Deliverable C1.1: Investigation of current climate change impacts and vulnerability & Recording of the Socio-economic profile

LIFE URBANPROOF

CLIMATE PROOFING URBAN MUNICIPALITIES

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The project is being implemented by the following partners:

Coordinator Beneficiary	
DEPARTMENT OF ENVIRONMENT	Department of Environment, Ministry of Agriculture, Rural Development and Environment *(Cyprus)*
Associated beneficiaries	
	National Technical University of Athens *(Greece)*
	National Observatory of Athens *(Greece)*
IUAV Università Iuav di Venezia	University of Venezia *(Italy)*
COMUNE DI REGGIO NELL'EMILIA	Municipality of Reggio Emilia *(Italy)*
STROVOLOS MUNICIPALITY	Municipality of Strovolos *(Cyprus)*
LAKATAMIA MUNICIPALITY	Municipality of Lakatamia *(Cyprus)*
Municipality of Peristeri	Municipality of Peristeri *(Greece)*

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INTRODUCTION

This deliverable entitled "Deliverable C.1.1: Investigation of current climate change impacts and vulnerability & recording of the socio-economic profile" presents the results from the implementation of Activities C.1.1 and C.1.3 of C.1 Action. To this end, the results of climate change impacts under examination in the project area (municipality, region or country) are presented, as following:

Water resources

The chapter of "Water Resources" describes in detail all types of water sources (surface, underground and other water resources) that supply the study areas. More specifically, the information provided is about the water supply system of the study areas, the qualitative and quantitative status of the water resources as well as water supply and demand balance. Also observed and expected impacts, non-climate related pressures and adaptation measures are presented.

Floods

In the "Floods" chapter, information is presented about the flood hazard maps and flood risk maps of the study areas. A record in detail of the existing flood prevention infrastructure as well as planned is done. Information is given about the observed and expected impacts and non-climate related pressures in the areas of interest. Future measures related to the Flood risk Management Plan of each region is presented, too. Last but not least, an extensive report on adaptation measures of each case study takes place in this chapter.

Heatwaves and health

In the "Heatwaves and health" chapter, information is presented about the observed impacts of extreme events such as heatwaves and extreme cold on human health and wellbeing in general in all study municipalities. Climate change affects our health and well-being in many ways, through direct physical impacts (most of them due to amplified extreme weather events) and indirect social and economic changes. Many of the indirect effects of climate change will be simultaneously influenced by other global changes and socio-demographic pressures that act in conjunction with climate change.

Increase in energy demand due to high temperatures

In the "Increase in energy demand due to high temperature" chapter, information is presented about the observed impacts of high temperatures on energy supply and demand for heating and cooling in all study municipalities. Both energy supply and energy demand are sensitive to changes in climate, in particular in temperature. The increasing frequency of extreme weather events, including heat waves, droughts and potentially storms, poses additional challenges for energy systems. In addition, climatic chances are reducing the demand for space heating and increasing the demand for space cooling in all study municipalities.

Peri-urban fires

Forest fires constitute a major environmental and socioeconomic issue in the Mediterranean. According to the EEA, the largest proportion of people and residential areas vulnerable to fire are found in southern European countries. Greek cities and the greater Athens area in particular, have a high percentage (> 16 %) of residential areas that are at direct high risk of fire. Cities in northern Italy present no forest fire risk, while in Cyprus cities face medium fire risk. In Peristeri, for the current climate, up to 120 days per year with high meteorological fire danger conditions (FWI>30) have been calculated using meteorological data of the period 1958-2014. From data obtained by the Hellenic Fire Service,Poikilo Mountain which is close to the Municipality of Peristeri, during the period of 2009-2016, experienced 26 fires which burnt 41 ha in total. According to RCM output, about 72 days of high fire risk for the current climate are predicted for the greater Athens area, while this increases up to 15 days per year in the near future (2021-2050) according to the projections. In the Cypriot partner municipalities, 5-50 days with high fire danger conditions have been calculated using meteorological data of the period 1983-2012. In Athalassa Forest National Park, adjacent to Strovolos Municipality, from the total area of 840 ha, 32 ha have burned in the period from 2000 to 2015. Regional climate models depict 115 days with high fire danger in the current climate (1961-1990) in the greater area of Nicosia, while an increase of 5 days per year in the near future, is projected.

Ozone

Ozone (O_3) is a 'secondary' pollutant formed from gases such as nitrogen oxides (NOX) and volatile organic compounds (VOCs) in the presence of solar light. Ozone levels typically become particularly high in regions where considerable emissions of these gases combine with stagnant meteorological conditions, high levels of solar radiation and high temperatures during the summer. Air pollution caused by high ozone concentrations is a common problem in large cities throughout the world. It is a well-known fact that individuals exposed for a long period of time to high concentration of ozone may experience serious health problems such as breathing problems, asthma triggering, reduced lung function and other lung diseases. Climate change is expected to impact the future ozone concentrations. Available long term observations from the partner municipalities have been analysed in order to provide insights regarding the historical ozone air-quality. The analysis reveals that for the Strovolos-Lakatamia municipality an increasing trend of about 6 days/decade in the ozone exccedance days is calculated whereas in Reggio-Emilia the trend exhibits a decrease of about 3 days/decade. Finally for Peristeri a non-statistically significant trend is calculated. In addition, the relationship of daily maximum 8-hour average ozone concentrations with daily maximum temperatures is also examined with the results indicating a strong relationship between the two variables in the project areas.

Socio-economic characteristics related to climate change

Climate change and extreme weather conditions have undermined overall development efforts. Major economic sectors, such as agriculture and fisheries, are largely dependent on weather conditions. In addition, increased environmental, as well as demographic pressures that are affected from climate change have direct or indirect effects resulting in natural resources depletion. To this end, certain demographic, economic and health indicators are assessed at municipal level compared to the whole country for each one of the project pilot areas.

1 WATER AVAILABILITY AND DROUGHTS

Water resources are closely interrelated with climate as the water cycle depends on climate factors. More specific, water is received through precipitation while a large part is evaporated directly or is returned to the atmosphere via plants (transpiration). Evapotranspiration is strongly dependant on climatic factors such as temperature, radiation, vapor pressure and wind. In addition, higher temperatures increase water-holding capacity of the atmosphere and evaporation, resulting in increased climate variability, with more intense precipitation and more droughts (Trenberth et al., 2003). Climate changes such as increases in temperature, sea level and precipitation variability affect freshwater systems and their management (Kundzewicz et al., 2007) with a potential of high vulnerability not only for water resources but also to human societies and ecosystems as a concequence (Bates et al., 2008).

1.1 Cyprus

1.1.1 Existing situation

Water needs in the study area are covered from various sources. Water sources are related with the exploitation of underground, surface water as well as with the use of recycled water. In this chapter all these water sources, their special characteristics and information about the qualitative and quantitative status is presented in detail. Also water balance and demand of the study areas is analyzed.

1.1.1.1 Water Supply Sources

The two study areas use water for various uses from different sources. In particular both municipalities use water for drinking, irrigation and industrial purposes. Water sources can be divided into surface (dams), underground (boreholes) and other water sources (e.g. treated water)

All water resources are described in detail in the following chapters.

1.1.1.1.1 Surface Water Sources

Surface water sources are related to dams. All the drinking water of the two municipalities is provided from the water supply network of the Southern conveyor project (Figure 1-1).

More specifically, drinking water supply in the two areas is achieved through the water refinery of Tersefanou (Figure 1-1).

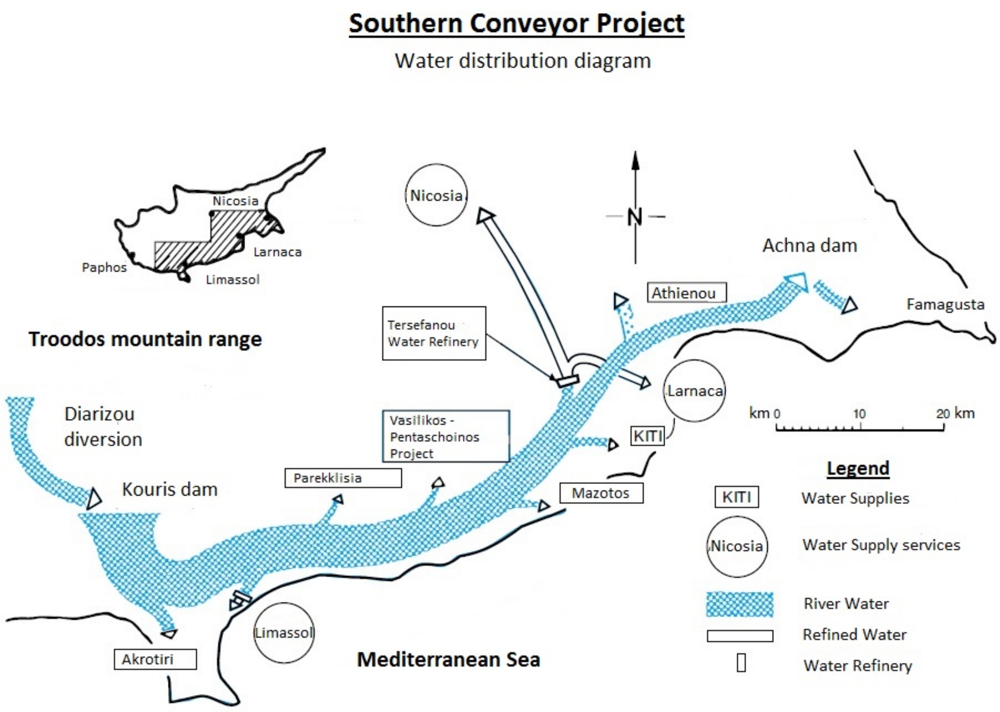


Figure 1-1: Water distribution diagram of "Southern conveyor project"

The project is supplied with water from dams that are in different catchment areas. Dams (Figure 1-2) and their general characteristics are presented below [first year of operation / capacity]:

- Arminou dam (Diarizou diversion to Kouris dam) – [1998 / 4.3 hm^3]
- Kouris dam – [1988 / 115 hm^3]
- Polemidhia dam
- Germasoyia dam – [1968 / 13.5 hm^3]
- Kalavasos dam – [1985 / 17.1 hm^3]
- Maroni river
- Dhypotamos dam – [1985 / 15.5 hm^3]
- Kiti dam – [1964 / 1.614 hm^3]

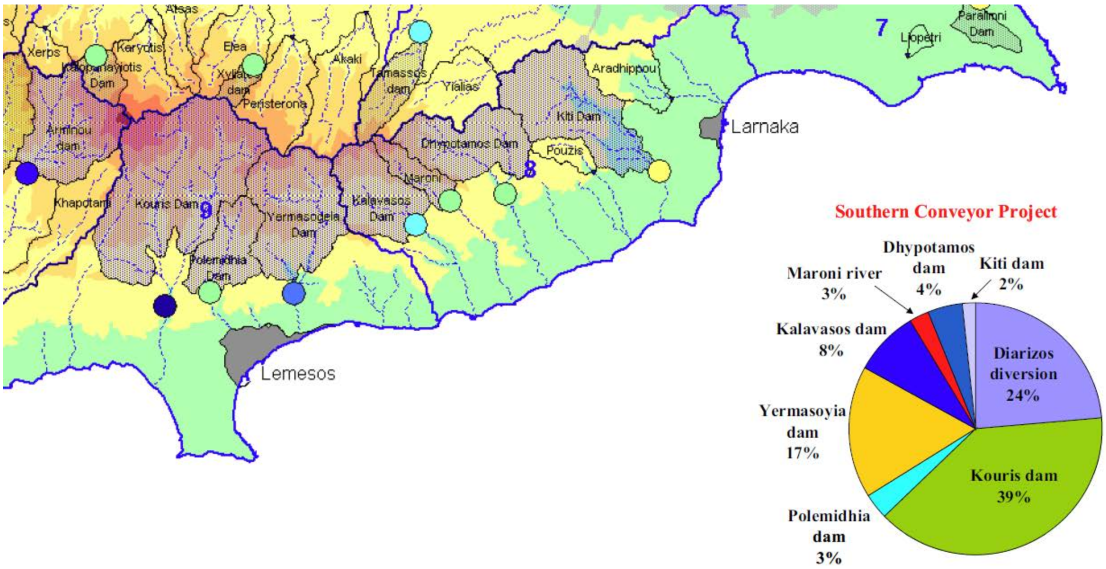


Figure 1-2: Dams that supply the Southern conveyor network - Water supply quota to the Southern Conveyor Project (Rossel, 2002)

The damswith the highest participation rates of water supply are the Kouris dam (39%), Arminou dam (24%, through Diarizos diaversion) and Yermasoyia dam (17%). For this reason, emphasis will be given in the special characteristics of these dams except from Yermasoyia its water is used only for irrigation and enrichment of the aquifer.

The mean values of annual inflow at the dams are:

- Kouris dam: 30 mcm
- Diarizos diversion: 18 mcm
- Kouris dam (after Diarizos diversion): 48 mcm

Time series of total run-off to the Kouris dam is presented in the next figure.

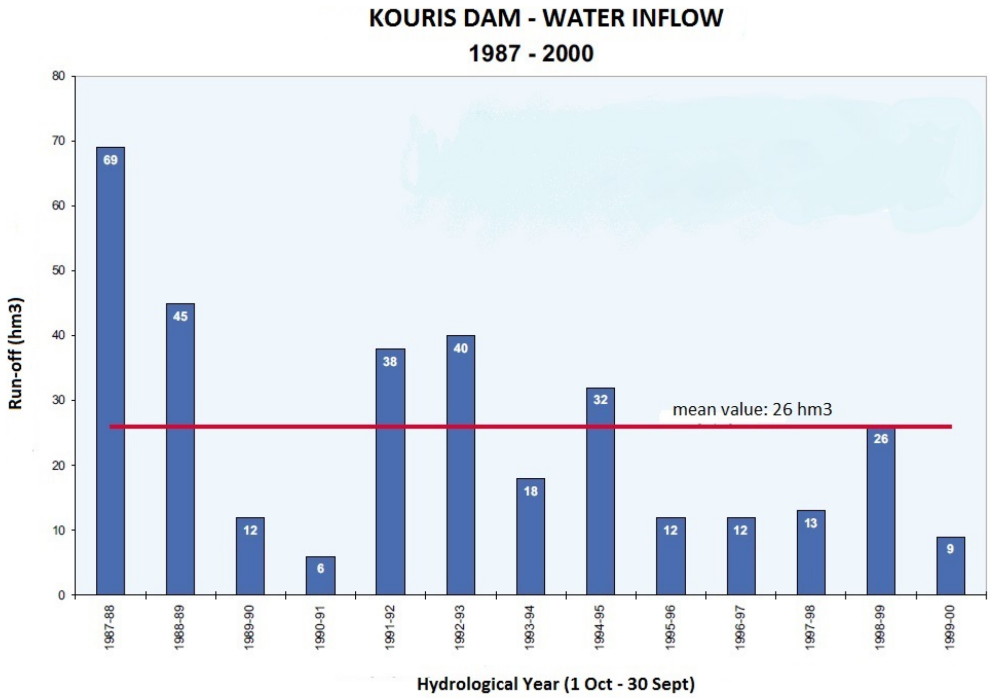


Figure 1-3: Time series water inflow to the Kouris dam (Rossel, 2002).

The relation between the annual inflow and annual precipitation to the dams is presented in the next figures.

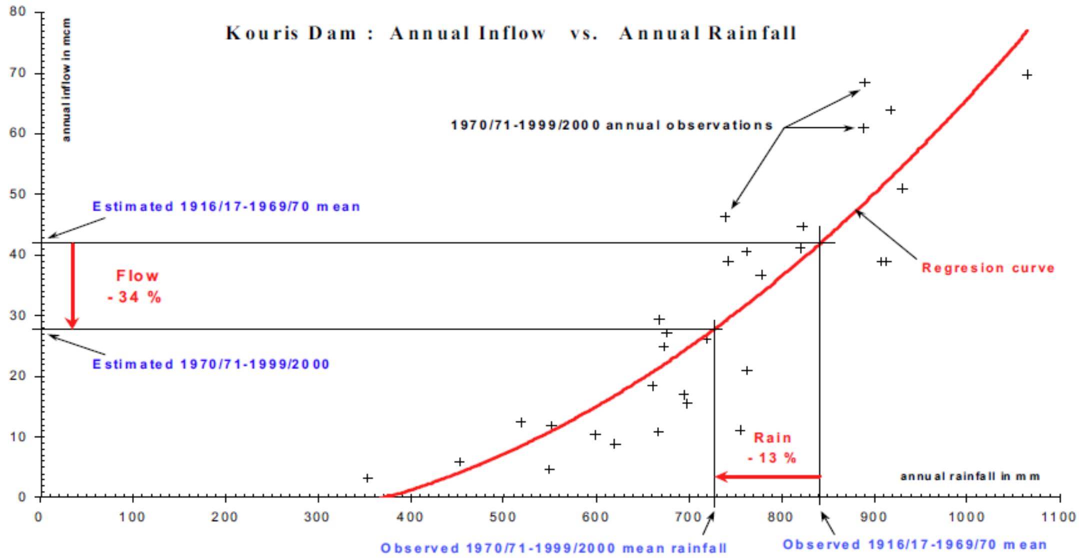


Figure 1-4: Relation between annual precipitation and annual inflow to the Kouris dam (Rossel, 2002).

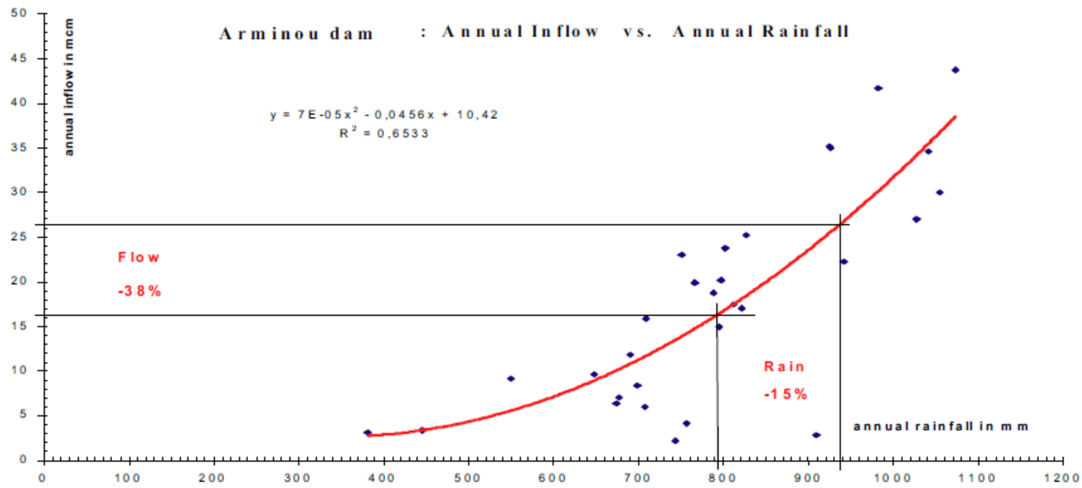


Figure 1-5: Relation between annual precipitation and annual inflow to the Arminou dam (Rossel, 2002).

The qualitative and ecological status of the dams are characterized as "good" according to WDD (2014).

1.1.1.1.2 Underground Water Resources

Wells/Boreholes

In the study area there is a large number of boreholes mainly used for irrigation purposes (Figure 1-7).

The study area is located at the Central and Western Mesaoria aquifer (Figure 1-6).

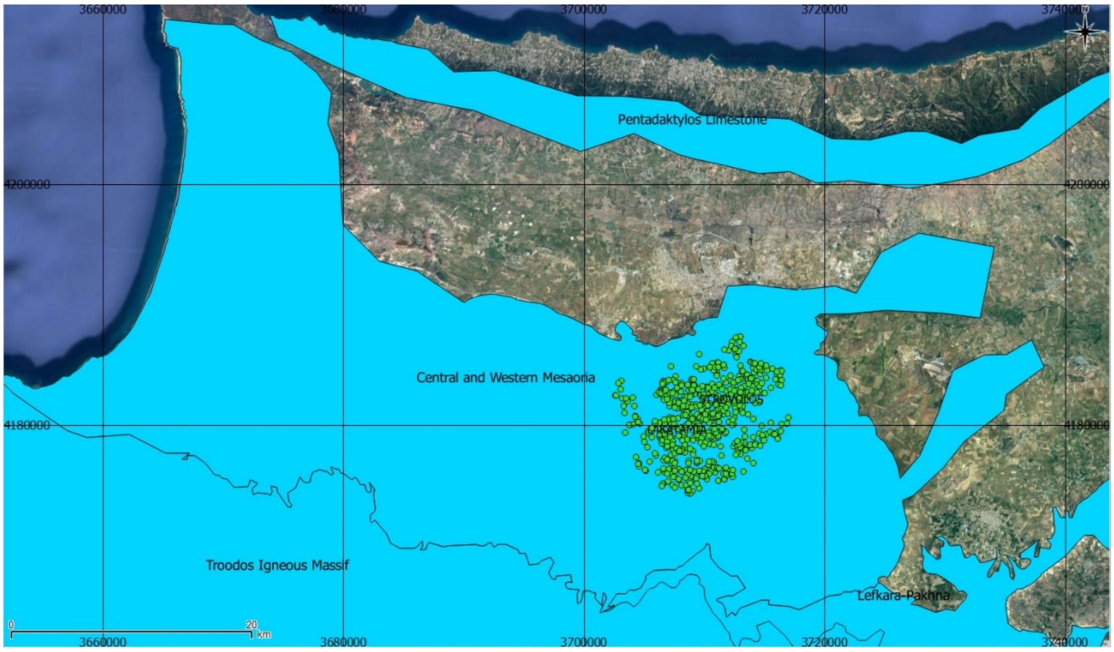


Figure 1-6: Location of municipalities and boreholes in relation to the underground aquifer

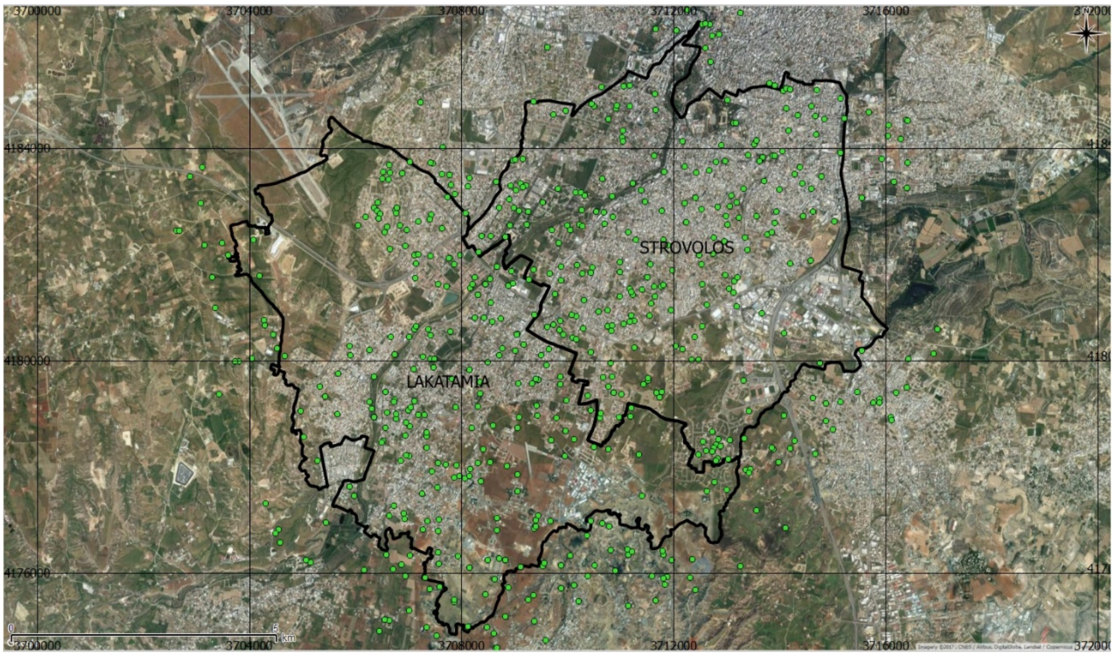


Figure 1-7: Boreholes located at the area of interest.

The average capacity (median value) of all these boreholes located at the study area (buffer: 1 km) is about 250 m^3 each.

The boreholes are distinguished in (based on their use):

- Irrigation: 342
- Industrial purposes: 3
- Livestock purposes: 6
- Home garden irrigation: 264
- Other purposes: 9

According to the data presented above, the majority of the boreholes are used for irrigation purposes.

In this case, the Tamasos Dam should be mentioned as a regulator project of the Pedieos River. The flow regulation of the river is very important because several flood impacts are avoided and at the same time, enrichment of the aquifer is achieved.

The location of the dam in relation to the municipalities and the catchment area is presented in Figure 1-8.

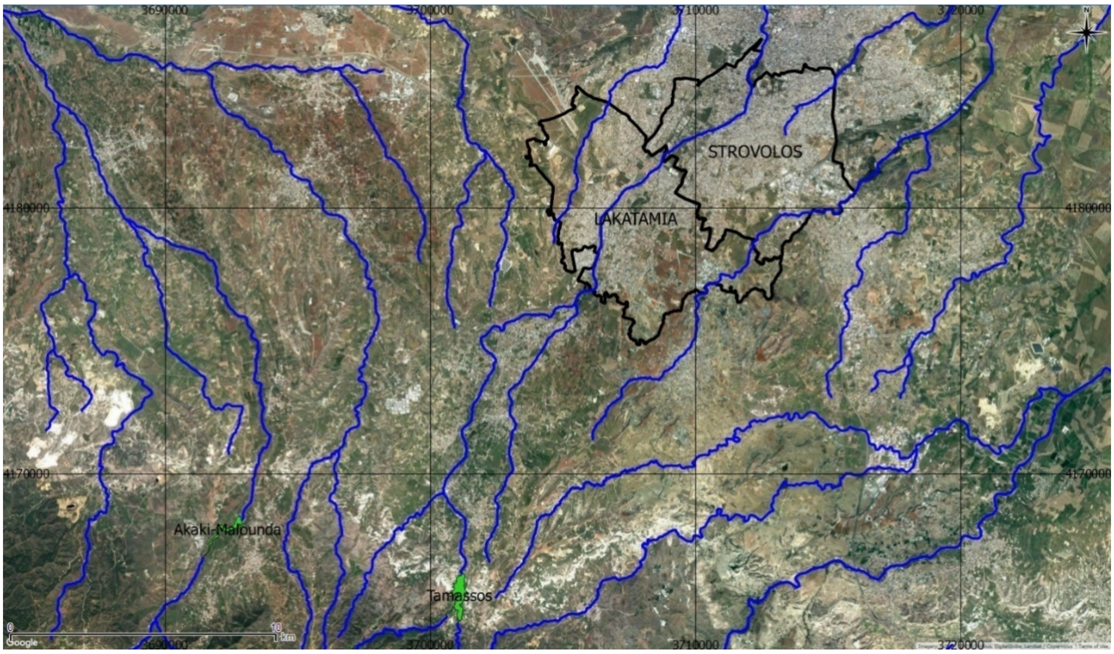


Figure 1-8: Location of the Tamassos dam in relation to the municipalities and the catchment area.

The annual inflow at the dam is about 5.2 mcm. The relation between annual inflow and precipitation is presented below.

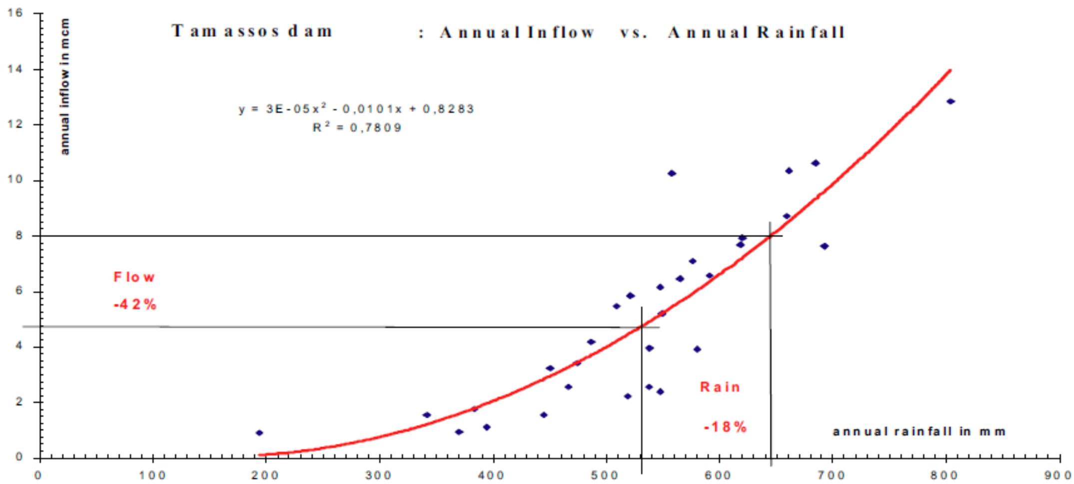


Figure 1-9: Relation between annual precipitation and annual inflow to the Tamassos dam (Rossel, 2002).

The qualitative status (Figure 1-10) of the Central and Western Mesaoria aquifer is "good" in contrast with the quantitative status (Figure 1-11) which is characterized as "bad" (TAY, 2016).

Water balance of the aquifer is negative for the two calculated time periods (2000- 2008 & 2008-2013). More specifically, for the first time period water balance was about -4.2 hm^3 and for the second -6.04hm^3.

These calculations indicate that the water being pumped wasmuch more than the quantity of waterthat enriches the aquifer.

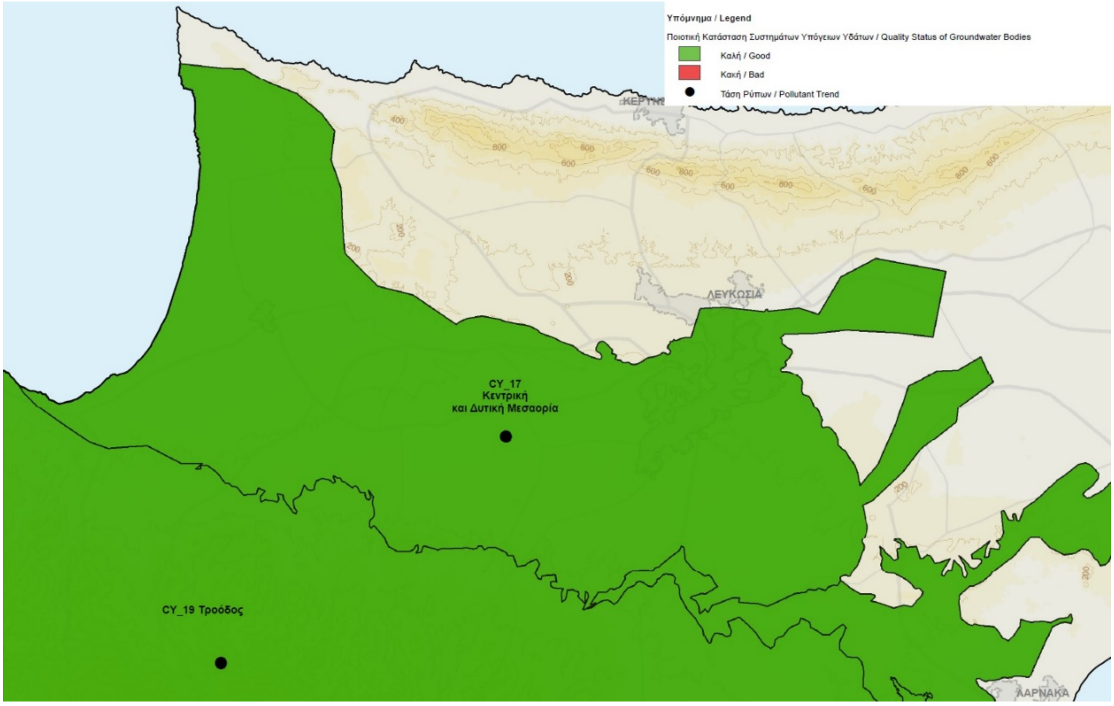


Figure 1-10: Qualitative status of Central and Western Mesaoria aquifer (TAY,2016)

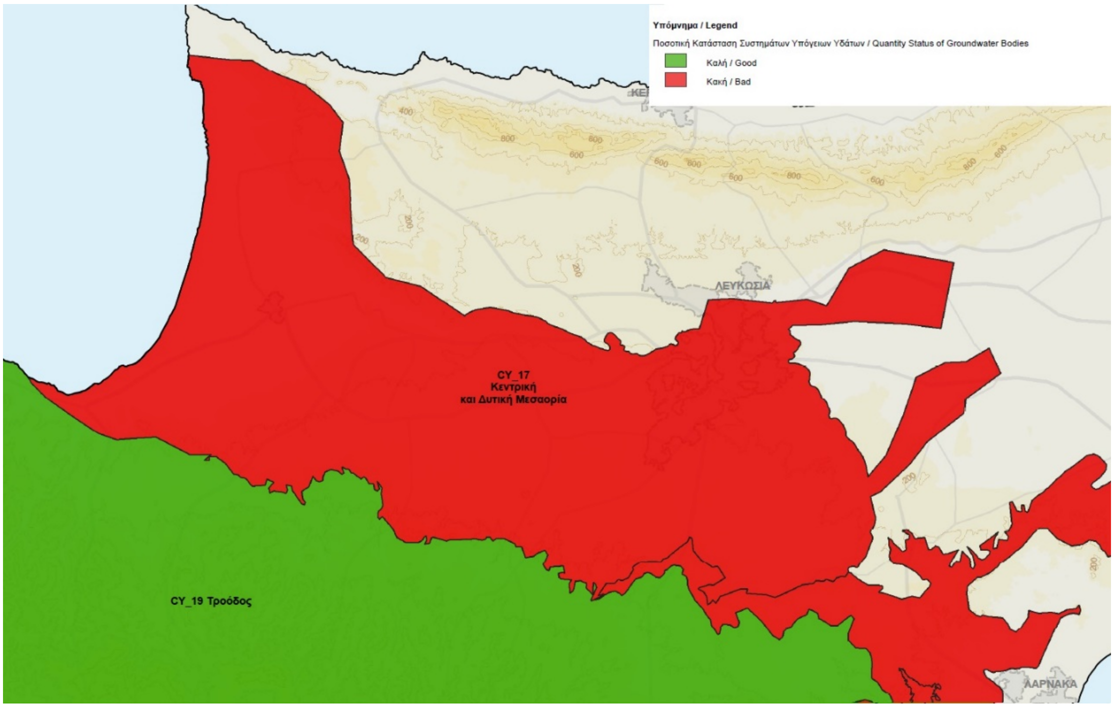


Figure 1-11: Quantitative status of Central and Western Mesaoria aquifer (TAY,2016)

Finally, as far as the qualitative and quantitative characteristics of the dam these are mentioned as "good" according to TAY (2016).

1.1.1.1.3 Other water supply sources

Waste Water Treatment Plants

The two municipalities (Strovolos and Lakatamia) are supplied with recycled water from two waste water treatment plants for irrigation purposes only. More specifically, Strovolos municipality is supplied with water from the waste water treatment plant of Vathia Gonia and Lakatamia municipality form the Anthoupoli's plant.

The location of two waste water treatment plants is presented in the next figure.

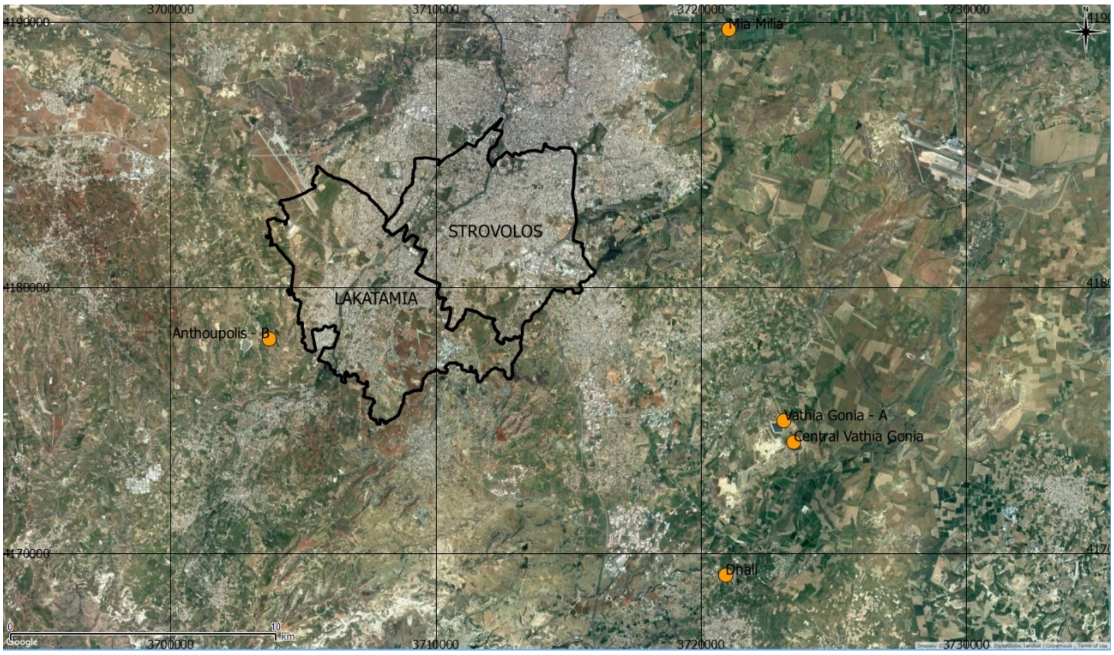


Figure 1-12: Locations of sewage treatment plants in relation to municipalities.

Amounts of recycled water disposed to municipalities for irrigation purposes in 2016:

- Strovolos municipality: 16000 m^3
- Lakatamia municipality: 3797 m^3

1.1.1.2 Water Supply and Demand Balance

Lakatamia municipality is supplied with water from the Tersefanou – Nicosia pipeline.

Time series of drinking water consumption is listed below.

Table 1-1: Time series of drinking water consumption – Lakatamia municipality

Year	Drinking Water Consumption (m³)
2011	2.380.720
2012	2.500.843
2013	2.316.710
2014	2.330.030
2015	2.533.086
2016	3.044.530

It is noted that there are no significant changes in water consumption from 2011 to 2016.

Strovolos municipality is supplied with water from the Water Board of Nicosia. The quantities of water consumed and the purpose of use (from 2005 to 2007) are presented in the next figure.

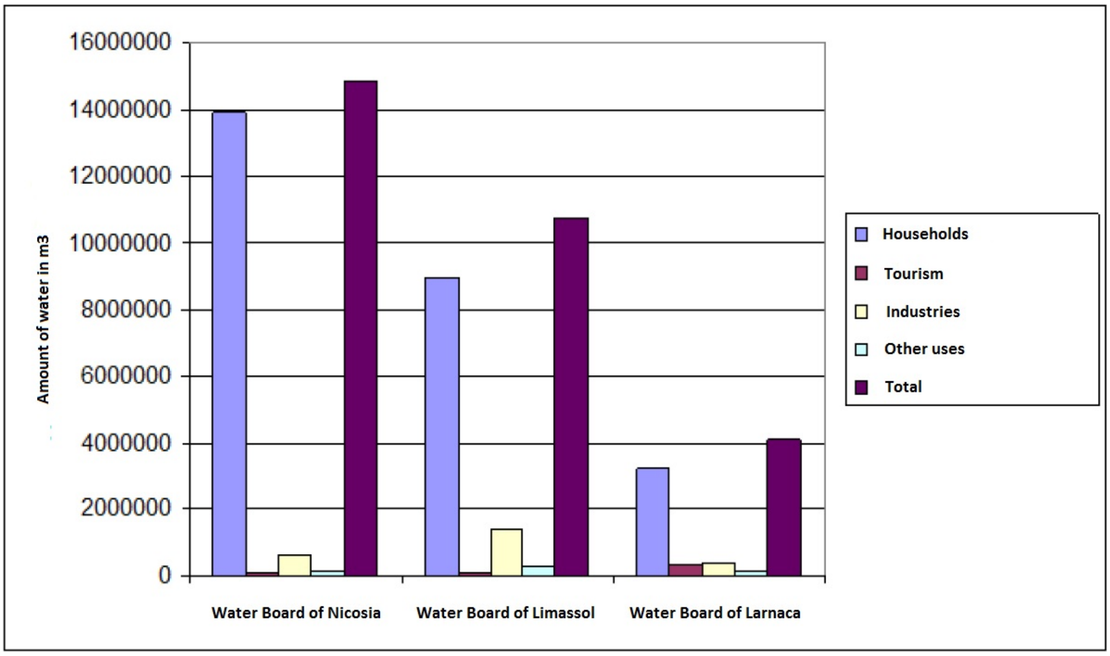


Figure 1-13: Amount of water consumed and purpose of use – Water Board of Nicosia (TAY, 2016)

According to Figure 13 most of the water consumed is intended for domestic use.

The annual water demand (in m³) for the two villages is presented in the next table

(Savvides et.al. , 2001).

