,234,561	8,077,239	1,005,260	451,183	1,564,904	2,593,450	2,462,442	1,157,322
2004-2008	16,912,317	14,561,611	1,489,551	818,266	2,274,138	4,934,537	5,045,119	2,350,706
2009-2013	22,315,707	19,159,577	1,887,078	1,094,127	2,903,223	6,542,092	6,733,057	3,156,129
2014-2018	23,745,724	20,395,969	2,011,669	1,162,143	3,117,093	6,922,784	7,182,281	3,349,755

Source: Own estimates

Table 54: Irrigation water consumption (in m³) for potatoes production by region over the past 50 years - 5-year averages

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	1,383,178	1,297,560	278,019	59,753	427,264	323,525	208,998	85,619
1974-1978	1,482,702	1,390,923	298,023	64,053	458,007	346,804	224,036	91,779
1979-1983	1,428,218	1,339,811	287,072	61,699	441,177	334,060	215,804	88,407
1984-1988	2,287,590	2,145,989	459,806	98,824	706,637	535,067	345,655	141,602
1989-1993	2,551,425	2,393,492	512,836	110,222	788,135	596,778	385,520	157,933
1994-1998	2,730,784	2,561,748	548,888	117,970	843,539	638,730	412,621	169,036
1999-2003	3,362,505	3,154,366	675,863	145,260	1,038,678	786,490	508,074	208,139
2004-2008	3,645,081	3,419,450	732,661	157,467	1,125,965	852,584	550,772	225,630
2009-2013	4,318,711	4,051,383	868,061	186,568	1,334,050	1,010,147	652,557	267,328
2014-2018	4,508,343	4,229,277	906,177	194,760	1,392,627	1,054,501	681,211	279,066

Source: Own estimates

Table 55: Irrigation water consumption (in m³) for permanent crops (except vineyards) production by region over the past 50 years - 5-year averages

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	409,053	326,138	17,180	28,388	21,066	167,139	92,364	82,915
1974-1978	448,918	357,922	18,855	31,155	23,119	183,428	101,366	90,996
1979-1983	458,597	365,639	19,261	31,827	23,618	187,383	103,551	92,958
1984-1988	821,975	655,361	34,523	57,045	42,332	335,859	185,602	166,614
1989-1993	931,379	742,589	39,118	64,638	47,966	380,562	210,305	188,791
1994-1998	929,935	741,437	39,057	64,538	47,892	379,972	209,979	188,498
1999-2003	1,180,907	941,537	49,598	81,955	60,817	482,518	266,649	239,370
2004-2008	2,149,065	1,713,449	90,261	149,145	110,677	878,108	485,259	435,615
2009-2013	3,096,309	2,468,687	130,045	214,884	159,460	1,265,152	699,147	627,622
2014-2018	2,976,859	2,373,450	125,028	206,594	153,308	1,216,345	672,175	603,409

Source: Own estimates

Table 56: Irrigation water consumption (in m³) for vineyards production by region over the past 50 years - 5-year averages

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	127,145	106,954	11,570	4,946	14,151	43,852	32,435	20,191
1974-1978	127,338	107,117	11,588	4,953	14,173	43,919	32,484	20,221
1979-1983	140,368	118,078	12,774	5,460	15,623	48,413	35,808	22,290
1984-1988	258,706	217,624	23,542	10,064	28,794	89,228	65,996	41,083
1989-1993	284,777	239,554	25,915	11,078	31,696	98,219	72,647	45,223
1994-1998	314,249	264,347	28,597	12,224	34,976	108,385	80,165	49,903
1999-2003	512,221	430,880	46,612	19,925	57,010	176,665	130,668	81,341
2004-2008	1,859,866	1,564,520	169,248	72,349	207,003	641,468	474,452	295,347
2009-2013	2,194,835	1,846,296	199,730	85,379	244,285	756,999	559,903	348,540
2014-2018	2,454,295	2,064,553	223,341	95,472	273,163	846,486	626,091	389,742

Source: Own estimates

Table 57: Irrigation water consumption (in m³) for market gardening production by region over the past 50 years - 5-year averages

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	1,100,463	933,963	50,401	46,440	65,037	313,412	458,673	166,500
1974-1978	1,133,038	961,609	51,893	47,814	66,963	322,689	472,250	171,429
1979-1983	1,226,605	1,041,020	56,179	51,763	72,492	349,337	511,249	185,585
1984-1988	2,284,307	1,938,691	104,621	96,398	135,003	650,571	952,099	345,616
1989-1993	2,549,633	2,163,874	116,773	107,595	150,683	726,136	1,062,687	385,760
1994-1998	2,853,964	2,422,159	130,712	120,437	168,669	812,809	1,189,532	431,805
1999-2003	3,334,659	2,830,125	152,727	140,723	197,078	949,711	1,389,886	504,534
2004-2008	7,776,472	6,599,892	356,162	328,167	459,589	2,214,739	3,241,233	1,176,580
2009-2013	10,537,898	8,943,514	482,636	444,699	622,790	3,001,193	4,392,196	1,594,384
2014-2018	11,285,064	9,577,633	516,856	476,230	666,947	3,213,986	4,703,614	1,707,430

Source: Own estimates

Table 58: Irrigation water consumption (in m³) for kitchen gardens production by region over the past 50 years - 5-year averages

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	354,865	302,771	33,819	26,615	88,823	83,251	70,263	52,094
1974-1978	380,573	324,705	36,269	28,543	95,257	89,282	75,353	55,868
1979-1983	403,275	344,074	38,432	30,246	100,940	94,608	79,848	59,201
1984-1988	771,086	657,890	73,484	57,831	193,003	180,897	152,675	113,195
1989-1993	845,723	721,571	80,597	63,429	211,684	198,407	167,453	124,152
1994-1998	917,870	783,127	87,473	68,840	229,743	215,332	181,738	134,743
1999-2003	844,269	720,331	80,459	63,320	211,321	198,066	167,165	123,939
2004-2008	1,481,833	1,264,300	141,219	111,138	370,903	347,638	293,403	217,533
2009-2013	2,167,953	1,849,697	206,606	162,596	542,639	508,602	429,255	318,255
2014-2018	2,521,163	2,151,056	240,267	189,087	631,047	591,465	499,190	370,107

Source: Own estimates

3.2.3 Livestock water consumption

The estimated quantities of the livestock water consumption by region and by livestock species is presented in the following tables.

Table 59: Cattle water consumption (in m³) by region over the past 50 years - 5-year averages

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	529,482	368,014	42,003	67,758	158,478	63,837	35,938	161,468
1974-1978	728,916	506,630	57,824	93,280	218,170	87,882	49,475	222,286
1979-1983	722,633	502,263	57,326	92,475	216,289	87,124	49,048	220,370
1984-1988	785,736	546,122	62,331	100,551	235,177	94,732	53,331	239,614
1989-1993	894,792	621,921	70,983	114,507	267,818	107,880	60,733	272,871
1994-1998	1,003,849	697,720	79,634	128,463	300,459	121,029	68,136	306,128
1999-2003	1,052,805	726,627	87,941	131,782	304,371	127,490	75,155	326,179
2004-2008	1,076,479	735,785	104,864	103,378	288,999	136,505	102,038	340,694
2009-2013	868,202	579,991	81,905	72,143	214,086	126,968	84,889	288,211
2014-2018	830,106	557,866	76,412	68,715	193,318	128,172	91,249	272,240

Source: Own estimates

Table 60: Pig water consumption (in m³) by region over the past 50 years - 5-year averages

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	151,086	140,654	14,051	18,471	30,715	50,607	26,811	10,432
1974-1978	180,449	167,990	16,781	22,061	36,684	60,442	32,021	12,459
1979-1983	218,291	203,219	20,300	26,688	44,377	73,117	38,737	15,072
1984-1988	360,091	335,228	33,487	44,024	73,204	120,613	63,899	24,863
1989-1993	408,794	380,568	38,017	49,978	83,105	136,927	72,542	28,226
1994-1998	457,497	425,908	42,546	55,932	93,006	153,240	81,184	31,588
1999-2003	485,817	454,074	41,928	70,825	107,105	151,062	84,923	31,732
2004-2008	453,470	424,980	36,795	53,737	91,304	148,045	95,101	28,825
2009-2013	344,036	318,985	22,630	29,500	67,240	124,047	75,568	25,050
2014-2018	270,698	244,760	14,691	24,854	50,193	94,569	60,453	25,938

Source: Own estimates

Table 61: Sheep water consumption (in m³) by region over the past 50 years - 5-year averages

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	41,961	27,114	1,962	2,578	7,861	8,809	5,904	14,846
1974-1978	40,283	26,031	1,884	2,475	7,547	8,457	5,668	14,253
1979-1983	27,012	17,455	1,263	1,659	5,060	5,671	3,801	9,557
1984-1988	33,160	21,428	1,551	2,037	6,212	6,962	4,666	11,733
1989-1993	42,810	27,664	2,002	2,630	8,020	8,988	6,024	15,147
1994-1998	52,461	33,899	2,453	3,223	9,828	11,014	7,381	18,561
1999-2003	68,263	44,158	2,901	4,230	11,976	14,898	10,153	24,105
2004-2008	76,678	50,397	3,661	5,549	15,798	15,353	10,014	26,281
2009-2013	69,347	48,717	4,237	5,604	15,753	14,528	8,594	20,631
2014-2018	64,241	46,339	4,200	4,819	15,065	14,430	7,825	17,902

Source: Own estimates

Table 62: Goats water consumption (in m³) by region over the past 50 years - 5-year averages