Table 1-2: Annual water demand per municipality (m3) (Savvides et.al. , 2001)

Municipality	Year			
	2000	**2005**	**2010**	**2020**
Strovolos	4530682 (m^3)	4955336 (m^3)	5390319 (m^3)	6318226 (m^3)
Lakatamia	1841516 (m^3)	2014119 (m^3)	2190919 (m^3)	2568071 (m^3)

1.1.2 Observed and expected impacts

The preparation of the National Adaptation Plan for Cyprus has been based on an assessment of the current and future vulnerability of specific socio-economic sectors of Cyprus against climate change (CYPADAPT, 2014). In specific, the vulnerability assessment related to water resources conducted was based on the following impact categories, namely:

- Water availability

It has to be noted that the assessment of the overall vulnerability was based on the result of the impact in regards to its adaptive capacity, where impact was defined by the product of multiplying sensitivity with exposure. In this context sensitivity to runoff to changes in rainfrall, groundwater overexploitation,freshwater stress indicators (such as freshwater availability per capita, water exploitation index, water availability index) were examined against the adaptive capacity of the system against water demand due to continuous population expansion in the area. More specifically, the assessment shed light to the following observed impacts:

- o For the period 1971-2000, the total quantity of water in the 15 main reservoirs of Cyprus, and runoff were reduced by 40% compared with the design estimations for the period 1917-1970 (Rossel, 2002).
- o For the period 1987/88-2010/11, high variability in dam inflow was recorded resulting in high sensitivity of surface water resources against climate change.
- o For the period 2000-2008, the quantitative status in 11 out of 19 groundwater bodies in Cyprus were characterized bad in respect to the Water Framework Directive principles. In this context, the groundwater resources of Cyprus were highly exposed to climate change.
- o The Water Stress Indicator that was estimated for the free part of Cyprus was considered to be very low, highlighting the lack of possibility in depending exclusively on freshwater resources.
- o The Water Exploitation Index that was calculated for Cyprus was particularly high, resulting in severe water stress.

  - The Water Availability Index result highlighted that water demand in Cyprus is higher than the freshwater availability.

However, it has to be noted that the measures taken in regards to the protection of water resources have decreased some of the impacts, but have not fully satisfied water demand.

- Water quality

Phenomena, such as eutrophication, stratification and low levels of dissolved oxygen and decreased water flows are common for the water bodies of Cyprus. What is more, climate change phenomena, as well as certain phenomena resulting from the intense socio-economic activities increase the exposure of the water bodies against climate change. To this end, the exposure was estimated based on certain indicators as following:

  - Status of surface water bodies (river water bodies, lake water bodies, coastal water bodies)
    The assessment that was conducted based on the Surface Water Vulnerability Index, estimated the pollution potential at the surface water bodies of Cyprus. The main outcome of the project (Pig Wasteman project, LIFE Third Countries) was that the most polluted, thus the most vulnerable to climate change, surface waters are located at the NW and central areas of Cyrpus.
  - Status of groundwater bodies
    For the period 2000-2008, 42% of the 19 groundwater bodies were classified under the bad qualitative condition based on the Water Framework Directive principles. In this framework, the exposure of groundwater bodies to climate

Cyprus.

- Floods (see also Chapter 2.1.2)
- Droughts

Due to the numerous depleted aquifers and the lack of perennial rivers, the limited water resources located in Cyprus are particularly vulnerable to droughts. In addition to the aforementioned, the phenomena of reduced precipitation during the period 1961-1990 (severe drought was recorded during 29% of the years during the period 1901-2010, droughtduring the 12% of the same period, and below normal was the characterization for 11% of this period) increase the vulnerability of Cyprus against drought. In this framework, the Sensitivity to Desertification Index was also estimated highlighting that only the 1.5% of the total areas in Cyprus do not face desertification.

In order to combat the desertification phenomena, several adaptive measures have been designed for the drought prone areas of Cyprus. However, adaptive strategies are considered limited, resulting in moderate adaptive capacity of the island against droughts.

1.1.3 Non-climate related pressures

The non-climate related pressures observed in the study area are associated with human activities. Impacts are related with the quantitative and qualitative characteristics of the surface and groundwater resources of the study area.

As far as human activities in the area are concerned, they are mainly related to livestock farming as shown in the next figure.

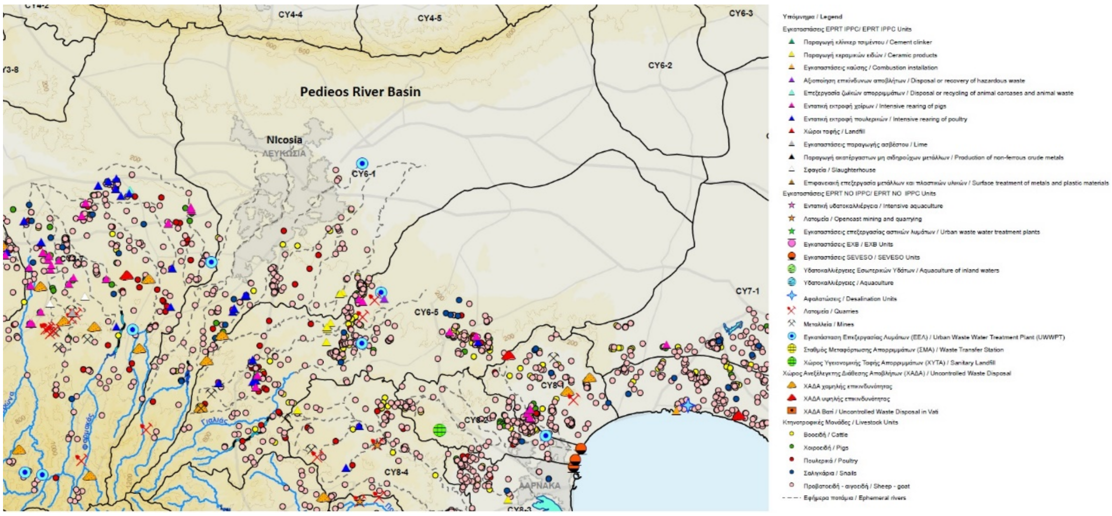


Figure 1-14: Environmental pressures map (TAY, 2015).

Also human activity in the area affects (due to over-pumping, mainly for irrigation purposes) to a significant extent the quantitative status of the underground water resources.

The water balance of the aquifer in recent years is negative fact that indicates over-pumping of groundwater.

1.1.4 Adaptation measures

TheMinistry of Agriculture, Rural Development and Environment of Cyprus coordinated the adaptation policy-making process focusing on eleven (11) policy areas (CYPADAPT, 2014). The 250 measures, actions and practices proposed have been based on scenarios and projections for the future period 2021-2050. These adaptation measures apply to all the policy areas that have already or expected to be affected by climate change in Cyprus[1]. More specifically, the holistic framework proposed includes future measures, as well as measures of direct applicability, divided in selected sectors of importance for Cyprus to combat climate change. Water resources are included in the water sector of the National Adaptation Strategy

[1] http://climate-adapt.eea.europa.eu/countries-regions/countries/cyprus

that has been developed for Cyprus[2]. In this context, the following measures have been proposed in order of decreasing priority:

Measure 1: Maintenance and repair of water transport systems and related infrastructure

Water losses in water distribution networks -especially in rural areas- are quite high. Water losses in the networks, also known as unaccounted-for water in the distribution networks of the main urban areas, have been estimated to range from 15% to 20% (while this percentage is higher in rural area, i.e. from 20% to 30%). Saving water from network replacement is expected to be very effective compared to other savings measures. A survey conducted in 2009-10 on the water supply networks of municipalities that are not served by Water Boards,highlighted that over 80% of the networks have been replaced in 63.4% of municipalities.

Therefore, it is proposed to continue replacing and repairing all old and inadequately maintained water distribution networks, as well as to detect leaks by adopting appropriate technologies.

Measure 2: Control and avoidance of waterborne requirements in all areas with insufficient water resources (e.g. tourist facilities, aquatic crops)

The operation of water-borne facilities, such as golf courses, tourist facilities and aquifers in areas with limited water reserves, must be controlled and/or prohibited by:

- imposing restrictions on water consumption by water supply networks,
- meeting the needs for potable water production by private desalination units using alternative water resources for irrigation of golf courses (eg recycled water, storage and use of rainwater),
- using renewable energy sources (e.g. solar) for the cases of water production from private desalination units,
- developing adaptation scenarios for using swimming pools during periods of limited water availability. For example:
    - banning the use of drinking water for swimming pools,
    - establishing a pool fee at the stage of licensing and/or operating a swimming pool,
    - prohibiting the connection of the swimming pool with the water supply system in the new town planning licenses,
    - obligating coverage of swimming pools during the hours of non-use in order to limit evaporation,
    - constructing swimming poolsnear the sea for operation with sea water,
    - limiting the operating hours of the pools,

[2]http://climate-adapt.eea.europa.eu/countries-regions/countries/cyprus

    - granting licenses from the local water supply for the supply of water to the swimming pools provided that water saving measures are implemented.
- Limiting crops, such as bananas or squash, thus providing incentives for cultivation of other less hydroponic crops.

To sum up, it is proposed (i) to redefine licensing and prohibition of water demanding activities, as well as (ii) to develop and test adaptation scenarios for the control of water demanding plants in areas with insufficient water resources.

Measure 3: Enhancement of the efficient use of water in buildings, agriculture and industry

Efficient use of water in buildings (homes, schools, offices, restaurants, hotels, hospitals, airports etc.) is achieved by using low-water equipment (e.g. cisterns, showers) and more efficient household appliances (e.g. dishwashers and washing machines). In particular, the tourism sector in some parts of Europe (including Cyprus) has many potential savings of 80-90%, by implementing measures, such as installation of low-power appliances in rooms andcafes (Benito et al., 2009). It should be noted that large private enterprises in Cyprus already have efficient drinking patterns. However, the public and household sectors, as well as many small and medium-sized enterprises, have not yet adopted this measure to a satisfactory extent. To this end, the mandatory adoption of the measure by all large private companies and the public sector is proposed. In addition the adoption of incentives in the domestic sector and small and medium-sized enterprises (provision of free equipment, subsidies, tax deduction) could also be an effective measure.

As far as agriculture is concerned, it has been estimated that an average 43% of the total water consumption could be saved in Europe. In Cyprus, the Department of Agriculture implements a program to improve irrigation performance since 1965, providing farmers with technical and financial support to change traditional surface irrigation methods with advanced irrigation systems. Irrigation efficiency has increased from 45% in 1960 to 90-95% in 2010 (TAY, 2011). Other measures that can be promoted with regard to irrigation practices include rational irrigation planning (e.g. irrigation hours, irrigation at night hours to limit evaporation), the use of models and tensiometers to calculate the actual irrigation needs (collection and processing of agro-meteorological data) and research and adoption of even more sophisticated irrigation systems.

In industry, efficient water use can be achieved by introducing changes in production, treatment, purification, cooling and/or heating processes to reduce water demand. It is estimated that these changes can lead to an average reduction of 43% in the total water demand of the sector (Benito et al., 2009).

Measure 4: Reuse of treated urban waste water only after rigorous control of its suitability

The use of treated urban waste water provides additional protection against drought, favors water supplies from local sources and saves high-quality water where it is not needed. However, the possibility of reuse depends on the availability and accessibility on sewage treatment infrastructures, as well as on the acceptance by potential end-users and consumers. The urban waste water collection and treatment infrastructure in Cyprus has been expanding and improving considerably in recent years. Processed waste water is used to irrigate green, athletic fields and certain crops, as well as for enriching aquifers. However, recycled water is distributed only in the lowland and coastal areas, as the construction of the necessary transport infrastructure in the mountainous areas and the energy costs of pumping water in these areas make this investment technically and economically unfeasible.

For the implementation of this measure, the following are proposed:

- The Government should provide as soon as possible the necessary infrastructure in order to use urban waste water for irrigation of green areas, sports grounds and specific crops on a national scale. Also, for the interim period up to the construction of the relevant infrastructure it is proposed to carry out a cost-benefit analysis for the transport of treated urban waste water by tankers from areas where there is no distribution network. For distribution through a network, studies need to be conducted in order to identify infrastructure requirements.
- Strict preventive measures should be applied so as to monitor the quality of treated urban waste water to avoid environmental, public health and agricultural pollution.
- Incentives provision for wastewater use in agriculture, industry and the domestic sector, while effective disincentives (e.g. fines) should be applied for the use of groundwater for irrigation of green areas.
- Information campaigns should be launched regarding water resource efficiency.

Measure 5: Periodic reviews of progress and priorities, and appropriate adaptation of objectives, instruments and resources taking into account climate change

Periodic water policy revisions (e.g. Cyprus River Basin Management Plan) should take into account the impacts of climate change both during the monitoring and assessment of the state of Water, as well as at the planning and selection stages of the reclassification measures.

Measure 6: Extending the use of water supply meters

Using water meter counters allows users and providers to monitor water consumption and the effectiveness of implementing savings measures. The installation of water meters in Cyprus is almost universal for drinking water consumers, while a significant proportion of the

Communities do not have central water meters, so no water leakage or loss can be checked. For irrigation, the use of meters is mainly limited to areas under special control/protection. In particular, Law 79(I)/ 2010 promotes the installation and monitoring of water meters in drilling in order to avoid over-discharge. It is expected that this Law will reduce the phenomenon of over-exploitation of groundwater. Therefore, it is proposed to install water meters for all water users and suppliers, as well as the simultaneous installation of modern systems for automatic collection and evaluation of meter readings for effective monitoring.

Measure 7: Awareness raising campaigns

Awareness campaigns make a significant contribution to saving water.Over the last decade, awareness campaigns have been intensified with presentations in schools, advertisements, information material distribution and other initiatives. Although it is difficult to quantify the effectiveness of awareness campaigns, there has been a downward trend in water consumption during the intensification of campaigns (TAY, 2011). Based on the abovementioned, the continuation of the awareness-raising campaigns is proposed in order to cultivate a sense of responsible water use for people, regardless of the lack of resource.

Measure 8: Utilization of rainwater (collection on a separate sewerage network and storage in special facilities)

Utilization of rainwater through storage and re-use can result in further savings in the consumption of natural water resources. Over the last two decades in Cyprus, a separate sewerage network has being developed with the aim of collecting rainwater. Until now, the network has been completed for the majority of major urban centers in Cyprus. In agriculture, incentives are provided for the collection of rainwater in small-scale reservoirs and its use for irrigation is ensured with the measure "Modernization of agricultural holdings" of the Agricultural Development Program 2007-13 for Cyprus.

In addition, a study for the investigation of the use of rainwater in Cyprus (TAY, 2009β) has been carried out, proposing the following:

- Launch public awareness campaign on rainwater management.
- Ensure adequate water quality to avoid health problems.
- Provision of incentives to collect and use rainwater (reduction of fees) in buildings/houses.
- Provision of incentives to install sterns or use of existing absorbent pits (if appropriate) in buildings/homes (always considering groundwater pollution).
- Provision of incentives to filter rainwater before storing or enriching the soil in buildings/homes (always considering building statics).
- Imposition of fines for water pollution.

- Imposition of conditions on new building permits to ensure the reduction or storage of water flowing at the roads.

In addition, extension of the measures to agriculture and industry should also be considered. In particular, the following measures are proposed:

i) Continue to provide incentives to farmers to collect rainwater in small-scale reservoirs through the Agricultural Development Program.

However, rainwater collection systems can limit runoff to the upstream part of a basin, thereby reducing the water supply to the downstream part. In addition, soil surface has a very low drainage factor of the order of 0.1-0.3. Based on the abovementioned, when approving and granting incentives and selecting the appropriate features of the rainwater collection system to be built, the following parameters should be considered:

i) climatic factors in the area (rainfall distribution and intensity, evapotranspiration rate),
ii) characteristics of the surface area (soil infiltration rate, water storage capacity and soil depth),
iii) hydrogeological characteristics of the area,
iv) characteristics of the crops and
v) socio-economic factors (e.g. costs and benefits, social acceptance) to assess the efficiency and environmental and social impacts of implementing the measure.

Various methods, such as clearing or alteration of plant cover, increasing soil slope and soil compaction, can also be applied to increase drainage capacity. Finally, it must be ensured that rainwater collection tanks are not used for groundwater storage and that this measure shall not encourage the illegal construction of dams and lagoons.

- Provision of incentives to industry to install rainwater collection tanks and use of collected water in various processes.

Measure 9: Effective water pricing

Pricing policies under the Water Framework Directive 2000/60/EC should, inter alia, provide incentives for wise water use by citizens. In order to implement the provisions of the Directive, the competent authorities commissioned a study to develop a new pricing system through which the following main differentiations are proposed in relation to the old system (TAY, 2009α):

In regards to drinking water, it is proposed to continue the pricing in ascending scales, which consists of a fixed charge, i.e. the fixed and a volumetric charge in at least two steps. While the fixed charge and the first scale of volumetric charging are aimed at recovering the costs (financial, environmental and resource), the second scale, as well as all those that are ultimately adopted by water-supply providers, are aimed at enhancing water savings. For water from private drilling outside Government Water Works, while it has not a hitherto been charged, it is proposed that the individual be charged beyond the financial cost, as well as with an additional charge for environmental costs and resource costs.As far as irrigation water is concerned, it is proposed to continue using the existing mixed billing system (fixed and volumetric charge), increasing prices to a point where the viability of the sector is not negatively affected. Also, the use of the over-consumption charge should be maintained, with the application of a very high price for irrigation quantities that exceed the annual approved quantity (the approval is granted annually depending on the water status and the reserves in the dams). For uses involving grass irrigation, soccer, golf, sports, irrigation of green areas and hotel and house gardens, as well as for industrial use, prices are higher in order to cover full costs.In addition, in order to promote the use of recycled water, the proposed values of recycled water should be considerably lower than the cost of such water, taking into account the environmental benefits from its use.

In addition, several scenarios were examined with values of water demand depending on its value (TAY, 2009α), both in water supply and irrigation. The basic version adopted considering Cyprus existing situation regarding water resources is that there is almost zero flexibility in water demand depending on the water values. Based on the abovementioned, it is important to continuously monitor its effectiveness and optimize it where necessary to achieve savings in water consumption.

Measure 10: Incentives to reuse "polluted water" (in buildings and industries)

Much of the daily water consumption for various uses in the domestic sector is not required to be drinkable and can be replaced by lower quality water, such as polluted water. Semi-polluted waters are the waters coming from bathrooms, showers, wash basins, washing machines, and from the washing of fruits and vegetables. With the recycling of semi-pure water, drinking water savings of more than 35% could be achieved (Benito et al., 2009). For a while, a government subsidy was provided to Cyprus to install a system for the recycling of polluted water for the treatment of polluted water and its reuse for the lavatories and irrigation of the building gardens. The subsidy covered the installation of a system of recycling of polluted water in homes, schools, stadiums, institutions, swimming pools, gyms, hotels, industries etc. connected to the water supply systems of all municipalities and communities of free Cyprus. To this end, the following are proposed:

- Launching of public awareness campaign for the management of polluted water
- Continuationof providing incentives for installing a recycling system for non-polluting waters

Measure 11: Implementation and regular revisions of the Drought Management Plan

In order to implement this measure, the following are proposed:

- Implementation of the necessary measures for the implementation of the Drought Management Plan.
- Implementation and strengthening of early warning systems.
- Periodic re-evaluation of the indicators and the limits assigned to them.

Measure 12: Developing drought risk maps

Measure 13: Preparation of drought risk assessment studies in areas where water availability is limited

Measure 14: Strengthening institutional regulations, plans and policy mechanisms to reduce the impact of drought

This measure is based on the following actions:

- Identify roles and strengthen cooperation and coordination between all central and regional competent authorities.
- Incorporate and strengthen drought measures in the water sector-specific sectoral policies (e.g. agriculture, biodiversity, forests, tourism).
- Strengthen the capacity of the competent bodies to implement the drought plan
- Strengthen the relevant legislation to better control and implement them.

Measure 15: Intensify monitoring of water quality used for enrichment of underground aquifers

- Systematic monitoring of water quality used for enrichment of underground aquifers as well as water quality in these aquifers.
- Review of existing Artificial Enrichment Licenses taking into account the concentration thresholds set by Directive 2006/118 / EC.
- Predicting an alternative method of disposing of recycled water in cases where it is found that some of the parameters of the underground body have deteriorated.

Measure 16: Extension of protection zones under the Water Framework Directive 2000/60/EC

- Extension, after a special study, of the protection zones to the whole water supply points for water supply purposes
- Revision of the Register of Protected Areas

Measure 17: Rehabilitation/rehabilitation of coastal aquifers

This measure is proposed separately, as the Measures for the negative effects on the water status of the Measures Program do not include measures for abandoned coastal aquifers due to sanitation. Although it is a difficult and lengthy process, steps must be taken to address this issue. For this reason, it is proposed to carry out a study on the procedures required to accelerate the rehabilitation of coastal aquifers that have been sanitized.

Measure 18: Provide incentives to farmers to apply techniques that protect water quality

Measures in order for farmers to reduce run-off, especially after application of manure, should be encouraged. The efficiency of fertilizers and the methods of application should be improved. The use of phytopharmaceuticals next to water bodies may be effective in reducing nutrient leaching. Farmers should therefore be aware of existing best practices. In this context, the following are proposed:

- The continuation and strengthening of measures in the Rural Development Program in order to reduce the use of chemical preparations and the implementation of practices for the reduction of run-offs and a summary of the statutory water protection zones in the aforementioned program.
- The continuation and strengthening of the System of Farm Advisory System.

Measure 19: Appropriate Waste Management to Prevent Pollution of Surface and Groundwater

This measure includes the following:

- Restoration of Uncontrolled Waste Disposal Sites
- Issue/renewal/review of waste disposal sites and systematic compliance check
- Secure disposal of sewage water

Measure 20: Control of groundwater exploitation by legislative measures, regular inspections by competent authorities and fines

Measure 21: Preparation and implementation of flood risk management plans for Areas of Potential Significant Flood Risk

Measure 22: Definition and installation of riverbed protection zones

Measure 23: Conservation and restoration of wetlands and river beds as natural flood protection

Measure 24th: Extension of the separate rainwater sewerage network

Over the past two decades, a separate sewerage network has been developed in Cyprus to collect rainwater. So far, the network for the majority of urban areas in Cyprus has been completed. This measure promotes the extension of the separate sewerage network to cover all urban Regions of Cyprus.

Measure 25: Extending the Implementation of Sustainable Urban Sewerage Systems Rainfall

These systems are a set of management practices and projects designed to drain and control surface water in a more sustainable way than traditional practices, taking into account long-term environmental and social objectives. The main measures include: preventive works, green roofs, filters, absorbent wells, retention lakes, drains.

1.2 Greece

1.2.1 Existing situation

Water needs in the study area is entirely covered from the water supply network of Attica its supply is based on various underground and surface sources from deferent areas of Central Greece. No in situ or any other type of water sources such as recycled water are being used. This chapter is presenting the main and special characteristics of Attica's complex water supply network. Information about the qualitative and quantitative status of water resources, water supply and demand balance of the study area are also included.

1.2.1.1 Water Supply Sources

The Municipality of Peristeri area is located to the areas of EYDAP's competence, which are directly supplied by its network (ΕΥΔΑΠ, 2017). No in situ water resources are identified in the study area, therefore all the water sources utilized by the EYDAP network will be analyzed.

In order to cover the water demand of these areas, EYDAP water supply network exploits surface and underground water resources.

In summary, the water supply system of Attica consists of (Koutsoyiannis et.al, 2000):

- Surface and groundwater resources
- Boreholes
- Water storage projects, such as reservoirs and dams

- Aqueducts
- Watertreatmentplants

In general, the Attica water supply system is complex because it exploits different types of water resources from various hydrological basins of Central Greece. In Figure 15 the water supply system of Attica is presented.

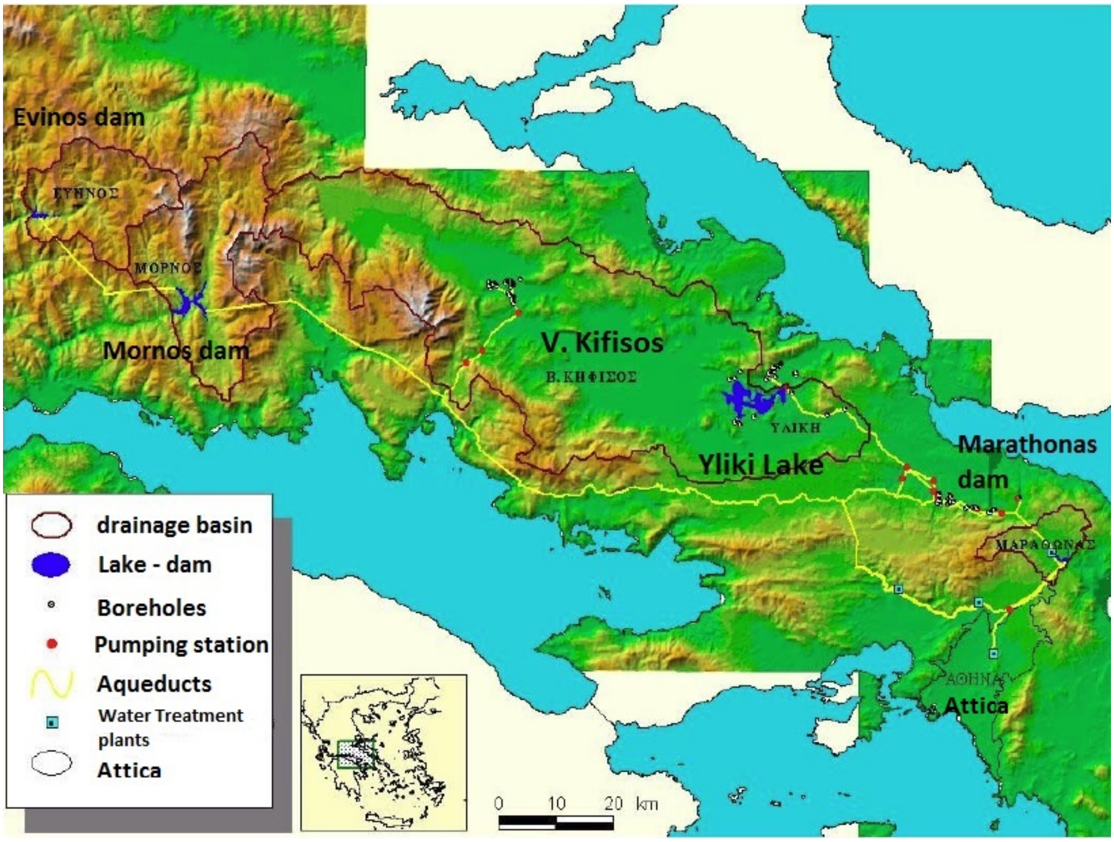


Figure 1-15: Water supply network of Attica (Koutsoyiannis et.al, 2000)

Water resources can be distinguished as main, support and backup. The main resources refer to the Mornos and Evinos reservoirs, the support resources in the Yliki and Marathonas reservoirs and the backup resources in the underground water resources. The exploitation of groundwater bodies is through wells and boreholes.

1.2.1.1.1 Surface Water Sources

As mentioned before the surface water resources which EYDAP exploits are Mornos r., V. kifissos r. and Yliki Lake. The detailed features of all surface water bodies are described below (Koutsoyiannis et.al, 2000).

Lakes

The natural lake of Yliki is one of the auxiliary surface water resources which contributes to the water supply system of Athens. Is located in Central Greece, 8 km north of Thebes at 78 masl. It has been an important source of drinking water for Athens since 1958. The surface area of the lake is calculated at 24.5 Km^2. Yliki lake is in the same river basin as the V. Kifissos River. This specific river basin covers 2460 Km^2 of land and the average annual run-off is about 317.6 hm^3 of water (EYDAP, 1996). The location of V. Kifissos river basin and Yliki lake are presented at the Figure 15.

Specific characteristics of Yliki natural lake are listed in the table below (Koutsoyiannis et.al, 2004):

Table 1-3: General features of Yliki Lake

First year of operation	1957
Water catchment area (km^2)	2466.6
Minimum water abstraction level (m)	43.5
Overflow level (m)	79.8
Total capacity (hm^3)	594.75
Beneficial capacity (hm^3)	584.75
Non – recoverable volume (hm^3)	10
Maximum surface (km^2)	27.74

The average annual and monthly rainfall statistics of the lake are listed in the next table:

Table 1-4: Monthly rainfall statistics of Yliki Lake

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Annual
Mean	71.1	89.8	108.7	34.2	79.8	70.7	40.7	33.6	20.7	6.8	12.6	29.5	657.6
St.Dev.	59.8	55.0	61.1	52.9	47.1	43.6	32.9	28.9	25.5	10.3	25.6	34.8	157.3
Max.	269.9	250.5	286.7	331.8	233.4	195.6	165.6	159.1	167.8	50.5	209.4	142.4	1192.7

Min.	0.0	2.1	7.0	5.0	0.0	5.7	0.0	0.0	0.0	0.0	0.0	0.0	333.6

All the statistics are presented above are related to the data collected from 1907-08 to 2002-03.

Average annual run-off of the V. Kifissos river and Yliki lake is calculated at 317.6 hm^3. The safe water abstraction from the basin is about 140 hm^3/year.

The average annual and monthly run-off statistics of the basin is presented in the next table:

Table 1-5: annual and monthly run-off statistics of Kifissos basin

	Oct.	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sept.**	**Annual**
Mean	23.3	33.2	49.4	63.6	66.4	70.9	49.1	25.9	12.9	4.4	3.8	13.8	412.6
St.Dev.	11.3	18.6	34.1	32.7	35.6	32.9	28.8	17.2	12.3	7.8	5.5	9.2	167.9
Max.	51.3	114.6	217.1	168.4	170.6	179.0	177.1	80.8	61.1	51.4	31.4	58.2	840.7
Min.	0.0	7.4	11.0	15.8	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.8

The run-off and rainfall time series on the lake are presented in the following bar charts.

These time series data was taken for two critical water sources of the lake (Yliki lake sub-basin and canal of Karditsa).

Rainfall and run-off charts for the canal of Karditsa which is one the most important fresh water resources of Yliki Lake are presented below (Koutsoyiannis et.al, 2000).

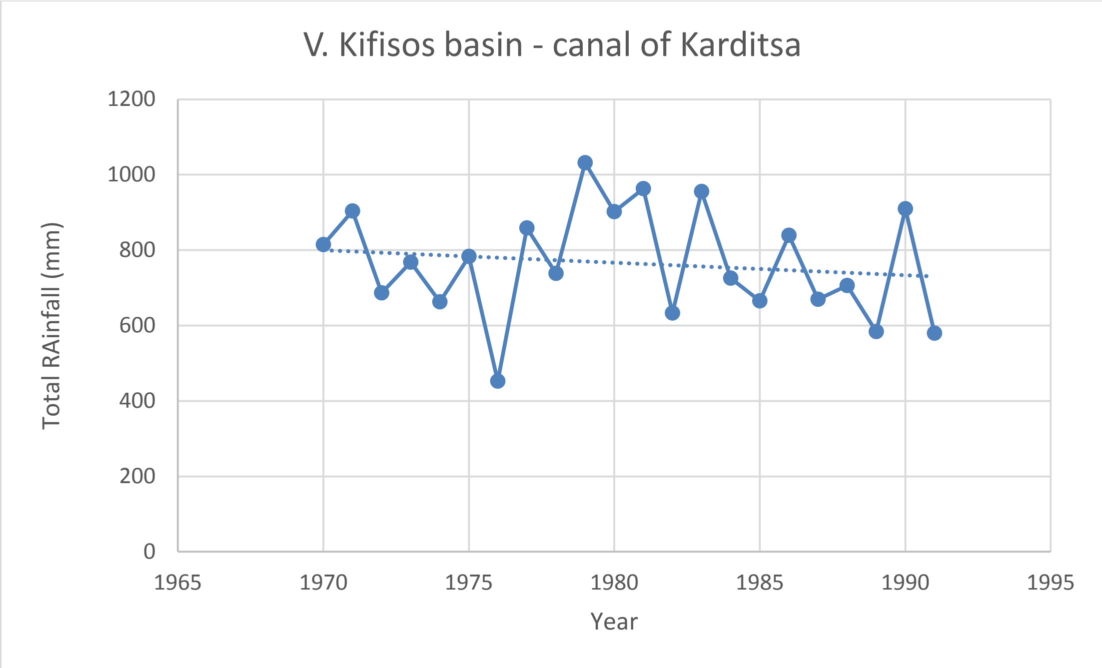


Figure 1-16: Time series of total precipitation on V.Kifisos basin – Canal of Karditsa

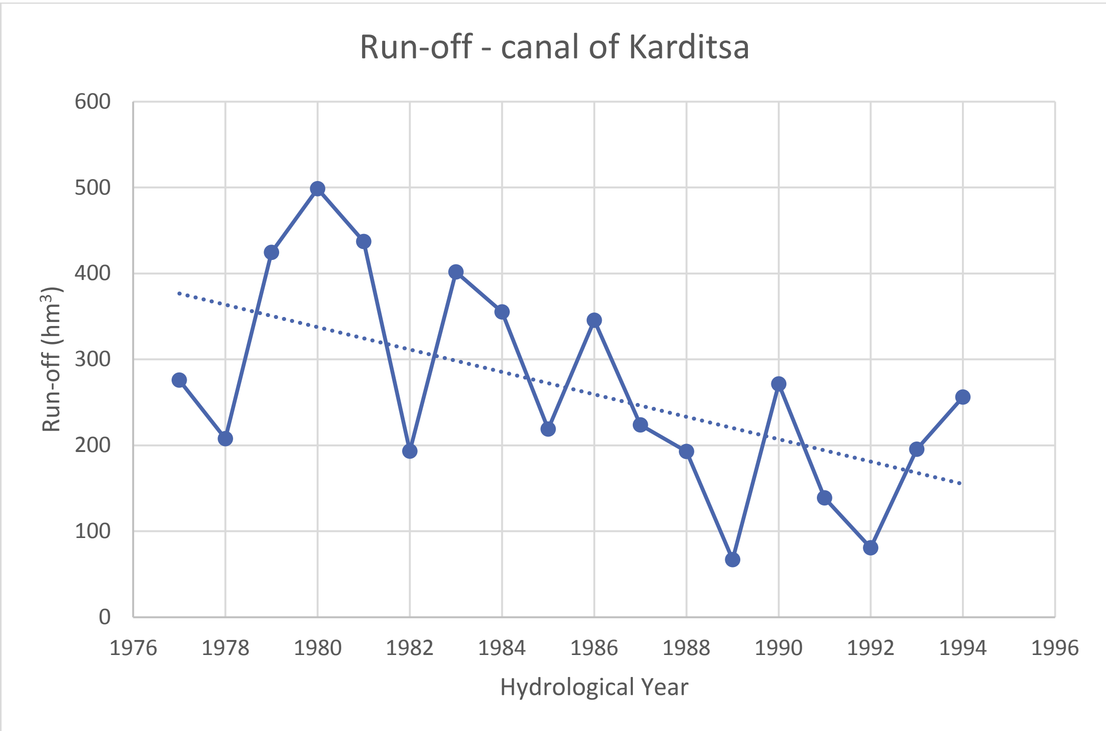


Figure 1-17: Time series of total run-off on canal of Karditsa

Rainfall and run-off charts for the Yliki lake sub-basin are presented in the next figures.

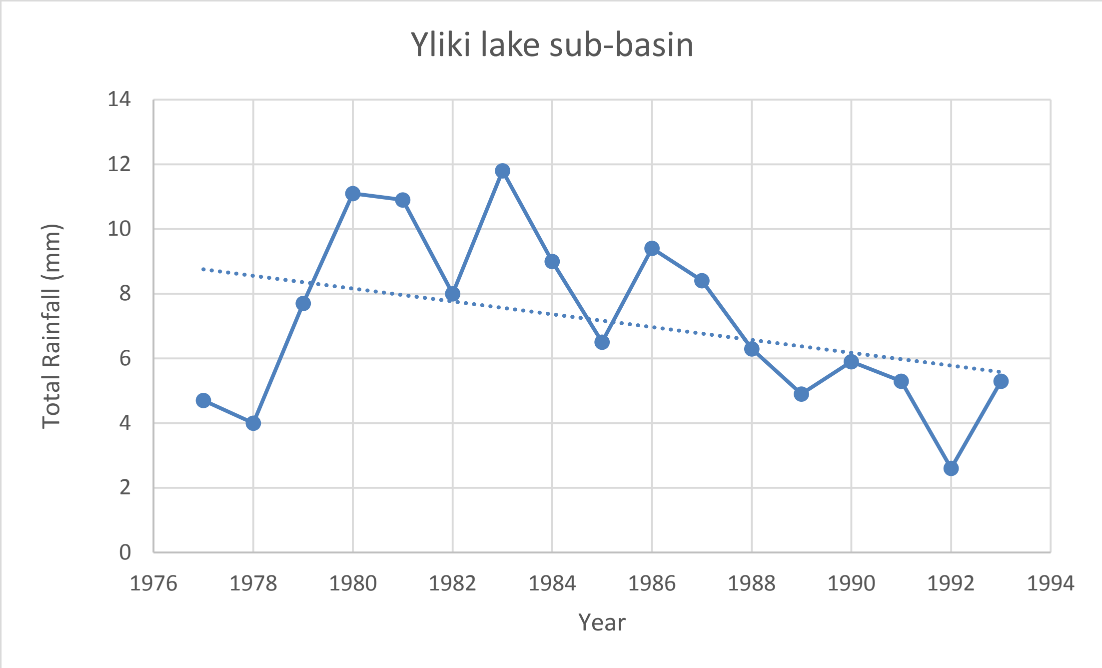


Figure 1-18: Time series of total precipitation on Yliki Lake sub-basin

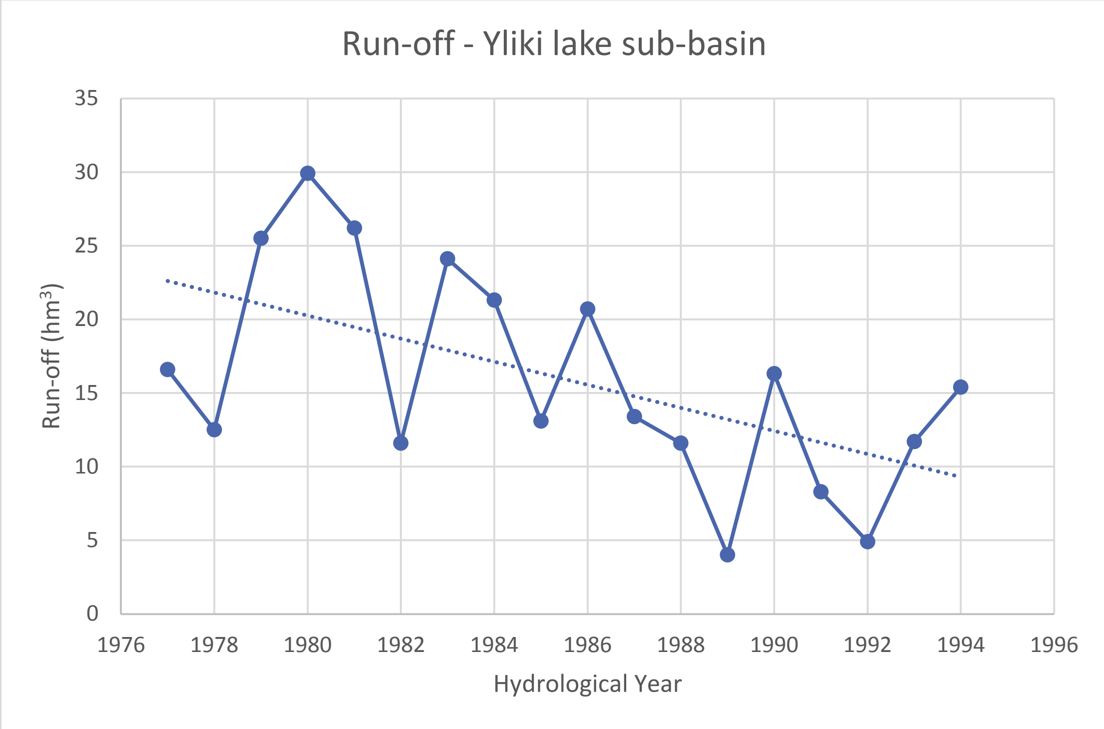


Figure 1-19: Time series of total run-off at Yliki Lake

According to these charts there is a positive correlation between the rainfall data and the run-off data. A rainfall decrease trend is followed by a run-off decrease trend on both cases.

The qualitative and quantitative status of the Yliki lake water is good according to the "River Basin Management Plan of the East Central Greece (GR07)" which was prepared by the Ministry of the Environment and Energy of Greece (2013).

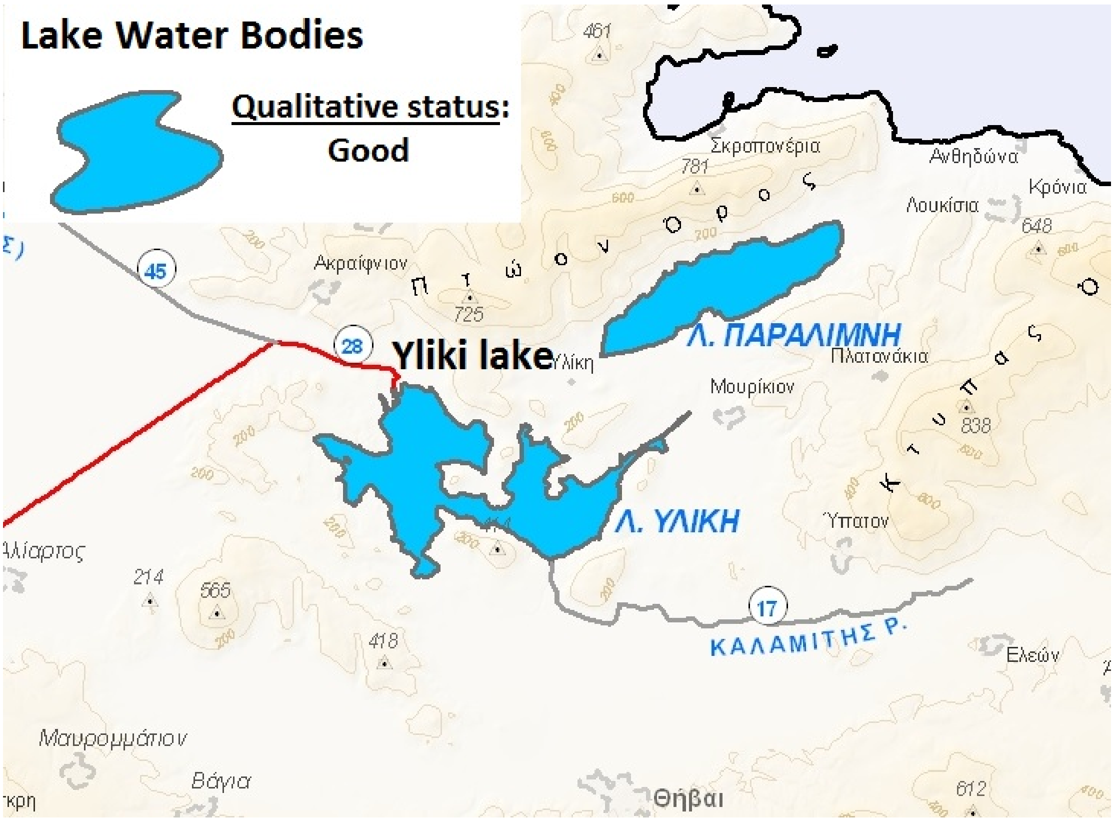


Figure 1-20: Qualitative status of Yliki Lake (ΥΠΕΚΑ, 2013).

Dams

Evinos Dam

Evinos dam (Figure 1-15) is one of the two main water storage infrastructures supplying the Attica water supply system. Water from this dam is driven into the other main dam of Mornos through a diversion canal.

The general characteristics of the dam are presented in the Table 1-4 (Koutsoyiannis et.al, 2004).

Table 1-6: General features of Evinos dam

First year of operation	2001
Water catchment area (km²)	351.9
Minimum water abstraction level (m)	458.3

Overflow level (m)	505
Total capacity (hm^3)	137.63
Beneficial capacity (hm^3)	112.05
Non – recoverable volume (hm^3)	25.58
Maximum surface (km^2)	3.6

The time series of rainfall data from three important locations (Ag.Dimitrios, Poros Riganiou, Achladokastro) of Evinos river basin are presented in the following charts (Koutsoyiannis et.al, 2000).

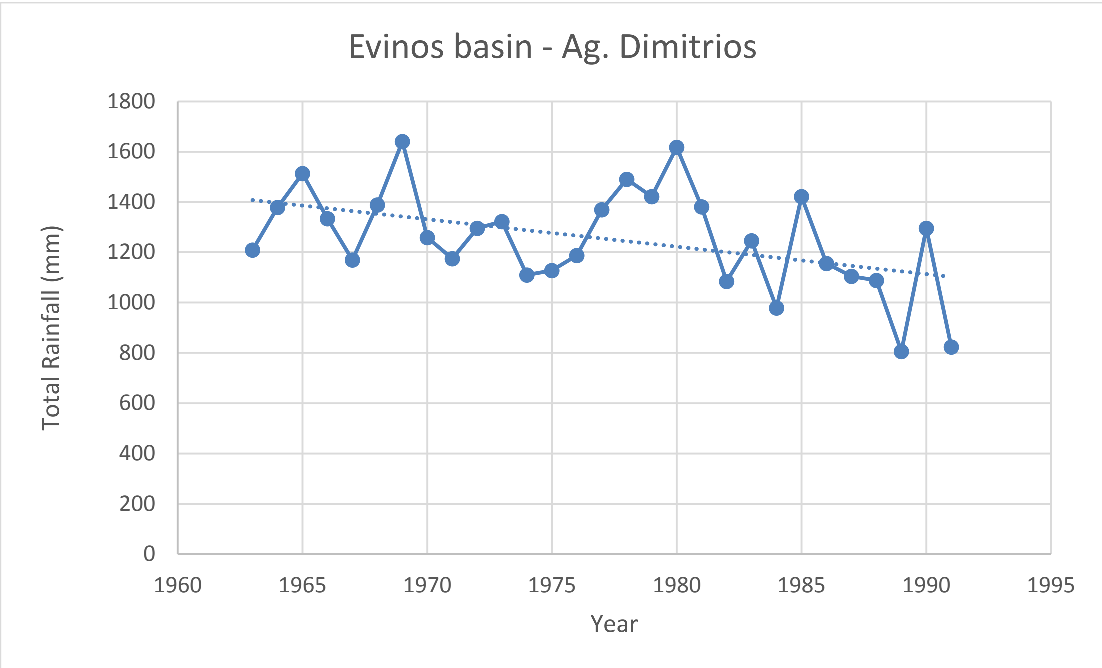


Figure 1-21: Time series of total precipitation on Evinos basin - location Ag. Dimitrios

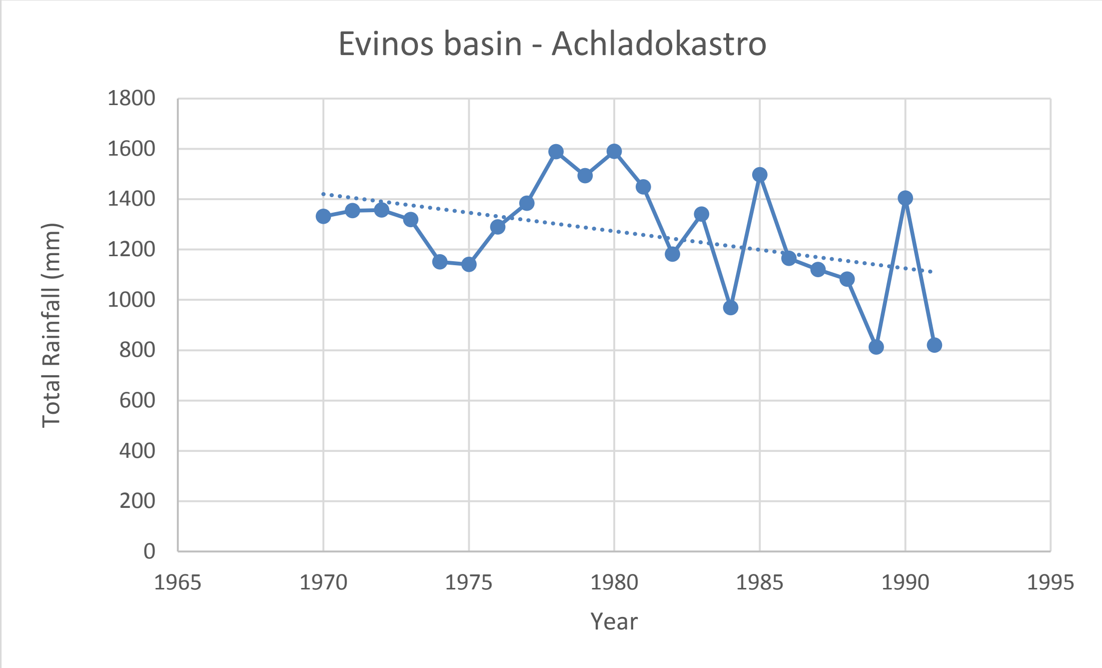


Figure 1-22: Time series of total precipitation on Evinos basin - location Achladokastro

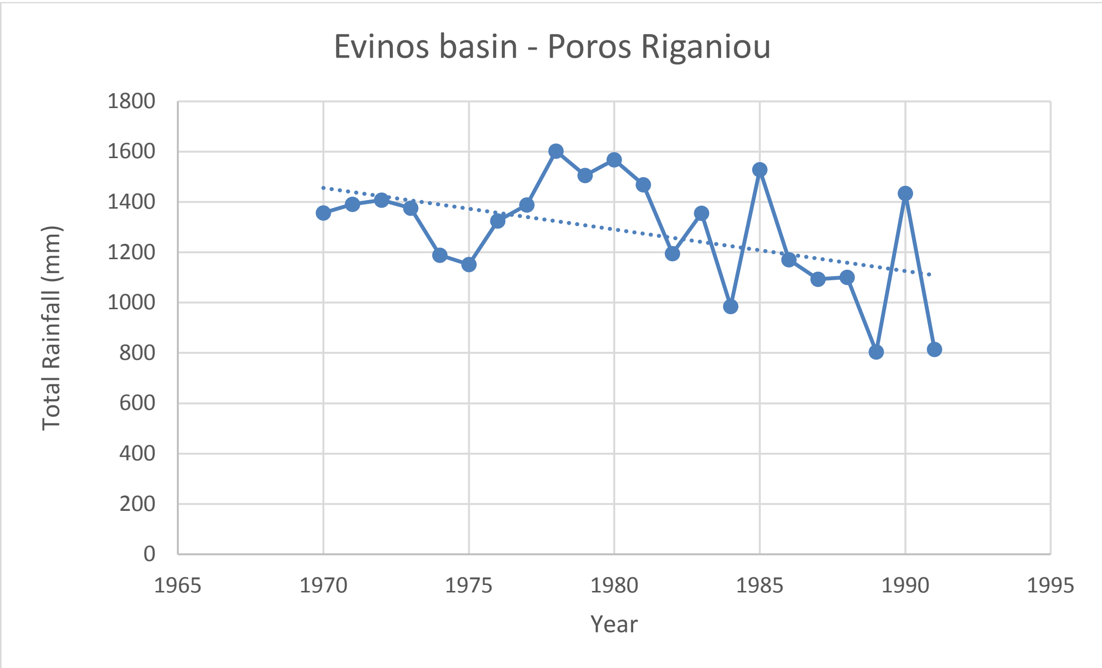


Figure 1-23: Time series of total precipitation on Evinos basin - location Poros Riganiou

According to the data presented above, rainfall values shows a clearly reduction trend over time. This trend is similar with this of the run-off data over time (Figure 24).

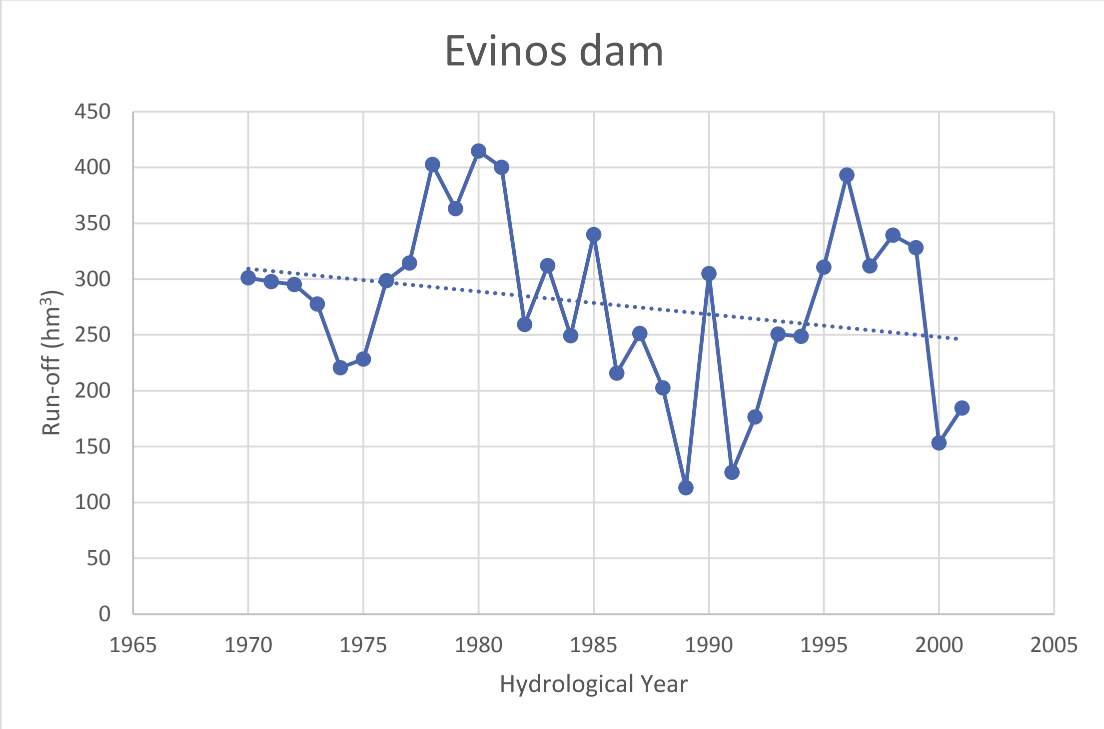


Figure 1-24: Time series of total run-off at Evinos dam

As mentioned before, Evinos dam, supplies Mornos dam with water through a diversion canal. The quantities of water that diverted to Mornos dam in annual basis are presented below.

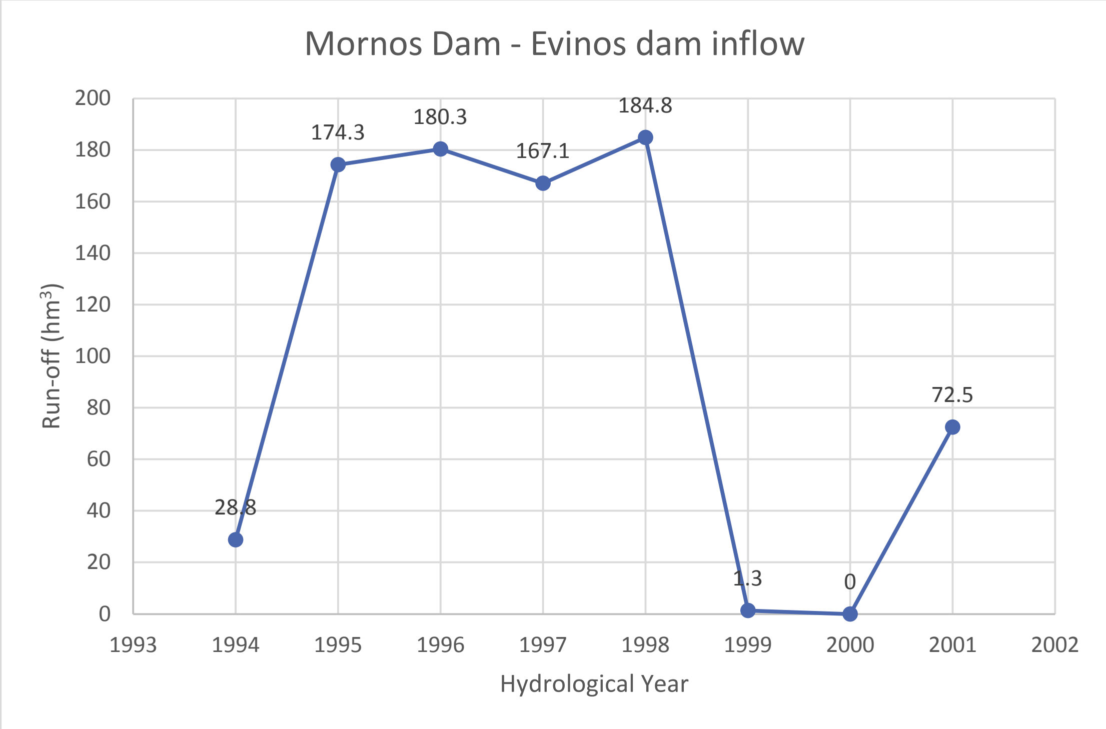


Figure 1-25: Time series of total water inflow from Evinos dam to Mornos dam

The run-off factor is about 0.64 in the location of the Evinos dam. For the run-off factor calculation the water inflows to Mornos dam were not taken into account (approximately 250 hm^3 per year) (Στουρνάραςet.al., 2011).

The qualitative and quantitative characteristics of water are considered to be good according to the River Basin Management Plan which prepared by the Ministry of Environment and Energy of Greece.

The qualitative status of the two main dams (Mornos & Evinos dam) is presented in Figure 26.

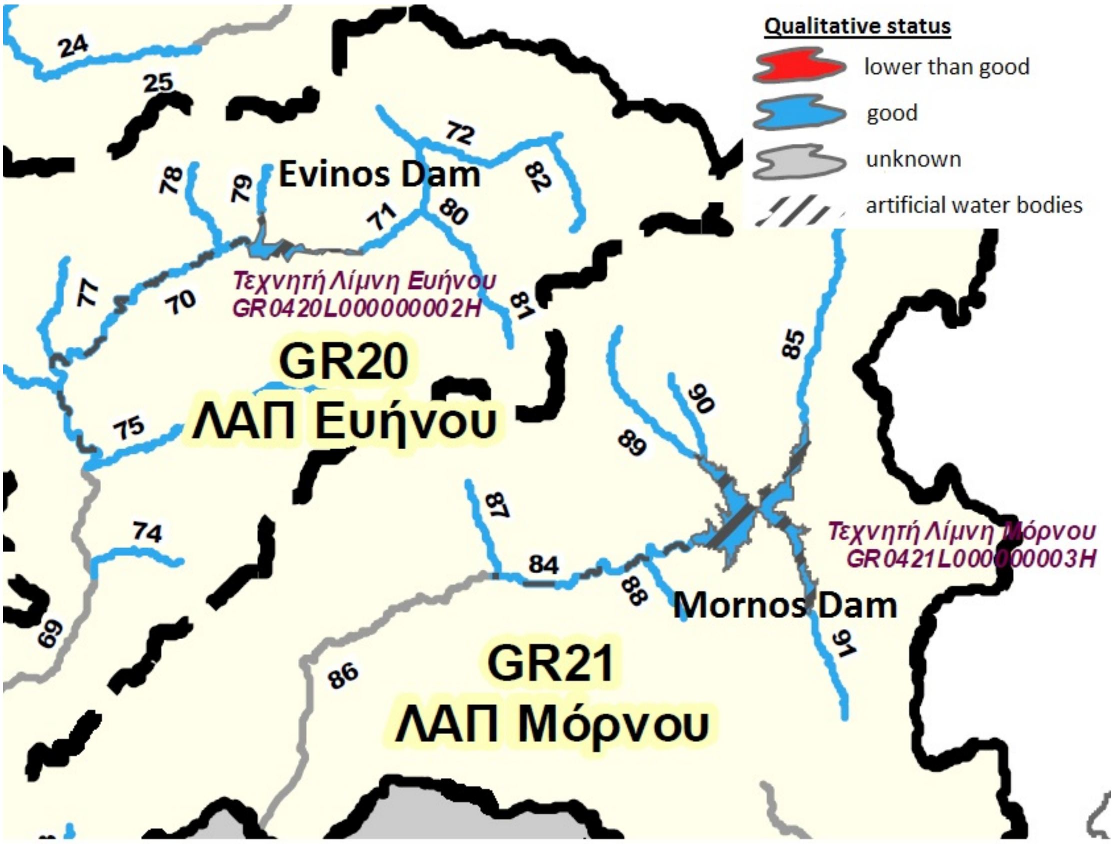


Figure 1-26: Qualitative status of the dams (Evinos & Mornos) water (ΥΠΕΚΑ, 2014)

Mornos dam

Mornos dam (Figure 15) is the main source of water supply system of Attica. It was constructed between 1972- 1979 and its operation began in 1981. Specific features of the dam are shown in the table below (Koutsoyiannis et.al, 2004).

Table 1-7: General features of Mornos dam

First year of operation	1981
Water catchment area (km²)	588.1
Minimum water abstraction level (m)	384
Overflow level (m)	435
Total capacity (hm³)	763.71
Beneficial capacity (hm³)	630.23

Non – recoverable volume (hm^3)	133.48
Maximum surface (km^2)	19.93

Time series rainfall data of the dam are presented in the next diagram (Koutsoyiannis et.al, 2000).

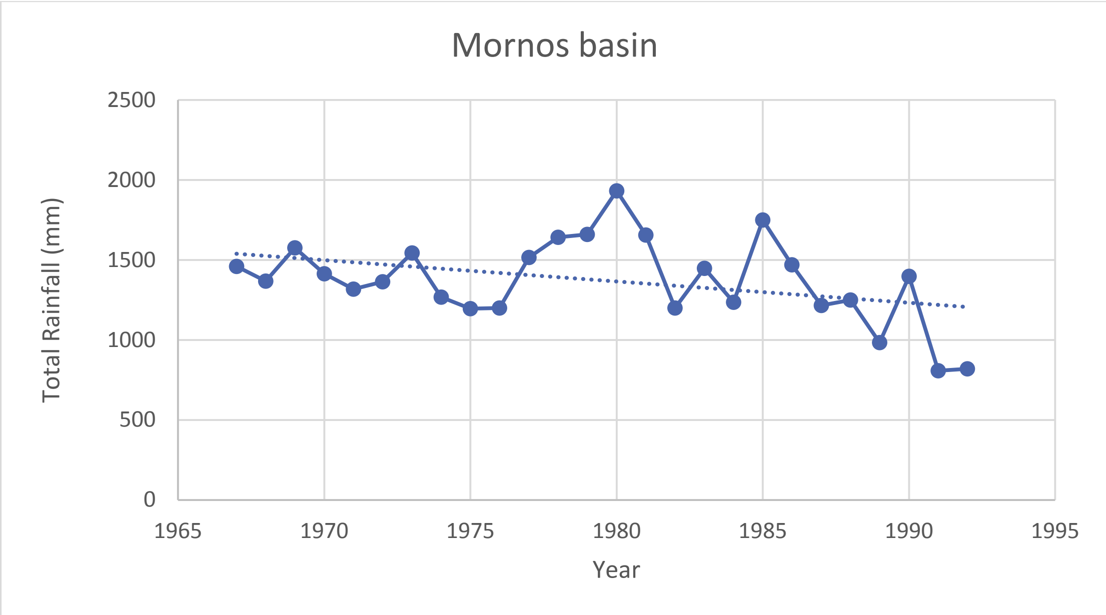


Figure 1-27: Time series of total precipitation at Mornos basin

According to the diagram above, total rainfall in this area seems to have a decreasing trend.

The same trend is presented on the values of the run-off as shown in the next diagram.

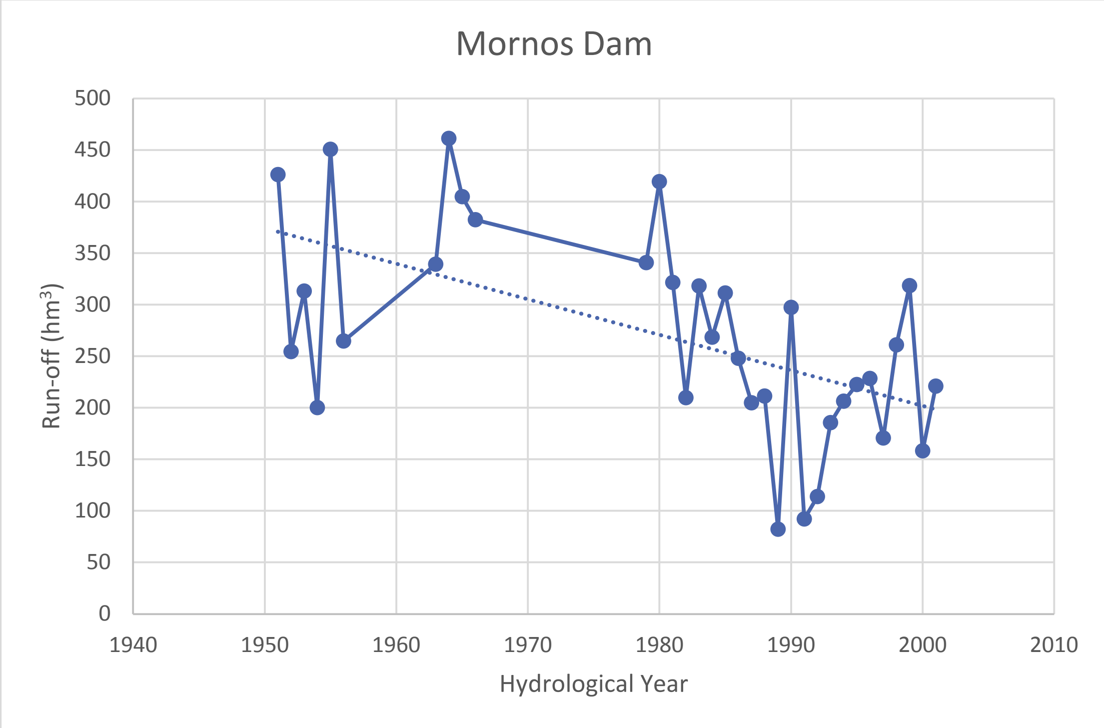


Figure 1-28: Time series of total run-off at Mornos basin

The run-off factor is about 0.37 in the location of the Mornos dam.

The qualitative and quantitative status of the water is characterized as good as shown in previous chapter (Figure 1-26).

Marathonas dam

The dam of Marathonas (Figure 15) is one of the backup water resources of the water supply system of Attica. The general characteristics of the dam are shown in the Table 6 (Koutsoyiannis et.al, 2004).

Table 1-8: General features of Marathonas dam

First year of operation	1931
Water catchment area (km^2)	118
Minimum water abstraction level (m)	204.4
Overflow level (m)	224
Total capacity (hm^3)	42.85

Beneficial capacity (hm^3)	33.2
Non – recoverable volume (hm^3)	9.65
Maximum surface (km^2)	2.57

The usefulness of the dam is for water storage in order to be used in emergency situations.

For safety reasons the annual water reserves of the dam is about 25 - 40 hm^3.

Due to the lack of data the preparation of a hydrological balance was impossible.

It is estimated that the annual run-off in the Marathonas dam is about 13, 4 hm^3.

However, limited information about the water quantities given to Attica are presented in the next chart (Figure 29) (Koutsoyiannis & Mamasis, 2000).

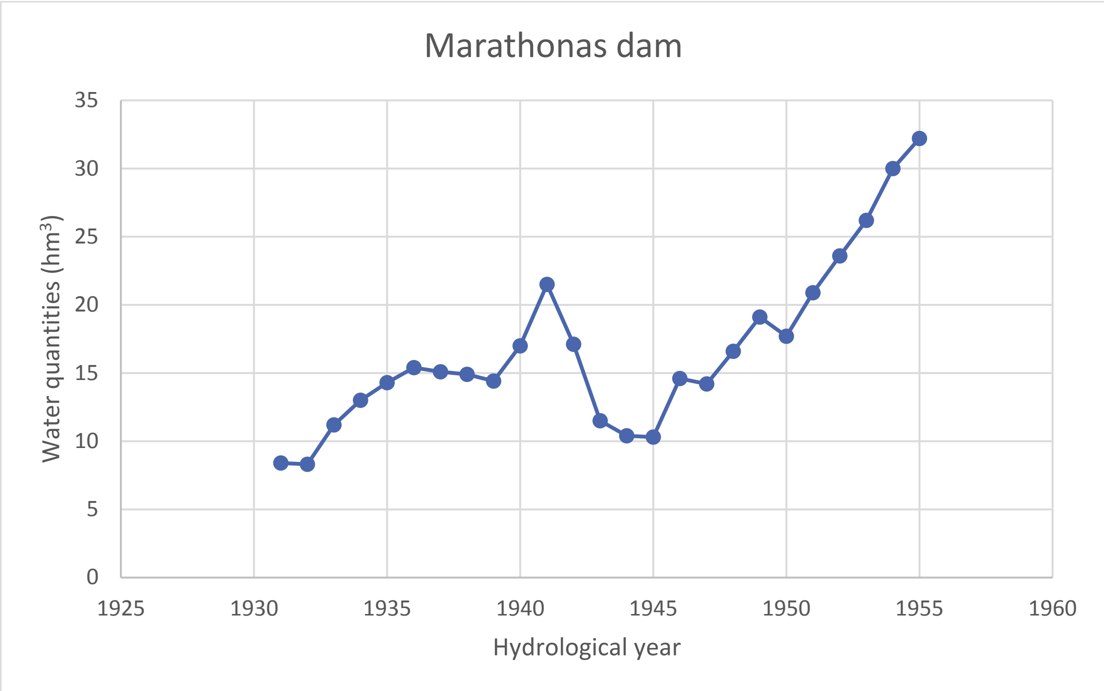


Figure 1-29: Time series of fresh water supply quantities to Attica

In general, the quantities are low due to the role of the dam in the whole water supply network.

The qualitative status of the dam is characterized as good as shown in the next figure (ΥΠΕΚΑ, 2013).

Figure 1-30: Qualitative status of Marathonas dam (ΥΠΕΚΑ, 2013)

1.2.1.2 *Groundwater sources*

Wells/boreholes

The water supply system of Attica includes three groups of drinking water boreholes. These boreholes are part of the emergency water supply system. The drinking water capacity ranges from 55, 2 hm^3 to 44 hm^3 per year.

The three groups are the following (Koutsoyiannis et.al. , 2002; ΥΠΕΚΑ, 2013):

- Northeast Parnitha boreholes (qualitative status: bad , quantitative status: good)
- Yliki Lake area boreholes (qualitative & quantitative status: good)
- V. Kifisos area boreholes (qualitative & quantitative status: good)

The locations of these boreholes are shown in Figure 1-15.

1.2.1.3 *Water Supply and Demand Balance*

There is limited datafor the annual water consumption of the Peristeri municipality, so in this chapter, data are related mostly with Attica region.

The total water consumption of Peristeri municipality for 2 hydrological years (2014-2015 & 2015-2016) are presented below.

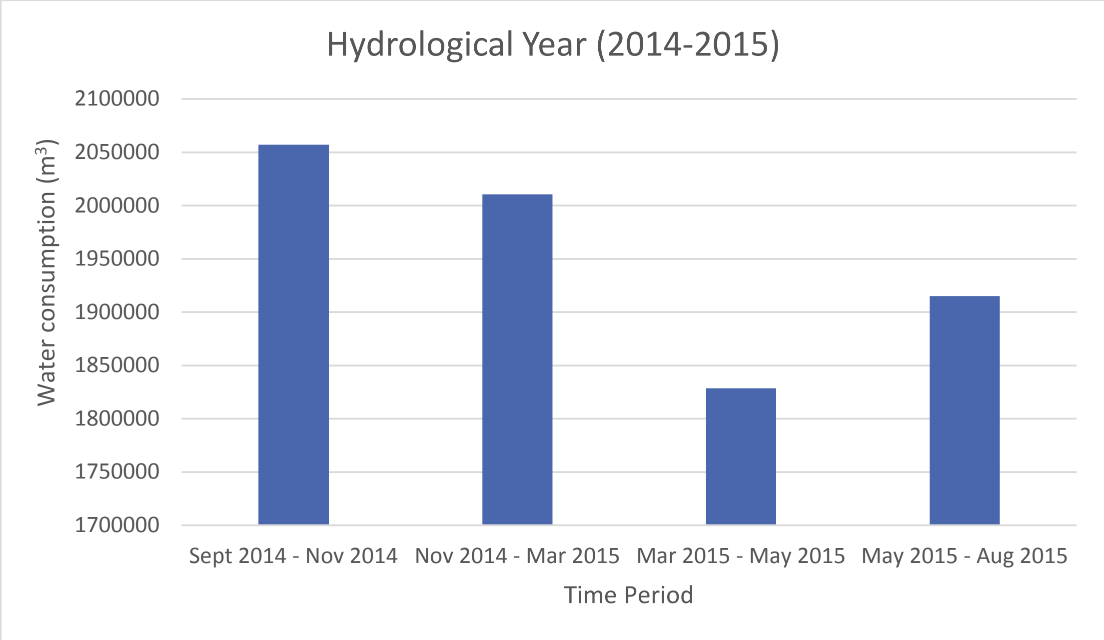


Figure 1-31: Water consumption at Peristeri municipality for the hydrological year 2014-2015.

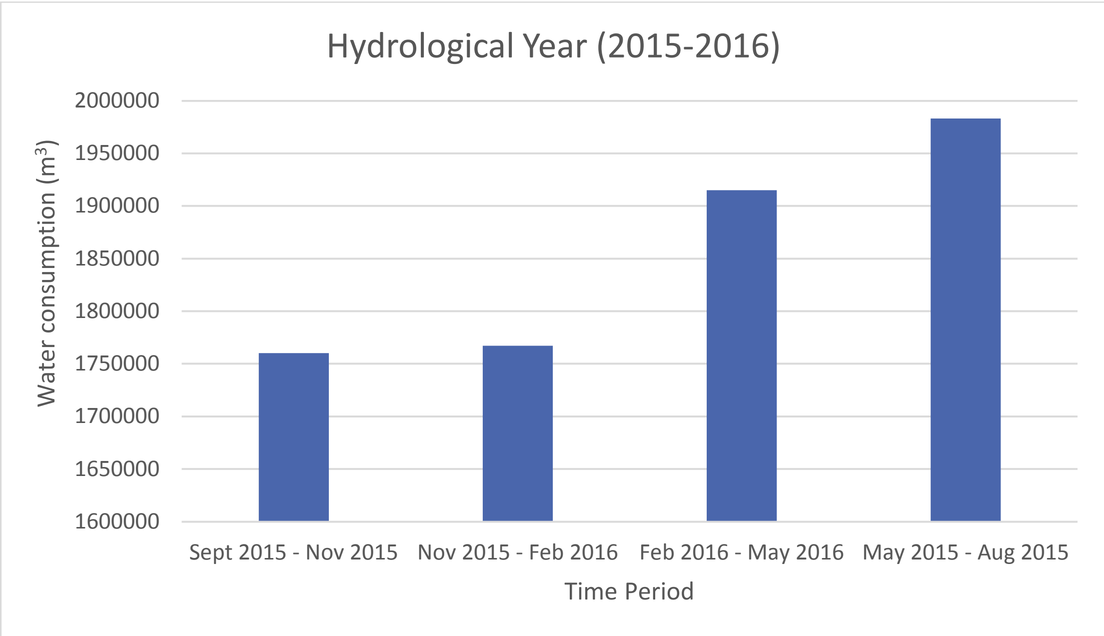


Figure 1-32: Water consumption at Peristeri municipality for the hydrological year 2015-2016.

Water consumption for these hydrological years is about 7.5 hm^3. More specifically total water consumption for the time period 2014-2015 was about 7.811094 hm^3 and 7.425607 hm^3 for 2015-2016.

Also there is no any significant difference on water consumption between the sub periods of the hydrological years.

Maximum differences of water consumption between hydrological year's sub periods ranges more or less in 200000 m^3.

Time series of water consumption of Attica is presented in the next diagram (Koutsoyiannis et.al, 2000).

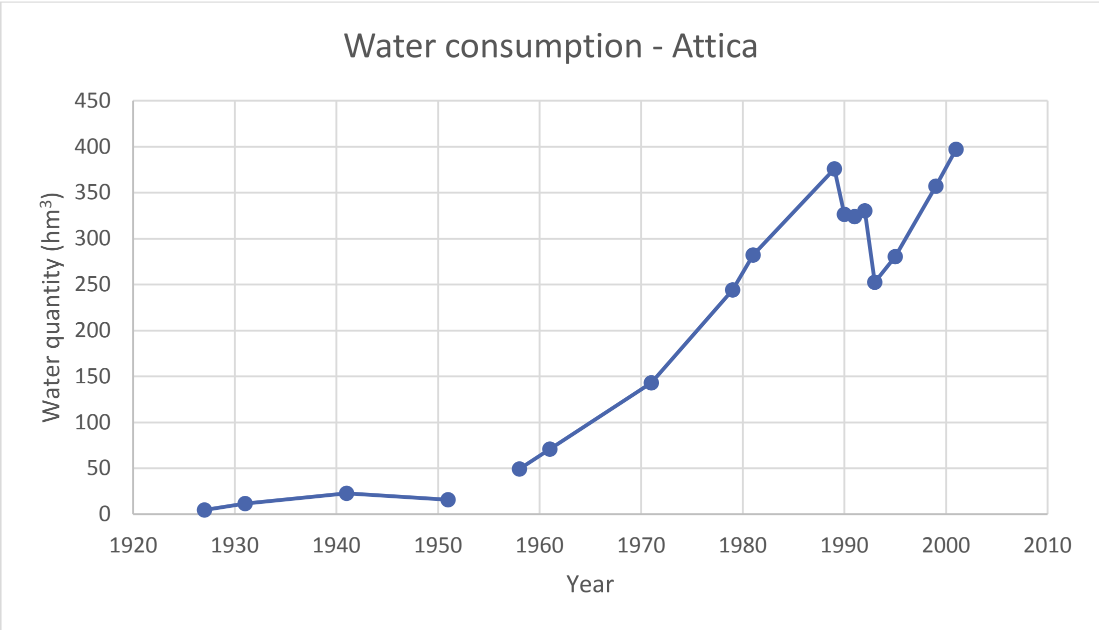


Figure 1-33: Time series of water consumption in Attica (Koutsoyiannis et.al, 2000)

According to the diagram water consumption of Attica has an increasing trend due to the continuous population growth. The reduction in water consumption observed in 1990 is due to a drought period (1990-1993). In that period the selling price of water had been increased in order for a water consumption decreasing to be forced.

Total consumption of water can be categorized depending on usage. The main uses of water and their quantification are listed below (Koutsoyiannis et.al, 2000):

- Common use (households & small businesses) : 62-68%
- Water Consumption to support local authorities : 13-17%
- Industrial and professional consumption (industries, hotels, sport and tourist facilities) : 7-11%
- Public and municipal consumption (public spaces): 7-9%

- Refined water : 1-3%
- Other uses fire Department, ports, philanthropic institutions: 1%

The above values refer to the 1990 decade (Koutsoyiannis et.al, 2000)

The following figure shows the time evolution of both common and total water consumption in hm³.

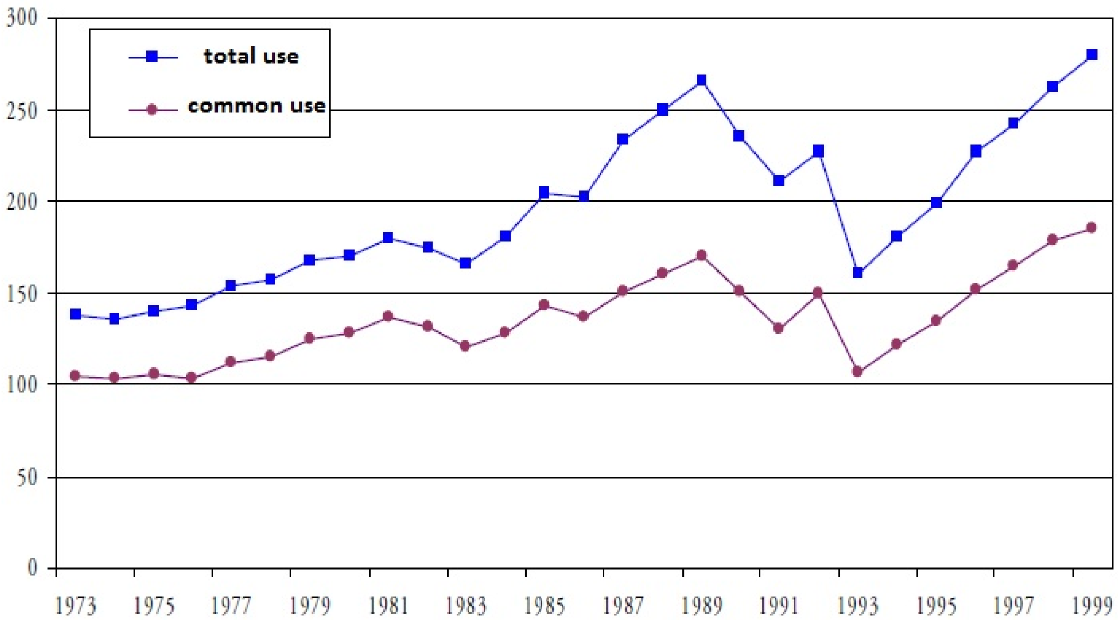


Figure 1-34: Time series of total and common use of fresh water in Attica

The next figure shows the time evolution of all the rest uses (in hm³) except from thecommon use of water.

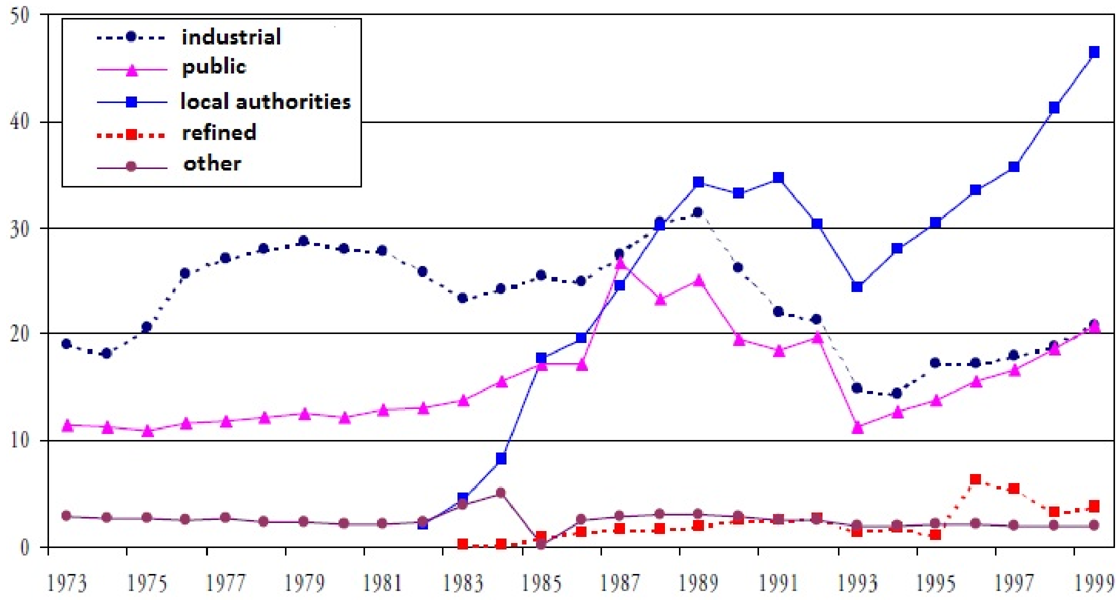


Figure 1-35: Time series of all uses of fresh water in Attica except from the common use

As can be shown in the diagrams above the biggest part of the total water consumption corresponds to common usage (Koutsoyiannis et.al, 2000).

In general all the rest uses of water follow the trend of total consumption.