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	14,018	9,990	1,216	1,560	4,132	2,050	1,030	4,027
1974-1978	17,463	12,446	1,515	1,943	5,147	2,554	1,283	5,017
1979-1983	21,787	15,527	1,891	2,424	6,422	3,186	1,601	6,260
1984-1988	23,736	16,917	2,060	2,641	6,997	3,471	1,744	6,820
1989-1993	27,215	19,396	2,362	3,028	8,022	3,980	1,999	7,819
1994-1998	30,256	21,563	2,626	3,367	8,918	4,424	2,223	8,693
1999-2003	31,312	22,482	2,946	3,333	9,225	4,357	2,617	8,830
2004-2008	35,175	26,653	4,500	4,154	9,013	6,178	2,807	8,523
2009-2013	29,552	22,731	4,467	3,345	7,016	5,243	2,660	6,821
2014-2018	28,185	21,265	4,873	2,431	6,366	5,354	2,242	6,700

Source: Own estimates

Table 63: Poultry water consumption (in m³) by region over the past 50 years - 5-year averages

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	76,222	59,365	8,311	7,717	19,590	13,654	10,092	16,857
1974-1978	95,160	74,115	10,376	9,635	24,458	17,046	12,600	21,045
1979-1983	119,565	93,123	12,286	11,355	29,979	22,170	17,334	26,443
1984-1988	123,305	96,036	12,485	11,524	30,731	23,049	18,247	27,270
1989-1993	148,569	115,712	14,170	13,358	36,202	29,080	22,902	32,857
1994-1998	173,833	135,389	15,956	15,252	41,766	34,962	27,453	38,444
1999-2003	253,438	197,130	22,595	21,458	58,143	53,927	41,006	56,307
2004-2008	230,832	183,398	17,165	15,426	37,918	68,477	44,412	47,435
2009-2013	193,295	152,309	11,475	9,540	19,830	70,066	41,398	40,986
2014-2018	182,277	141,150	10,484	8,664	17,747	65,646	38,609	41,126

Source: Own estimates

Table 64: Total livestock water consumption (in m³) by region over the past 50 years - 5-year averages

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	812,768	605,137	67,544	98,084	220,776	138,957	79,775	207,630
1974-1978	1,062,271	787,210	88,381	129,394	292,006	176,381	101,047	275,061
1979-1983	1,109,288	831,586	93,066	134,601	302,128	191,268	110,520	277,702
1984-1988	1,326,029	1,015,730	111,914	160,777	352,321	248,827	141,887	310,299
1989-1993	1,522,181	1,165,261	127,534	183,501	403,167	286,854	164,201	356,920
1994-1998	1,717,896	1,314,480	143,215	206,236	453,978	324,669	186,377	403,415
1999-2003	1,891,636	1,444,472	158,313	231,628	490,821	351,735	213,854	447,153
2004-2008	1,872,634	1,421,213	166,984	182,244	443,032	374,558	254,372	451,757
2009-2013	1,504,432	1,122,733	124,715	120,131	323,925	340,852	213,110	381,699
2014-2018	1,375,506	1,011,381	110,661	109,483	282,688	308,171	200,378	363,905

Source: Own estimates

Overall, the livestock water consumption in the Maltese Islands has increased by around 70%, over the last 50 years. The highest increase is presented in the Northern and Western regions (about 150% and 120%, respectively), and the lowest in the Northern Harbour region (around 12%).

As far as the regional livestock water consumption is concerned, about three-quarters are consumed in Malta and the rest in Gozo and Comino. The South Eastern region consumes as much livestock water as Gozo and Comino (around 25% of the total quantity), followed by the Western region (around 20%). The rest regions consume about 10% of the total quantity each.

As regards the livestock species, the water consumed by cattle has increased by about 60% over the past 50 years and accounts for about 60% of the total livestock water. Almost 70% of this water is consumed in the region of Malta and 30% in Gozo and Comino. The water consumed by pigs has increased by around 80% over the last 50 years and corresponds to about 23% of the total livestock water. About 93% is consumed in the region of Malta (almost one-third of the total water for pigs is consumed in the Western region) and the rest 7% in Gozo and Comino. Poultry consume about 11% of the total livestock water, showing an increase of about 140% over the last five decades. Again, the majority of the water is consumed in Malta (about 78%), and mainly in the South Eastern and Western regions (almost 45% of the total poultry water). Sheep and goats consume about 3.5% and 2%, respectively. Almost 70% of the water is consumed in Malta, mainly in the Western (21%), South Eastern (20%) and Northern (14%) regions.

3.2.4 Tourism water consumption

The water consumed by tourists residing in collective accommodation over the past 50 years and by LAU is presented in the following table. It is noted that daily cruise passengers are considered in 'Other services' water consumption (which includes restaurants, cafes, etc.).

Table 65: Tourism water consumption (in m³) by region over the past 50 years - 5-year averages in collective accommodation

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	356,310	340,276	12,930	153,124	2,290	5,104	166,827	16,034
1974-1978	735,252	702,166	26,682	315,975	4,725	10,532	344,252	33,086
1979-1983	1,197,093	1,151,274	43,748	518,073	7,747	17,269	564,437	45,819
1984-1988	1,106,704	1,067,946	40,582	480,576	7,186	16,019	523,584	38,758
1989-1993	1,618,235	1,564,992	59,470	704,246	10,530	23,475	767,271	53,243
1994-1998	1,590,437	1,543,819	58,665	694,719	10,388	23,157	756,890	46,617
1999-2003	1,550,193	1,514,599	57,555	681,570	10,191	22,719	742,564	35,594
2004-2008	1,467,995	1,440,112	54,724	648,050	9,690	21,602	706,046	27,884
2009-2013	1,503,497	1,480,212	56,248	666,095	9,960	22,203	725,705	23,285
2014-2018	1,825,905	1,798,156	68,330	809,170	12,099	26,972	881,584	27,749

Source: Own estimates

Based on the estimates, the overall consumption in the last 50 years has increased by more than 400% (about 430% in Malta and 70% in Gozo and Comino), i.e. from about 270,000 in 1969 to 2,000,000, in 2018. The vast quantity of tourism water (more than 98%) is consumed in Malta. Actually, almost all the water is consumed in Northern and Northern Harbour regions (about 48% and 44% of the total tourism water, respectively). Southern Harbour, Western and South Eastern consume all together about 6% of the total tourism water.

3.2.5 Other Services water consumption

The water consumed in all other services but tourism, in the last five decades, is presented in the following table in terms of regional 5-year averages.

Table 66: Other services consumption (in m³) by region over the past 50 years - 5-year averages in collective accommodation

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	628,828	600,531	22,820	270,239	4,041	9,008	294,423	28,297
1974-1978	1,287,573	1,229,632	46,726	553,334	8,274	18,444	602,853	57,941
1979-1983	2,132,243	2,050,658	77,925	922,796	13,798	30,760	1,005,379	81,584
1984-1988	1,958,523	1,889,932	71,817	850,470	12,717	28,349	926,580	68,590
1989-1993	2,815,050	2,722,489	103,455	1,225,120	18,319	40,837	1,334,759	92,561
1994-1998	2,870,256	2,786,118	105,872	1,253,753	18,747	41,792	1,365,954	84,137
1999-2003	2,741,840	2,679,034	101,803	1,205,565	18,026	40,186	1,313,454	62,806
2004-2008	2,657,953	2,607,480	99,084	1,173,366	17,545	39,112	1,278,373	50,473
2009-2013	2,714,526	2,672,517	101,556	1,202,633	17,982	40,088	1,310,259	42,008
2014-2018	3,301,470	3,251,274	123,548	1,463,073	21,877	48,769	1,594,006	50,196

Source: Own estimates

On average, the water consumption increased by about 425% (more than 440% in Malta and 77% in Gozo and Comino). More than 95% of the 'Other services' water is consumed in the region of Malta and mainly in the Northern and Northern Harbour regions (about 90% of the total 'Other services' water).

3.2.6 Industrial water consumption

Finally, the 5-year averages of industrial water consumption by region is given in the table below.

Table 67: Industrial water consumption (in m³) by region over the past 50 years - 5-year averages in collective accommodation

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	1,180,282	1,065,234	250,215	310,730	154,821	176,718	172,749	115,000
1974-1978	1,318,132	1,192,390	256,122	355,146	168,881	190,573	221,668	125,682
1979-1983	1,464,576	1,333,461	260,968	410,414	176,083	202,517	283,479	131,040
1984-1988	1,697,939	1,537,445	281,410	418,526	220,605	274,028	342,875	160,413
1989-1993	2,029,887	1,844,772	347,224	496,639	256,687	315,214	429,007	185,022
1994-1998	1,850,942	1,679,665	302,822	440,401	241,047	293,777	401,617	171,188
1999-2003	2,022,790	1,832,631	309,866	480,046	273,047	334,307	435,488	190,104
2004-2008	2,539,315	2,271,100	330,524	501,431	327,238	492,115	619,790	268,237
2009-2013	2,941,595	2,624,304	354,710	532,596	379,884	601,635	755,478	317,291
2014-2018	3,322,785	2,980,693	385,889	654,765	422,122	647,953	869,964	342,092

Source: Own estimates

The overall consumption increased by more than 180% in the Maltese islands, over the past 50 years. About 90% of the industrial water is consumed in Malta and the rest in Gozo and Comino. As far as the other LAUs are concerned, the Northern Harbour and Northern regions consume around 45% (23.5% and 21%, respectively), Southern Harbour and Western regions present an equal share of about 16% and South Eastern follows with around 13%.

3.2.7 Total water consumption

Based on the above-presented estimates, the total water consumption is calculated and summarised in the following Table 68 and in Figure 44. The overall increase in the total water consumption, in the last 50 years, has exceeded 250%, driven mainly by the consumption in irrigation (more than 600%) and services (about 500%).