According to a report prepared by the National Bank of Greece, water consumption is stabilized since 2006 to 400 hm^3 per year (Στρουρνάραςet.al. , 2011). On peak days, water demand ranges within the total capacity of aqueducts.

1.2.2 Observed and expected impacts

Water needs based on the various human activities and the water availability define the concept of water resources. Both parameters are characterized by location, quantitative variability over time and quality. In specific, quality can be distinguished in the quality based on its physical and chemical properties, as well as on the characteristics required according to its use. In regards to water resources in Greece, it is worthmentioning the variety of its rich water resources compared to the rest of the broader Mediterranean region.

In this framework, the National adaptation strategy was adopted (Τράπεζα της Ελλάδος, 2011). More specifically, the hydrological balance of Greece was estimated for the time periods 2021-2050 and 2071-2100 under the use of scenarios, so as to evaluate water potential. The main outcomes of the assessment highlighted certain negative impacts on the water resources of Greece, as following:

- Aquifer infiltration and recharge shall be decreased, due to the decrease of rainfall and higher evapotranspiration;
- Coastal aquifers shall suffer from increased salinity of coastal, because of the advance of the sea-water intrusion and the decline of groundwater levels due to over-exploitation;
- Pollution increase in coastal water bodies and sea as a result of the decreaseddilution;
- Degradation of deltaic regions shall be accelerated in areas where transversal dams have been constructed;
- Coastal wetlands shall be contaminated;
- Water deficits and soil changes shall amplify desertification.

Precipitation levels are expected to be decreased by 3% during the period 2021-2050 (Scenario B2), and by 8% (Scenario A2). Total water potential is also expected to be decreased by 14% and 22% respectively. In regards to 2071-2100, precipitation is expected to be decreased by 7% (Scenario B2) and 20% (Scenario A1B), while water potential by 30% and 54% respectively. These outcomes are considered of utmost importance especially considering that the irrigation water demand covers 75-80% of the total water potential.

1.2.3 Non-climate related pressures

The qualitative and the quantitative status of all water resources that analyzed in previous chapters is characterized as good based on the Water Framework Directive principles. However, for the case study of northeast Parnitha boreholes the qualitative status is considered to be bad. These pressures which are located in the groundwater resources are related to human activities. More specifically, these pressures are a result of intense industrial and agricultural activity located in the area (ΥΠΕΚΑ, 2013).

1.2.4 Adaptation measures

Based on the National Adaptation Plan of Greece (ΥπουργείοΠεριβάλλοντοςκαιΕνέργειας, 2016), general objectives, guidelines and implementation tools have been set in order to present an effective and growth oriented adaptation strategy according to the EU directives, as well as based on the international experience.

In regards to water resources, the integrated and sustainable management of water resources is a safeguard against the numerous and continuous pressures of aquatic environments. According to the predicted climate variability, these pressures will increase rapidly, thus affecting the hydrological cycle and its processes (i.e. evaporation, condensation, precipitation, runoff, filtration etc.). From the point of view of climate change, the parameters that should be taken into consideration are the following:

1) the reduction of rainfall frequency and the increase of rainfall intensity resulting in floods, reduction of runoff and secondary sedimentation, reduction of primary sedimentation,intensification of irrigation, reduction of water levels in reservoirs, etc.,
2) the temperature increase resulting in prolonged irrigations, prolonged and intensive domestic water uses, shifted snowmelt etc.

The proposed measures and actionsrefer to the mitigation of the impacts that are evident to groundwater and surface water, in order to maintain the water good condition while meeting both anthropogenic and environmental water needs.

Action 1. Development of a geo-portal for climate change on water resources

The purpose of this action is to gather all the information (data, studies, descriptions) on the impacts of climate change on water resources and the information dissemination.

- Measure 1. Collection of studies, publications, research projects and results on climate change in the water resources in Greece.
- Measure 2. Development of a database by recording the abovementioned information per water body.

This geo-portal can be integrated into the information platform of the National Observatory Network Qualitative and quantitative characteristics of water.

Action 2. Infrastructure addressing the impacts of climate change on water resources.

- Rising sea levels / Coastal zones:
  Design and development of protection zones between the seaside and the residential development zone.
  Discourage residential and business development in coastal areas with erosion risk.
  Relocation of buildings and facilities to safer and higher locations. In particular, new construction in coastal areas must incorporate relocation capability.
- Reduce (quantitative and qualitative) the performance of waterworks.
  Avoiding or limiting the use of waterworks consists in reducing or totally disrupting the abstraction of coastal aquifers, as well as the discharge of surface water discharged into the sea.
- Change in the level of runoff basin.
  The change in basin level of runoff is related to the corrosion or deposition at the upstream branches of the hydrographic network.
- Changing the weight of construction.
  The entry of the sea into the hinterland results to the increase of the underground water level, with a change in the apparent weight of the constructions. Fluctuations in water elevation cause stress on building foundations.
- Precautionary measures

Study of groundwater bodies vulnerability.

- Hydrographic studies of source discharges.
  Construction, analysis and study of hydrology of basic sources of discharge, in order to estimate the available water benefit during the dry period of each year.
- Anti-corrosion protection of soils.
- Desertification
  Areas of high risk are the Aegean islands, Crete, a part of Thessaly, East Central Greece and the Eastern Peloponnese. Updating the National Action Plan to Combat Desertification (Joint Ministerial Decision 99605/3719/2001, Government Gazette 974 B).
- Maintaining ecological provision
  It is of utmost importance to assess the eco-supply considering climate change data. The gap, in Greece, is temporarily covered by the Joint Ministerial Decision for renewable energy sources.
- Irrigation water
  The impacts of climate change in Greece affect irrigation water.
- Irrigation networks
  The existing irrigation networks have significant water losses due to poor maintenance. To this end, a large program of irrigation network repairs, extension of the use of irrigation networks, Irrigation with re-usable water, placing a water meter etc.should be designed.
- Returned irrigation flow
  This is a problem found in irrigation areas with water from the same irrigated area, especially when irrigation is common. After each pumping-irrigation, a residual irrigation water returns to the aquifer, having undergone four pollution processes. The irrigation water becomes even more polluted due to the groundwater velocities in the porous media are of the order of a few meters or tens of meters per year.To this end, switching irrigation water use, where possible, partially or wholly is of utmost importance.
- Water supply networks
  Water losses from the water supply networks of cities are significantdue to their poor maintenance. Repairing damaged parts and replacing sections of asbestos pipes of water supply networks would be considered appropriate.
- Bottled water
  Bottled water is atype of drinking water that must comply with quality standards. It must be noted that there is no zone of perimeter protection for each water supply in Greece.
- Desalination
  Small desalination units for the water supply of islands face significant problems, such as high purchase and maintenance costs, energy-intensive operation, disposal and organoleptic characteristics of desalinated water polluting the underground water before it enters the water supply network.

Measure 1. Development of a monitoring network for the effects of climate change on groundwater.
Measure 2. Upgrade of the existing meteorological networks.
Measure 3. Creation of a single national body for monitoring changes in water demand and development of a relevant national database.
Measure 4. Changes in water demand with a possible installation of a national water abstraction database.

Action 3. Effective water use

- Measure 1. Promoting water saving in all sectors and uses, especially in areas with water shortcomings.
- Measure 2. Encourage the treatment of waste watere and use of recycled water.
- Measure 3. Improve efficiency in the energy sector in terms of water abstraction and consumption.
- Measure 4. Optimization of the existing water stock in the agricultural sector and creation of artificial reservoirs in accordance with environmental constraints.
- Measure 5. Encourage change in consumer patterns.

Action 4. Development of land-based activities and uses considering the available local water resources.

- Measure 1. Development of scenarios of potential adaptation for activities using large quantities of water in areas already encountering deficiencies.
- Measure 2. Optimization of existing water storage methods.
- Measure 3. Rational water use in activities, such as the agricultural sector, tourism.
- Measure 4. Promotion of rainwater use.

Action 5. Inclusion of climate change impacts in regards to water resources on the forthcoming water management plans for the time periods 2013-2018 and 2016-2021.This action aims to integrate the expected climate changeimpacts and the adaptation measures required in water management planning tools on a hydrographic basin scale.

Action 6. Assessment of the climate change impact on hydroelectric power generation.

Action 7. Educational programsfocusing on the impact of climate change on water resources.

However, apart from the existing National Adaptation Plan, the Operational Program for the Municipality of Peristeri (Δήμος Περιστερίου, 2015) also includes a number of measures and actions that contribute to the reduction of the vulnerability against climate change indirectly. In particular for the case of the Municipality of Peristeri, specific measures have been included in the Operational Program for the time period 2015-2019 addressing climate change impactsindirectly. More specifically, the aforementioned plan is based on four (4) pillars, namely:

- Environment and Life quality

- Local development and economy
- Social development
- Municipal development

Each one of the pillars includes measures and goals based on the thematic priority of the pillar. In this framework, specific measures and goals in regards to the first and fourth pillar are closely related to the indicators increasing climate change impacts.

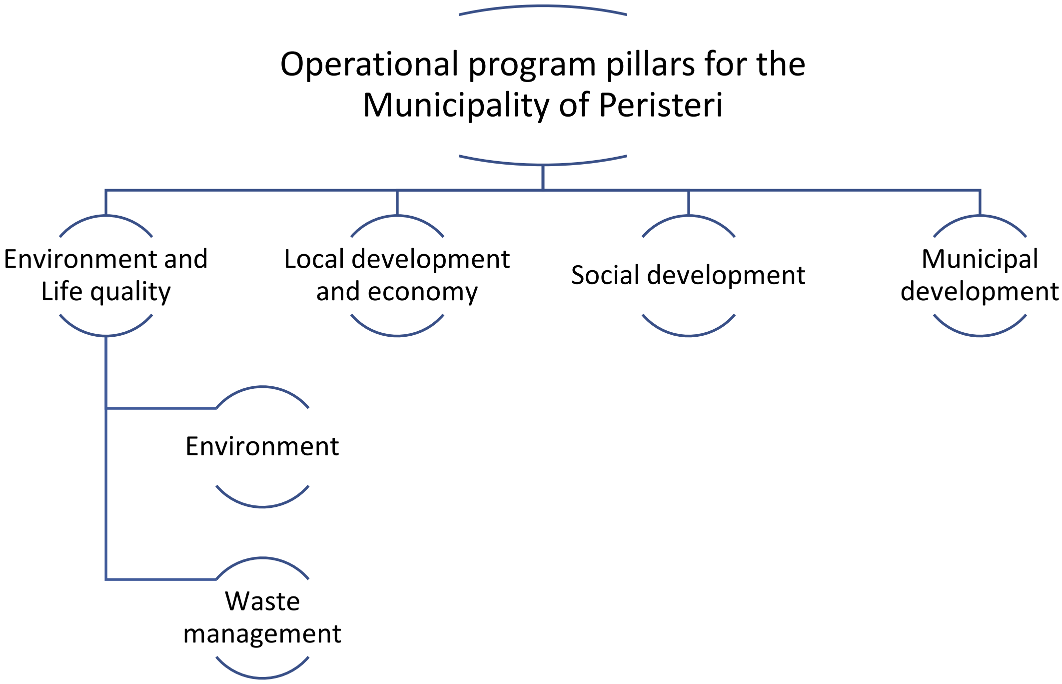


Diagram 1-1: Measures of the Operational Program for the Municipality of Peristeri affecting climate change impacts indirectly

Based on the first pillar of the Operational Program for the Municipality of Peristeri, i.e. Environment and Life quality specific measures may decrease the intensity of the climate change impacts observed at the Municipality of Peristeri. In particular:

Measure 1.1: Environment

A series of measures is foreseen in regards to the environment of the Municipality of Peristeri. More specifically:

- Achievement of a healthy, attractive and clean urban environment.
- Upgrading the functionality and quality of life in degraded areas of the Municipality.
- Efficient / Economical use of energy with emphasis on improving the energy efficiency of buildings and the more economical and environmentally cleaner coverage of the municipal energy needs.

- Extension and upgrading of green areas and communal areas, strengthening the proportion of green areas in dense building areas.
- Estimation of the environmental impact of the municipal authority's interventions, as well as the development of monitoring and control where necessary.
- Development of actions promoting Renewable Energy Sources.
- Raising-awareness actions.
- Co-operation and Co-ordination with neighboring Municipalities and associated institutions.
- Development of measures to control and address pollution (atmosphere, soil, water) and radiation sources.
- Promotion of innovative actions (eg green roofs).

The aforementioned measures have been further defined by a specific action plan. More particularly:

1. Participation in the Environmental Association: Participation of the municipality in PESYDAP for the protection of Poikilo Mountain, etc.
2. Environmental Awareness.
3. Reconstruction of the square on Kosmas Aetolou Street.
4. Conduction of a Study for recording Energy Optimization proposals Environmental focusing on environmental protection and based on the cost reduction of energy needs.
5. Conduction of a study regarding the installation of alternative energy generators along with the installation of alternative forms of energy in municipal and other strategically selected buildings.
6. Installation of alternative energy generators in selected building blocks.
7. Creation of a green roof in the City Hall of the Municipality of Peristeri focusing on the creation of "thermal islands".
8. Energy upgrading of public buildings.
9. Raising awareness regarding energy-saving ways.
10. Bioclimatic design of Chorafa area focusing on the upgrade of the existing infrastructure.
11. Bioclimatic regeneration of a wider area of the 1st Playground with a view to improving environmental conditions.

Measure 1.4: Waste management

Measures are foreseen regarding waste management at the Municipality of Peristeri:

- Improving the level of cleanliness of the area.
- Reinforcement of waste recycling actions.
- Dissemination of household recycling / composting methods,
- Raising-awareness actions.
- Industrial waste management.

Specific actions are also available for the implementation of the abovementioned measures:

1. Conduction of a study regarding the management of the industrial and municipal waste of the Municipality of Peristeri.
2. Supply of a waste collection vehicle and containers in regards to the industrial waste of Peristeri Municipality.
3. Relocation of the Peristeri Municipality's garage.
4. Purchase of mechanical waste collection bins.
5. Raising awareness about waste management.
6. Pilot implementation of a project for recycling products with compensatory benefits in a selected neighborhood.
7. Supply of plastic waste bins.

1.3 Italy

1.3.1. Existing situation

The situation of water resources in Italy is characterized by inequality of availability natural and man-made pressures on national territory, which is equally so heterogeneous infrastructure quality and management modes, in the face of a regulatory framework generally adequate and advanced, but only partially applied. Such complexity and dissociation is intertwined with serious management problems and the quality of information and theirs availability on national territory. The same quantification of the total water resources available in Italy is not easy determination. Eurostat (European Commission, 2011a) estimates the amount of 175 billion m3 maximum potentially available annually, assuming you use all the outflow in the rivers; however, the irregular nature of outflows and the practical difficulties of using many resources dramatically lower this availability to about 110 billion m3/year. A study done from IRSA-CNR (1999) estimates the sum of surface resources in 52 billion m3/year actually available (866 m3 per capita). However, this estimate of availability water as the average value distributed over the year, has a very limited information value, because it does not take into account the seasonal diversity of water needs, of different regimes pluviometric and climatic variability also in relation to the territorial diversity (Rusconi, 2011).

1.3.1.1 The side of demand: economically viable economic sectors

In planning and managing water resources, the ultimate objective is the optimal one acquisition of water demand in every sector respecting the environmental system, such as required by DQA. As far as man-made uses are concerned, various steps must be taken strategies of use that adequately consider the variability of the determinant phenomena water availability. In addition to direct impacts on the various elements of the hydrological cycle, described in the previous paragraphs, it can be said that climate change will surely be responsible for various indirect impacts not only on man-made uses, but also on the environment. There quantification of indirect impacts is affected by a degree of uncertainty even greater than that of climatic and hydrological scenarios, even more so because of the uncertainty about evolution of socio-economic systems (Garnier et al., 2011; Delpla et al., 2009; Semenza & Menne, 2009).Civil Sector (Hydroponable) - Civil use, connected to human needs, will be the one for which the impacts caused by climate change will have to be minimized, as it is the priority of all others. The increase in domestic consumption due to changes climate is estimated to be rather modest; some estimates show an increase of around 5%. An indirect effect should be the increase in energy demand for cooling of buildings which, in turn, produce an increase in water consumption for cooling(Bates et al., 2008).Agriculture - In Italy, agricultural development in the various areas of the country has been strong affected by the availability of water resources and irrigation farming systems have always represented a strong point in terms of income and employment, with an important one contribution to the added value of the sub-fund and exports. In recent years the policies increasingly integrated European and national, agricultural and environmental, have recognized the role water central and irrigation management has taken on a strategic role as a tool of adaptation to change. In this regard, it is highlighted how climate change in act involve new and complex issues:

1. The speed of change, which may be greater than the ability to adapt agro-ecosystems, and the response in terms of management by farms;
2. The greatest occurrence and scope of extraordinary, unpredictable events, which increases the uncertainty relatively "to what conditions" to adapt;
3. The effects of climate change on world agricultural production, on the one hand seem to offer new production opportunities in marginal areas, combined with others dynamics of globalization, may also have negative impacts on many existing production systems, with predictable significant impacts on food security (Production level), increased agricultural instability and, ultimately, on access to food for many population groups, especially in the more countries Poor (market level).

1.3.1.2 Precipitation (Time Series)

The European cumulative precipitation averages do not indicate significant variations since 1950 (Haylock et al., 2008). At a sub-continental scale, there is a significant increase in the precipitation on North-East Europe of the order of 70 mm over the last 50 years, and, conversely, a decrease in precipitation of approximately the same size, on the Iberian Peninsula and in particular about North-West Spain and the North of Portugal. As far as Italy is concerned, Figure 1 shows the series of annual average rainfall obtained from an updated version of the database presented in Brunetti et al., (2006), in addition to two series. Representative of northern and southern Italy, separated by the 43rd parallel. Such series has a sequence of maximum and minimum relative, superimposed on a slightly decreasing trend.

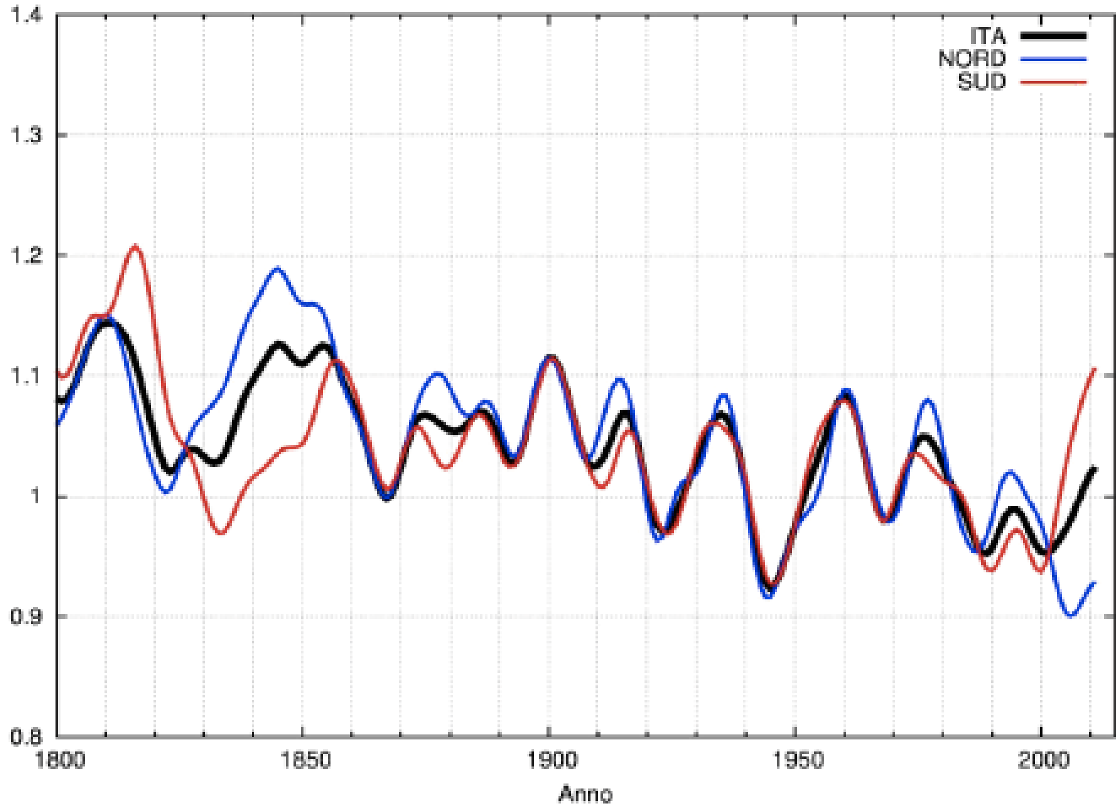


Figure 1-36: Series of annual average rainfall-Italy (Brunetti et al., 2006)

The trend over the whole period (1800-2011) is slightly negative (-0.58 ± 0.15% / decade) and most pronounced in the North (-0.71 ± 0.19% / decade). The negative trend becomes more and more marked but decreases the statistical significance of the signal. The last decade is characterized from opposite trends to the North and South: a continuation of the negative trend in the North and rise of precipitation in the South. On the seasonal level there is a noticeable decrease in winter and spring for Southern Italy (-22% and -12% from 1800 to today, respectively) with a trend reversal over the last decades, while for northern Italy the seasons with the strongest negative signal are the summer and the fall (-19% and -25% from 1800 to today, respectively).

PERIODO	TREND PRECIPITAZIONE MEDIA ITALIANA [%/DECENNIO]	TREND PRECIPITAZIONE MEDIA PER IL NORD ITALIA [%/DECENNIO]	TREND PRECIPITAZIONE MEDIA PER IL SUD ITALIA [%/DECENNIO]
1800-2011	-0.58±0.15	-0.71±0.19	-0.53±0.17
1900-2011	-0.8±0.4*	-1.0±0.4*	-0.6±0.4**
1950-2011	-1.1±0.9**	-1.8±1.0**	-0.6±1.1**
1980-2011	+0.8±2.0**	-2.0±2.4**	+3.3±3.0**

Figure 1-37: Precipitation trend of Italy (1800-2011) Source: ISAC - CNR

The trends of precipitation accumulated in Italy during the period 1961-2006 were estimated by Toreti et al., (2009) based on the series of 59 synoptic stations, grouped into three areas (North, Center, South and Islands). The results do not show, for that time, trend statistically significant on the annual series, while on a seasonal basis the winter series of northern Italy shows a significant trend of decreasing the average precipitation of 1.47 mm / year. More recently, ISPRA (Desiato et al., 2012) calculated cumulative precipitation abnormalities annual for the North, Center and South Italy, using the "Thiessen Polygons" method or of "Voronoi dashed" (Li and Heap, 2008) to overcome the heterogeneity of the number and of the spatial distribution of stations with precipitation data available year by year. The results show negligible negative trends in the North and South and a negative trend significant in the Center (-0.29% / year), (Figure 3). The analysis of the series does not highlight points discontinuity of trends over the 50 years.

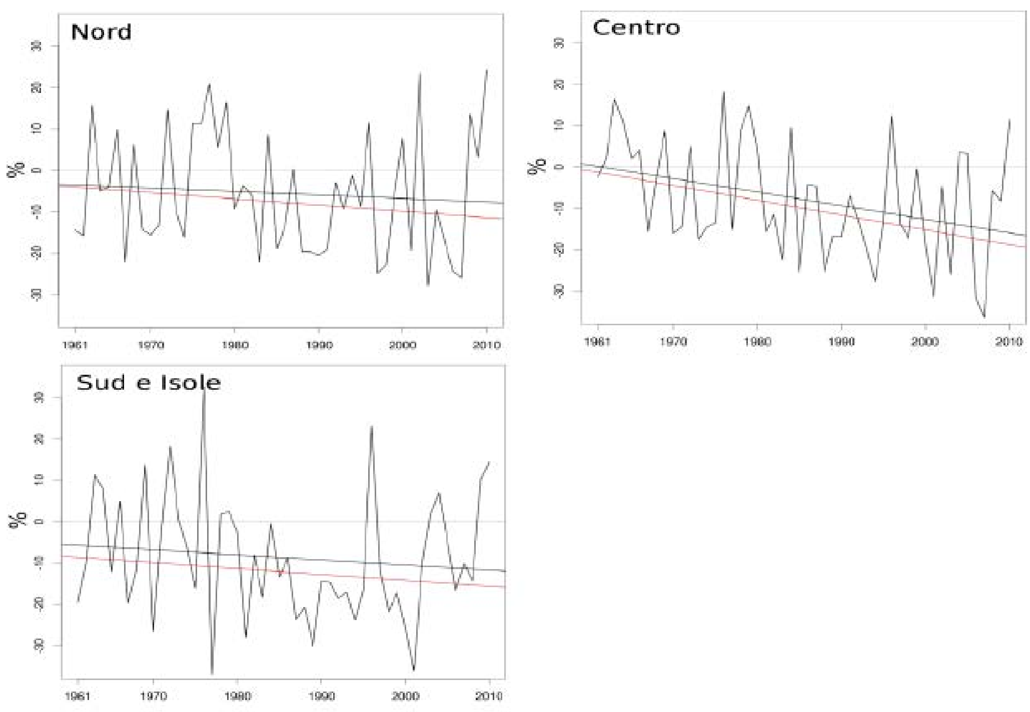
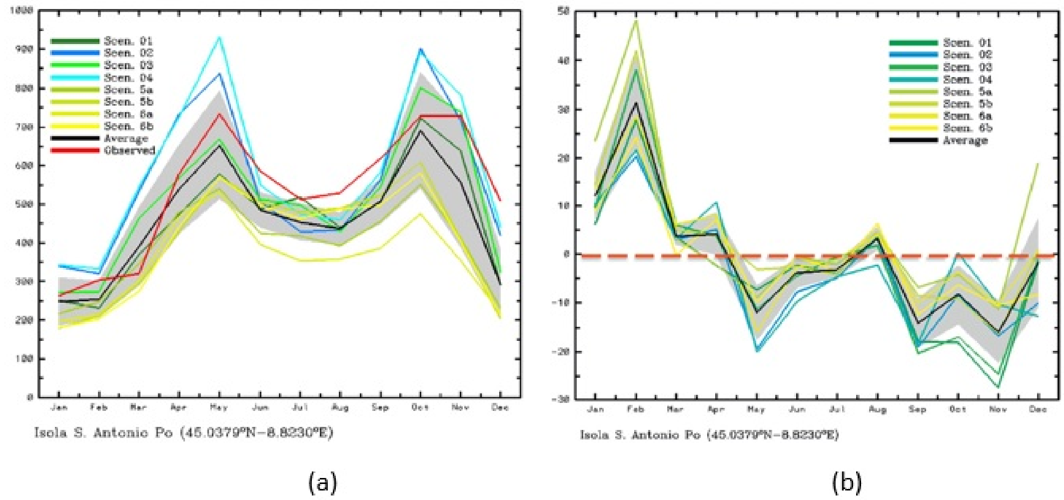


Figure 1-38: Trends of precipitation in Italy during the period 1961-2006 grouped into three areas (North, Center, South and Islands) (Toreti et al., 2009)

1.3.1.3 Annual discharge cycle



(a) Annual discharge cycle for the reference period 1960-1990, for 8 scenario simulations and for the validation simulation. Black curve is the ensemble average.

(b) Change of discharge annual cycle of the future period 2020-2050 compared to the reference period 1960-1990. Units are percentage.

The two main periods of runoff decrease are placed at the beginning and end of the summer season, in which the observed annual cycle shows the minimum values of discharge. This implies an extension of the hydrological dry seasons and thus increasing water stress over the basin. The water availability in river basins will also likely be reduced due to a seasonal shift of runoff and an increase of winter flow associated with increasing temperatures.

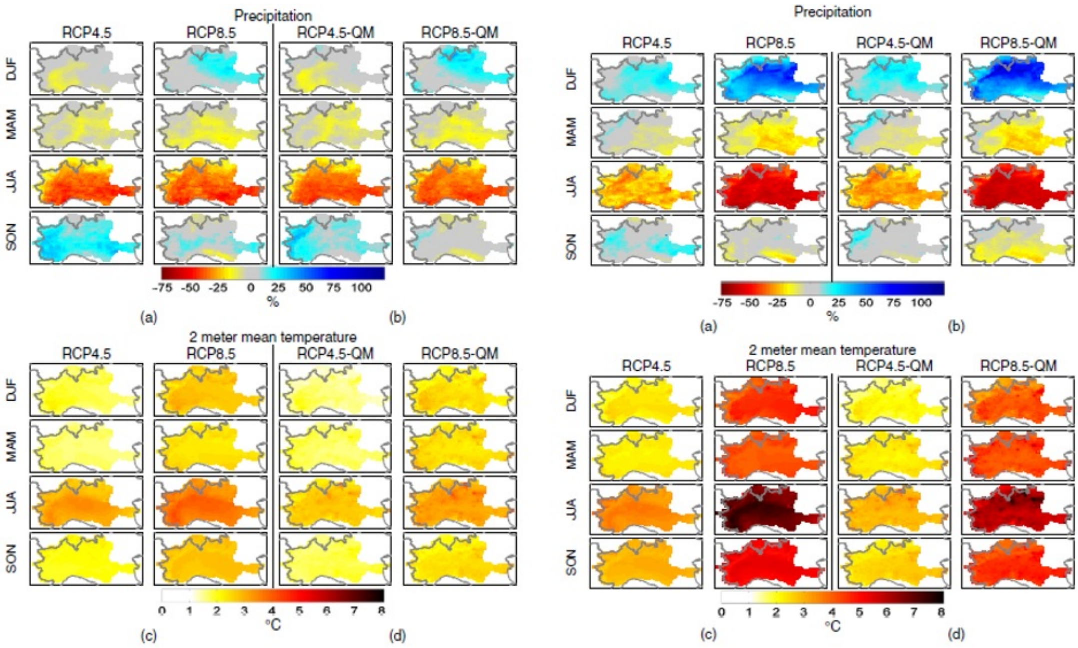


Figure 1-39: Anomalies in seasonal precipitation in % (a,b) and two meter mean temperature in °C (c,d) over Po River basin

Anomalies in seasonal precipitation in % (a,b) and two meter mean temperature in °C (c,d) over Po River basin, for the period 2041-2070 (1) and 2071-2100 (2). (a)-(c) projections refers to raw CMCC-CM/COSMO-CLM outputs, (b)-(d) projections to the bias corrected climate data.

1.3.1.4 Water Supply and Demand Balance

We observe a modest increase of the total withdrawals, with a strong replacement from the industrial uses to the irrigation uses and, partially, to the civil uses. There is an important decrease in the groundwater withdrawals. Is interesting also to note that the civil withdrawals are stable from 1985. The increase in surface water withdrawals depends from the regional policies developed to answer at the subsidence problems posed by the unsustainable uses of groundwater in the South East part of the region (Bologna, Ravenna and the coastal zone), using a canal (Canale Emiliano Romagnolo, CER), which can tale about 60 m^3/sec from the Po River for the agricultural uses and the Ridracoli Dam built at the end of the 80's for the civil uses and a strong regulation about dwells and groundwater withdrawals. Actually the groundwater deficit is estimated at around 25 Mcm/y, with the worst problems in Bologna and Parma. If we look at the surface water the estimated deficit due to the future application of the environmental flow is around 50 Mcm/y. The average regional consumption for domestic uses is 170 l/capita/day (l/c/d). The estimated overall (real and apparent) leakages from the civil networks are 123 Mcm./y, which means about the 26% of the civil withdrawals. Among others, the application of River Environmental Minimum

Flow Requirement is the most demanding task. The needs for realising higher volume of water to the rivers impacts the actual use of resources with particular significance during summer when the water flow is low while the water demand is at the highest level. In most of the cases, it is needed to revise .historical. Water withdrawal, that were already present in the last centuries for irrigation and old mills and in the 20ies century for drinking purposes. The level of the conflicts is therefore pretty high. At the end of the year 2003 the regional Government approved the draft of the regional Water Protection Plan which represents the planning tool of Public Administrations (Region and other local institutions) to achieve the qualitative aims for the 2016 defined by European Directives, the Water Framework Directive (WFD) etc. and Italian Laws (D.Lgs. 152/99), through an integrated approach which connects the qualitative aspects (pollution ecological aspects, biodiversity.) and the quantitative aspects. (Water conservation, minimum flow etc.). The regional strategy is based on the twin track approach and considering the regional situation is firstly based on the development of new regional policies for water conservation and demand government, not forgetting the infrastructural development where necessary (for instance the local connections with the Canale Emiliano Romagnolo). The conservation Program, integral part of the regional Water Protection Plan, includes also a Directive to develop a Drought contingency Programme. The main Conservation program actions are leakages reductions in civil and agricultural uses, substitution of obsolete irrigation technologies, waste water reuse for irrigation, education and information, retrofitting in the civil sector, water saving and clean technologies in the industrial sector, pilot projects (rain harvesting) and studies on ground water recharge. As EA suggest Climate change can have an effect on: a) demand for water; b) availability of water. In Emilia-Romagna the increase of temperature from 2000 to 2016 means a modest increase in the domestic water demand (few millions of cubic meter). The irrigation season in Regione Emilia- Romagna is the summer. The demand for irrigation water depends from a lot of factors:temperature, precipitation, wind etc. If we look at studies for North Italy and our region we can see that for summer there is a weak trend for an increase in precipitation and quite no increase in temperature. The increase in CO_2 concentration should mean also a more efficient use of water from the most of the agriculture plants. For these reasons, without a regional modelling of climate change, the draft Plan decided, as for the industrial demand, to suppose a neutral situation. We think anyway to stimulate at the national and regional level, an approach to the climate change based on studies and regional modelling, adaptation and mitigation. On the availability of water our strategy, as the EA for a longer period, assume that for the next 12 years the public systems (also for agriculture) maintain their actual supply, based on the last elevenyears average, which was a strongly drought period, this assumption looks like conservative. This approach is built also on the time to revise the Planning (as in the WFD the Plan is revised every six years) and on the process of program assessments, which will be implemented with the plan. The demand scenarios without the actions are for Civil Water uses an 8% population growth, stability in the unitary consumption and a natural reduction of water losses from 26% to 20%. The Industry is in reduction from the 70's. For Agriculture there is still a forecast of growing irrigation surface, but with a growing technological efficiency at the field with an almost stable demand (not clear indication from Common Agriculture Policy yet).

Table 1-9: Withdrawals in Emilia - Romagna 1978

Table 1. Withdrawals in Emilia - Romagna 1978

	Civil Uses	Industrial Uses	Agriculture Uses	Total
Groundwater	350	240	150	740
Surface water	negligible	290	852	1142
Total	350	530	1002	1882

Studies for the middle of the 80' gave:

Table 2. Withdrawals in Emilia - Romagna 1985

	Civil Uses	Industrial Uses	Agriculture Uses	Total
Groundwater	310	227	193	730
Surface water	170	337	681	1188
Total	480	564	874	1918

Our last (2000) data are:

Table 3. Withdrawals in Emilia - Romagna 2000

	Civil Uses	Industrial Uses	Agriculture Uses	Total
Groundwater	282	171	222	675
Surface water	205	62	1183	1450
Total	487	233	1405	2125

On average, the total water per inhabitant is estimated to be about 700 m^3 / year, while for drinking use, using data from 2008, is 150 m^3 / year (ISTAT, 2012). The values are they rank at the top of the ranking at European level, but national division is far from homogeneous: Northwestern regions show greater use, accounting for about 39% of total, 27% in the Northeast, 19% in the Center and 15% in the South. Compared to the different uses, according to the study IRSA-CNR previously quoted, irrigation is ranked first with 49% of the total, followed by industrial sector (21%), civil (19%) and energy (11%). Finally, with regard to drinking, the volume of sales per capita in 2008 is 72.9 m3 / year (About 200 l / g) per inhabitant: a figure indicating on one hand the high overall incidence of losses in water systems and, on the other, the use of self-supplying forms in the territories rural and low urbanization (domestic water wells). This value is lower than 9.2%. In 1999, due to the change in the accounting system, which is now more linked to consumption real measured directly by counters, both for a slight reduction in consumption.

1.3.2 Observed and expected impacts

1.3.2.1 Projections to 2041–2070

In terms of seasonal anomalies in precipitation, in winter, RCP4.5 and RCP8.5 projections show opposite behaviours: the first one sees an average reduction of 3.8%, mostly localised in the western Po Valley in Piemonte region and on the Apennines, the latter an increase of 7.3% mostly in the eastern Po Valley in Lombardia. Winter bias corrected precipitation shows similar patterns. In summer, the precipitation is about 1/3 less than in the control period under both scenarios either for rawand bias corrected precipitations for RCP4.5(-QM) the reduction is almost constant across the season, while RCP8.5(-QM) show the highest reduction in July. The Po Valley is characterised by the maximum anomalies while Alps are characterised by lower changes. In autumn, RCP4.5(-QM) project more precipitation, on average 18%(13%) than the control period, in all months, especially on the eastern part of the basin and along the main river channel, instead, under RCP8.5(-QM) negligible variations 0.9%(−1.6%) are expected.

All temperature anomalies are positive with slightly higher values for RCP8.5(-QM) than RCP4.5(-QM). The anomalies range between 1.7 °C(2.4 °C) in spring and 3.1 °C(3.7 °C) in summer for RCP4.5(RCP8.5), and between 1.6 °C(2.4 °C) in winter and 2.7 °C(3.1 °C) in summer for RCP4.5-QM(RCP8.5-QM). In particular, the Po Valley is expected to warm more than Alps.

1.3.2.2 Projections to 2071-2100

In terms of seasonal anomalies in precipitation, RCP4.5(-QM) winter precipitation is characterised by a positive anomaly, 11%(15%), in particular over Po Valley,whereas negligible differences are found on Alps. On the same months, RCP8.5(-QM) expects an increase of about 38%(50%) over the whole Po River basin in particular on Alps. In spring, both scenarios show a reduction of precipitation on the eastern part of the basin, more marked under RCP8.5(-QM), while on the western Alps, RCP4.5(-QM) expects a light increase and RPC8.5(-QM) a reduction. In summer, RCP4.5(-QM) precipitation reduction is increasing from June to August and, on average, it is comparable with the 2041–2070 period, but with no more evident dependency on altitude. The RCP8.5(-QM) precipitation reduces by about 57%(60%), which is almost the double that of the 2041–2070 period. As last, in autumn, RCP4.5(-QM) precipitation increases of about 5.3%(2.0%) and changes are localised in Piemonte and along the Po River main channel (RCP4.5 only); similarly to 2041–2070 period, RCP8.5(-QM) precipitation reduces on Apennines and partially on Alps while it is unvaried in the Po Valley, the overall reduction is less than 5%(10%). Temperatures are expected to increase in all months, and RCP8.5(-QM) projects higher values than RCP4.5-QM. RCP4.5 temperature anomaly will range between 2.3 °C in winter and spring and 3.5 °C in summer and, for RCP8.5, between 4.1 °C in spring and 7 °C in summer. For bias corrected temperature, the range of variability is similar to raw data.

LOW FLOWS

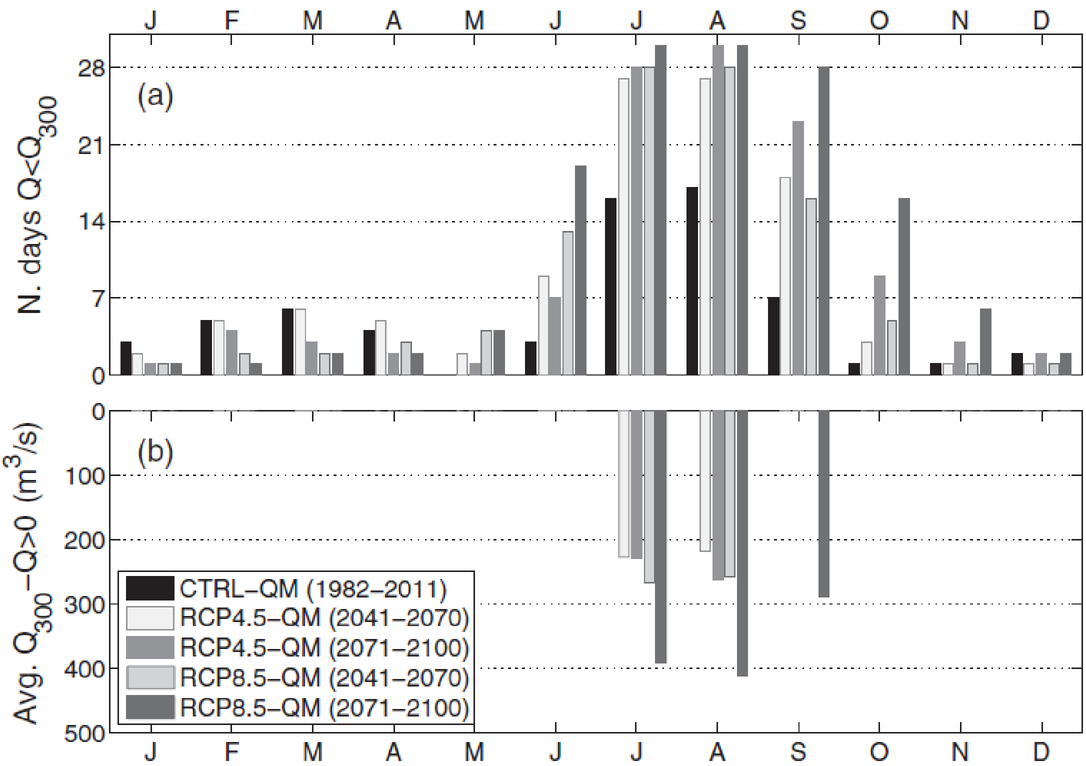


Diagram 1-2:

(a) Average number of days within each month with Q<Q300 for the CTRL-QM, RCP4.5-QM and RCP8.5-QMsimulations.

(b) Average monthly deficit with respect to Q300 threshold (which is estimated on the basis of CTRL-QM simulation)

Under the assumption that the total water demand will not change in the future, Fig. 9 depicts for each month, for CTRL-QM, RCP4.5-QM and RCP8.5-QM discharges, (a) the average number of days in which the discharge is below the Q300 threshold and (b) the monthly average deficit. It is evident that, low flows are concentrated between July and September and their duration is expected to increase. In the 2041–2070 period, according to RCP4.5-QM(RCP8.5-QM) simulation low flow duration changes from 16 to 27(28) days in July, from 17 to 27(28) in August and from 7 to 18(16) in September. The extension of hydrological drought period is reported also in Coppola et al. (2014) on the 2021–2050 period. According to 2071–2100 projections the low flow occurrence changes to 28(30) days in July; 30(30) days in August and 23(28) days in September. In July–September period, the low flow duration is similar under the two scenarios with differences between 2041–2070 and 2071–2100 periods; considering the average deficit, RCP8.5-QM projection shows the most severe deficit in July and August, about 70% higher than RCP4.5-QM one (both in 2041–2070 and 2071–2100 periods) and 50% higher than RCP8.5-QM in the 2041-2070 period, and, in addition, for the water scarcity is prolonged to September, Fig. 9(b).

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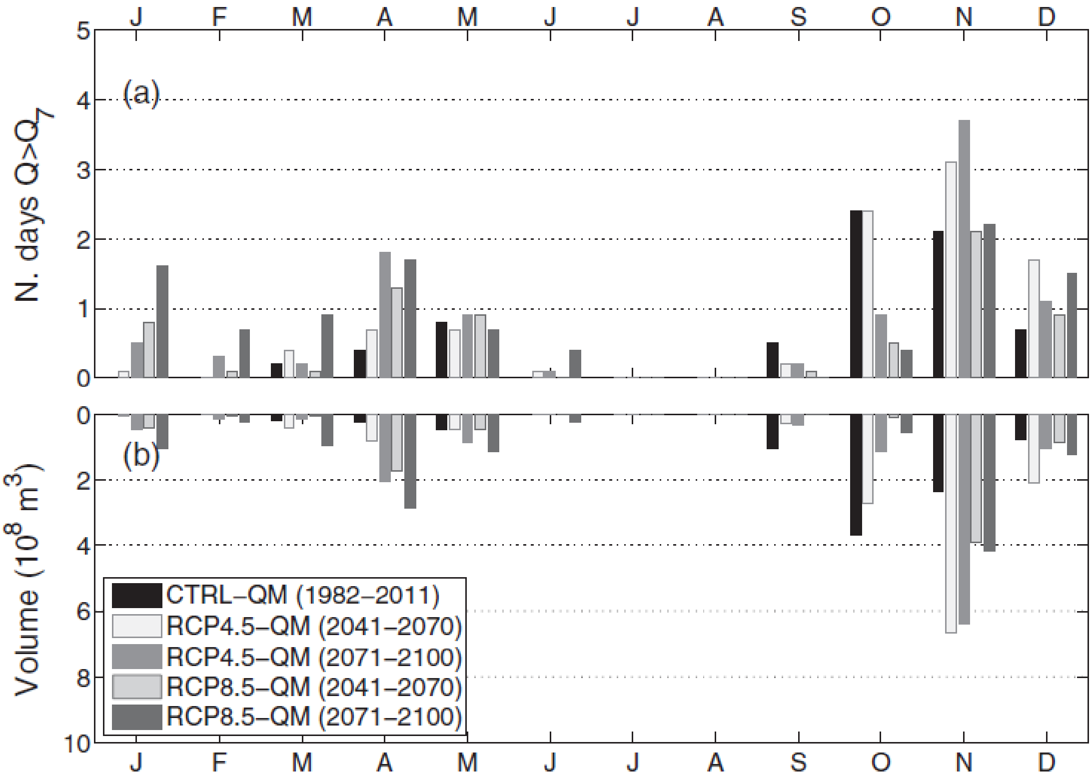
HIGH FLOWS



(a) Average number of days within each month with Q>Q7 for the CTRL-QM, RCP4.5-QM and RCP8.5-QMsimulations.

(b)Monthly average volume associated with Q>Q7 (which is estimated on the basis of CTRL-QM simulation).

In the control period, high flows occur mostly in autumn and spring (flood seasons) and the volume associated with autumnal events is higher than the spring ones. According to the simulations performed, in the future, discharges exceed Q7 more often from November to June and less often in September and October, Fig. 10(a). In autumn, RCP4.5-QM shows higher exceedance probability than RCP8.5-QM, in winter the behaviour is opposite, this is coherentwith the precipitation anomaly described in Sections 4.2 and 4.3. In terms of volume associated with the threshold exceedance, Fig. 10(b), in winter it is comparable to the control period, with the exception of RCP4.5-QM on 2041–2070 in December; in spring, projections at 2071–2100 are both characterised by a significant increase in the volume, while at 2041–2070 only April is quite different from the control period; in summer almost no exceedance occur and volume associated are negligible; in September and October, both projections show less frequent and lower volumes than the control period and RCP4.5-QM dominates RCP8.5-QM projection but in November both projections are more severe than the control period. With reference to the Q7 threshold adopted to study changes in high flow volume and frequency, we estimate the changes in discharges for the following return periods: 10, 20, 50 and 100 years, Table 3. The evaluation confirms the expected increase in the exceedance frequency of the threshold. RCP4.5-QM simulation projects an increase of discharges with T b 100 years and the 100-year statistics is almost unvaried at 2041–2070, and a generalised reduction at 2071–2100. RCP8.5-QM simulation projects, in the 2041-2070 period, an increase of the maximum discharges with increasing return period, while, in the 2071-2100 period, maximum discharges are about 10% higher than in the control period, indipendently on the return period considered.

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2 FLOODS

Despite the considerable rise in the number of reported major flood events and economic losses caused by floods in Europe over recent decades, no significant general climate related trend in extreme high river flows that induce floods has yet been detected. Although there is yet no proof that the extreme flood events of recent years are a direct consequence of climate change, they may give an indication of what can be expected: the frequency and intensity of floods in large parts of Europe is projected to increase (Lehner *et al.*, 2006; Dankers and Feyen, 2008). In particular, flash and urban floods, triggered by local intense precipitation events, are likely to be more frequent throughout Europe (Christensen and Christensen, 2007; Kundzewicz *et al.*, 2006). Flood hazard will also probably increase during wetter and warmer winters, with more frequent rain and less frequent snow (Palmer and Räisänen, 2002)(EEA/JRC/WHO, 2008).

2.1 Cyprus

2.1.1 Existing situation

In order to mitigate and address the negative effects of floods on human health, the economy, the environment and the cultural heritage, the European Commission has put into force Directive 2007/60 / EC. This Directive provides actions that all Member States are required to implement. These relate to the Preliminary Flood Risk Assessment (PFRA) for each River Basin District, the preparation of flood hazard and flood risk maps and the preparation of Flood Risk Management Plans (FRMPs). The aim of these actions is to identify areas where there are serious potential flood risks, to assess the potential negative consequences and to identify the necessary measures for the prevention, protection and preparedness of the state.

2.1.1.1 Flood hazard maps

Floodhazard maps that have been made from the Water Development Department of Cyprus present the possibility a flood to take place in a specific areawhich corresponds to a given probability.

In particular, these maps are associated with floods of low, medium and high probability of overruns and return periods (T) of five hundred (500), one hundred (100) and twenty (20) years respectively. The construction scale of the maps is 1: 5,000.

FHMs are presented below and provide information of the flooded area, depth grading and locations with the existing technical works such as bridges/drains andmounds / terraces.

Summarized flood hazard maps of Pedieos River for the two municipalities, are presented in the following figures.

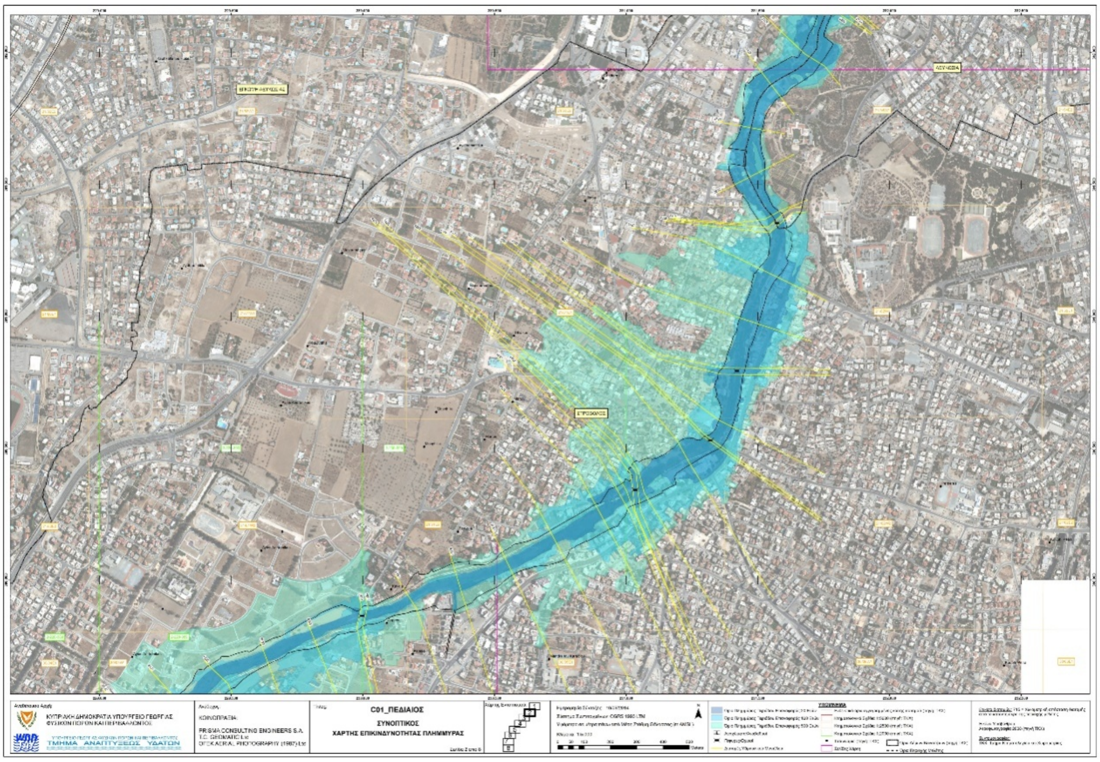

Figure 2-1: Summarized flood hazard map - Pedieos River – section 1

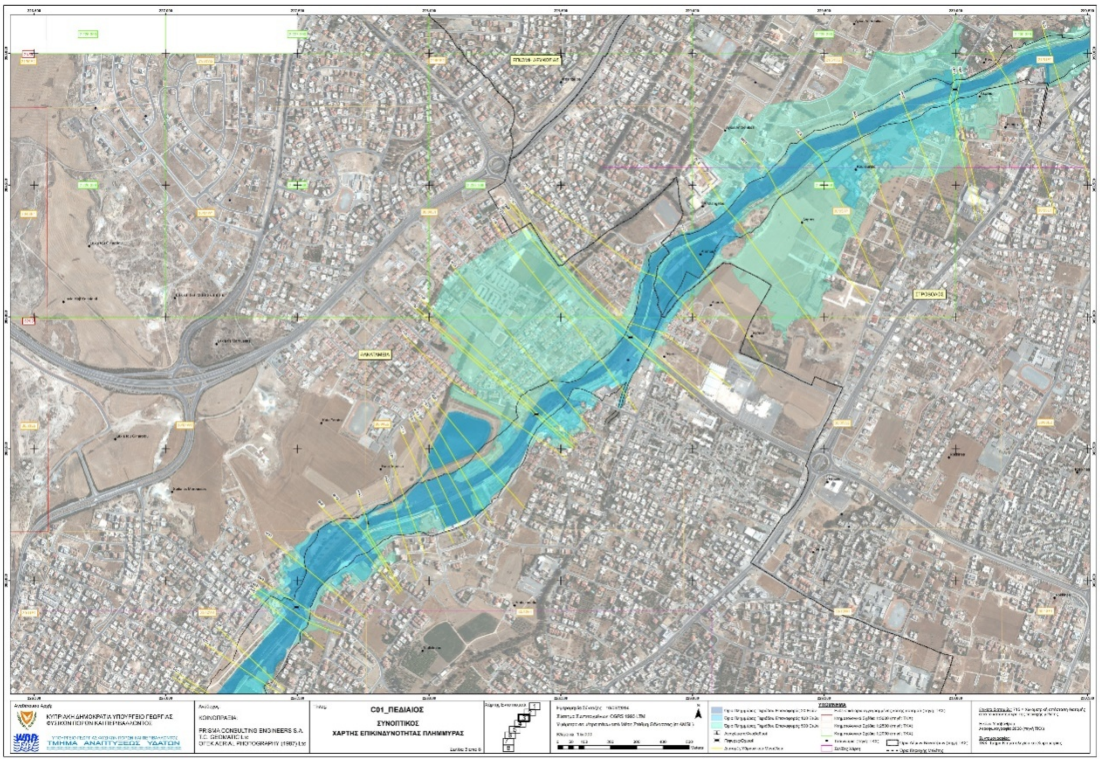

Figure 2-2: Summarized flood hazard map - Pedieos River – section 2

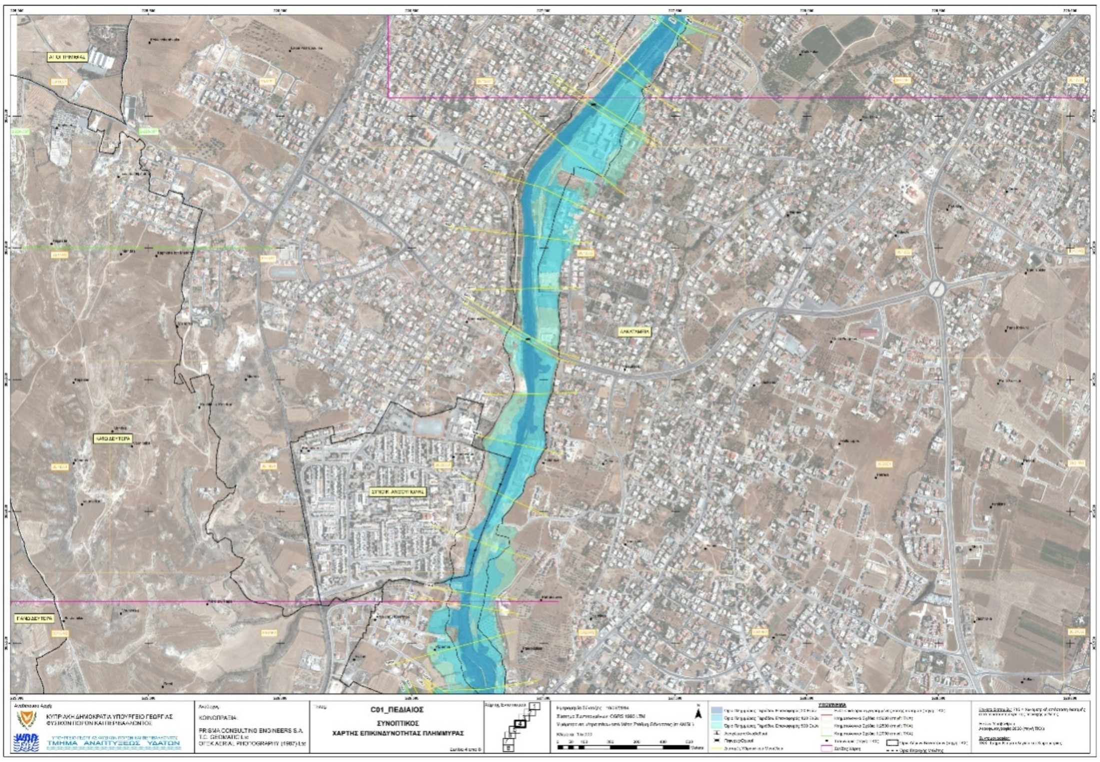

Figure 2-3: Summarized flood hazard map - Pedieos River – section 3

Summary flood hazard maps for Kalogeros River, are presented in the following figures.

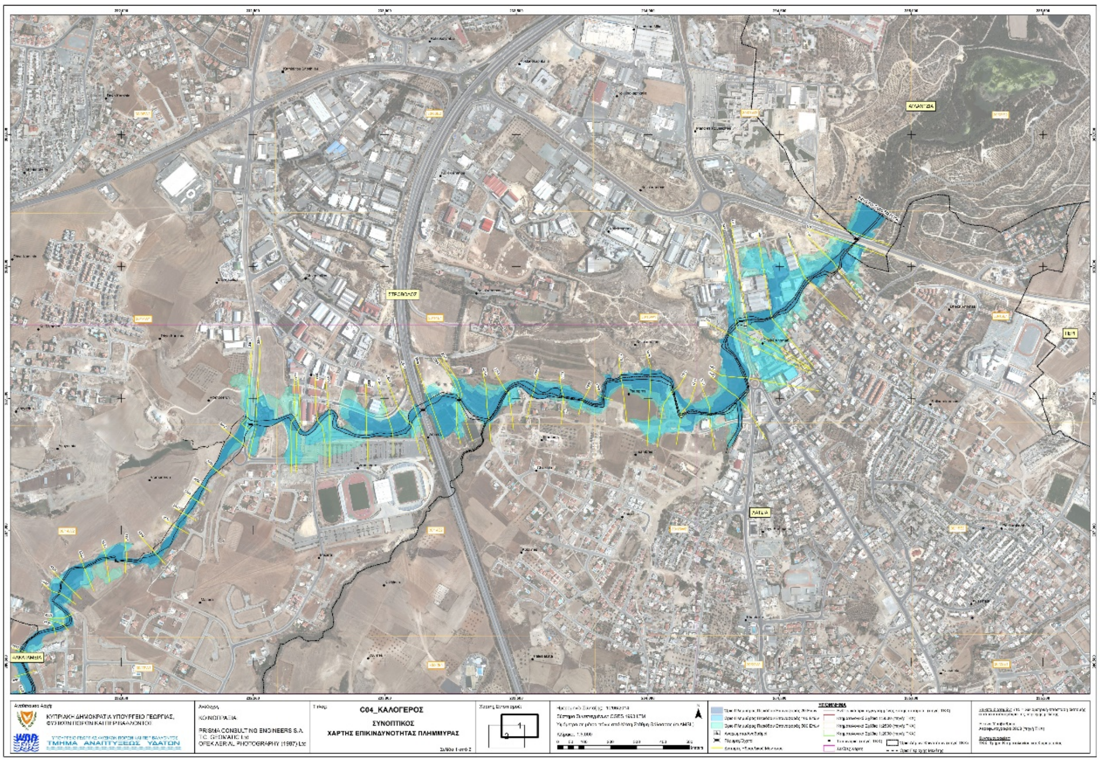

Figure 2-4: Summarized flood hazard map - Kalogeros River – section 1

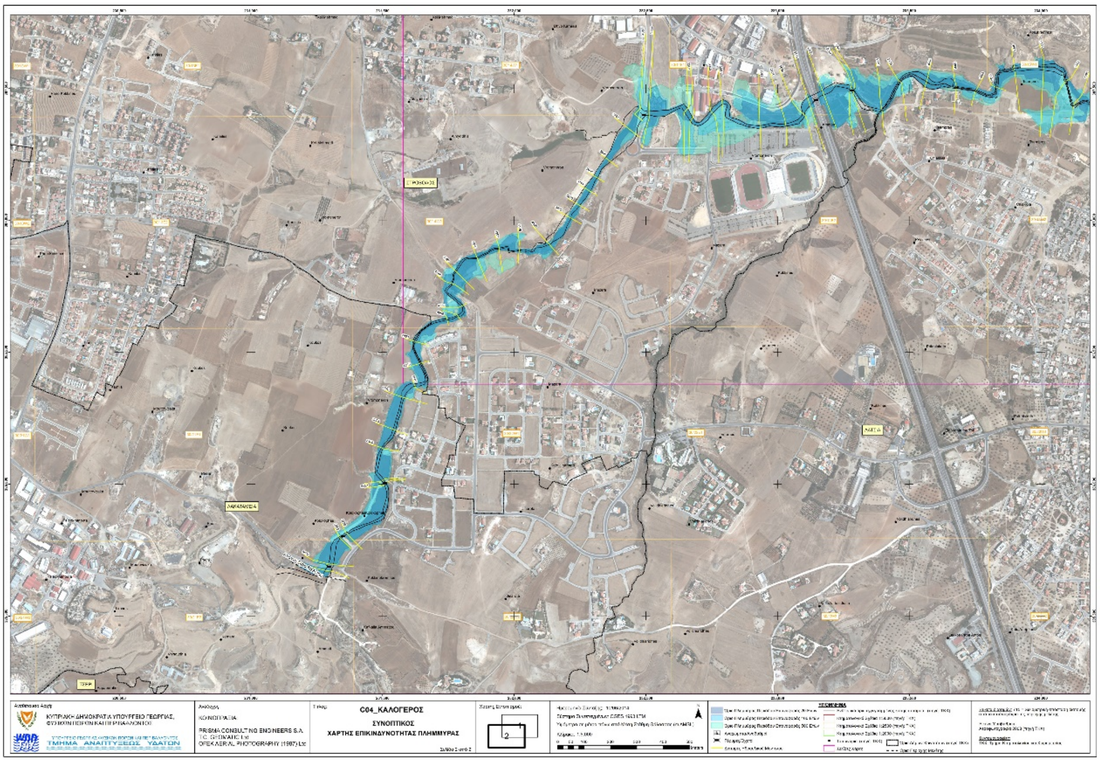

Figure 2-5: Summarized flood hazard map - Kalogeros River – section 2

The flooded areas for all the return periods and for the two rivers (Perieos & Kalogeros) are presented in the next figure.

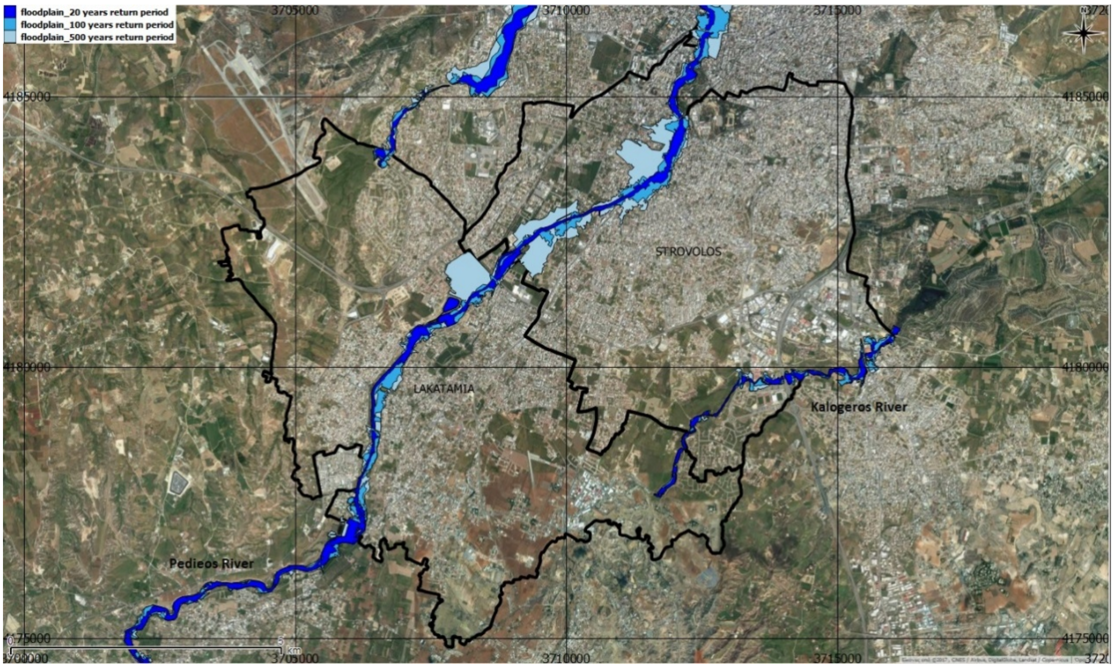

Figure 2-6: Summarized flood hazard map of the two rivers (Pedieos River & Kalogeros River)

The general conclusion deduced from the observation of the above figureis that the area affected by the floods is increasing with an increase of the return periods. The largest flooded area is observed for the 500-year return period, as expected.

These areas are mainly located in the municipality of Strovolosand in the northern part of Lakatamia municipality.

Comparing the two cases, it is clear that most of the problems observed are located in Pedieos River.

2.1.1.2 Flood risk maps

Flood risk maps have been made on the same scale and for the same return time periods as those of flood risk. The information on the maps concerns to three (3) flood scenarios, the indicative number of inhabitants, the type of urban planning zone (e.g. protected areas, residential areas that may be affected), bridges/drains (overflowing or not) and other important facilities and locations (e.g. waste water treatment plants, pumping stations, archaeological sites).

According to the maps mentioned in the three different return periods, the flood zone corresponding to the area of interest changes and mainly affects residential areas.

Flood risk maps for the three return periods for Pedieos River are shown below.

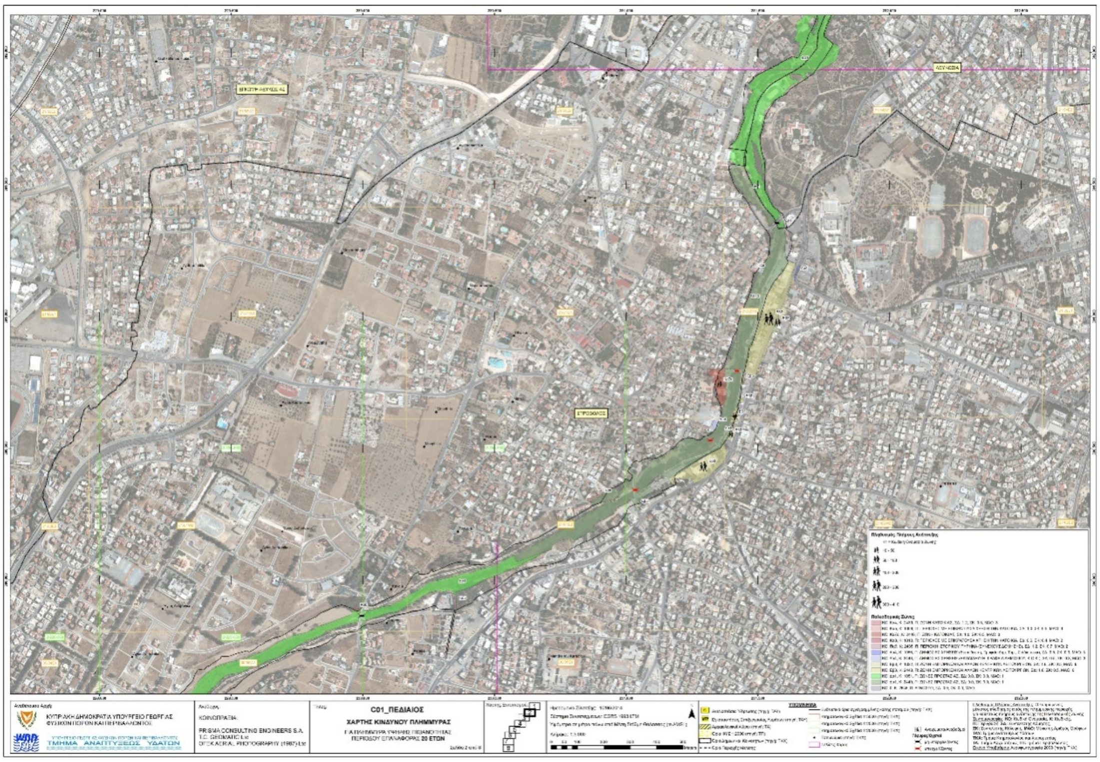

Figure 2-7: Flood risk map - Pedieos River – section 1 (20 years return period)

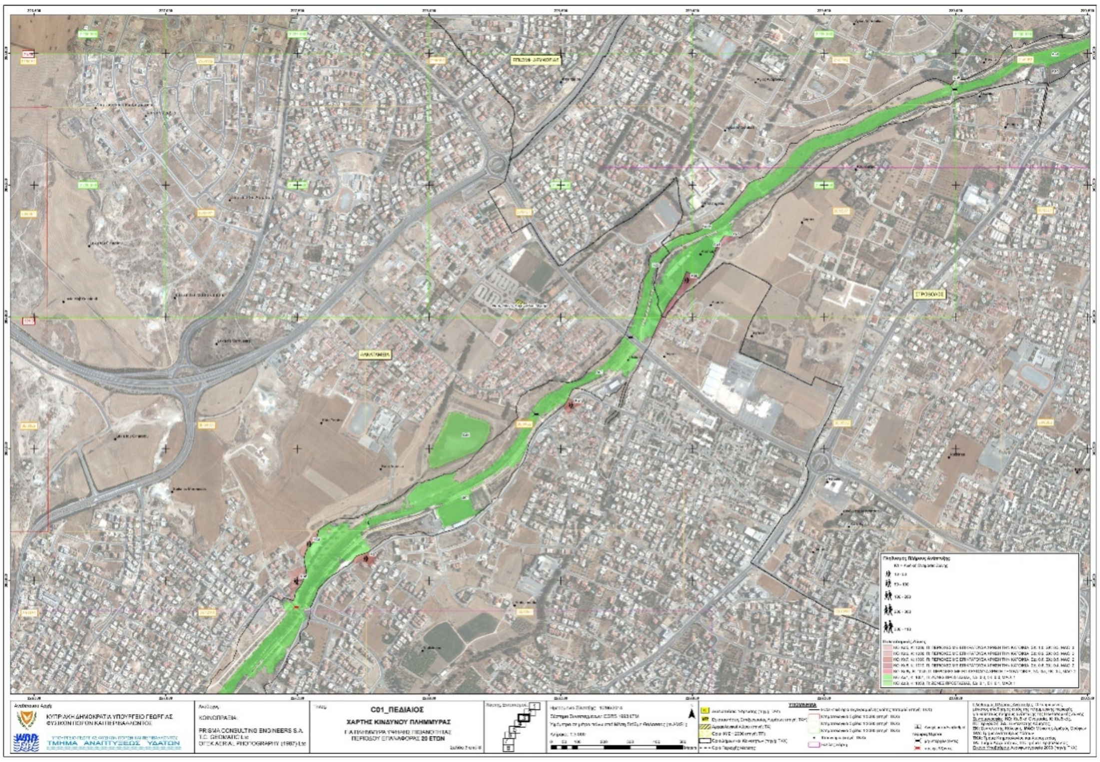

Figure 2-8: Flood risk map - Pedieos River – section 2 (20 years return period)

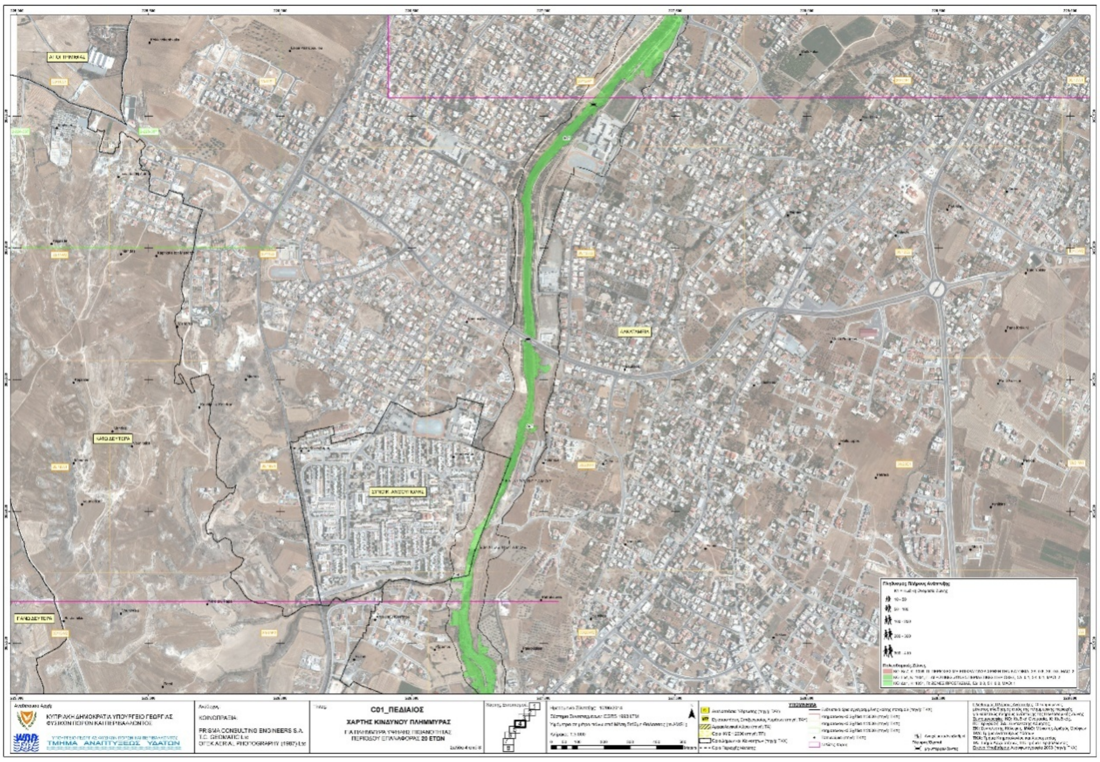

Figure 2-9: Flood risk map - Pedieos River – section 3 (20 years return period)

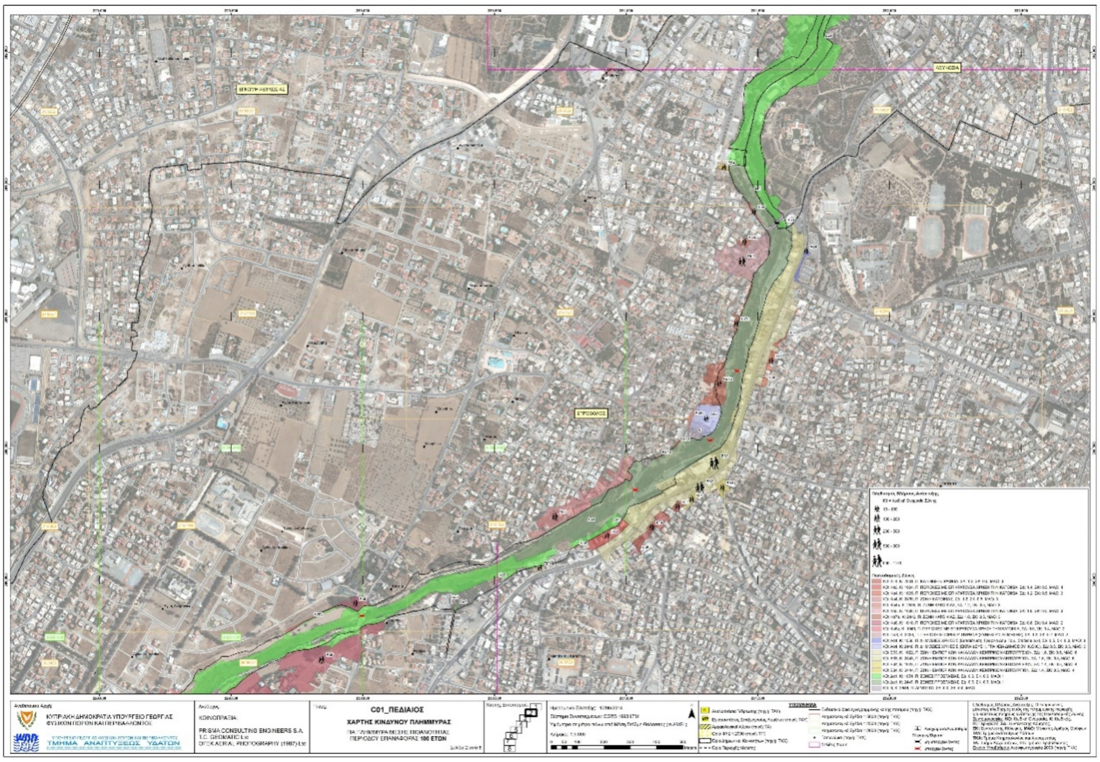

Figure 2-10: Flood risk map - Pedieos River – section 1 (100 years return period)

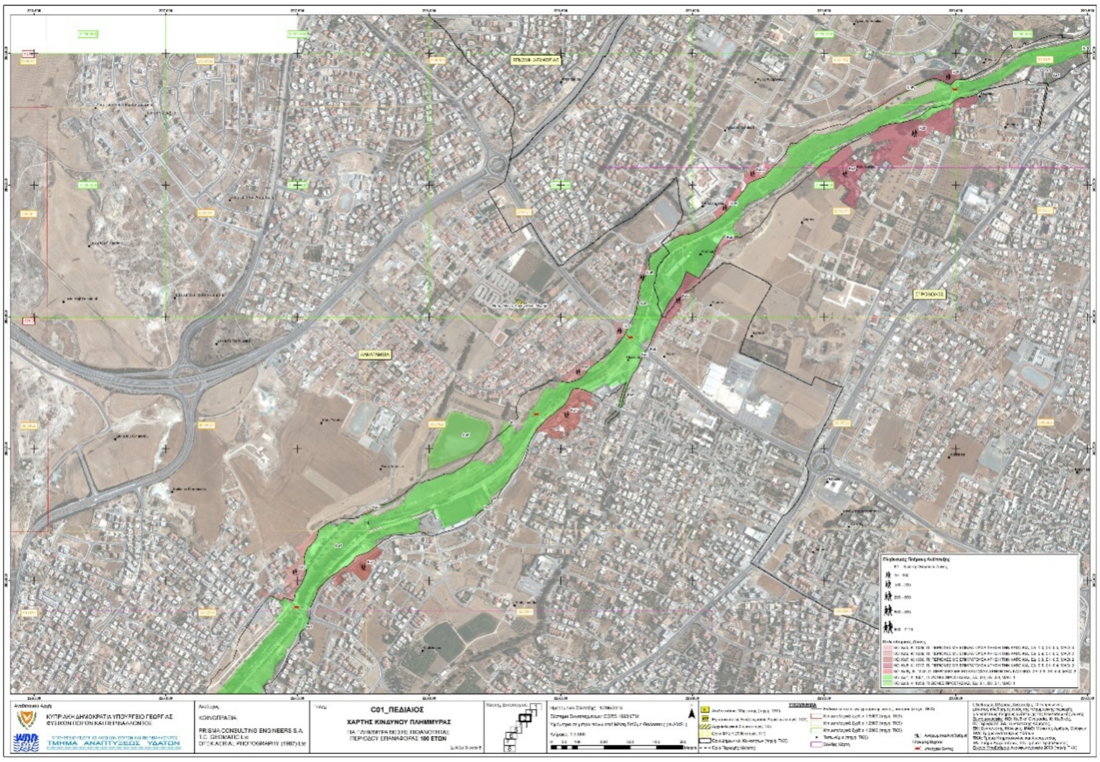

Figure 2-11: Flood risk map - Pedieos River – section 2 (100 years return period)

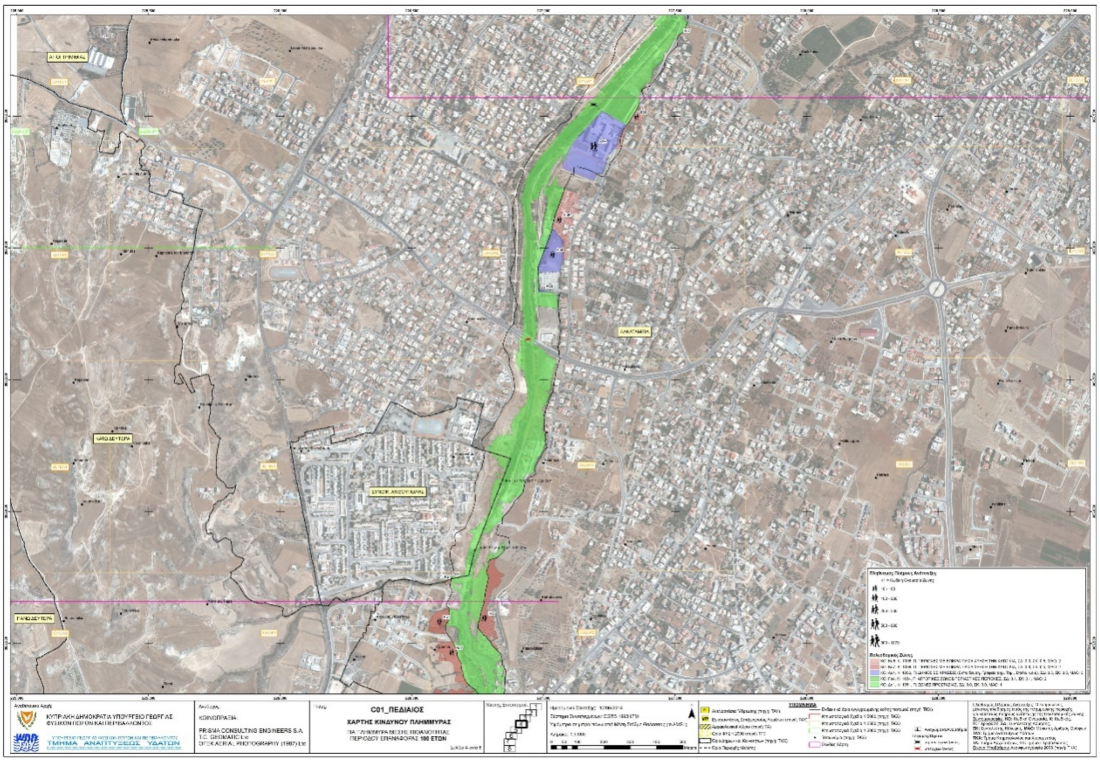

Figure 2-12: Flood risk map - Pedieos River – section 3 (100 years return period)