Table 68: Total water consumption (in m³) by use over the past 50 years - 5-year averages

Period	Domestic water	Irrigation water	Livestock water	Tourism water (collective accommodation)	Other services water	Industrial water	Total water consumption
1969-1973	9,570,367	3,374,704	812,768	356,310	628,828	1,180,282	15,923,259
1974-1978	9,820,110	3,572,569	1,062,271	735,252	1,287,573	1,318,132	17,795,907
1979-1983	10,098,632	3,657,064	1,109,288	1,197,093	2,132,243	1,464,576	19,658,895
1984-1988	10,387,453	6,423,664	1,326,029	1,106,704	1,958,523	1,697,939	22,900,312
1989-1993	12,540,718	7,162,937	1,522,181	1,618,235	2,815,050	2,029,887	27,689,008
1994-1998	13,149,782	7,746,803	1,717,896	1,590,437	2,870,256	1,850,942	28,926,115
1999-2003	15,781,595	9,234,561	1,891,636	1,550,193	2,741,840	2,022,790	33,222,615
2004-2008	16,463,369	16,912,317	1,872,634	1,467,995	2,657,953	2,539,315	41,913,584
2009-2013	17,857,163	22,315,707	1,504,432	1,503,497	2,714,526	2,941,595	48,836,919
2014-2018	21,042,190	23,745,724	1,375,506	1,825,905	3,301,470	3,322,785	54,613,580

Source: Own estimates

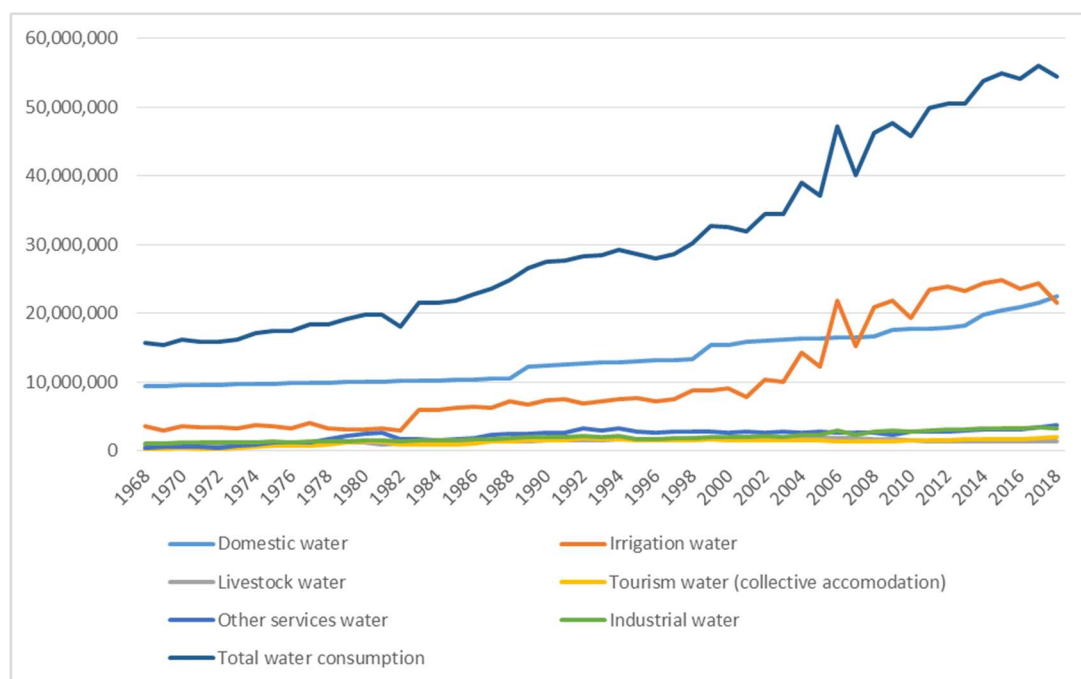


Figure 44: Total water consumption and consumption by use over the past 50 years

As shown in the table below, the agriculture consumes, over the past 15 years, the greatest share of water (more than 45%), followed by the domestic sector (around 40%), the services sector (around 9%) and the industrial sector (about 6%).

Table 69: Share of total water consumption by use over the past 50 years - 5-year averages

Period	Domestic water	Irrigation water	Livestock water	Tourism water (collective accommodation)	Other services water	Industrial water
1969-1973	60.1%	21.2%	5.1%	2.2%	3.9%	7.4%
1974-1978	55.2%	20.1%	6.0%	4.1%	7.2%	7.4%
1979-1983	51.4%	18.6%	5.6%	6.1%	10.8%	7.4%
1984-1988	45.4%	28.1%	5.8%	4.8%	8.6%	7.4%
1989-1993	45.3%	25.9%	5.5%	5.8%	10.2%	7.3%
1994-1998	45.5%	26.8%	5.9%	5.5%	9.9%	6.4%
1999-2003	47.5%	27.8%	5.7%	4.7%	8.3%	6.1%
2004-2008	39.3%	40.4%	4.5%	3.5%	6.3%	6.1%
2009-2013	36.6%	45.7%	3.1%	3.1%	5.6%	6.0%
2014-2018	38.5%	43.5%	2.5%	3.3%	6.0%	6.1%

Source: Own estimates

Further, Table 70 presents the 5-year averages of the total water consumption by region and Table 71 illustrates the corresponding shares per region. Steadily, over the past decades, Malta consumes around 90% of total water. In the most recent years, about 26% of total water is consumed in the Northern region, about 20% in the Northern Harbour and Wester regions, 13% in Southern Harbour and 12% in the South Eastern region. The overall increase in the total water consumption in Malta and Gozo and Comino is around 240% and 260%,

respectively. The largest water consumption increase were in Northern and Western regions (about 510% and 350%, accordingly).

Table 70: Total water consumption (in m³) by region over the past 50 years - 5-year averages, all uses

Period	Malta	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	15,923,259	14,371,078	3,375,664	4,192,112	2,088,593	2,383,968	2,330,737	1,551,532
1974-1978	17,795,907	16,098,403	3,457,050	4,795,288	2,279,922	2,572,455	2,993,684	1,696,695
1979-1983	19,658,895	17,898,922	3,503,773	5,509,984	2,363,503	2,717,646	3,804,011	1,758,964
1984-1988	22,900,312	20,735,349	3,796,078	5,644,036	2,975,621	3,696,484	4,623,126	2,163,864
1989-1993	27,689,008	25,163,636	4,737,014	6,773,209	3,501,789	4,300,541	5,851,079	2,524,113
1994-1998	28,926,115	26,246,704	4,719,612	6,880,119	3,771,470	4,597,501	6,277,997	2,678,024
1999-2003	33,222,615	30,099,125	5,087,877	7,883,401	4,484,305	5,492,121	7,153,423	3,122,605
2004-2008	41,913,584	37,487,386	5,456,635	8,279,513	5,402,216	8,120,577	10,228,421	4,426,555
2009-2013	48,836,919	43,569,221	5,888,570	8,842,097	6,306,630	9,988,611	12,543,311	5,267,698
2014-2018	54,613,580	48,990,047	6,342,855	10,757,983	6,938,633	10,651,548	14,299,028	5,623,533

Source: Own estimates

Table 71: Share of total water consumption by region over the past 50 years - 5-year averages, all uses

Period	Malta region	Southern Harbour	Northern Harbour	South Eastern	Western	Northern	Gozo and Comino
1969-1973	90.3%	21.2%	26.3%	13.1%	15.0%	14.6%	9.7%
1974-1978	90.5%	19.4%	26.9%	12.8%	14.5%	16.8%	9.5%
1979-1983	91.0%	17.8%	28.0%	12.0%	13.8%	19.4%	8.9%
1984-1988	90.5%	16.6%	24.6%	13.0%	16.1%	20.2%	9.4%
1989-1993	90.9%	17.1%	24.5%	12.6%	15.5%	21.1%	9.1%
1994-1998	90.7%	16.3%	23.8%	13.0%	15.9%	21.7%	9.3%
1999-2003	90.6%	15.3%	23.7%	13.5%	16.5%	21.5%	9.4%
2004-2008	89.4%	13.0%	19.8%	12.9%	19.4%	24.4%	10.6%
2009-2013	89.2%	12.1%	18.1%	12.9%	20.5%	25.7%	10.8%
2014-2018	89.7%	11.6%	19.7%	12.7%	19.5%	26.2%	10.3%

Source: Own estimates

3.3 Water demand

In order to estimate the total water demand, the water lost in leakages (real losses) throughout the water distribution infrastructure, e.g. service-pipe leakage, leakage on fittings, reservoirs, trunk/transfer/street mains, etc., was taken into consideration. For calculation purposes, it is assumed that real water losses are related to the public water distribution network. The first step towards estimating the water losses is to separate the sectoral water use into public and self-supply water sources. According to the 2nd WCMP (ERA, 2015), the domestic demand and the commercial water demand are addressed by both public and

private (i.e. tankers and self-production) water supply sources. Yet, significant data gaps still exist with regards to the self-supply volumes of water. The agricultural sector water demand is practically covered by self-supply sources (only a few hundred thousand m³ per year are provided by public water), especially over the last two decades. The 'Other services' water demand is assumed to be entirely dependent on the public water supply (see also Table 72).