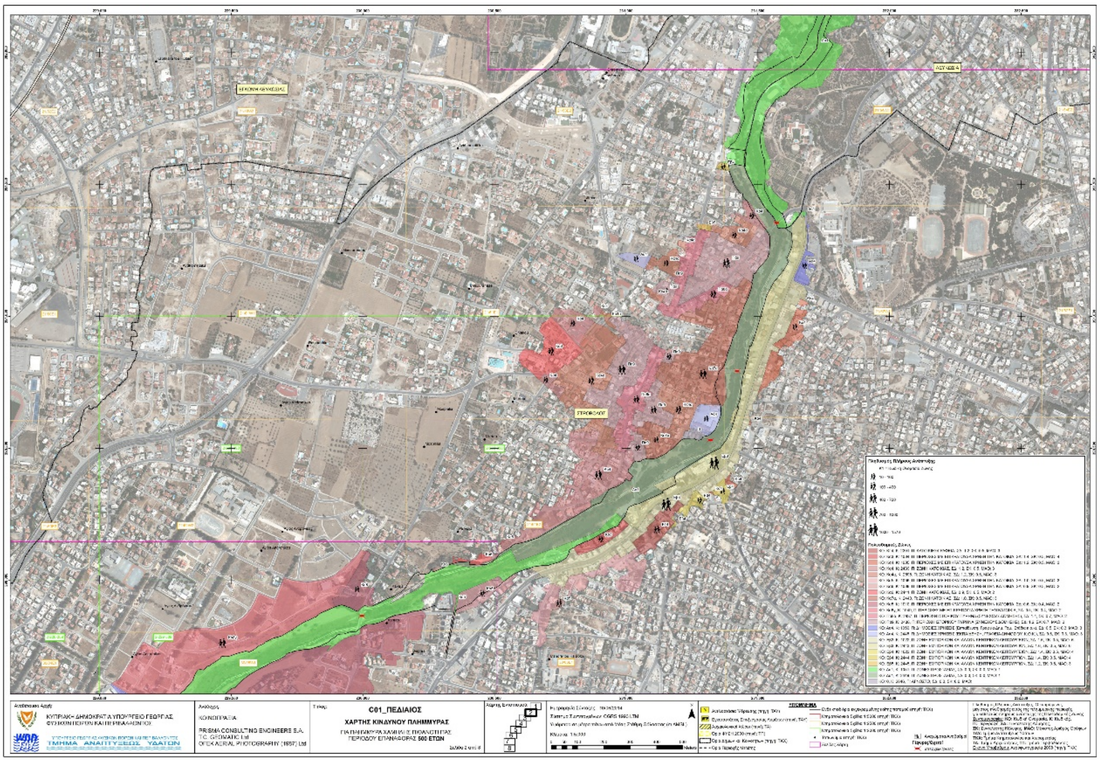

Figure 2-13: Flood risk map - Pedieos River – section 1 (500 years return period)

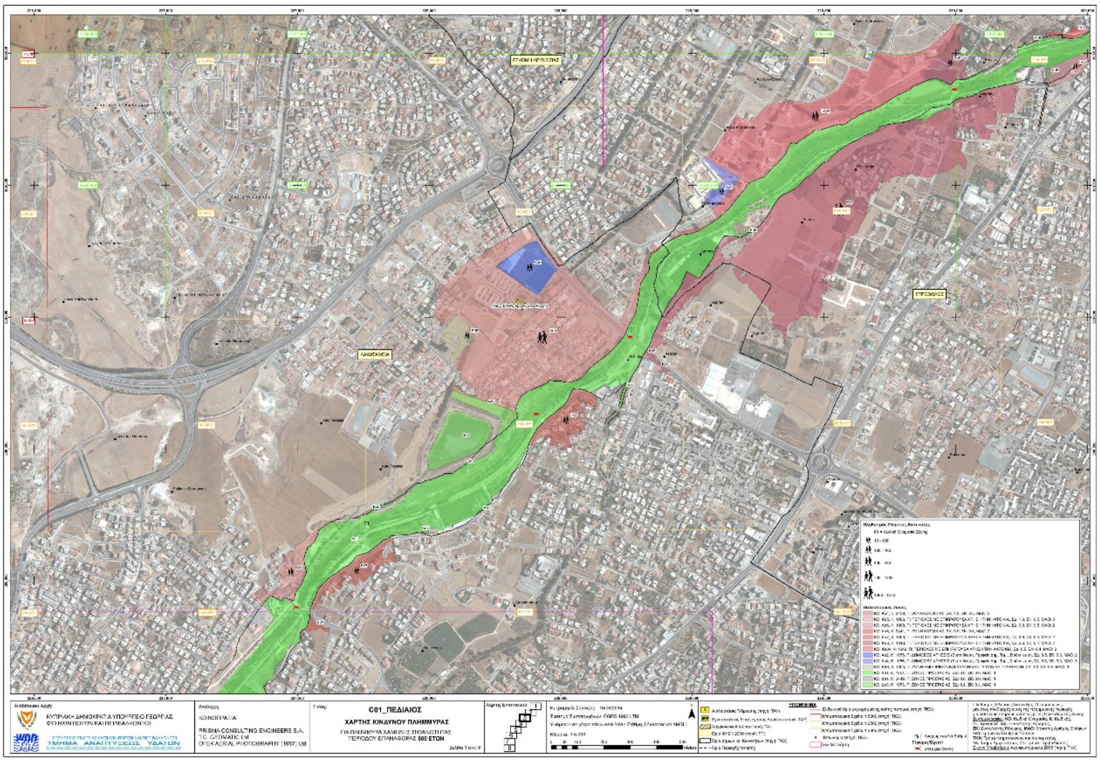

Figure 2-14: Flood risk map - Pedieos River – section 2 (500 years return period)

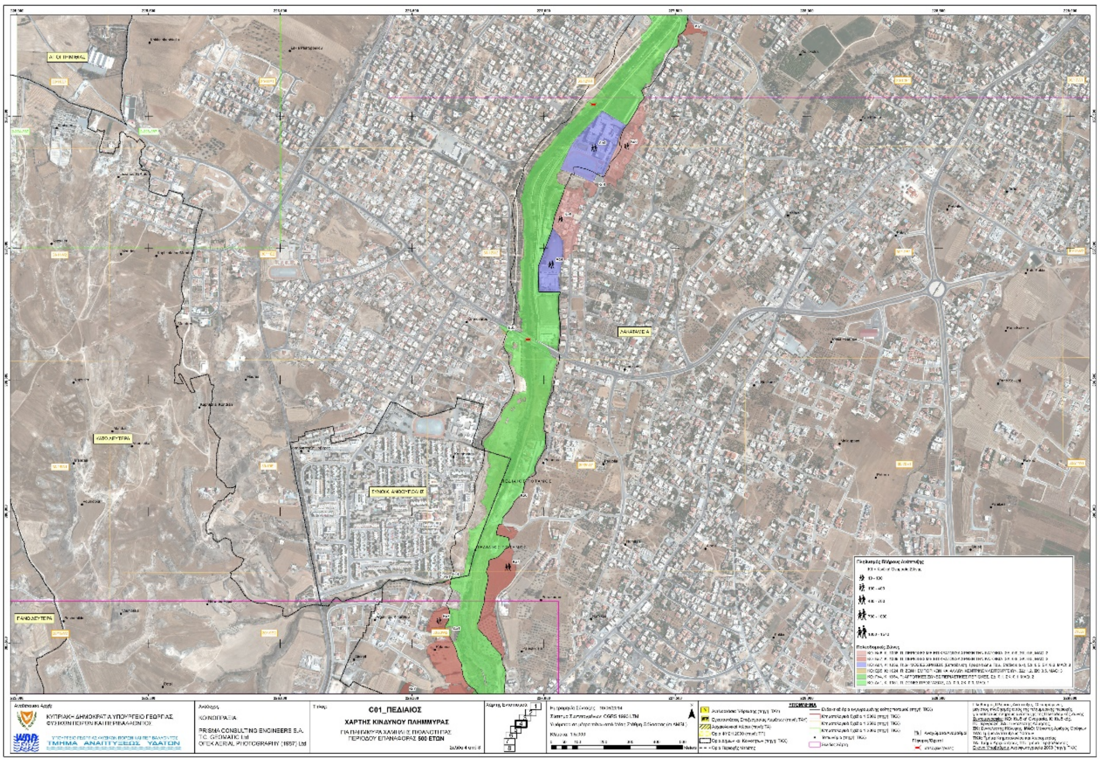

Figure 2-15: Flood risk map - Pedieos River – section 3 (500 years return period)

For the return periods of 20 and 100 years, the affected areas are mainly protection areas along the river. For the 500-year return period the affected areas are mainly related to residential areas.

More specifically with respect to the rest periods, the following are observed (TAY, 2016):

- <u>20 years return period</u>: residential areas, offices and services are mainly affected. Several bridges and streets are flooded.
- <u>100 years return period</u>: areas of continuous urbanization, residential areas, offices and services, as well as areas with commercial and other related activities and areas of public use affected. Almost all hydraulic constructions overflow.
- <u>500 years return period</u>: areas of continuous urbanization, residential areas, offices and services, as well as areas with commercial and other related activities and areas of public use affected. All hydraulic constructions overflow.

The main problems of bridges/drains overflowing are presented in the flood scenarios of 100 and 500 years.

No other important facilities and locations(e.g. waste water treatment plants, pumping stations, archaeological sites)are observed in the flood area (500 years return period).

Flood risk maps for the three return periods for Kalogeros River are shown below.

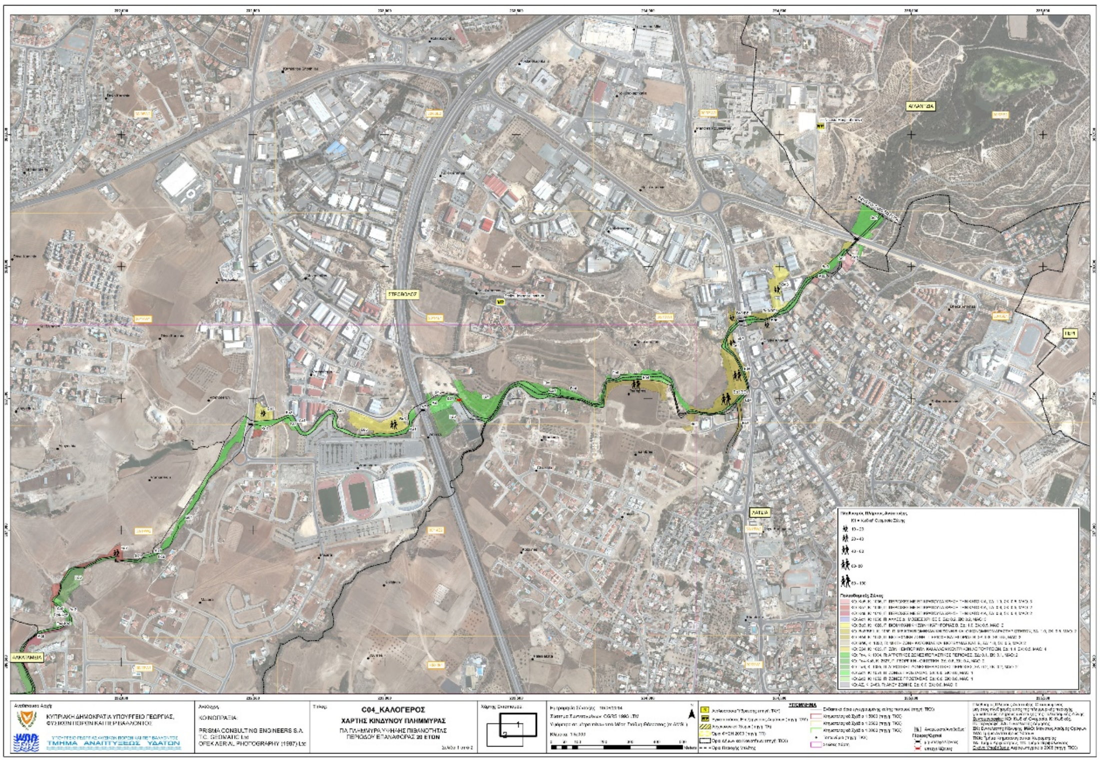

Figure 2-16: Flood risk map - Kalogeros River – section 1 (20 years return period)

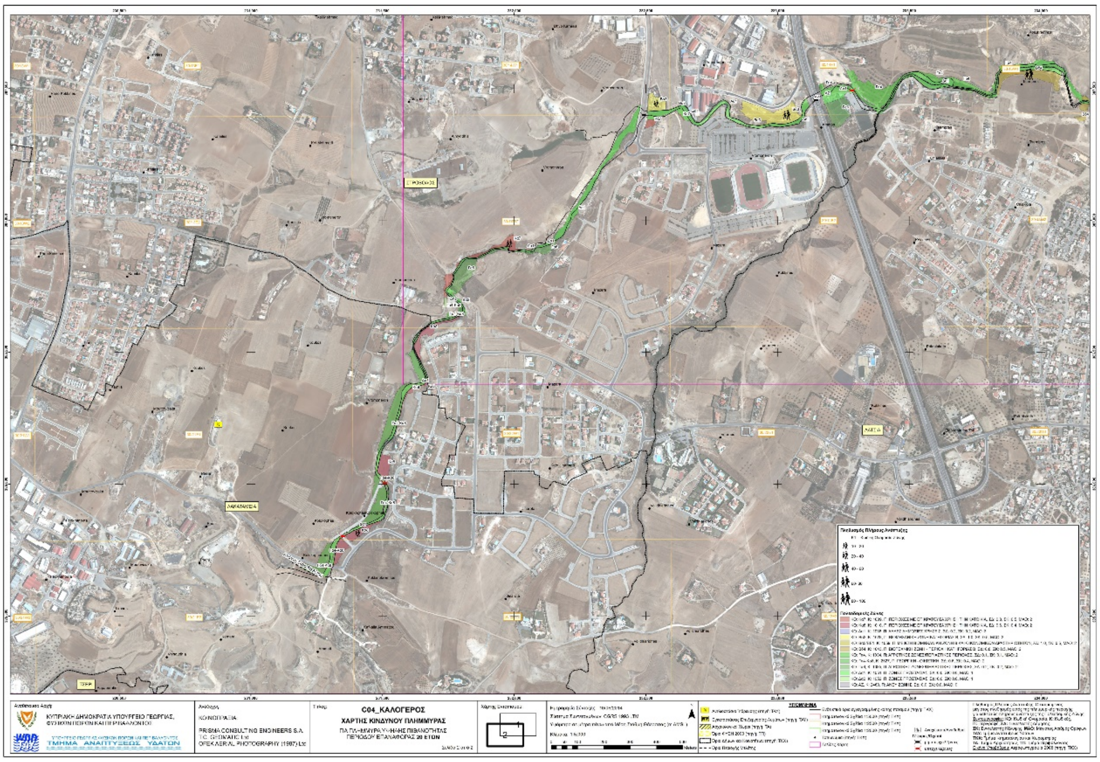

Figure 2-17:Flood risk map - Kalogeros River – section 2 (20 years return period)

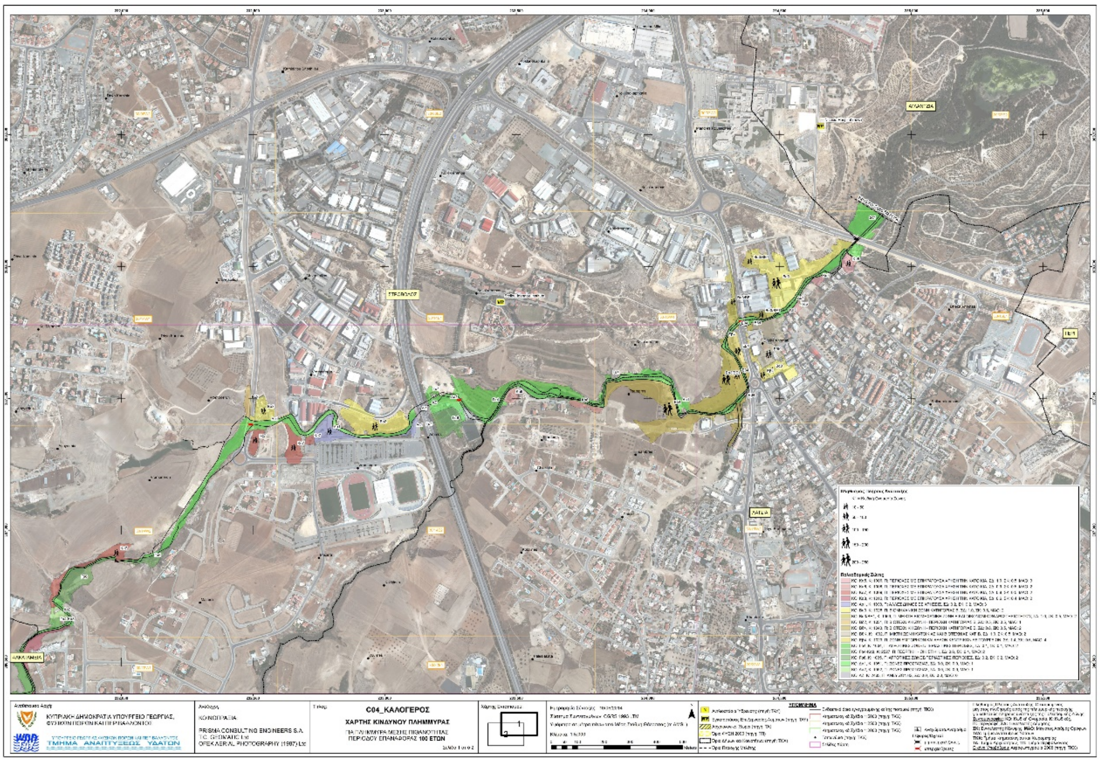

Figure 2-18: Flood risk map - Kalogeros River – section 1 (100 years return period)

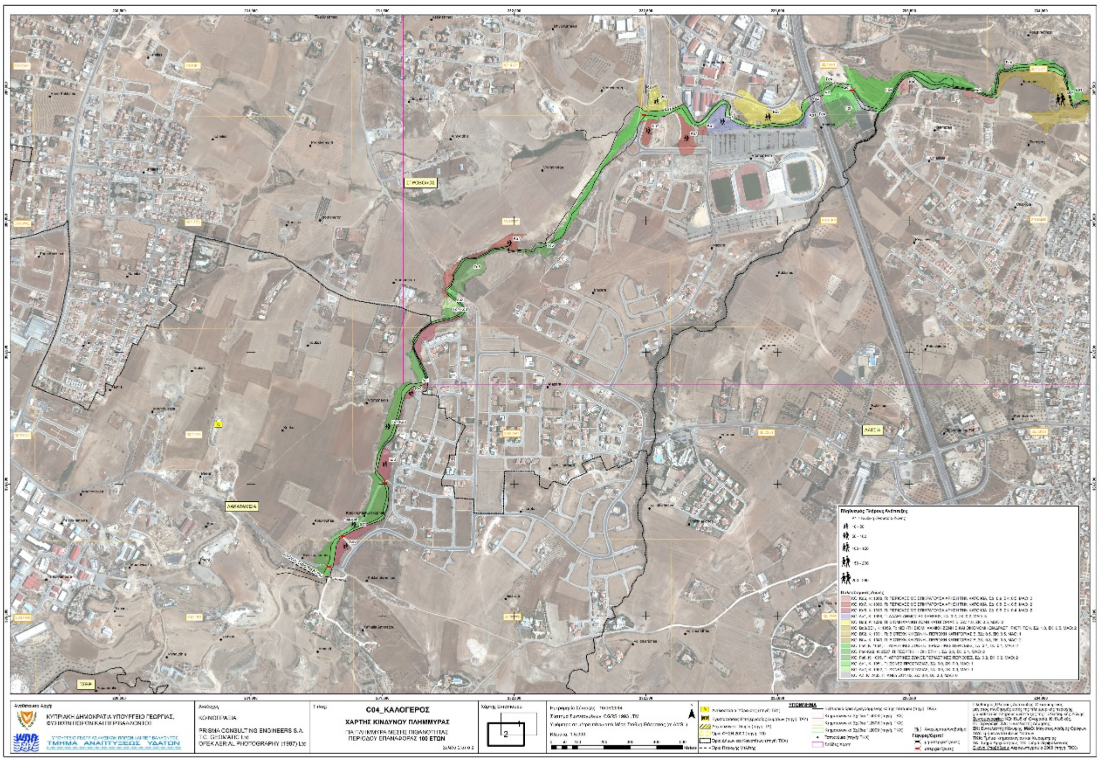

Figure 2-19: Flood risk map - Kalogeros River – section 2 (100 years return period)

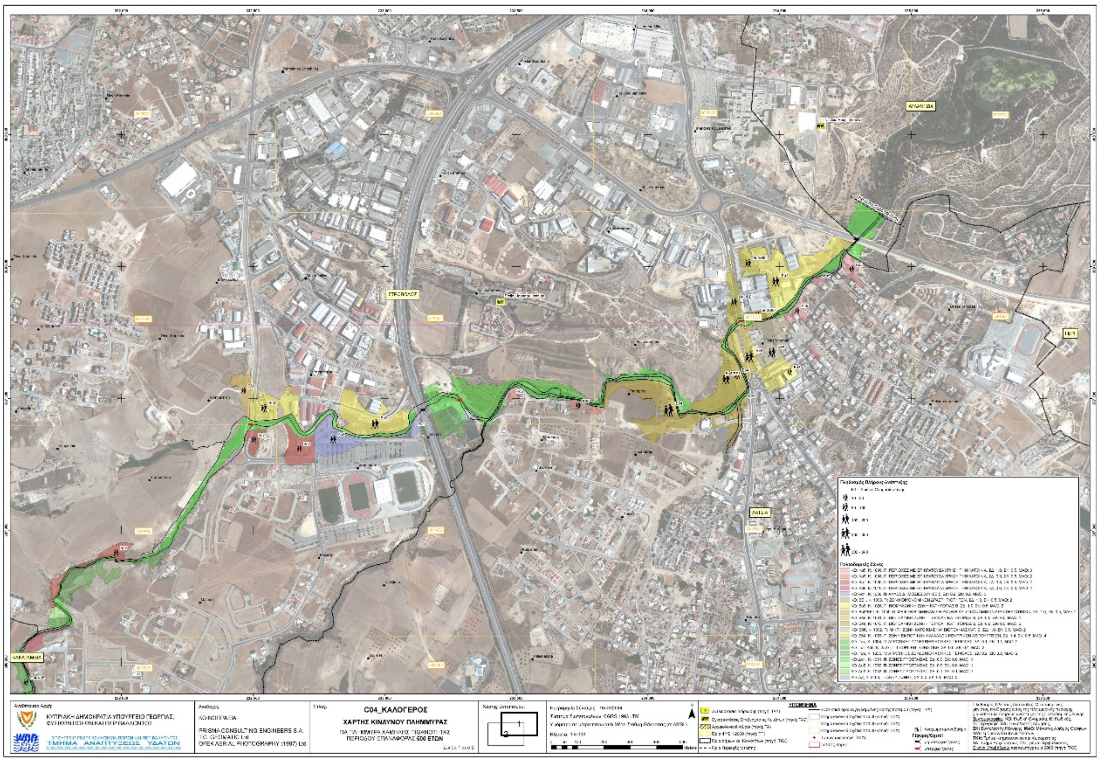

Figure 2-20: Flood risk map - Kalogeros River – section 1 (500 years return period)

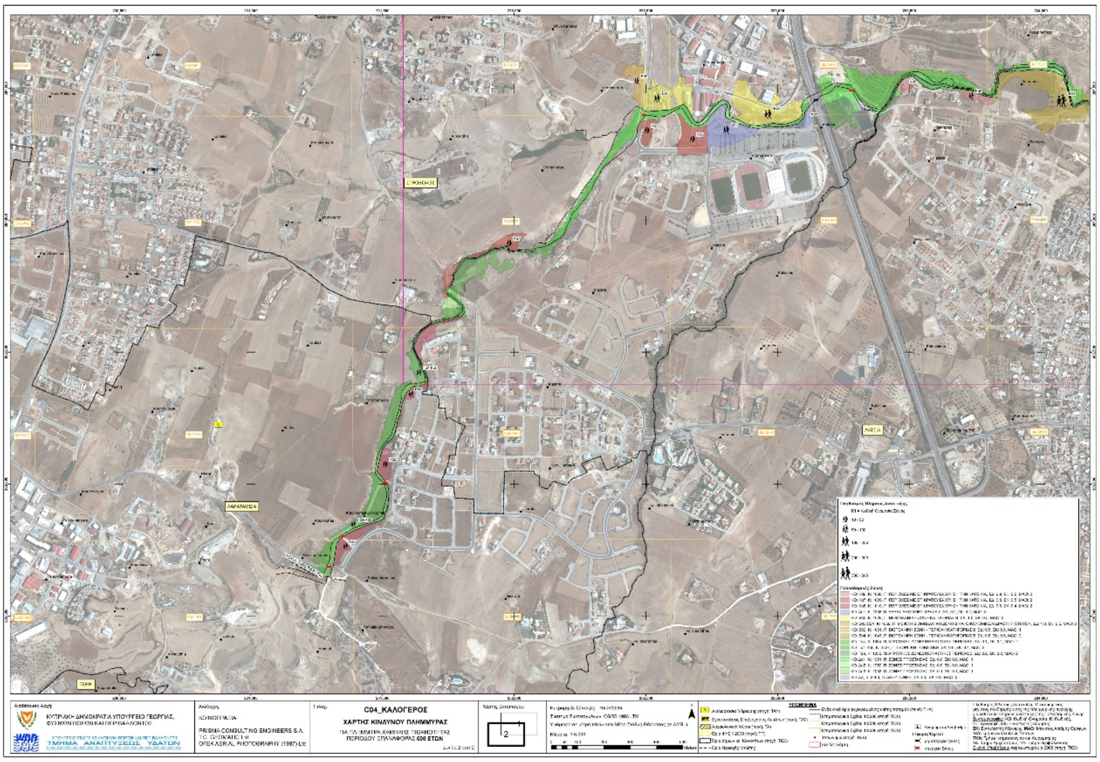

Figure 2-21: Flood risk map - Kalogeros River – section 2 (500 years return period)

Concerning the three return periods for Kalogeros River, there are no big differences among the flooded areas.

The current land use of the areas are mainly related to river protection zones and industrial zones.

More specifically with respect to the rest periods, the following are observed (TAY, 2016):

- <u>20 years return period</u>: residential areas and industrial zones are mainly affected. All the drains and streets are flooded
- <u>100 years return period</u>: residential areas and industrial zones are mainly affected. All the drains, some bridges and roads are flooded.
- <u>500 years return period</u>: residential areas and industrial zones are mainly affected. All the drains, some bridges and roads are flooded.

2.1.2 Observed and expected impacts

The National Adaptation Plan for Cyprus has been prepared considering the main outcomes of the assessment that was conducted regarding the current and future vulnerability of specific socio-economic sectors of Cyprus against climate change (CYPADAPT, 2014). In specific, the vulnerability assessment related to water resources conducted was based on the following impact categories, namely:

- Water availability (see also Chapter 1.1.2)
- Water quality (see also Chapter 1.1.2)
- Floods

Flooding vents in Cyprus are characterized of very low and low hazard by 42% and 31% respectively, as well as moderate and high hazard by 22% and 4.5% respectively. Only 0.5% flooding events are characterized as of very high hazard. Based on the abovementioned, sensitivity to floods can be considered limited in Cyprus. However, flooding events are expected to be increased due to climate change (WDD, 2011d). In specific, it has to be noted that urban centres, such as Larnaka, Limassol and Nicosia are particularly exposed to flood risks because of their dense structure and the lack of green spaces and the poor stormwater drainage network. To this end, the adaptive capacity of Cyprus against flooding events has been enhanced with the construction of flood protection infrastructure and the design of river protection zones.

- Droughts (see also Chapter 1.1.2)

2.1.3 Non-climate related pressures

Flood problemsinclude overflow and flow obstruction. The main reasons are the following (TAY, 2016):

- Narrow river beds
- Small cross-sections in transversal technical works and roadways

All of the abovementionedcauses constitute effects of human activity in the study area.

2.1.4 Adaptation measures

The increased frequency and intensity of flooding events in Cyprus have resulted in a series of adaptation measures that can distinguished to flood risk management activities and the construction of flood risk prevention infrastructure. More specifically:

Flood risk management plan

According to the flood risk management plan (TAY, 2016) the proposed flood protection measures are divided into:

- General prevention measures
- General protection measures
- General preparedness measures
- General rehabilitation measures
- Specific measures for Pedieos River

The specific measures of all types mentioned above are listed below.

General prevention measures:

- Integration of flood risk assessment results into spatial and urban planning through Development Plans (Local Plans, Area Plans and Statement of Rural Policy)
- Securing a protection zone along rivers for licensing new developments.
- Development of interactive Hazard and Flood Risk Maps for better knowledge of flood risk
- Ensuring the quality of rainwater management studies and flood protection projects designing

General protection measures:

- Exploitation of existing landfill projects to halt floods
- Projects to enrich and reduce flow in river beds upstream of potential flood risk areas
- Stormwater disposal in absorbent pits
- Promoting practices to reduce water flow from properties
- Promoting practices to reduce and manage run-off from public spaces
- Investigation of the feasibility of providing financial incentives to private individuals for storm water management by applying sustainable systems that help reduce surface run-off
- Promoting private rainwater utilization systems
- Preparation of a regulation of required annual cleaning, maintenance and management of riparian vegetation
- Maintenance of stormwater drainage network
- River protection from uncontrolled discharges and interventions
- Technical projects for the containment of flood debris
- Supervision / coordination of implementation and maintenance of flood control projects at provincial level
- Restoration of continuity of important streams
- Restoration and improvement of hydraulic features of streams
- Rationalization of the process of licensing of crossing rights from rivers / streams
- Rationalization of the design of road crossings from rivers / streams
- Financial support for private flood protection measures in licensed constructions

- Establishment of a process for the elaboration of Strategic Water Management Plans (Master Plan) in the process of planning new areas within development zones

General preparedness measures:

- Improvement of a warning mechanism for adverse weather and flood events
- Updating of Extreme Weather Plans with the results and conclusions of Hazard and Flood Risk Maps
- Local Government and Communities sensitization campaigns against flood risk

General rehabilitation measures:

- Improvement of the flood damage recording and assessment mechanism
- Record flood impacts for better knowledge of the phenomenon in order to improve the level of prevention and response / remediation of mechanisms
- Promoting private flood insurance

Specific measures for Pedieos River:

- Warning mechanism for extraordinary weather phenomena and floods in the municipalities of Nicosia, Strovolos and Lakatamia

Flood prevention infrastructure

This chapter analyzes the flood prevention infrastructure, as well as the problems observed so far.

Initially, two major projects should be mentioned: (i) Tamassos dam (Figure 1-8) and (ii) Mangli Lake (Figure 57) are major projects and despite the fact that their purpose is the enrichment of the aquifer they also contribute in halting the floods.

Figure 2-22: Location of the Mangli Lake in Lakatamia Municipality

These projects contribute to the flood protection of the two municipalities.

Tamassos dam can store about 2,8 hm^3 of water and it has been designed for a flood flow of 800 m^3/sec (TAY, 2016).
If the total storage volume of Tamassos reservoir be compared to the flood volumes for the 20, 100 and 500 years return periods the following conclusions are drawn (TAY, 2016):

- if the reservoir is empty then the total flood volume of 20 years return period can be stored (for a 48 h storm)
- for the 100 years return period, 64.1 % of the total water volume can be stored (for a 14.4 h storm)
- for the 500 years return period, 37.3 % of the total water volume can be stored (for a 14.4 h storm)

Mangli Lake is a small artificial lake that receives a part of the flood run-off. The total capacity of the lake is about 200.000 m^3.

The rest of the flood protection infrastructure involves bridges and drains along the rivers.

2.2 Greece

2.2.1 Existing situation

In order to mitigate and address the negative effects of floods on human health, the economy, the environment and the cultural heritage, the European Commission has put into force Directive 2007/60 / EC. This Directive provides actions that all Member States are required to implement. These relate to the Preliminary Flood Risk Assessment (PFRA) for each River Basin District, the preparation of flood hazard and flood risk maps and the preparation of Flood Risk Management Plans (FRMPs). The aim of these actions is to identify areas where there are serious potential flood risks, to assess the potential negative consequences and to identify the necessary measures for the prevention, protection and preparedness of the state.

2.2.1.1 Flood hazard maps

The flood hazard maps that have been made from the Ministry of Environment & Energy of Greece present the possibility a flood to take place in a specific area, quantified based on hydraulic and hydrological magnitude (depth, flow velocity, etc.) which correspond to a given probability.

In particular, these maps are associated with floods of low, medium and high probability of overruns and return period (T) of a thousand (1000), one hundred (100) and fifty (50) years respectively. The construction scale of the maps is 1: 25,000.

FHMs are presented below and provide information of the flooded area, maximum depth of water, flow rate, and arrival and residence times of the flood wave at various points of interest.

Further important information of the map concerns the existing technical works (uphills, bridges, drains, embankments, dams, cross sections) and points of interest (health units, sports facilities, cultural heritage sites, industries, landfills, airports etc.)

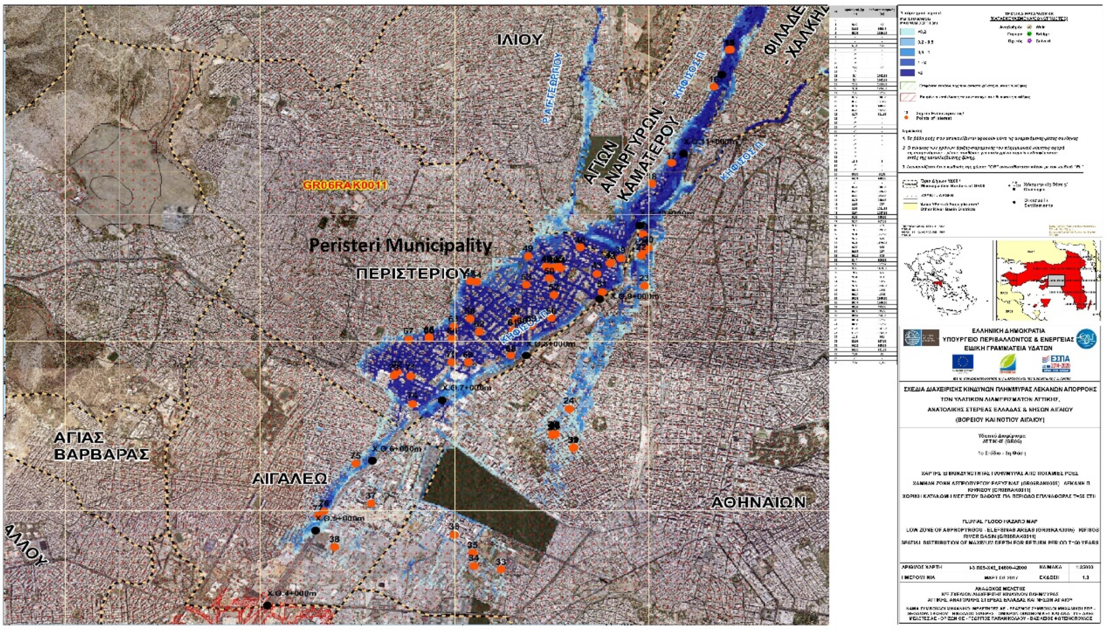

Figure 2-23: Peristeri municipality flood hazard map – Return period of 50 years

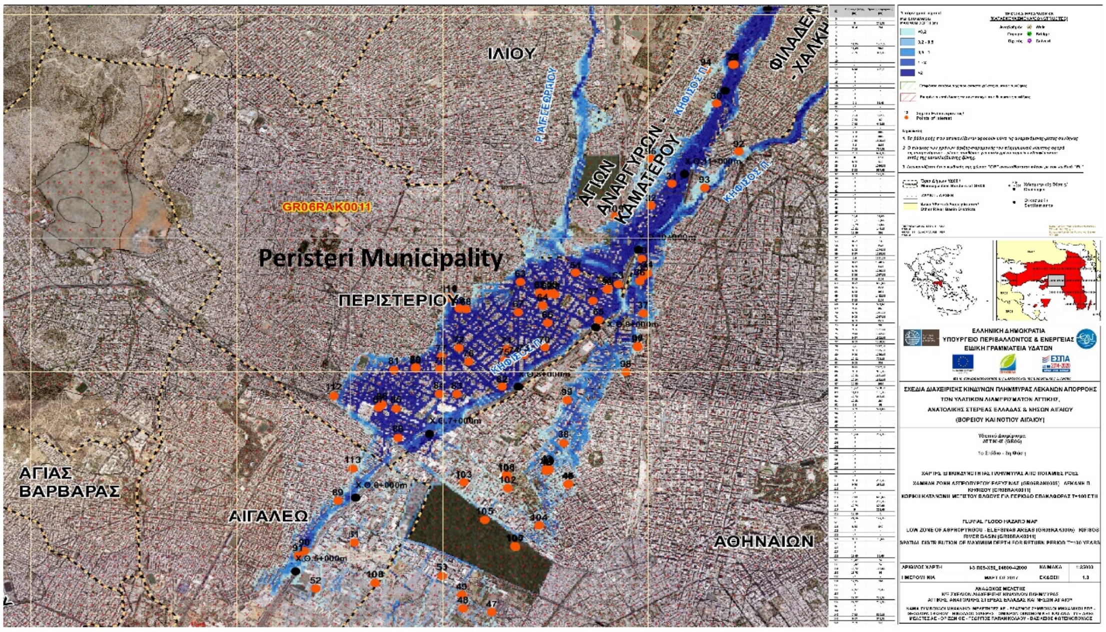

Figure 2-24: Peristeri municipality flood hazard map – Return period of 100 years

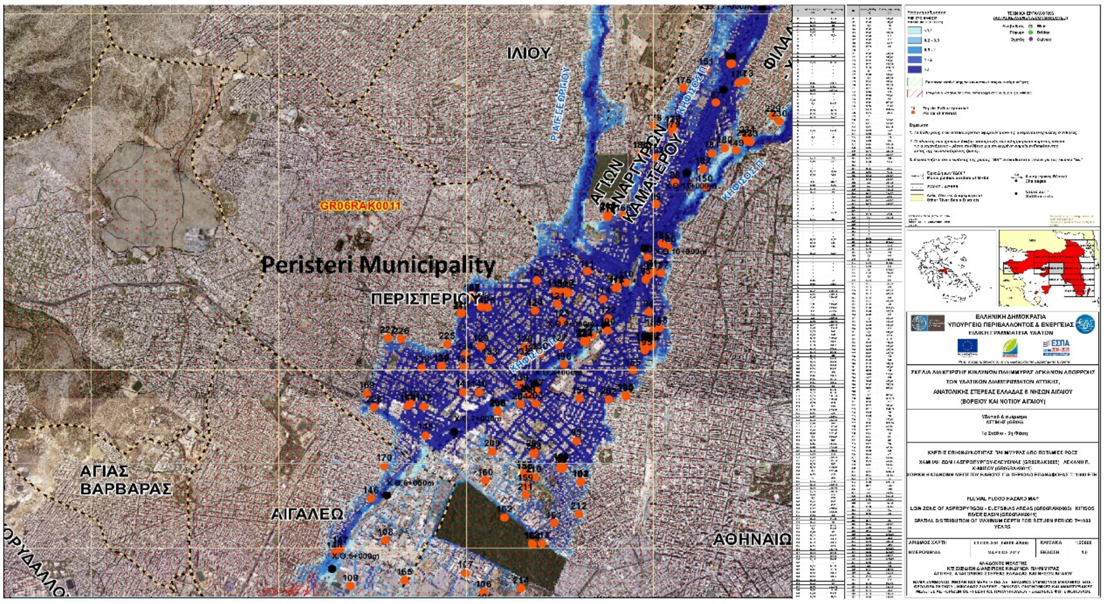

Figure 2-25: Peristeri municipality flood hazard map – Return period of 1000 years

Observing the maps related to the three flood scenarios (T = 50, T = 100, T = 1000) it is concluded that a significant area in the southeastern part of the area of interest (Peristeri Municipality) is heavily affected. It is noteworthy that this area does not change significantly for the three scenarios, which shows that the effects of a high probability of flooding may be similar to those of a low probability. In contrast, these areas show a large variation compared with the coterminous municipalities. According to the map, the area of interest seems that the affected points of interest as 35 while there are no technical works.

The municipality of Peristeri, in comparison with its neighboring municipalities, is heavily affected by high probability of floods. It should be noted that the modeling carried out for the construction of the maps did not take into account flood relief projects (e.g. rainwater drainage network).

2.2.1.2 *Flood risk maps*

Flood hazard maps have been made on the same scale and for the same return time periods as those of flood risk. The information on the maps concerns to three (3) flood scenarios, the indicative number of inhabitants, the type of economic activity and the protected areas that may be affected.

According to the maps referring to the three different return periods, the flood zone corresponding to the area of interest does not change strongly.

The part of the study area which is affected by the floods is characterized entirely as a developed tourist area.

In this area the following points of interest are identified:

- Ten (10) industries, one of which (1) is covered by the IPPC (Integrated Pollution Prevention & Control) Directive,
- Two (2) civil protection areas,
- One (1) health-clinic center,
- Two (2) sports and sports centers,
- More than twenty (> 20) education infrastructure

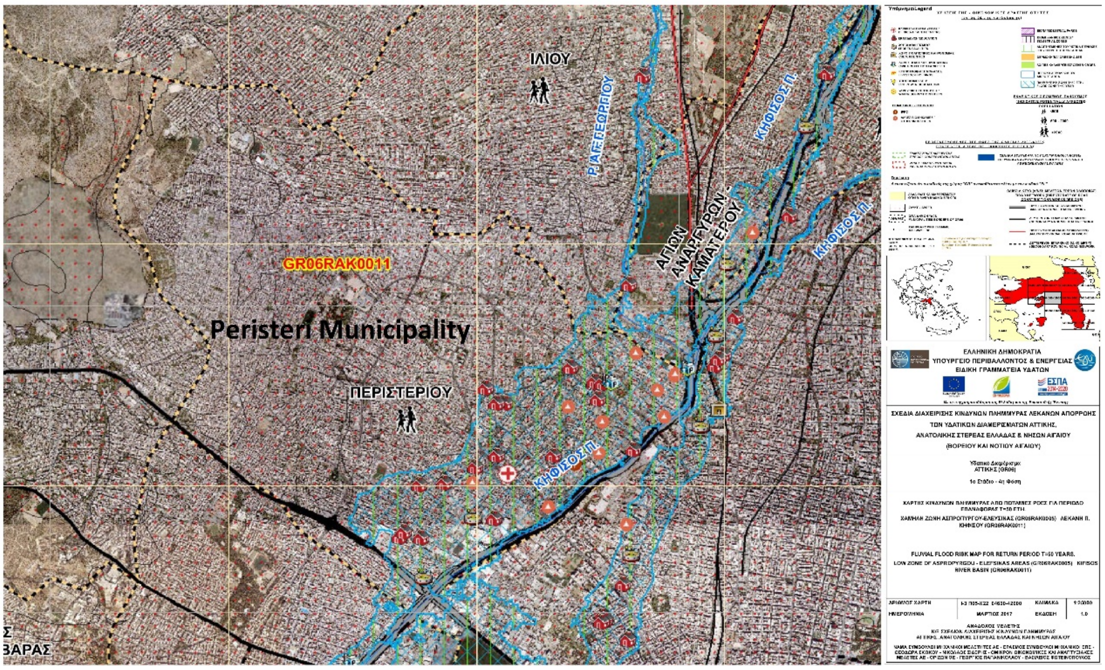

Figure 2-26: Peristeri municipality flood risk map – Return period of 50 years

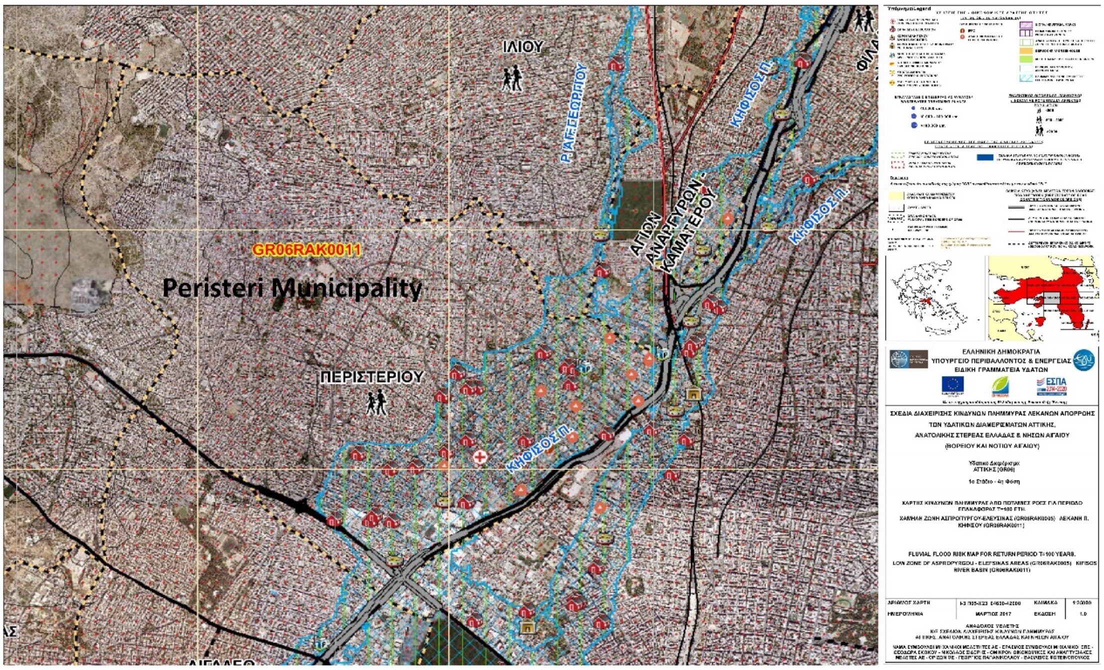

Figure 2-27: Peristeri municipality flood risk map – Return period of 100 years

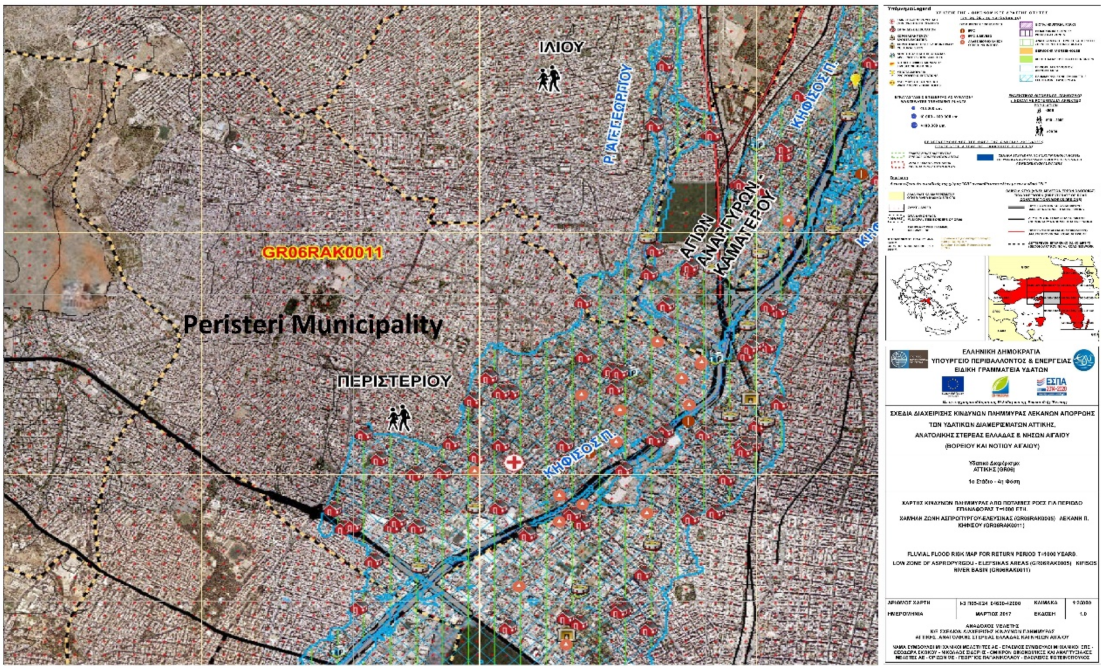

Figure 2-28: Peristeri municipality flood risk map – Return period of 1000 years

In the area of interest there are no energy infrastructures, sewage treatment plants, livestock farms, drinking water boreholes, cultural heritage sites and special protection zones.

The potentially affected population is estimated at more than two thousand (> 2000) inhabitants.

2.2.2 Observed and expected impacts

In regards to floods, the future variability of heavy rainfall and flood occurrence regime were examined in the study of the environmental, economic and social impacts of climate change in Greece (ΤράπεζατηςΕλλάδος, 2011). The analysis included data regarding the projected changes in the probability intensity that is associated to highly probable floods (Cannon et al., 2008; Diakakis, 2011). The main outcomes of the analysis highlighted the wide variety in flooding probability across the Greek regions based on the climate scenario, as well as increase in the average values for all the scenarios for the time periods 2071-2100 and 2090-2099. More specifically, a 2.6 times higher probability of flooding was evaluated under Scenario A2, while a 3 times higher probability was projected under Scenario B2 for the areas of Western Peloponnese,Epirus and Western Macedonia. However, 50% lower was the probability of flooding under Scenario A2 and 90% lower under Scenario B2 for the areas inCentral Greece and Central Macedonia. A remarkable increase of 168% in probability of flooding was evaluated under the Scenario A1B for almost all the country with maximum values in Central Macedonia and Thessaly, while a 35% decrease was recorded for the Southern Peloponnese, Northern Crete and the Dodecanese.

In addition, in order to assess the future variation of flood hazards, 19 hydrological basins were selected based on specific criteria thus ensuring a representative sample of geomorphology of Greece. In this framework, the Sutcliffe (1978) method was used, and the peak flows changes were calculated along with a 5-year return period for the selected basinσ. The projected changes were assigned a sign and magnitude. Using the method proposed by Sutcliffe (1978), the change in peak flows was calculated with a 5-year return periodfor these basins (Figure 64). The main outcomes of the analysis highlighted that the future flood variation and landslide risk present an increasing trend, while a decline is expected to occur in certain areas.

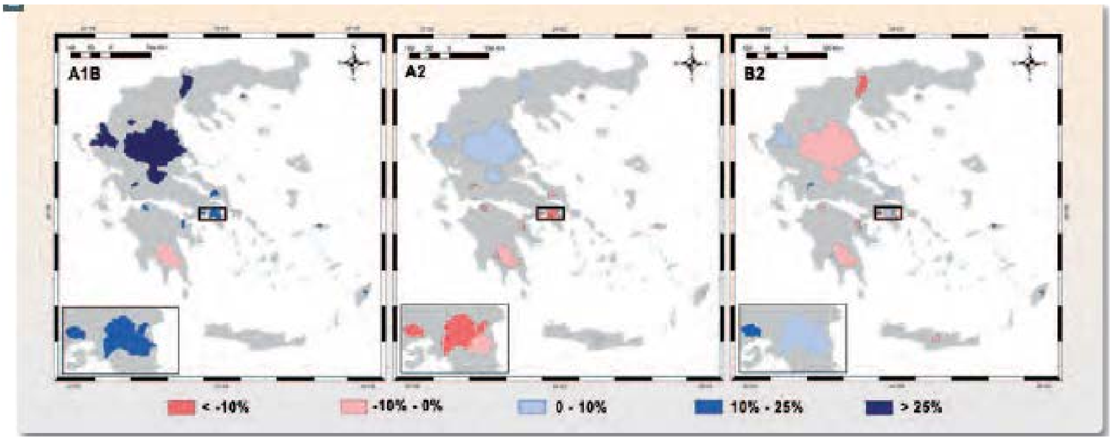

Figure 2-29: Percentage in peak discharge with a 5-year period for the 19 hydrological basins selected

Source: Τράπεζα της Ελλάδος, 2011

2.2.3 Non-climate related pressures

The municipality of Peristeri is an area with high flood risk, especially at its southeastern part.

The causes that are not related to climate change are listed below:

- Urbanization (runoff increasing)
- Poor drainage network or drainage network failures
- Poor land use planning
- Proximity of structures to the hydrographic network (reduction of the rivers cross sections)

All of the causes presented above are due to human activities and they increased the flood risk of the area over time.

2.2.4 Adaptation measures

The flooding events that have taken place at the Municipality of Peristeri have resulted in a series of adaptation measures that can distinguished to flood risk management activities and the construction of flood risk prevention infrastructure. More specifically:

Flood risk management plan

According to the study prepared by the Development Association of Western Athens (ASDA, 2010) actions aiming at the prevention and management of floods arise.

These actions are divided into constructive and non-constructive actions as well as actions taking place inside or outside the urban fabric.

Non-structural actions are categorized into:

- Informative in nature, aimed at informing citizens
- Maintenance of infrastructures and networks to ensure the efficient drainage of the rainwater, especially along the hydrographic network
- Improving operational preparation

Construction actions aimed at increasing surface drainage, intercepting upstream waters and addressing water drainage problems.

Indicatively, the measures that meet the above mentioned actions are:

- Expansion of river beds, with emphasis to the cross-sectional areas
- Cleaning and increasing cross section areas of bridges (especially at Ilion and Kamatero municipalities witch are neighboring to Peristeri municipality)
- Expanding and enhancement of the existing drainage network
- Replacement of impermeable surfaces with permeable ones
- Barriers construction for storm water restrain
- Regular cleaning of drainage network catchment wells and creating new larger ones

The proper planning and implementation of the above actions, located within and outside the area of interest, can drastically reduce the impact of floods on the urban fabric of the Municipality of Peristeri.

Flood prevention infrastructure

Flood prevention infrastructure in Peristeri municipality seems to be incomplete according to the municipality's Operational Program 2015-2019 (2015).

The existing flood prevention infrastructure relates to storm water drainage network (e.g. Anthoupoli, Aspra Chomata, Nea Zoi and Lofos Axiomatikon municipality areas). Furthermore, in many areas of the municipality the drainage network seems to be inefficient and in others is absent.

Due to the flood problems faced by the municipality, a series of actions are envisaged:

• Development and construction of a network of main and secondary rainwater pipelines

• Cleaning and maintenance of catchment wells

• Elaboration of hydraulic studies in order to protect certain areas such as Thibes and Ag. Ierotheos areas that are often flood-related.

Stormwater management

According to Λέκκας(2010), the problems which the municipality of Peristeri and the neighboring municipalities are facing regarding the drainage network are the following (Figure 2-30):

1. Area between the streets of Constantinople, Thebes, Chios and Andreas Papandreou: problems drainage due to low percentages of ground inclination

2. Athens and Sfakion Avenue cross: despite the fact that the drainage network at this area is quite extensive, problems occur due to heavy rainfall

3. Athens and Kavalas Avenue cross: increased flood risk due to the reduction of the cross section of Haidarrodera r.

4. Kyprou Str. and Dionysios Solomos Str. cross: concentration of rainwater after rainfall due to insufficient drainage network

Specific locations where drainage problems have been observed are shown in the figure below (Figure 2-30).

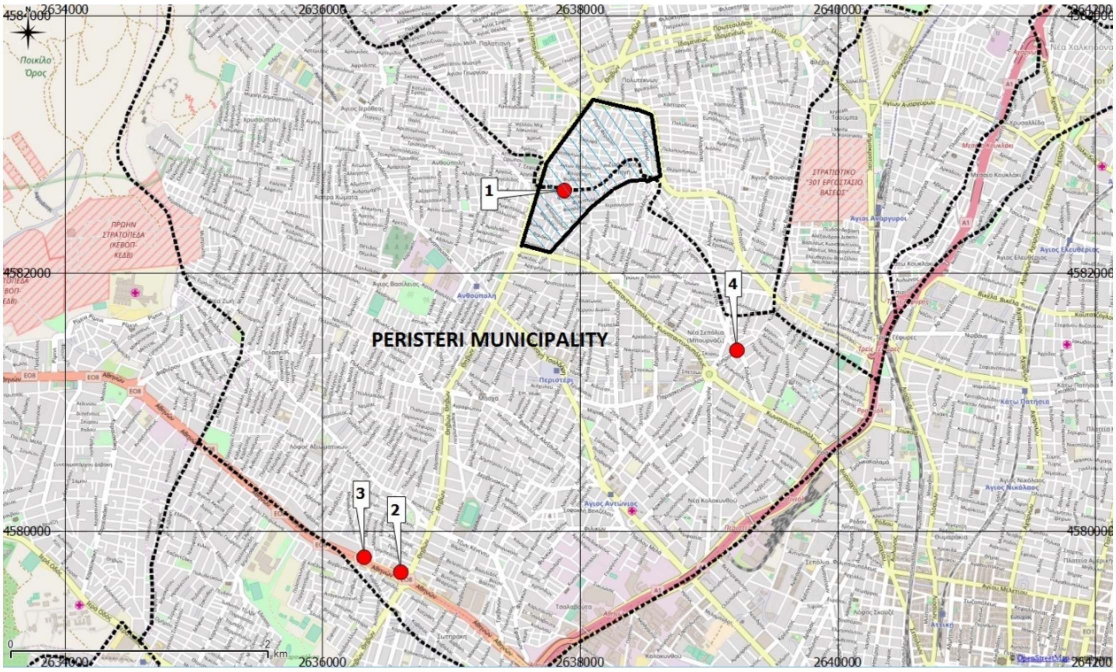

Figure 2-30: Locations where problems at drainage network observed

The general drainage network architecture of Peristeri municipality is presented at the following figure.

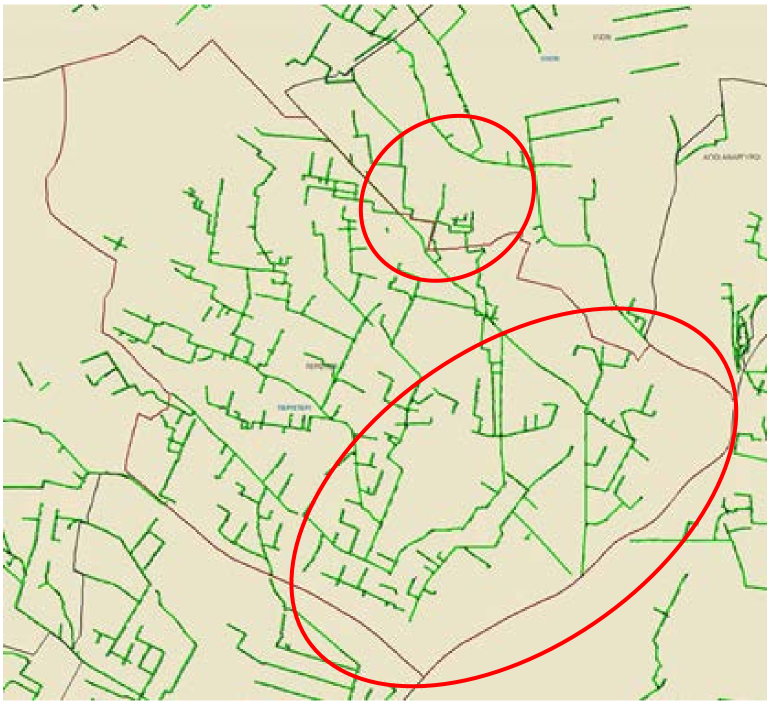

Figure 2-31: Drainage network of Peristeri municipality (the areas where the network is poor are marked)

As can be seen in the figure above, the drainage network density is low in high flood risk areas in which problems had been observed.

However, several measures are also foreseen in the National Adaptation Plan focusing on combating floods due to the increase of certain climate change impacts. More specifically:

Agriculture: Risk management of climate change disasters for agriculture includes adaptation and extension of agricultural insurance for damage caused by extreme weather events that is not currently covered (e.g. high temperatures, drought, floods).

Forestry: Warmer temperatures and drier conditions increase the chances of a fire starting. To this end limiting fires is of utmost importance for protecting forests. In particular, ensuring the burned areas restoration within 10 days after contributes to the decrease of soil erosion and flood potential.

Energy: Power transmission and distribution networks, as well as centers high-voltage infrastructure are particularly vulnerable to extreme weather events and floods. Network protection projects are of utmost importance in order to avoid power outages due to extreme weather effects.

Infrastructure: Changes expected from climate change will affect transport infrastructure and networks, regardless the means of transport. To this end, it is particularly important to examine the necessity of building dams-dykes for protecting the infrastructure at coastal areas from floods.

However, apart from the National Adaptation Plan, a number of relative measures has been included in the Operational Program for the Municipality of Peristeri. More specifically, the aforementioned plan is based on four (4) pillars, namely:

- Environment and Life quality
- Local development and economy
- Social development
- Municipal development

Each one of the pillars includes measures and goals based on the thematic priority of the pillar. In this framework, specific measures and goals in regards to the first and fourth pillar are closely related to the indicators increasing climate change impacts.

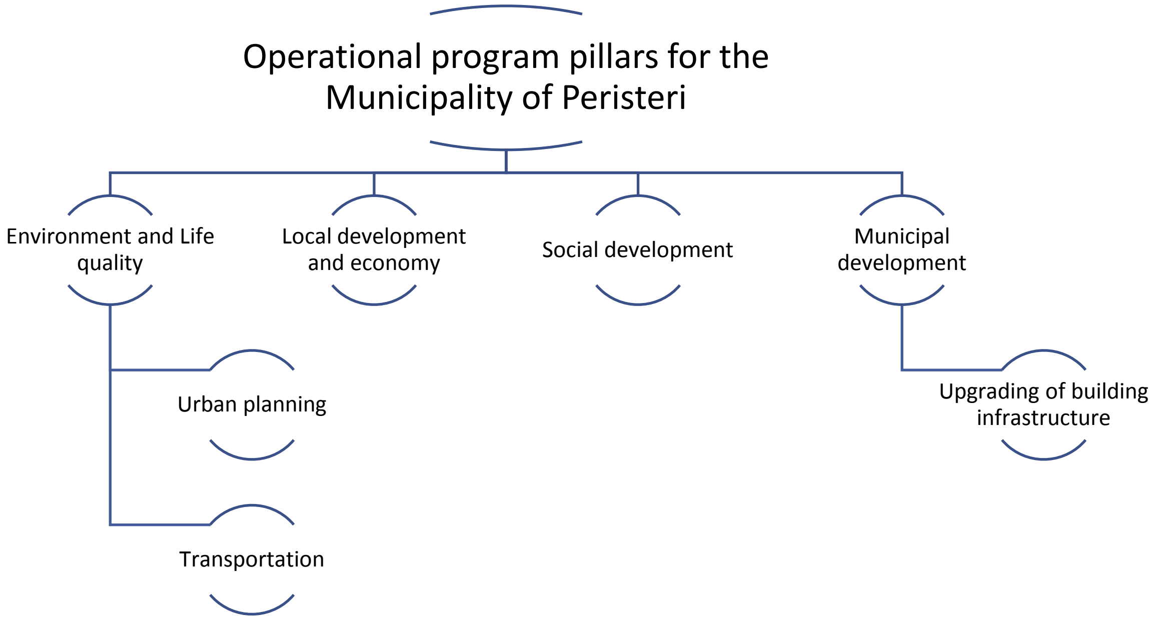

Diagram 2-1: Measures of the Operational Program for the Municipality of Peristeri affecting climate change impacts indirectly

Based on the first pillar of the Operational Program for the Municipality of Peristeri, i.e. Environment and Life quality specific measures may decrease the intensity of the climate change impacts observed at the Municipality of Peristeri. In particular:

Measure 1.2: Urban planning

The operational program of the Municipality of Peristeri has also included specific measures considering urban planning. In particular the measures foreseen are the following:

- Creating conditions for the provision of affordable and safe housing to the public, particularly in areas with increasing residential development.
- Exploitation and aesthetical upgrade of buildings.
- Revision of the General Urban Plan.
- Completion and update of spatial planning, as well as limitation of arbitrary building.
- Upgrading and rehabilitation of the urban environment.
- Land-use planning, particularly in areas with many industrial units.
- Addressing land use problems and conflicts.

A coherent action plan has been designed in order to implement the aforementioned measures. In specific, 12 actions have been described:

1. Creation of a green roof at the municipal shops and reconstruction of refugee apartment blocks of Evangelistria area.
2. Bioclimatic regeneration of the refugee apartment building at Evangelistria area.
3. Greening of Agios Antonios area.

4. Aesthetical and functional upgrading of the municipal areas of the Municipality of Peristeri.
5. Restoration of the traffic island of Cyprus Highway from Ethnarchos Makarios Street to 28th October Street.
6. Conduction of study in order to investigate the potential for funding the aesthetical and functional upgrade of the Municipality of Peristeri.
7. GIS data validation in order to revise the existing General Urban Plan.
8. Compilation of topographic diagrams in Eleonas area for constructing Thessaly road.
9. Compilation of studies, Topographic and Cadastral Plans fordesigning new activities.
10. Compilation of studies, Topographic and Cadastral Plans forensuring common spaces.
11. Pending settlements of municipal property for the land registry.
12. Aesthetical upgrade in selected areas of the Municipality Peristeri.

Measure 1.3: Transportation

In regards to transportation, a cluster of measures is available:

- Effective traffic planning.
- Road network maintenance.
- Promoting free access to sidewalks.
- Strengthening public transport.
- Measures to reduce the use of vehicles.
- Tackling congestion, reducing airborne pollutants and noise levels associated with the car.
- Addressing the problem of parking by means of parking and transit services.
- Promotion of alternative interventions (promotion of bicycle paths, footpaths etc.).
- Interconnection of sites (e.g. green routes).
- Accessibility to the major hyper-local networks (METRO).

Specific actions have been described for the implementation of the measures regarding the rehabilitation of transports that may contribute to the decrease of climate change impacts, such as:

1. Reconstruction of asphalt carpets at specific areas of the Municipality (areas 13, 14, 1st & 4th Municipal Community, 2nd & 3rd Municipal Community)
2. Special construction interventions on roads with high altitude differences.
3. Aesthetic and functional upgrading of pavements.
4. Upgrading the municipal transport of Peristeri Municipality.
5. Creation of a road link between Municipalities of Western Attica and Attiki Hospital, as well as construction of a recreation and sports park.
6. Construction of underground parking spaces.
7. Development of a Traffic Study at the boundaries of the Municipality of Peristeri Municipality.

8. Mapping parking features for the installation of controlled parking system in town.
9. Conduction of a master plan for the development of parking facilities.
10. Traffic settings on high traffic junctions.
11. Completion of Alkimos Street construction.
12. Reformation of St. Polycarpou pedestrian street.
13. Rehabilitation of Am. Veakis street.
14. Road markings.

Based on the fourth pillar of the Operational Program for the Municipality of Peristeri, i.e. Municipal development, measures regarding the upgrading of the existing building infrastructure are of particular added value for combating climate change impacts in urban environments. In particular, the Operational Program of the Municipality of Peristeri focuses on the extension, maintenance and repair of the existing municipal buildings, as well as on the upgrade of their technical equipment. Specific actions are foreseen for the implementation of the aforementioned measures, namely:

1. Upgrading of Municipal Spaces and Installations to improve the level of service provision and work environment.
2. Creation of a safe and functional environment for staff.
3. Drilling maintenance.
4. Building reorganization of the Xylotechniki building complex.

2.3 Italy

2.3.1 Existing situation

River discharge is the most visible hydrological response of the territory to climate. Floods are the extreme manifestation of river discharge and they are defined as an increase in the river level (or in the discharge) and they can result in the presence of water over regions that usually are dry (flooded areas). Floods are usually due to (i) snow-melting (ii) heavy (intense) or (iii) prolonged precipitation. Floods driven by snow-melting are a seasonal phenomenon that can be monitored and results in an increase in water level within the river but usually does not cause damages because is a slow phenomenon. Floods driven by precipitation are a more casual phenomenon that occurs when the precipitation rate exceeds the soil infiltration capability and the water in excess reaches in a relative short time the river channel causing an increase in the river level. The soil infiltration capability is a function of soil type, land cover, land use and soil moisture antecedent condition. Changes in land cover and use contribute in increasing the risk of city flooding. Within this Research Paper, we will focus on the impact of land cover change in the annual maximum peak flood probability distribution. We addressed the problem by deriving the peak flood distribution from the one of precipitation through a lumped model. The methodology applied, uses as inputs the depth-duration curve of annual maximum precipitation and the curve number (function of the land cover) parameters and provides as output the peak flood probability distribution.

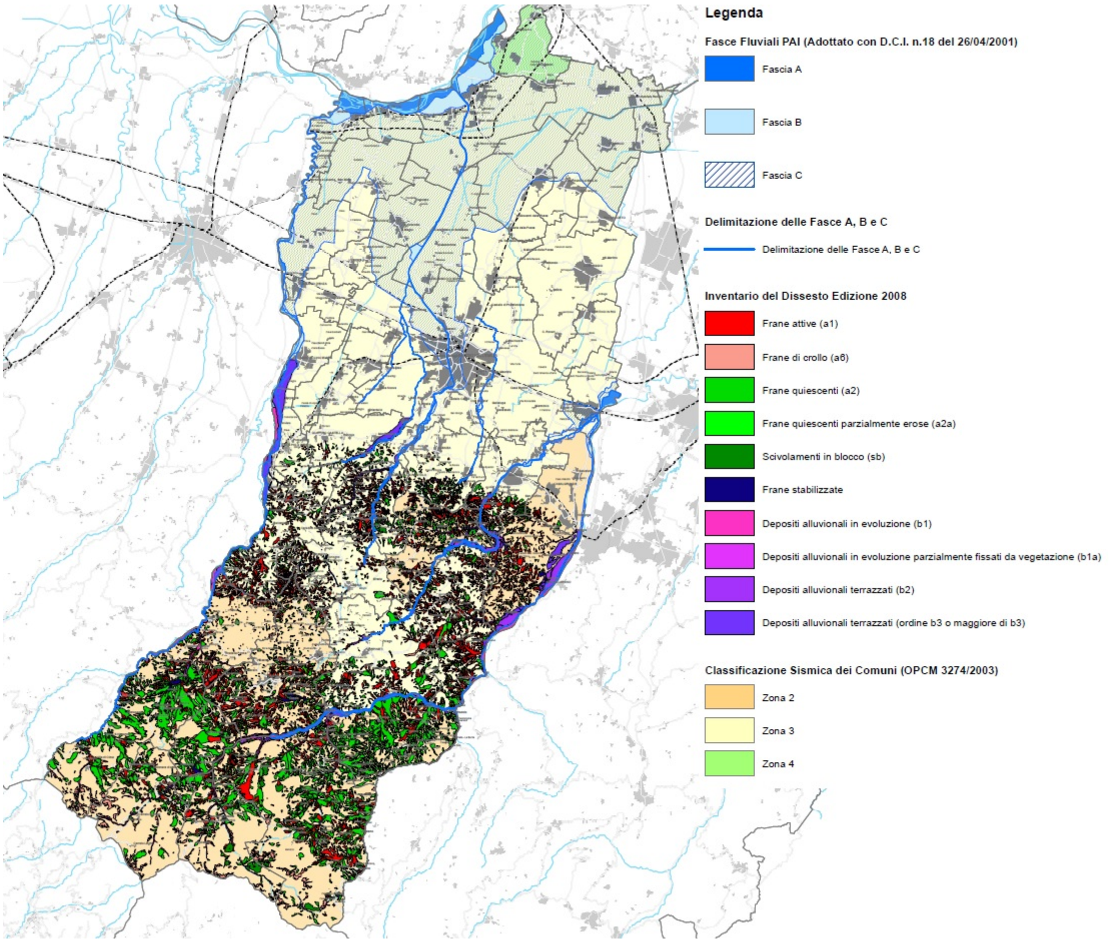

Figure 32: Map of hydraulic, geological and seismic map

2.3.2 Adaptation measures

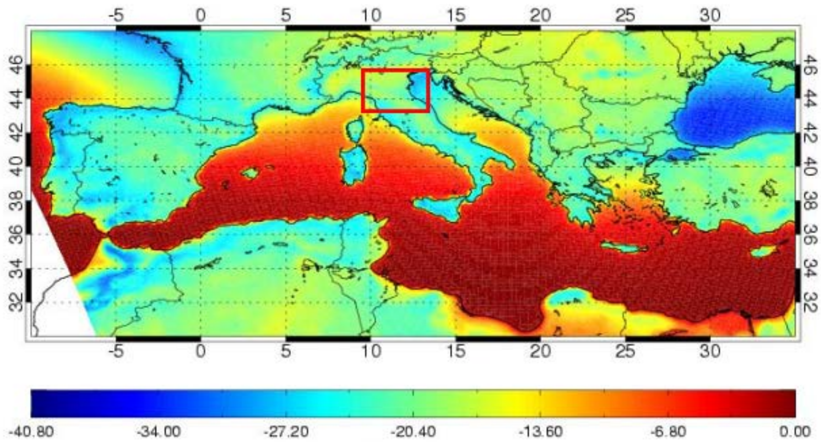

Figure 2-33: National of regional adaptation plan – operational program

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3 HEATWAVES AND HEALTH

Heat or hot weather that lasts for several days, often referred to as "a heat wave", can have a significant impact on society, including a rise in mortality and morbidity (WMO and WHO, 2015; EEA, 2017). Heat waves have caused far more fatalities in Europe in recent decades than any other extreme weather event. The effects of exposure can be directly related to heat (heat stroke, heat fatigue and dehydration, or heat stress) or can be the result of a worsening of respiratory and cardiovascular diseases, electrolyte disorders and kidney problems (Aström et al., 2013; Analitis et al., 2014; Breitner et al., 2014). Heat-related problems are greatest in cities; among many interrelated factors, the urban heat island effect plays an important role.

During hot weather, synergistic effects between high temperature and air pollution (particulate matter with a diameter ≤10 micrometres (PM 10) and ozone) were observed (Katsouyanni and Analitis, 2009; Burkart et al., 2013; De Sario et al., 2013). Long warm and dry periods, in combination with other factors, can also lead to forest fires, which have been shown to have severe health impacts (Analitis et al., 2012). Future climate change is very likely to increase the frequency, intensity and duration of heat waves.

As well as extreme temperature events, 'non-extreme' temperatures outside a local comfort temperature range are also linked to increased mortality and other adverse health outcomes. The effects of heat occur mostly on the same day and in the following three days (WHO, 2011; Ye et al., 2011). A multi-country global observational study found that moderate temperatures, rather than extreme temperatures, represented most of the total health burden (Gasparrini et al., 2015).

In large parts of Europe, summertime temperature records, which are associated with prolonged heat waves, have increased substantially in recent decades Figure 3-1. The summer of 2003 broke temperature records in large parts of western Europe; temperature records were again broken in different parts of Europe during the summers of 2006, 2007, 2010, 2013, 2014 and 2015 (Barriopedro et al., 2011; Coumou et al., 2013). The record warm summer of 2003 was an outstanding example of increased mortality during periods of extreme temperatures, with an estimated premature mortality of 70 000 people in Europe (Robine et al., 2008). The heat waves of the summer of 2015 caused more than 3 000 deaths in France alone (CRED, 2016).

The largest effect of heat has been observed among the elderly, but in some cities younger adults have also been affected (D'Ippoliti et al., 2010; Baccini et al., 2011). Elderly people are more vulnerable to the effects of heat waves, owing, in part, to poorer physical health and the effects of cognitive impairment on the perception of heat-related health risk; this is the population considered most at risk of heat-related mortality (Josseran et al., 2009). In addition to the elderly, those with chronic diseases and persons of lower socio-economic status also have a heightened risk of heat-related mortality (Wolf et al., 2015). Furthermore, health risks during heat extremes are greater in people who are physically very active. This has importance for outdoor recreational activities, and it is especially relevant for the impacts of climate change on occupational health (e.g. for manual labourers) (Lucas et al., 2014).

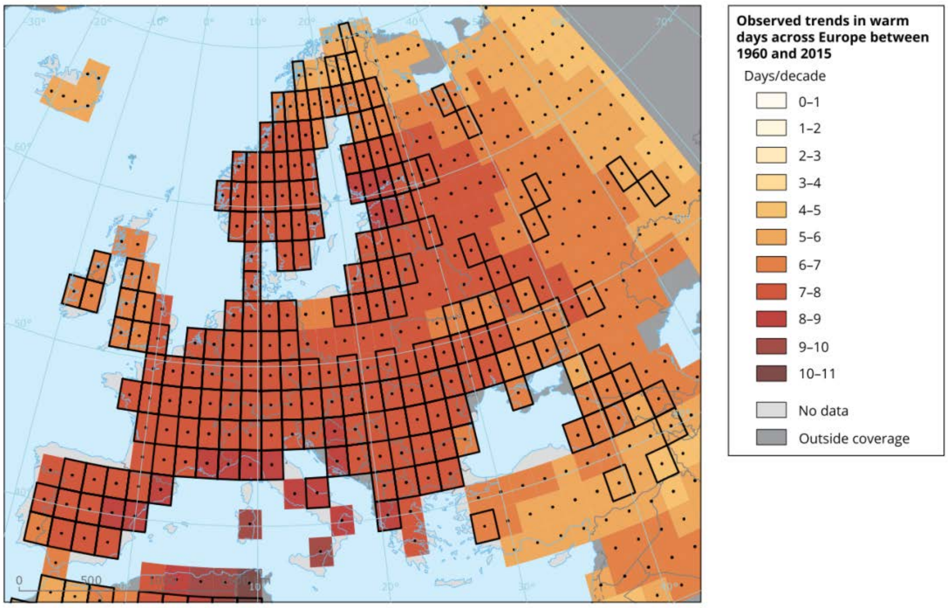

Figure 3-1: Observed trends in warm days across Europe between 1960 and 2015 (EEA, 2017).

According to the EEA report (2017) it is virtually certain that heat extremes will continue to become more frequent over most land areas in the future (Figure 3-2). The number of monthly heat records globally is projected to be more than 12 times as high under a medium global warming scenario by the 2040s as in a climate with no long-term warming (Coumou et al., 2013). The projected return period of extreme heat events, such as those experienced in 2003 in western Europe, will significantly shorten. This increase in heat extremes will lead to a marked increase in heat-attributable deaths under future warming, unless adaptation measures are taken. Highly urbanised areas are projected to be at an increased risk of heat stress compared with surrounding areas. Projections of future heat effects on human health need to consider that the European population is projected to age (EEA, 2017), because elderly populations are especially vulnerable (Lung et al., 2013; Watts et al., 2015).

Finally, several studies have estimated future heat-related mortality in Europe using similar methods and have arrived at largely comparable results, namely PESETA, ClimateCost and PESETA II (Ciscar et al., 2011; Kovats et al., 2011; Watkiss and Hunt, 2012; Paci, 2014).

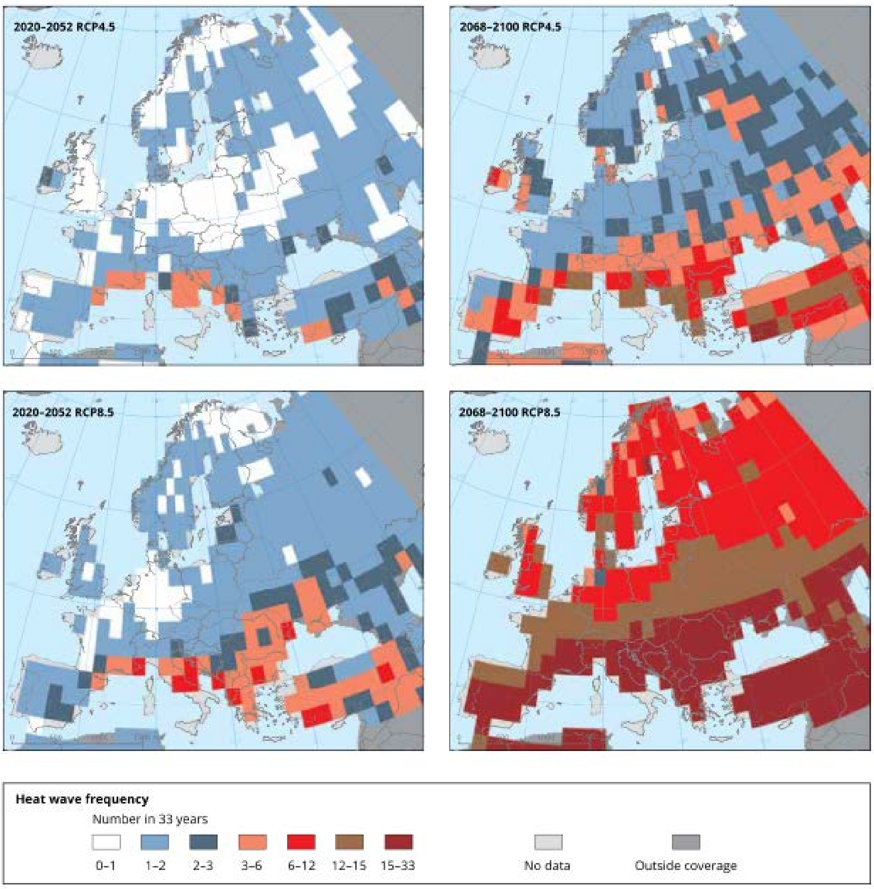

Figure 3-2: Number of very extreme heat waves in future climates under two different emissions scenarios (EEA, 2017)

3.1 Cyprus

3.1.1 Existing situation

Health status and demographics

Cyprus is the third largest island in the eastern part of the Mediterranean. The population in the government-controlled area of Cyprus was estimated at the end of 2015 at 848.300 compared to 847.000 at the end of 2014 recording an increase of 0,2% (CYSTAT, 2016).

The proportion of children below 15 was estimated at 16,4% while the proportion of old-aged persons 65+ was estimated 15,1% in 2015. Figure 3-3 illustrates the increasing trend of high aging population (most vulnerable to climate change warming) as well as the decreasing trend of young population for the period 1992-2015 in Cyprus (CYSTAT, 2016).

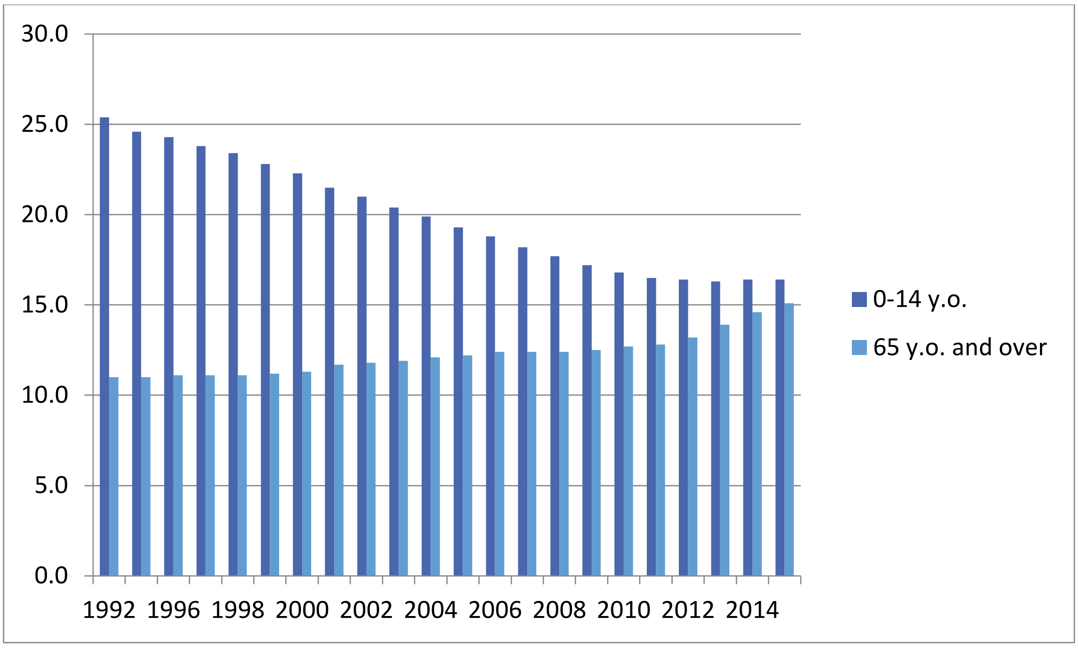

Figure 3-3: Proportion of children below 15 and old-aged persons 65 and over for the period 1992-2015 in Cyprus (CYSTAT, 2016)

In 2015 the number of births in the Government controlled area decreased to 9170 from 9258 in 2014 giving a crude birth rate of 10,9 per thousand population. The total fertility rate remains fairly low during the past few years. However, the total fertility rate for 2015 increased to 1,32 from 1,31 in 2014.