Table 72: Sectoral use of water resources

Sector	Water Resources
Domestic	Groundwater, Desalinated Water, Rainwater Harvesting
Agricultural	Groundwater, Rainwater Harvesting, Treated Sewage Effluents
Commercial	Groundwater, Desalinated Water, Rainwater Harvesting, Treated Sewage Effluents
Others	Groundwater, Desalinated Water, Rainwater Harvesting

Source: ERA (2015, p. 111)

To this end, the water losses were estimated by the water production data provided by the WSC (Section 3.1) and the network losses retrieved mainly by the WSC and the NSO (e.g. Source: NSO, 2006 & 2017 & 2020) and other sources (e.g. Birdi, 1997; FAO, 2006). Detailed data about the real water losses due to leaks from the network are available for almost the last two decades. In the early of '90s, the Ministry for the Environment estimated that approximately 20% of water was lost via leaks due to corroded pipes, pumping surges causing bursts, repeated manual valve closures, etc. (Birdi, 1997). Similar estimates were provided by the WSC (Rizzo and Muscat, 1992), although the WSC was expecting losses of the order of 40% (Birdi, 1997). For the '70s and '80s, the percent of leakages is assumed to vary between 25% and 35%. The annual leakages, as a percentage of the produced water by public sources are given in the dataset (Supplement 1 to this report).

Considering the above-mentioned information and the data retrieved by the Eurostat, the NSO and the WSC about the water use by supply category and economic sector (Appendix 2), the water demand by sector and region was estimated.

3.3.1 Domestic water demand

The domestic water demand was estimated for Malta and the regions of Malta and Gozo and Comino, over the past 50 years (Figure 45). The analysis took into consideration the share of public and private water and the percentage of water losses from the public network. The complete time series are included in the dataset (Supplement 1 to this report). For conciseness reasons only the 5-year averages are presented in Table 73 and discussed in this section.

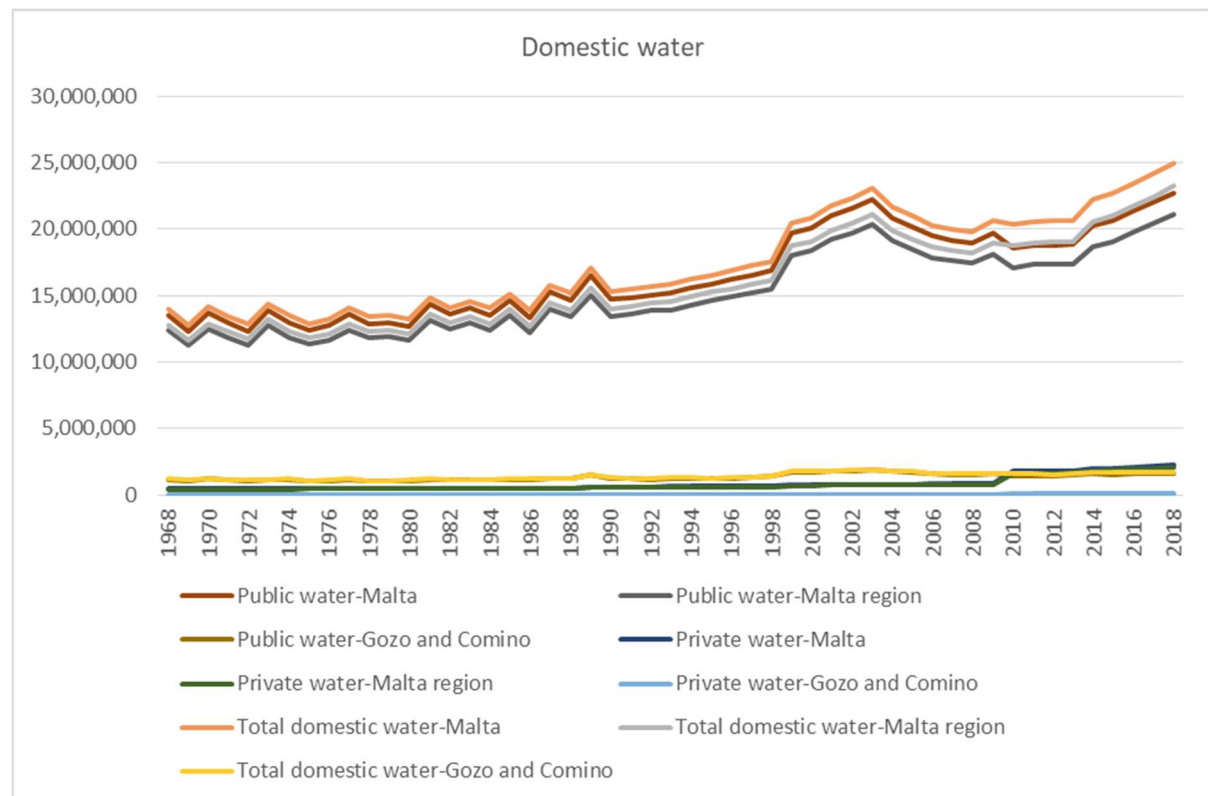


Figure 45: Public, private and total domestic water demand in Malta, Region of Malta and Gozo and Comino over that past 50 years

Table 73: Public, private and total domestic water demand in Malta, Region of Malta and Gozo and Comino over that past 50 years - 5-year averages

Period	Public water-Malta	Public water-Malta region	Public water-Gozo and Comino	Private water-Malta	Private water-Malta region	Private water-Gozo and Comino	Total domestic water-Malta	Total domestic water-Malta region	Total domestic water-Gozo and Comino
1969-1973	13,057,229	11,920,038	1,137,191	478,518	439,626	38,893	13,535,748	12,359,664	1,176,084
1974-1978	12,931,984	11,826,028	1,105,957	491,006	452,236	38,769	13,673,014	12,479,559	1,193,455
1979-1983	13,536,341	12,416,937	1,119,404	504,932	466,166	38,766	13,409,123	12,261,307	1,147,816
1984-1988	14,295,007	13,109,636	1,185,371	519,373	480,437	38,936	13,369,865	12,224,293	1,145,572
1989-1993	15,263,128	13,986,024	1,277,104	627,036	580,252	46,784	13,620,876	12,455,080	1,165,796
1994-1998	16,232,494	14,927,520	1,304,974	657,489	607,490	49,999	13,422,990	12,278,264	1,144,726
1999-2003	20,922,717	19,135,531	1,787,186	789,080	727,558	61,522	13,421,509	12,303,282	1,118,227
2004-2008	19,751,361	18,117,621	1,633,740	823,168	759,294	63,875	13,495,058	12,360,964	1,134,094
2009-2013	18,943,011	17,461,771	1,481,239	1,610,015	1,488,643	121,372	13,807,638	12,659,481	1,148,157
2014-2018	21,423,042	19,840,067	1,582,975	2,104,219	1,955,257	148,962	13,809,724	12,669,494	1,140,230

Source: Own estimates

The public domestic water demand in the Maltese islands has increased by around 65% in the last 50 years (about 66.5% in Malta and 40% in Gozo and Comino, respectively), i.e. from about 12.4 million in 1969 m³ to 22.7 million m³, in 2018. The increase in the demand of private domestic water is significantly higher. Yet, the contribution of private water sources is low (about 8-10% during the last decade, and even less the previous period). Overall, the annual percentage (Straight-Line) growth rate for the domestic water demand is 1.9%.

The domestic water demand, from a geographical perspective, follows – as expected – a similar trend to that of domestic water consumption, i.e. around 93% of the water is demanded in Malta and 7% in Gozo and Comino.

3.3.2 Irrigation water demand

As mentioned in the 2nd WCMP, the sector with the highest dependence on groundwater resources is the agricultural sector which accounted for almost half of the total groundwater abstraction in the Maltese islands (ERA, 2015). The irrigation water, contrary to the domestic water, comes primarily from private sources. It is estimated that self-supply of groundwater for agricultural use increased from around 13.5 million m³ in 2004 to around 27.5 million m³ in 2014 (NSO, 2015b). As mentioned before, given the absence of historical data for the irrigation water, its needs were estimated through the use of FAO's CROPWAT model. The irrigation needs were then used to estimate the irrigation water demand for the past 50 years in Malta and the regions of Malta and Gozo and Comino, considering the share of public water in order to account for the water losses throughout the water distribution infrastructure (Figure 46). Again, the complete time series are omitted here for conciseness reasons (the complete time series are given in the dataset – Supplement 1 to this report), and only the 5-year averages are presented (Table 74). The demand for public water in irrigation has decreased by more than 60% over the last 50 years. On the contrary, the irrigation water demand from private sources has increased by more than 650% in the region of Malta and 800% in the region of Gozo and Comino, respectively. In total, the irrigation water demand shows an upward trend, with an annual percentage growth rate, between 1969 and 2018, of 11.7%.

As regards the distribution of water demand for irrigation purposes in the regions of Malta and Gozo and Comino, around 85% is demanded in Malta and 15% in Gozo and Comino.

Table 74: Public, private and total irrigation water demand in Malta, Region of Malta and Gozo and Comino over that past 50 years - 5-year averages

Period	Public water-Malta	Public water-Malta region	Public water-Gozo and Comino	Private water-Malta	Private water-Malta region	Private water-Gozo and Comino	Total irrigation water-Malta	Total irrigation water-Malta region	Total irrigation water-Gozo and Comino
1969-1973	465,581	406,908	58,673	3,052,071	2,683,628	368,444	3,517,652	3,090,536	427,117
1974-1978	453,708	396,250	57,458	3,246,185	2,855,162	391,022	3,699,893	3,251,412	448,480
1979-1983	466,168	406,385	59,784	3,328,333	2,920,240	408,093	3,794,501	3,326,625	467,876
1984-1988	895,651	776,269	119,382	5,805,221	5,074,998	730,223	6,700,872	5,851,266	849,605
1989-1993	819,525	709,839	109,686	6,521,072	5,699,972	821,101	7,340,598	6,409,811	930,787
1994-1998	1,042,393	907,080	135,313	6,946,647	6,073,203	873,443	7,989,040	6,980,284	1,008,756
1999-2003	1,159,528	1,005,651	153,877	8,400,809	7,348,128	1,052,682	9,560,338	8,353,779	1,206,559
2004-2008	666,545	572,325	94,220	16,391,740	14,112,207	2,279,533	17,058,285	14,684,532	2,373,753
2009-2013	362,557	310,325	52,232	22,005,479	18,893,206	3,112,273	22,368,036	19,203,531	3,164,505
2014-2018	190,757	163,282	27,475	23,577,090	20,251,116	3,325,975	23,767,847	20,414,398	3,353,449

Source: Own estimates

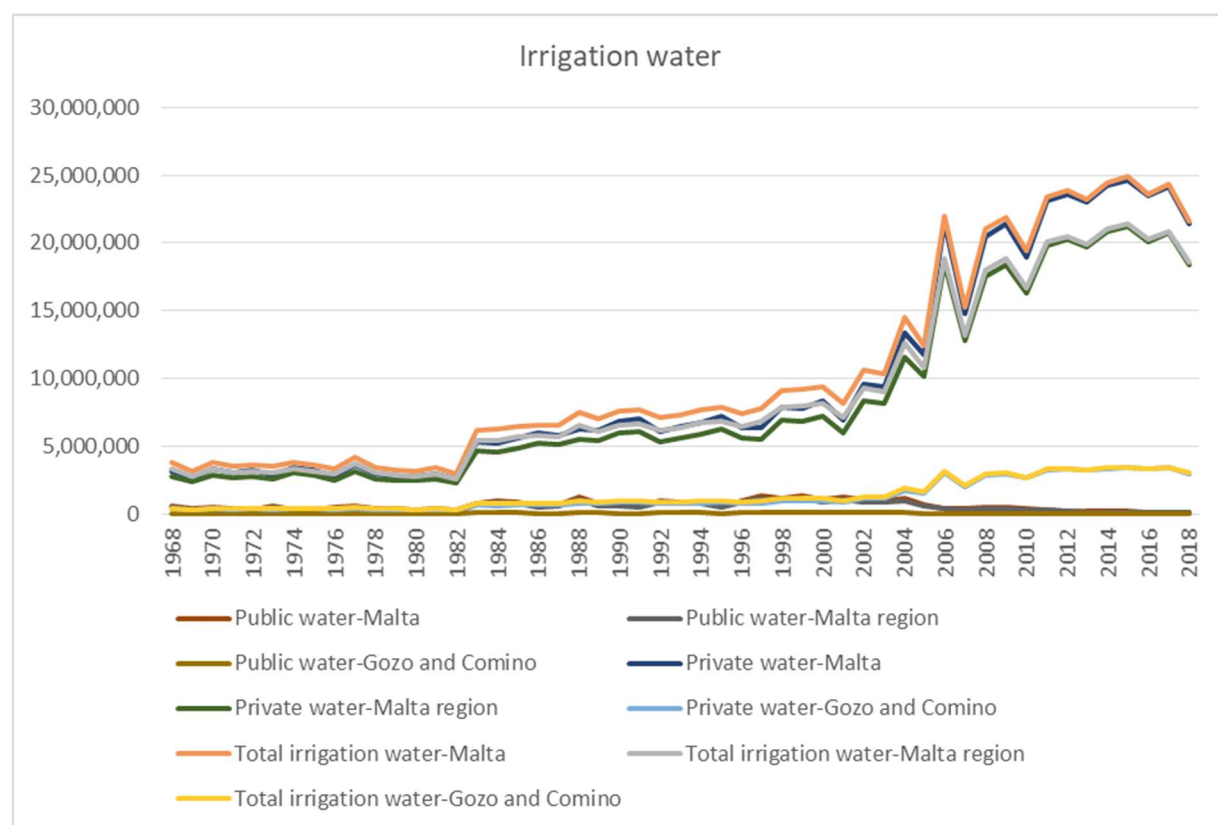


Figure 46: Public, private and total irrigation water demand in Malta, Region of Malta and Gozo and Comino over that past 50 years

3.3.3 Livestock water demand

The livestock water demand for the past 50 years in Malta and the regions of Malta and Gozo and Comino was estimated following the 'public-private' water supply shares, which were used for the irrigation water (Table 49). Using the complete time series (which is provided in the dataset - Supplement 1 to this report), the 5-year averages were estimated and summarised in Table 75. The demand for public water has decreased by about 90% over the past 50 years, while the demand from self-supply sources has increased by about 85% in Malta (84% in the region of Malta and 92.5% in the region of Gozo and Comino). The average annual growth rate of livestock water demand is 1.3%.

As regards the distribution of livestock water demand in the main regions, around 75% is demanded in Malta and 25% in Gozo and Comino.

Table 75: Public, private and total livestock water demand in Malta, Region of Malta and Gozo and Comino over that past 50 years - 5-year averages

Period	Public water-Malta	Public water-Malta region	Public water-Gozo and Comino	Private water-Malta	Private water-Malta region	Private water-Gozo and Comino	Total livestock water-Malta	Total livestock water-Malta region	Total livestock water-Gozo and Comino
1969-1973	112,498	83,216	29,282	734,721	547,043	187,678	847,219	630,259	216,961
1974-1978	138,802	102,081	36,721	962,336	713,196	249,140	1,101,138	815,278	285,860
1979-1983	138,085	102,945	35,140	1,011,096	757,907	253,189	1,149,181	860,852	288,329
1984-1988	184,060	139,807	44,253	1,198,966	918,400	280,566	1,383,026	1,058,207	324,819
1989-1993	175,689	133,272	42,417	1,384,558	1,059,910	324,648	1,560,247	1,193,182	367,065
1994-1998	232,896	177,375	55,521	1,539,090	1,177,665	361,424	1,771,986	1,355,040	416,946
1999-2003	242,068	183,443	58,623	1,717,388	1,311,309	406,068	1,959,456	1,494,753	464,691
2004-2008	81,790	61,825	19,993	1,809,211	1,373,011	436,515	1,891,001	1,434,836	456,509
2009-2013	25,453	19,013	6,440	1,482,660	1,106,418	376,242	1,508,113	1,125,431	382,682
2014-2018	11,036	8,086	2,948	1,365,750	1,004,207	361,324	1,376,786	1,012,293	364,272

Source: Own estimates

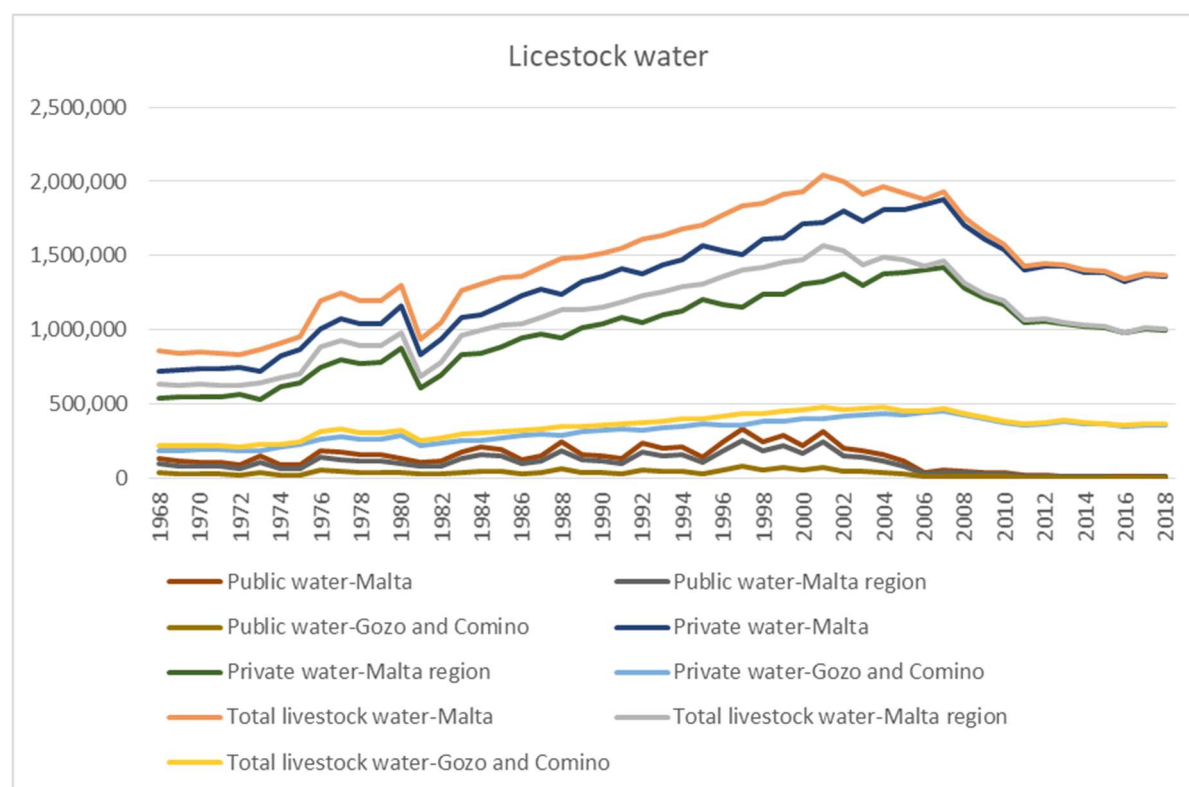


Figure 47: Public, private and total livestock water demand in Malta, Region of Malta and Gozo and Comino over that past 50 years

3.3.4 Tourism water demand

Towards estimating the tourism water demand (referring to collective accommodation establishments only), it was assumed that the self-supply water accounts for about 20% of the total demand in the sector during the last years (compared to about 5% in the past). The overall water demand in the tourism sector has almost quadrupled over the past 50 years (the 50-years' time series is provided in the dataset - Supplement 1 to this report), from about 500,000 m³ per year to 2.2 million m³ per year (Figure 48 and Table 76), following an average annual growth rate of 7.2%. Nevertheless, between 1982 and 1986 (in the early 1980s, wage and price controls were coupled with a sharp recession) and between 2006 and 2009 (due to the global financial crisis) the consumption reduced significantly but then raised again.

More than 98% of this demand is requested from the region of Malta, which accommodates the vast majority of inbound tourists.

Table 76: Public, private and total tourism water demand in Malta, Region of Malta and Gozo and Comino over that past 50 years - 5-year averages

	Public water- Malta	Public water- Malta region	Public water- Gozo and Comino	Private water- Malta	Private water- Malta region	Private water- Gozo and Comino	Total tourism water-Malta	Total tourism water-Malta region	Total tourism water-Gozo and Comino
1969-1973	488,414	463,533	24,881	17,815	17,014	802	506,229	480,547	25,682
1974-1978	967,012	917,316	49,696	36,763	35,108	1,654	1,003,774	952,424	51,350
1979-1983	1,602,194	1,531,046	71,148	59,855	57,564	2,291	1,662,049	1,588,610	73,438
1984-1988	1,461,876	1,398,433	63,443	102,136	98,565	3,571	1,564,012	1,496,998	67,014
1989-1993	1,865,233	1,786,516	78,717	161,823	156,499	5,324	2,027,057	1,943,015	84,042
1994-1998	1,777,274	1,716,887	60,387	221,023	214,571	6,452	1,998,297	1,931,458	66,839
1999-2003	1,836,945	1,780,250	56,695	232,529	227,190	5,339	2,069,474	2,007,440	62,034
2004-2008	1,505,077	1,468,276	36,802	278,545	273,276	5,268	1,783,622	1,741,552	42,070
2009-2013	1,401,516	1,375,790	25,725	300,699	296,042	4,657	1,702,215	1,671,833	30,382
2014-2018	1,652,380	1,621,841	30,539	365,181	359,631	5,550	2,017,561	1,981,472	36,089

Source: Own estimates

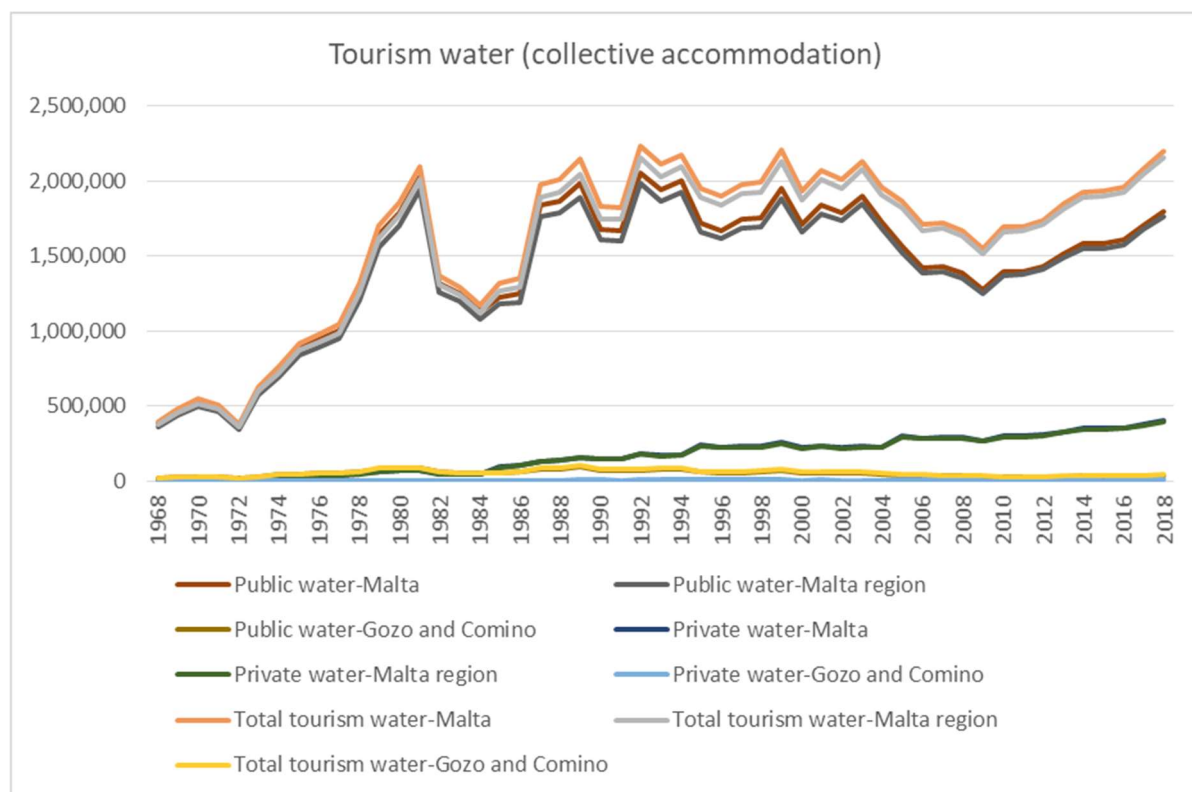


Figure 48: Public, private and total tourism water demand in Malta, Region of Malta and Gozo and Comino over that past 50 years

3.3.5 Other Services water demand

As mentioned before, it is assumed that the 'Other services' water demand is covered completely by public water. As shown in Figure 49 and Table 77, (the complete time series is given in the dataset – Supplement 1 to this report), the overall consumption increased by more than 300% over the past 50 years, with an annual growth rate of about 7.7%. The increase in demand was much higher in the region of Malta (about 325%) compared to that of Gozo and Comino (about 50%).

Similar to the domestic and tourism sectors, the vast majority of the water demand (about 98%) is requested from the region of Malta.

Table 77: Public, private and total ‘Other services’ water demand in Malta, Region of Malta and Gozo and Comino over that past 50 years - 5-year averages

	Public water-Malta	Public water-Malta region	Public water-Gozo and Comino	Private water-Malta	Private water-Malta region	Private water-Gozo and Comino	Total Other services water-Malta	Total Other services water-Malta region	Total Other services water-Gozo and Comino
1969-1973	907,138	860,915	46,223	0	0	0	907,138	860,915	46,223
1974-1978	1,782,568	1,690,960	91,607	0	0	0	1,782,568	1,690,960	91,607
1979-1983	3,005,312	2,871,936	133,377	0	0	0	3,005,312	2,871,936	133,377
1984-1988	2,850,832	2,727,083	123,749	0	0	0	2,850,832	2,727,083	123,749
1989-1993	3,599,771	3,448,405	151,366	0	0	0	3,599,771	3,448,405	151,366
1994-1998	3,726,161	3,599,699	126,461	0	0	0	3,726,161	3,599,699	126,461
1999-2003	3,823,687	3,705,993	117,695	0	0	0	3,823,687	3,705,993	117,695
2004-2008	3,359,930	3,277,869	82,061	0	0	0	3,359,930	3,277,869	82,061
2009-2013	3,162,563	3,104,651	57,912	0	0	0	3,162,563	3,104,651	57,912
2014-2018	3,734,529	3,665,551	68,978	0	0	0	3,734,529	3,665,551	68,978

Source: Own estimates

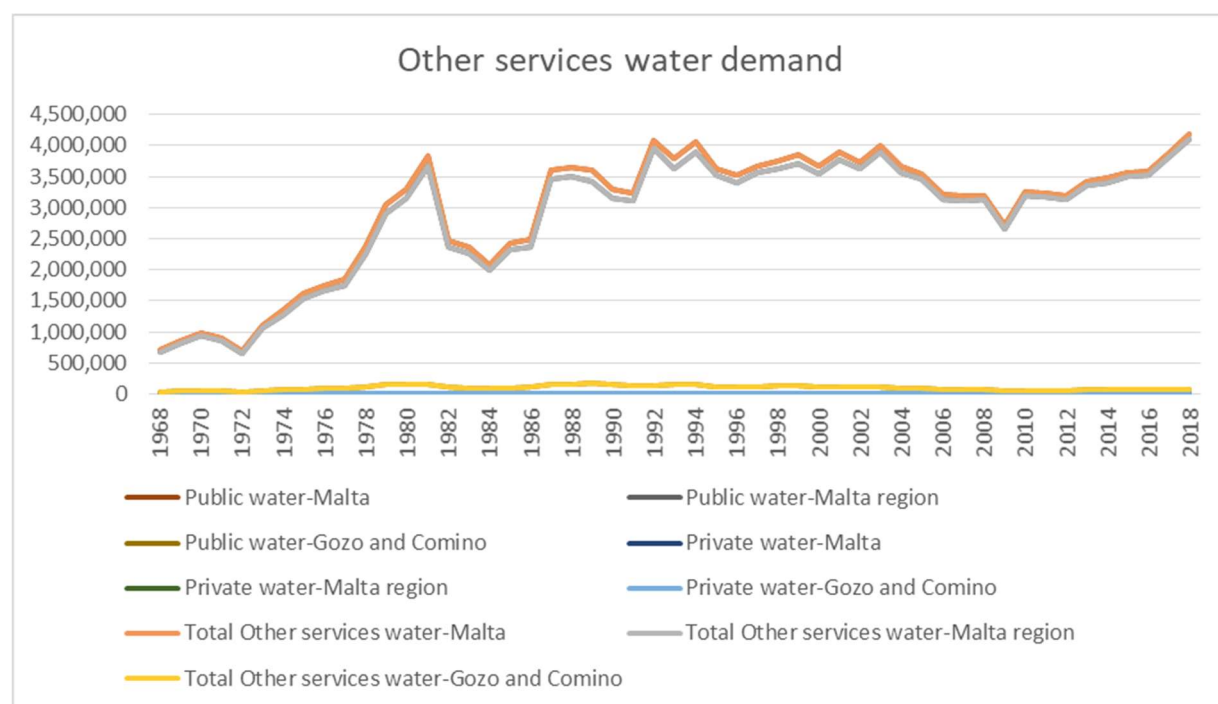


Figure 49: Public, private and total ‘Other services’ water demand in Malta, Region of Malta and Gozo and Comino over that past 50 years

3.3.6 Industrial water demand

In order to estimate the industrial water demand it was assumed that about one-third of this demand is covered by self-supply water. The industrial water demand increased by almost 140%, i.e. from about 1.4 million m³ to 3.6 million m³ per year, as shown in Figure 50. The average annual growth rate was almost half of that of the services sector (around 3.2%).

The increase in demand was slightly higher in the region of Gozo and Comino. Yet, the overall demand is much higher in the region of Malta. Indeed, the industrial water demand in the region of Malta is about 90% of the total Maltese industrial water demand (Table 78).

Table 78: Public, private and total industrial water demand in Malta, Region of Malta and Gozo and Comino over that past 50 years - 5-year averages

	Public water-Malta	Public water-Malta region	Public water-Gozo and Comino	Private water-Malta	Private water-Malta region	Private water-Gozo and Comino	Total industrial water-Malta	Total industrial water-Malta region	Total industrial water-Gozo and Comino
1969-1973	1,105,150	991,177	113,973	410,762	370,711	40,050	1,515,911	1,361,888	154,023
1974-1978	1,169,241	1,050,168	119,073	474,543	429,282	45,260	1,643,784	1,479,451	164,333
1979-1983	1,375,307	1,244,212	131,096	491,201	447,181	44,019	1,866,508	1,691,393	175,115
1984-1988	1,581,650	1,419,710	161,940	605,628	548,390	57,238	2,187,278	1,968,101	219,178
1989-1993	1,726,824	1,554,236	172,588	681,452	619,294	62,158	2,408,276	2,173,530	234,746
1994-1998	1,537,166	1,388,172	148,994	665,575	603,886	61,690	2,202,741	1,992,057	210,684
1999-2003	1,887,365	1,695,996	191,369	670,405	607,431	62,973	2,557,769	2,303,427	254,342
2004-2008	2,014,907	1,792,133	222,774	940,768	841,563	99,205	2,955,675	2,633,697	321,979
2009-2013	2,263,243	2,013,162	250,081	1,000,000	892,169	107,831	3,263,243	2,905,331	357,912
2014-2018	2,634,471	2,355,375	279,096	993,981	891,599	102,382	3,628,452	3,246,974	381,478

Source: Own estimates

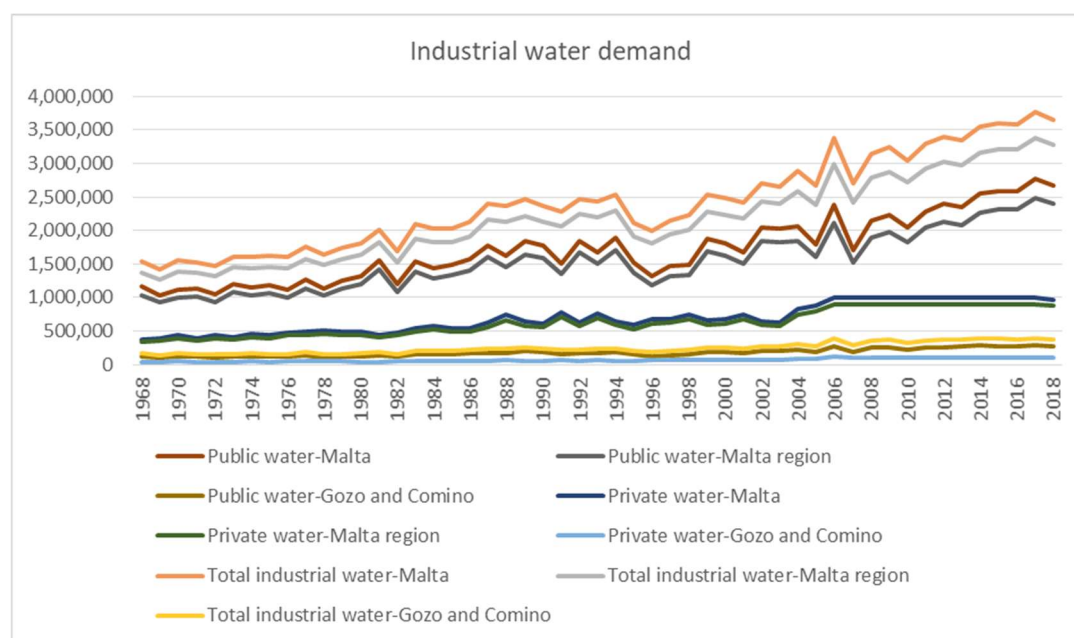


Figure 50: Public, private and total industrial water demand in Malta, Region of Malta and Gozo and Comino over that past 50 years

3.3.7 Total water demand

The annual total, public and private water demand as well as the water losses from the water distribution infrastructure, for Malta and the regions of Malta and Gozo and Comino, are illustrated in Figure 51. Further, Table 79 presents the 5-year averages for the same parameters.

The total water demand, according to the estimates, increased by almost 200%, i.e. from around 19.5 million m³, in 1969, to 58 million m³, in 2018. The public water demand almost doubled within this period (from 15.2 million m³ to 31.5 million m³), whereas the private water demand has increased more than sixfold (from 4.3 million m³ to 26.4 million m³), mainly due to the self-supply irrigation water. The average annual growth rate for the total water demand was 3.9% (Malta region: 3.9%; Gozo and Comino: 3.9%), for the public water 2.2% (Malta region: 2.3%; Gozo and Comino: 1.0%) and for the private water 10.2% (Malta region: 10.1%; Gozo and Comino: 10.7%).

During the same period, water leakages from the public water system decreased by 13% in Malta, 11% in the region of Malta and 36% in the region of Gozo and Comino (that is an average annual reduction rate of 0.3%, 0.2% and 0.7%, respectively).

The estimated water demand, i.e. the consumed (billed and unbilled) water and the water losses should be covered by the public and private water supply.

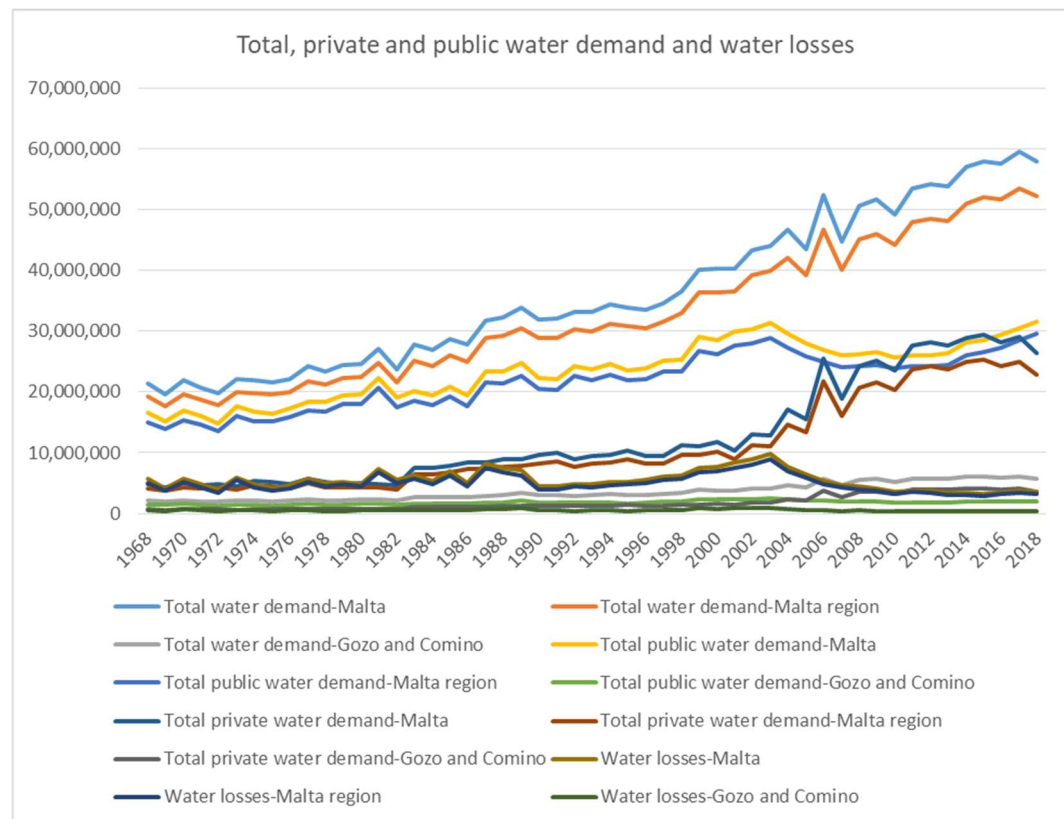


Figure 51: Public, private and total water demand and water losses in Malta, Region of Malta and Gozo and Comino over that past 50 years

Table 79: Public, private and total water demand and water losses in Malta, Region of Malta and Gozo and Comino over that past 50 years - 5-year averages

	Total water demand-Malta	Total water demand-Malta region	Total water demand-Gozo and Comino	Total public water demand-Malta	Total public water demand-Malta region	Total public water demand-Gozo and Comino	Total private water demand-Malta	Total private water demand-Malta region	Total private water demand-Gozo and Comino	Water losses-Malta	Water losses-Malta region	Water losses-Gozo and Comino
1969-1973	20,829,898	18,783,808	2,046,090	16,136,010	14,725,787	1,410,224	4,693,888	4,058,021	635,866	4,906,639	4,412,731	493,908
1974-1978	22,654,146	20,467,790	2,186,356	17,443,315	15,982,804	1,460,511	5,210,832	4,484,986	725,846	4,858,239	4,369,387	488,852
1979-1983	25,518,824	23,222,519	2,296,305	20,123,408	18,573,460	1,549,947	5,395,416	4,649,059	746,357	5,859,929	5,323,597	536,332
1984-1988	29,500,400	26,691,728	2,808,672	21,269,076	19,570,938	1,698,138	8,231,324	7,120,790	1,110,534	6,600,088	5,956,379	643,709
1989-1993	32,826,112	29,734,219	3,091,894	23,450,171	21,618,292	1,831,879	9,375,942	8,115,927	1,260,015	5,137,104	4,570,582	566,522
1994-1998	34,578,208	31,393,549	3,184,659	24,548,385	22,716,733	1,831,651	10,029,824	8,676,815	1,353,008	5,652,094	5,146,845	505,249
1999-2003	41,682,521	37,728,480	3,954,030	29,872,311	27,506,864	2,365,445	11,810,210	10,221,616	1,588,584	8,459,906	7,629,355	830,552
2004-2008	47,623,043	42,649,399	4,973,987	27,379,610	25,290,048	2,089,591	20,243,433	17,359,351	2,884,397	5,709,459	5,162,013	547,446
2009-2013	52,557,196	46,961,192	5,596,004	26,158,343	24,284,714	1,873,629	26,398,853	22,676,478	3,722,375	3,720,277	3,391,971	319,364
2014-2018	58,052,435	52,116,012	5,936,203	29,646,214	27,654,201	1,992,011	28,406,221	24,461,811	3,944,192	3,438,855	3,125,965	292,488

Source: Own estimates

4 CONCLUSION

Energy and Water Agency (EWA), under the Life 16 IPE/MT/008 project, published, EWA/CFT/5/2018 Tender, for the assessment of the sectoral water demand. The overall objectives of the tender and this contract are:

- To characterise the key components of past, present and future national water demand by the most important water use sectors in the Maltese islands which are the domestic, agriculture industrial and tourism sectors.
- To analyse the water demand of each sector historically (last 50 years).
- To forecast future water demand variations and trends on a regional level, including spatial variations in water demand, and determine projected changes in water demand to which water production and distribution infrastructure will need to respond.

The present report, constitutes of the 1st Deliverable of the EWA/CFT/5/2018 CONTRACT and refers to the analysis and assessment of water demand for the past 50 years, in order to characterize (quantitatively/qualitatively) key components affecting water demand in the four (4) main water sectors (domestic, agricultural, industrial, tourism) at regional level for all the administrative unit (LAU) systems.

Collecting the necessary for the analysis data proved to be a challenging task, due to lack of data in specific categories of water consumption and time periods, as well as due to discrepancies and inconsistencies, in some cases significant, between the various sources searched and gathered even between reports from the same organization (e.g. NSO), given that statistical authorities update and revise the data of previous years. In view of those difficulties EPSILON MALTA LIMITED provided in the Inception Report a hierarchy list data that identifies the data that is mandatory especially for the historic analysis of 50 years per sector and administrative units. EWA as the managing authority of this tender was asked to directly contact the National Statistics Office (NSO) of Malta in order to get all available historical data from 1967-2018. Unfortunately, NSO did not respond to this request imposed by EWA. Therefore EPSILON MALTA LIMITED proceeded the analysis with data obtained from EWA, available national databases (e.g. National Statistics Office, Malta Resources Authority, etc.), European and international organizations and databases (e.g. FAO's AQUASTAT, Eurostat, World Bank, EEA, DGENV) and other reliable sources, e.g. technical reports and scientific publications (a detailed list of all sources is provided in Section 5).

Provided that water demand depends on parameters, such as population, household income, water price, climate conditions, type and size of economic activities, etc., it's not surprising that total water demand in Malta almost doubled during the last 50 years. The total population in the Maltese Islands increased by almost 46.5%, the number of inbound tourists skyrocketed by more than 15 times, and the economic activity, as recorded by the nominal and real GDP improved by almost 59 times and 13.5 times, respectively. The GDP per capita, which is a preferred measure of wellbeing increased by almost 9 times, in real terms. At the same time, the estimated annual values of the Aridity Index and the Standardised Precipitation-Evapotranspiration Index show a downward trend, indicating dry periods and the coverage of agricultural, forest and semi natural areas is decreasing while urban areas increase.

Up to the 1980s, water supply in Malta was exclusively or principally based on groundwater. By the 1990s, reverse osmosis technologies started to be widely used as a means to meet the increasing demand. Apart from public water supply, all sectors and especially agriculture cover a part of their needs through self-supply water from rain water harvesting systems, private boreholes and private RO production. However, this data is so scant or estimates vary so much, that are considered not known.

Given the difficulties relating to data unavailability, the assessment was not carried out by developing a “bottom-up” methodology. A methodology was developed for the estimation of water consumption (and later on of water demand) for the main sectors and per LAU, in which unit water consumption coefficients from the literature are combined with expert judgment elicitation to establish the assumptions required.

The main conclusions drawn from the analysis, as summarised hereinafter:

- The domestic water consumption in the Maltese islands has increased by around 120% in the last 50 years (i.e. from about 9.4 to 22.4 million m³ per year. On average, more than 92% of domestic water is consumed in Malta region and 8% in Gozo and Comino. The domestic water consumed by tourists residing in private accommodation, during the last 5 years, is around 3.5% of the total domestic water in both Maltese Islands, but with an increasing trend.
- The irrigation water consumption in the Maltese islands is characterized by an increasing trend in the last 50 years. Specifically, the mean yearly irrigation water consumption in the Maltese islands has been increased from 3.2 million m³ in 1970s to 23.2 million m³ in the 2010s. On average, 87% of irrigation water is consumed in Malta and the rest in Gozo and Comino.
- Overall, the livestock water consumption in the Maltese Islands has increased by around 70%, i.e. from about 810,000 m³ to 1.4 million m³, over the last 50 years. The highest increase is presented in the Northern and Western regions (about 150% and 120%, respectively), and the lowest in the Northern Harbour region (around 12%). About three-quarters are consumed in Malta and the rest in Gozo and Comino. As regards the water consumption by livestock species, about 60% of the total livestock water is consumed by cattle, 23% by pigs, 11% by poultry and the rest by sheep and goats.
- The overall consumption of tourism water (referring to collective accommodation) in the last 50 years has increased by more than 400% (about 430% in Malta and 70% in Gozo and Comino), i.e. from about 270,000 m³ in 1969 to 2 million m³, in 2018. The vast quantity of tourism water (more than 98%) is consumed in Malta. Actually, almost all the water is consumed in Northern and Northern Harbour regions (about 48% and 44% of the total tourism water, respectively).
- On average, the water consumption for all other services but tourism increased from 630,000 m³ to 3.7 million m³, i.e. about 425% (more than 440% in Malta and 77% in Gozo and Comino). More than 95% of the ‘Other services’ water is consumed in the region of Malta and mainly in the Northern and Northern Harbour regions (about 90% of the total ‘Other services’ water).
- The overall consumption for industrial water increased by more than 180% in the Maltese islands, over the past 50 years (i.e. from about 1.2 million m³, in 1969, to 3.5 million m³, in 2018). About 90% of the industrial water is consumed in Malta and the rest in Gozo and Comino. The Northern Harbour and Northern regions consume around 45% (23.5% and 21%, respectively), of the total industrial water.
- The overall increase in the total water consumption, in the last 50 years, has exceeded 250%, i.e. from about 15.5 million m³, in 1969 to 54.4 million m³, in 2018, driven mainly by the consumption in irrigation (more than 600%) and services (about 500%). Over the past decades, Malta consumes around 90% of total water. In the most recent years, about 26% of total water is consumed in the Northern region, about 20% in the Northern Harbour and Western regions, 13% in Southern Harbour and 12% in the South Eastern region. The overall increase in the total water consumption in Malta and Gozo and Comino is around 240% and 260%, respectively. The largest water consumption increase were in Northern and Western regions (about 510% and 350%, accordingly).

- The domestic sector consumes steadily the greater share of total public water supply (about 72% in the recent years), followed by the Services sector, which consumes around one-fifth of total public water supply and the Industry, which consumes around 10% of total public water. The share of primary sector in the use of public water supply is between 0.5% and 1%. Taking into account the self-supply water as well, the agriculture sector becomes the largest water user of all freshwater resources in Malta (about 45% on average during the last five years), followed by the domestic sector (38.5%), the Services sector (9.5%) and the industrial sector (6%). A considerable proportion of water is lost in leakages throughout the water distribution infrastructure, although actual leakages decreased significantly and range between 11% and 13% in the last decade.
- The total water demand, according to the estimates, increased by almost 200%, i.e. from around 19.5 million m³, in 1969, to 58 million m³, in 2018. The public water demand almost doubled within this period (from 15.2 million m³ to 31.5 million m³), whereas the private water demand has increased more than sixfold (from 4.3 million m³ to 26.4 million m³), mainly due to the self-supply irrigation water. The average annual growth rate for the total water demand was 3.9% (Malta region: 3.9%; Gozo and Comino: 3.9%), for the public water 2.2% (Malta region: 2.3%; Gozo and Comino: 1.0%) and for the private water 10.2% (Malta region: 10.1%; Gozo and Comino: 10.7%).

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