According to data from the EU Statistics on Income and Living Conditions (Eurostat, 2017a) for the period 2010-2015, 26,7% of Cyprus population was at risk of poverty or social exclusion on average, a little higher than the respective percentage in the EU28 (24,3%). In addition, the average poverty risk for the elderly age class (55 and over) during the same period was quite higher (29,7%) compared to the average EU citizen in the same demographic group (21,8%) (Table 3-1). However, the percentage of poverty risk for the elderly age class (55 and over) has declined about 27% in 2015 compared to 2010. Additionally, the average poverty risk for the young population (less than 16 years) was 25,4% in Cyprus for the same period lower than the average in the EU28 (27,2%). But, the percentage of poverty risk for young population has increased about 36% in 2015 compared to 2010 in Cyprus.

Table 3-1: At risk of poverty or social exclusion in Cyprus and EU28 by age group (%) for the period 2010-2015 (Eurostat, 2017a)

Age groups	Region	2010	2011	2012	2013	2014	2015	Average 2010-2015
Less than 16 years	EU28	27,1	26,9	27,7	27,4	27,4	26,7	**27,2**
	Cyprus	21,5	23,1	26,8	27,1	24,6	29,2	**25,4**

From 16 to 24 years	EU28	29,4	29,7	31,3	31,6	31,6	30,9	**30,8**
	Cyprus	24,2	24,9	30,0	32,6	32,1	34,5	**29,7**
From 25 to 54 years	EU28	22,0	22,9	23,8	23,8	24,1	23,3	**23,3**
	Cyprus	20,3	20,6	24,8	27,2	26,7	28,9	**24,8**
55 years or over	EU28	22,2	22,7	22,2	21,7	21,0	20,7	**21,8**
	Cyprus	35,2	33,0	30,0	26,7	28,0	25,5	**29,7**
Total	EU28	23,7	24,3	24,7	24,6	24,4	23,8	**24,3**
	Cyprus	24,6	24,6	27,1	27,8	27,4	28,9	**26,7**

The standard of health in Cyprus is considered to be very high and compares favorably with that of developed countries, as it is shown by the various health indicators, such as the infant mortality rate which reached a very low level about 2,7 infant deaths per 1.000 live births in 2015, the expectation of life at birth estimated 79,8 years for males and 83,5 for females in the same year, as well as the number of persons per doctor which estimated 277 in 2015 (CYSTAT, 2016).

In 2015, hospital beds totaled 2.895. Of them, 1.534 were operating in the public sector and 1.361 in the private sector. The number of persons per hospital bed was estimated at 291 in 2015 while the number of hospital beds per nurse was 0,7.

The neoplasms have the highest share, 12,9% of the total patients discharged from general hospitals followed by diseases of the injury, poisoning and certain other consequences of external causes with 10%, the diseases of the circulatory system 9,5%, digestive system 8,5% and the diseases of the respiratory system 8,4%. All other disease categories including "not stated" account for the remaining 50,7% (CYSTAT, 2016). Diseases of the respiratory system are reported to be associated with climate changes also, due to increased concentrations of particulate matter (PM) and ozon in the atmosphere.

The five leading causes of death for the period 2004-2009 in Cyprus were diseases of the circulatory system, neoplasms, endocrine, nutritional and metabolic diseases, diseases of the respiratory system and external causes of injury and poisoning (Ministry of Health, 2011). Figure 3-4 illustrates the main causes of death in Cyprus for the period 2004-2009. Additionally, in 2014 the death rate regarding circulatory diseases was 351,8 per 100.000 inhabitants while the respective death rate for neoplasms was 201 per 100.000 inhabitants. Death rate of respiratory diseases was 86,2 per 100.000 inhabitants (Eurostat, 2017b).

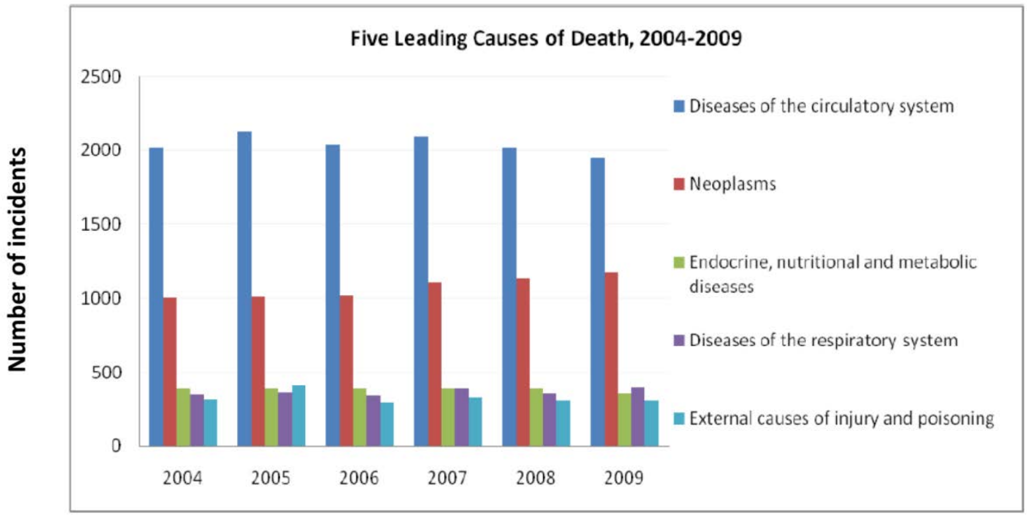

Figure 3-4: Five leading causes of death in Cyprus (Ministry of Health, 2011)

The two Cypriot municipalities under study, the Municipality of Lakatamia and the Municipality of Strovolos constitute two out of ten municipalities in total of the Nicosia District. Based on the 2011 census, the population of the Lakatamia municipality was 38,345 and the population of Strovolos municipality was 67,904. The entire population of the Nicosia District was 326,980 inhabitants. 73% of the Nicosia District's population lives in urban areas (CYSTAT, 2014). Figure 3-5 illustrates the increasing trend of population of Nicosia District as well as the quite similar trend of the urban population. It is obvious that the increase in population of Nicosia reflects the respective increase in population of urban areas.

Regarding the proportion of children below 15 in Nicosia, it was estimated at 15,4% while the proportion of old-aged persons 65+ was estimated 13,1% (CYSTAT, 2014). Figure 3-6 shows the total population by age in Nicosia according to the census of 2011.

As far as the educational level of Nicosia's population in urban areas is concerned, only the 0.5% of the population has never attended school and 2% did not finish the Primary school. The study of the educational level is important as it is a factor of vulnerability according to the Intergovernmental Commission (IPCC) along with income health status etc. (Smith et al., 2014).

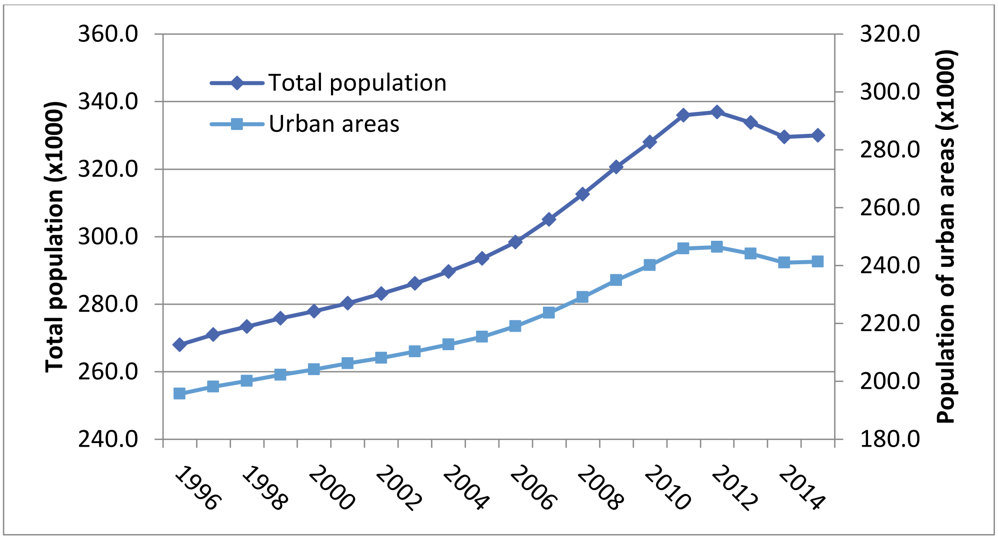

Figure 3-5: Trend of total population as well as population of urban areas in Nicosia district for the period 1996-2015

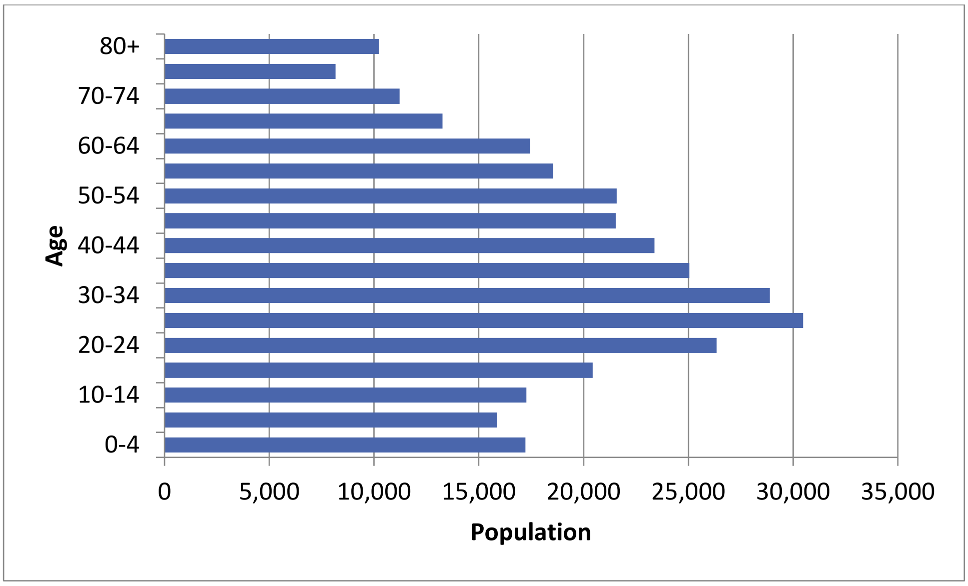

Figure 3-6: Population by age in Nicosia District (Census of 2011) (CYSTAT, 2014)

3.1.2 Observed and expected impacts

During the 2003 European heat wave, the highest temperature was recorded in Cyprus. In the capital, Nicosia, temperatures unofficially exceeded 57 °C while temperatures usually reach 45°C during the summer period. Many people reported such temperatures on their thermometers in their houses. The official record was 52.1 °C in urban Nicosia. As a result of deaths and high temperatures, the government had to recommend a 3 day curfew between 11am and 5pm (Absolute Astronomy, 2003).

According to the National Adaptation Plan (NAP) of Cyprus, which was developed within the framework of the EU project CYPADAPT (LIFE10ENV/CY/000723) (CYPADAPT, 2014a), the vulnerability of public health to climate change is mainly related to the deaths and health problems associated to the frequent heat waves and high temperatures especially during summer which in combination of high levels of humidity resulting in great human discomfort (see also section 3.4: "Humidex-All municipalities").

Figure 3-7 Illustrates a time series plot of the all-cause daily mortality for Cyprus, for the period from 2004-2011, together with the 30-days running mean (light blue line), and the daily maximum air temperature for Nicosia. It is shown a clear seasonal variation of mortality: higher in winter and in summer, lower during transient seasons. This is most noticeable in the smoothed 30-days running mean line. It is also apparent that there have been considerable heat or cold related deaths in Cyprus (CYADAPT 2014b).

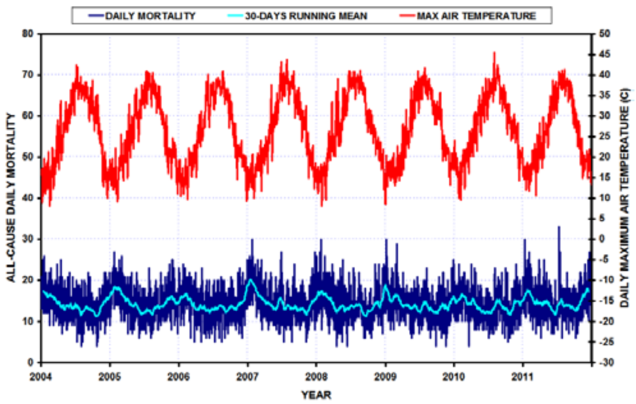

Figure 3-7: All-cause daily mortality data for Cyprus (blue line, left-hand axis) and daily maximum air temperature (red line, right-hand axis) for the period 2004-2011. The light blue line represents the smoothed 30-day running mean

Within the framework of the same project, "excess deaths" were calculated in Cyprus due to high temperatures, i.e. deaths above the expected for a specific period and population (Figure 3-8). A fairly linear increase of mortality with increasing temperature and thus high sensitivity is observed – with hotter days associated with greater morality risk. Heat-related deaths started to be discernible when the maximum temperature was 38 °C or above (CYPADAPT 2014b).

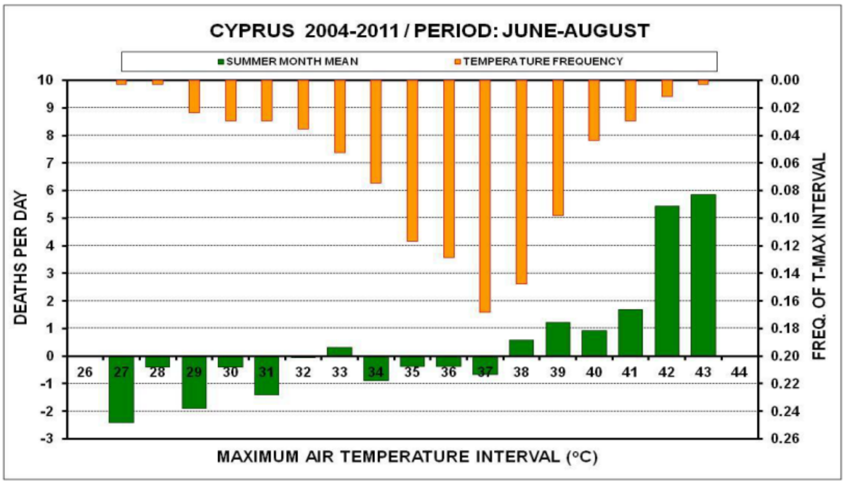

Figure 3-8: Daily excess summer deaths (green bars, left-hand axis) in Cyprus by maximum air temperature interval for the years 2004-2011. The frequency of occurrence of each temperature interval (right-hand axis) is shown using orange bars

In Cyprus, a relationship between high temperatures and cardiovascular mortality was observed for cerebrovascular diseases, ischaemic and other heart diseases, with the highest risk associated with ischaemic heart diseases (Lubczynska et al. 2015). The relationship is strongest on the actual day of the event and the relative risk remains significantly elevated for approximately one day following the event. The increase in risk is most evident on days with the highest temperatures. The highest relative risks are observed for the daily mean temperature time series, which suggests that consecutive high day- and night-time temperatures are the most hazardous. The identification of this relationship in Cyprus raises concerns especially in light of the climate projections indicating a large increase in hot weather extremes in the region. The findings of this study will be used in a follow-up study with the goal of establishing and testing a function representing the past temperature-mortality relationship and future projections for the entire EMME region, under the hypothesis that such a function established for Cyprus will be more representative of the EMME region than the functions used for other parts of the world.

Tsangari et al. (2016) examined and quantified the effect of high temperatures on all-cause mortality and investigated the role of air pollution as a potential confounder of this association in Cyprus. In summary, the results shown that high temperatures during the warm months of the year in Cyprus can result in increased mortality rates, particularly on the day of exposure and on the following day, independent of relative humidity, secular trends or seasonality. Particulate air pollution (PM 10) did not appear to have a significant confounding effect on the temperature–mortality relationship. The significance of the effect of temperature on mortality remained after the inclusion of air pollution in the model.

3.1.3 Non-climate related pressures

A non-climate related pressure on health sector that increases its overall vulnerability due to climate change is certainly the high proportion of older people who are also more sensitive to extreme events mainly to heatwaves. As already mentioned in the section "Existing Situation", the proportion of elderly population was estimated about 15% while variation of old-age population from 1992 to 2015 showing an positive trend (Figure 3-3). Actually, elderly people are about the 15% of the population in 2015 compared to the 10% in 1992.

3.1.4 Adaptation measures

The public health response of Cyprus in heat waves is based at forecasting heat waves, issuing warnings and providing advices for self protection from heat waves, through the mass media (television, radio, newspapers, public web sites). In addition, during severe heat waves in Cyprus (as in summer 2003), the government in order to protect its citizens from adverse health effects, recommends a curfew between the high risk hours of the day. Furthermore, working regulations prohibit outdoor labour work when temperature exceeds 40 °C. However, people frequently ignore curfews out of negligence, with all the adverse effects that may follow.

The majority of houses and indoor public areas as well as private trade facilities in Cyprus, are fully air-conditioned. Furthermore, there are communal centers fully air-conditioned to accommodate people with no access to an air-conditioned environment during days of elevated temperatures. However, the protection of the population from heat waves is not always possible. In addition, bioclimatic architecture is another technological intervention that alleviates the indoor living discomfort level of the population due to high temperatures but it is at an early stage of implementation in Cyprus.

According to the National Strategy for adaptation to climate change of Cyprus (CYPADAPT 2014a,b) the ability of its health care system to respond to heat related incidents is considered sufficient. However, it is the rapid nature of some heat-related health effects such as heat strokes that people do not make it to the hospital.

Furthermore through the National Adaptation Plan of Cyprus the following high rated measures were proposed, in decreasing order of priority, for the adaptation of public health to the increased temperatures and heatwaves (CYPADAPT 2014a):

Measure 1: Providing advices for self-protection from heat waves, through the mass media

Measure 2: Creation and maintenance of urban parks and the implementation of other green practices to reduce the urban heat island effects

Measure 3: Preparation of an emergency plan in order to determine the responsibilities of the various health centers, social care services and municipal health centers

Measure 4: Reinforcement and preparation of medical / nursing staff in response to climate-related emergencies. The aim of this measure is to inform, raise awareness and educate medical and public service staff on the impact of climate change on health

Measure 5: Development of contingency plans in health and social care systems to cope with increasing numbers of patients

Measure 6: Development and implementation of an information system on climate change related diseases. The aim of this measure is to inform and raise public awareness of the impact of climate change on health and its education to address and protect against these impacts

Measure 7: Recommendation of a curfew between the high risk hours of the day. Prohibition on outdoor work when weather conditions exceed predetermined limits

Measure 8: Establishment and strengthening of early warning systems

Measure 9: Operation of fully air-conditioned communal centers in each municipality (eg town halls, schools, Centers for the Protection of the Elderly) to provide protection to the population at risk

3.2 Greece

3.2.1 Existing situation

Peristeri is a modern urban center of the Western Sector of Attica. It is characterized by dense construction and multiracial, as in recent years, a significant number of immigrants from Asian countries have settled, mainly in the eastern districts of the municipality

Based on 2011 census, the permanent population of the Municipality of Peristeri amounts to 139.981 people, ie 6% of the population of the Attica Region. Based on population criteria, it is second in the Attica Region, after the Municipality of Athens. It has a total area of 10,050 km^2 and is considered a relatively densely populated city since the average density is 13,723.18 inhabitants / km^2. This is significantly higher than the corresponding national average (83.1 inhabitants / km^2), but it is roughly coinciding with the average of the Attica Region (13.787,98 inhabitants / km^2).

The Municipality of Peristeri has a marginal population growth over the past 30 years. According to the last census of ELSTAST (2011), it showed a small change compared to the corresponding census of 2001. An important element of the population of the Municipality is the tendency to increase the average age of the inhabitants (40,7 years). The following table (Table 3-2) presents the aggregated results of the demographic composition of Peristeri municipality (Census 2011 of ELSTAT). The Table 3-2 also shows that the "legitimate" population of Peristeri accounts for 85% of the population, while the remaining 15% referring to the population of migrants residing in the city, mainly from Asian and African countries.

Table 3-2: Aggregated results of the demographic composition of Peristeri municipality (ELSTAT, 2011)

Population		Age classes (Average age 40,7 years)	
Permanent	139.981	0-9	13.291
Legitimate	118.893 (85%)	10-19	13.512

Housings	68.290	20-29	18.773
Citizenship		30-39	23.226
Greek	129.662 (92,6%)	40-49	22.765
		50-59	18.133
Other	10.319 (7,4%)	60-69	12.909
		70+	17.372

A comparative analysis of demographic data from 1991 to 2011 shows a gradual aging of the population, by increasing the proportion of average age classes. Also, as a result of the above, the average age of the population as a whole for the Municipality also increases (Figure 3-9).

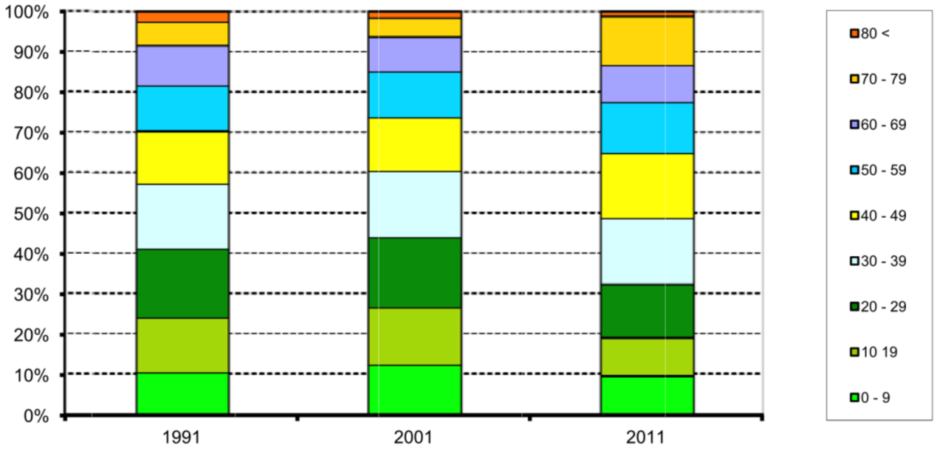

Figure 3-9: Proportion of average age classes for 1991, 2001 and 2011 in Peristeri Municipality

Regarding the educational level of the inhabitants of the Municipality of Peristeri, 11% of the population has a low educational level (ELSTAT, 2011).

Finally, a reference is made to the public health infrastructure in the wider area of the Municipality of Peristeri, in the Attica region, since one patient has the ability to move throughout the Region of Attica in case of hospitalization. The Table 3-3 presents the number of legal clinics for the area of Attica Region for 2015 (ELSTAT, 2017)

Table 3-3: Hospitals by legal type and form of ownership in Region of Attica for 2015 (ELSTAT, 2017)

Περιφέρεια	Total		Legal Entities of Public Law		Legal Entities of Private Law		Private clinics	
	Number of hospitals and clinics	Number of inpatient beds	Number of hospitals	Number of inpatient beds	Number of hospitals	Number of inpatient beds	Number of clinics	Number of inpatient beds
General	58	13.461	21	8.395	1	76	36	4.990

Specialized	39	6.030	14	3.451	2	154	23	2.425
TOTAL	**97**	**19.491**	**35**	**11.846**	**3**	**230**	**59**	**7.415**

3.2.2 Observed and expected impacts

The heat island phenomenon in Athens is well documented (Livada et al., 2007; Mihalakakou et al. 2004); it is characterized by much higher ambient temperatures in the center of the city and the densely populated areas, such as municipality of Peristeri, compared to the surrounding suburban and rural areas. As far as thermal comfort is concerned several studies, which evaluated different bioclimatic indices, concluded that thermal discomfort levels are quite high in Athens during summer period mainly because of the high ambient temperatures (Pantavou et al., 2008; Papanastasiou et al., 2015; Moustris et al., 2013; Nastos and Matzarakis, 2013; Pantavou et al., 2011). Within the framework of LIFE Urban Proof, Humidex is also calculated for all municipalities using meteorological observation from local stations. The results of this analysis can be seen in section 3.4: "Humidex – All municipalities"

With regard to the impact of high ambient temperatures on mortality rates in Athens, several studies are available studying either the impact of very high temperatures during heat waves or the relation of ambient temperature with mortality rates during the whole summer period.

Katsouyanni et al. 1993 investigated the mortality data of the July 1987 when a major heat wave hit Greece and compared with the respective data of 6 previous years. This comparison revealed a high increase in the number of deaths in Athens (97% increase, almost doubled) compared to all other urban areas (33% increase) and to all non-urban areas (27%). They also found that the daily number of deaths increased by more than 40 when the mean 24-h air temperature exceeded 30 °C.

In another study by D'Ippoliti et al. (2010), it was reasoned that for the period 1990–2004 and during heat waves, the mortality rate of people older than 65 years increased by 21.6% in Athens. The main reasons of the increased mortality are related to respiratory, cardiovascular and cerebrovascular problems.

Also, Baccini et al., 2008 & 2011 assessed the impact of summer heat on mortality in different European cities, among them Athens for the period 1992-1996 where they found that warm ambient temperatures have an important impact on population mortality mainly on older people. As far as Athens is concerned, this research concluded that the per cent change in mortality for all natural causes associated with a 1°C increase in exposure (increase in maximum apparent temperature) above the threshold (32.6±0.6 °C for Athens) by age group is 0.29 for 15-64, 3.5 for 75-74 and 7.3 for 75+. Also, the analysis of observed data shown that the mean number of attributable deaths (due to warm ambient temperatures) per year during the study period were 230 (172 to 290, 80% credibility interval). In addition the age-specific percentages of attributable deaths over the total number of deaths during the study periods were 0.64 for 15-64, 1,16 for 65-74 and 2.52 for 75+. The total percentage of attributable deaths over the total number of deaths was 1.88 (all classes of age, 15+)

Additionally, Nastos and Matzarakis, 2012 investigated the association between the daily mortality and the thermal conditions for the 10-year period 1992-2001 in the wider region of Athens using daily maximum and minimum air temperature as well as thermal indices such as the Physiologically Equivalent Temperature (PET) and the Universal Thermal Climate Index (UTCI). They resulted that mortality is in close relation to the air temperature and PET/UTCI. Additionally, the findings also showed that, statistically significant relationships between air temperature, PET, UTCI and mortality exist on the same day. More precisely, during the warm period (April – September) a 10°C increase in daily maximum air temperature, minimum air temperature, temperature range, PET and UTCI is related with and increase 3%, 1%, 10%, 3% and 5% of the probability having a death, respectively. Except for warm period they also examined the relationship between cold and mortality. The found that during the cold period (October – March), a 10°C decrease in daily maximum air temperature, minimum air temperature, temperature range, PET and UTCI is related with an increase 13%, 15%, 2%, 7% and 6% of the probability having a death, respectively.

3.2.3 Non-climate related pressures

The economic crisis in Greece affects the energy consumption for heating and cooling of houses. Santamouris et al. (2013) showed that in the period 2010-2012 consumption decreased due to the severe economic downturn. This in turn makes residents more vulnerable to the effects of climate change on both warm and cold conditions. Surely the most vulnerable are people of low economic potential, old people, immigrants etc.

3.2.4 Adaptation measures

Given the impact of climate change on people's health and quality of life, the health sector is called upon to cope with new circumstances and to support a health system that can guarantee a more efficient and effective provision of health services to citizens (Bank of Greece, 2016). With both adaptation actions and appropriate mitigation actions, the health sector can not only contribute positively to the necessary upgrading of health services but also provide a number of social and economic benefits (WHO and HCWH, 2009).

According to the Greek National Adaptation Strategy to Climate Change (Bank of Greece, 2016), the identification of vulnerable groups of the population such as elderly people and people already having respiratory and cardiovascular diseases, is an important prerequisite for dealing properly with these impacts.

An important role can be played by the Health Map (developed by the Ministry of Health, the Center for Disease Control and Prevention, and the Public Health School of Public Health (available at http://ygeiamap.gov.gr/), which represents the basic tool for the planning and implementation of national health policy. It is a mechanism for the continuous collection and processing of data regarding the level of health, morbidity and health needs of the population, the main factors affecting health, the measurement of needs in specific groups of the population etc. Analyzing these data, it reflects the real needs of primary and hospital health services, as well as health prevention and promotion services.

Below are some examples of adaptation to the extreme weather conditions (heatwaves) which are proposed by the Greek National Adaptation Strategy to Climate Change (Bank of Greece, 2016):

Improvement of the General Secretariat for Civil Protection action plans in cooperation with the relevant ministries (Risk prevention and management)

For the properly preparation to tackling heatwaves impacts, the following are required:

- Collaboration between all responsible bodies (green areas, air-conditioned areas and access to them, early warning systems, support networks for vulnerable groups). Regions are responsible for the designation of air-conditioned areas in their area of jurisdiction
- Actions in healthcare settings (education -eg familiarity with symptoms, patient information, preparation to receive increased incidents during the summer months- staff and facilities).
- Self-protection measures (personal habits, search for shady places, consumption of liquids containing no alcohol / caffeine etc.)

In municipality level, similarly to energy sector, Peristeri has defined a series of actions and policies through its Municipality Operational Plan for the period 2015-2019 (Municipality of Peristeri, 2016) which although they haven't been developed for the purpose of adaptation to climate change, they are indirectly contributing to the reduction of the vulnerability and subsequently to adaptation of health sector. These actions are mainly about upgrading green spaces or creating new green spaces aimed to alleviate the negative effects of urban heat island in human discomfort, informing and raising awareness among citizens (self-protection measure). More specifically, the actions proposed by the Operational Plan for the period 2015-2019 are:

Informing and raising awareness actions

1. Raising awareness of citizens in environmental issues.

Upgrading green spaces or creating new green spaces

2. Reconstruction of a square on Kosma Aetolou Street
3. Formation of a green roof in the City Hall of the Municipality of Peristeri
4. Bioclimatic restoration of free spaces of Chorafa area
5. Bioclimatic regeneration of the wider area of 1st Playground
6. Construction of green roofs in the municipal buildings of Evangelistria area with a view to create new green spaces
7. Holistic reconstruction of Evangelistria refugee blocks of flats with bioclimatic features

8. Increasing green areas and regeneration of the area of Agios Antonios (City entrance), mainly the surrounding area of refugee apartment building in Agios Antonios area
9. Aesthetic and functional upgrading of communal areas of the Municipality of Peristeri.

3.3 Italy

3.3.1 Existing situation

Reggio Emilia is a city in northern Italy, in the Emilia-Romagna region. The current population of the municipality is about 171.400 inhabitants (Istat, 2017). The municipality of Reggio Emilia is the main commune of the Province of Reggio Emilia with population about 530.000 inhabitants in 2016 (Istat, 2017). The total population of Emilia-Romagna region is about 4,4 million inhabitants. Figure 3-10 shows the increasing trend of the population of the Reggio Emilia municipality since 1986, about 30,8% increase in 2016 compared to 1986 (Figure 3-10). Same increasing trend is observed in Emilia Romagna Region (Figure 3-11) as well as the whole Italy (Figure 3-12).

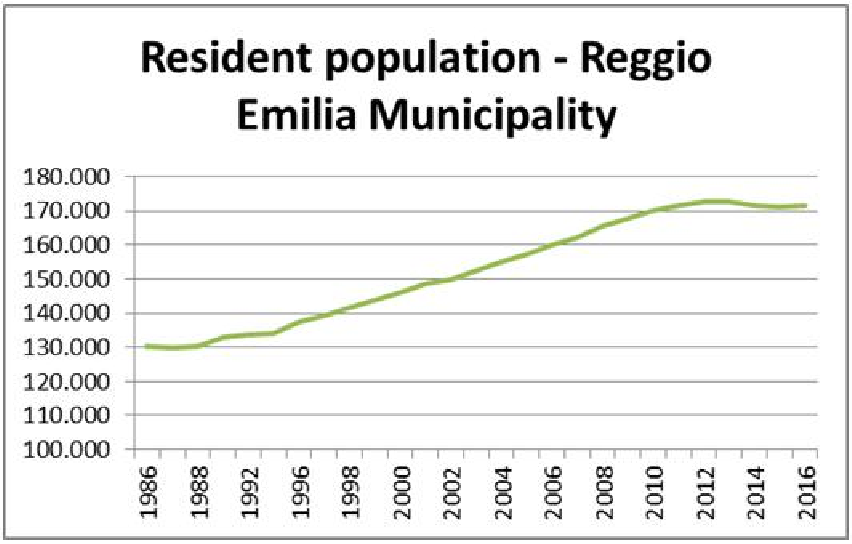

Figure 3-10: Variation of the resident population in Reggio Emilia municipality between 1986 and 2016

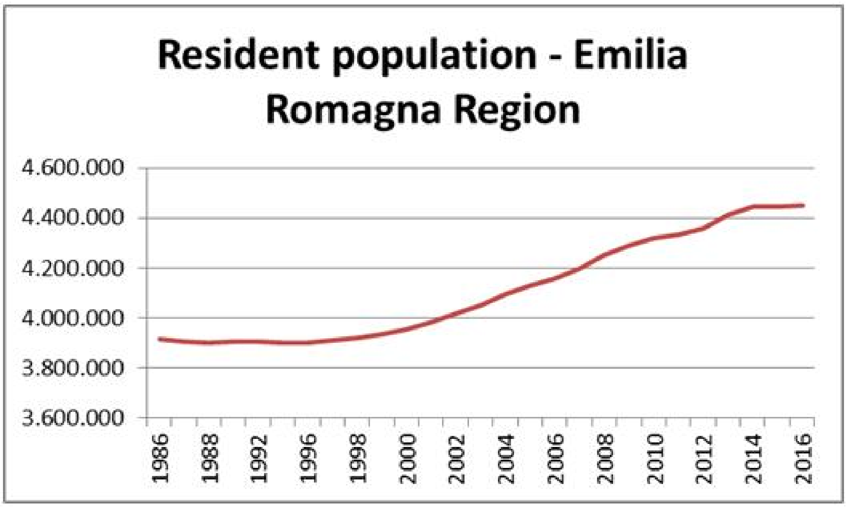

Figure 3-11: Variation of the resident population in Emilia Romagna Region between 1986 and 2016

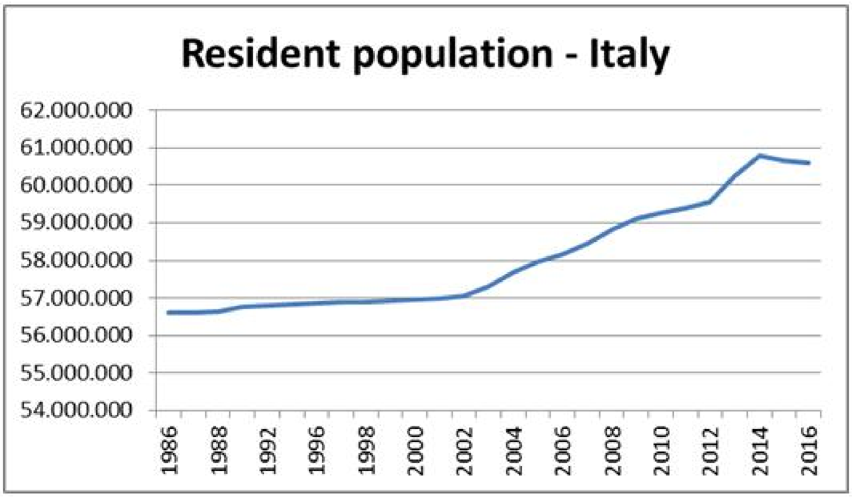

Figure 3-12: Variation of the resident population in Italy between 1986 and 2016

Regarding population projection of Reggio Emilia province, models show and increasing trend until 2051, about 42% increase compared to current population of the province (Figure 3-13)

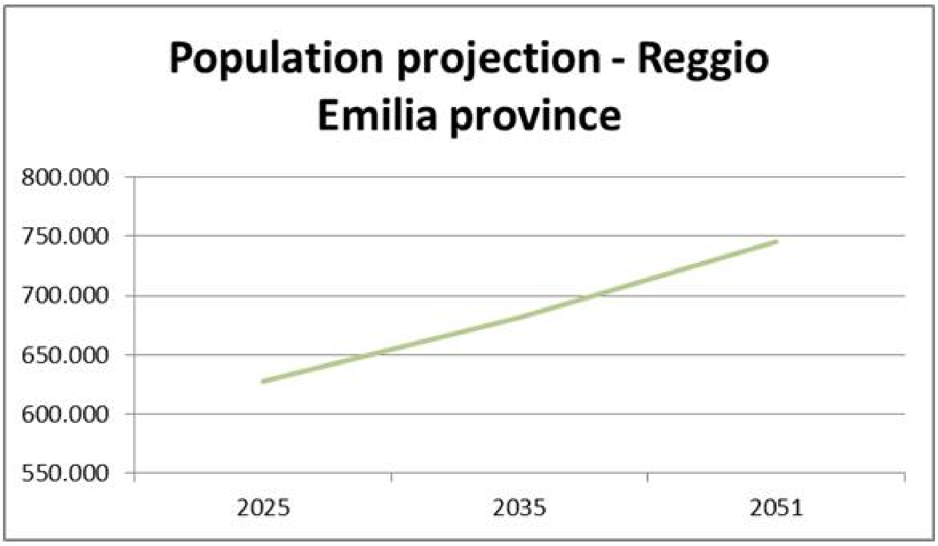

Figure 3-13: Population projection of Reggio Emilia province for the period 2025-2051

Regarding class ages of Reggio Emilia municipality in 2016, the proportion of young population (0-14 years) is about 14,5% while the proportion of elderly population (65+ years) was estimated about the 20%. Middle-aged classes (40-54 years) constitute the highest populated classes (Figure 3-14).

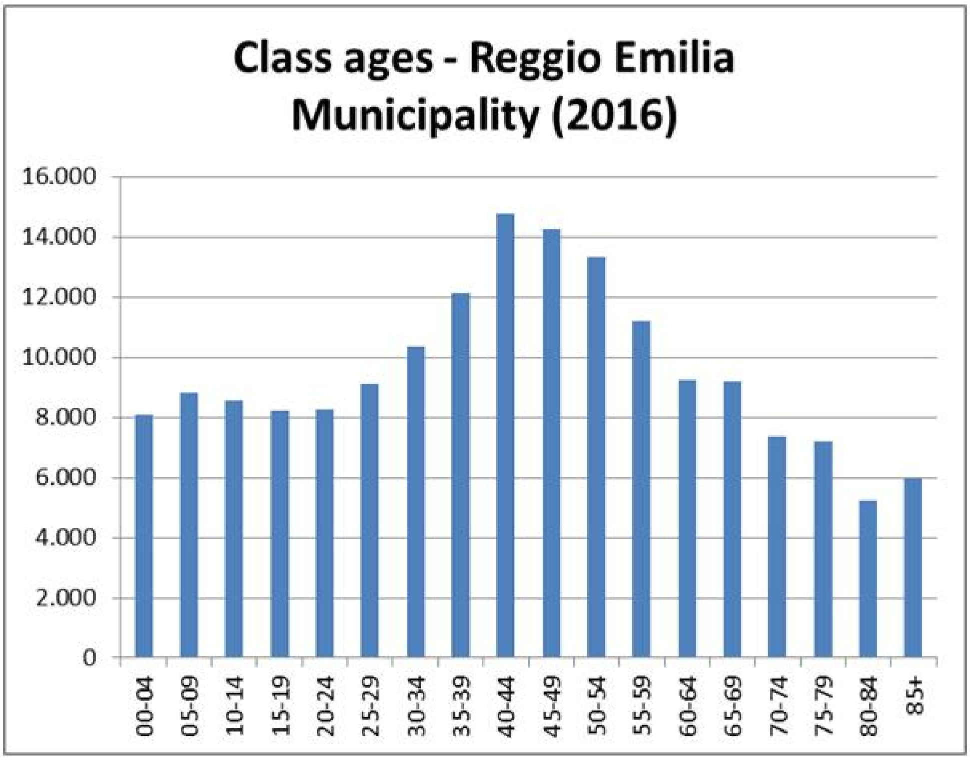

Figure 3-14: Class ages in Reggio Emilia Municipality, 2016

As for educational level of the population of Reggio Emilia municipality, in 2015, the 11% of the population does not have any certificate (19.050 inhabitants) while approximately 30% of the population has junior high school certificate (50.332 inhabitants).

Population at risk of poverty is presented in Figure 3-13 where is apparent an increase of about 80% in the number of families in absolute poverty in 2013 compared to 2005. On the other hand, life expectancy has the same increasing trend in Italy as well as in Emilia Romagna Region but the values of the latter are higher than the national average (Figure 3-16).

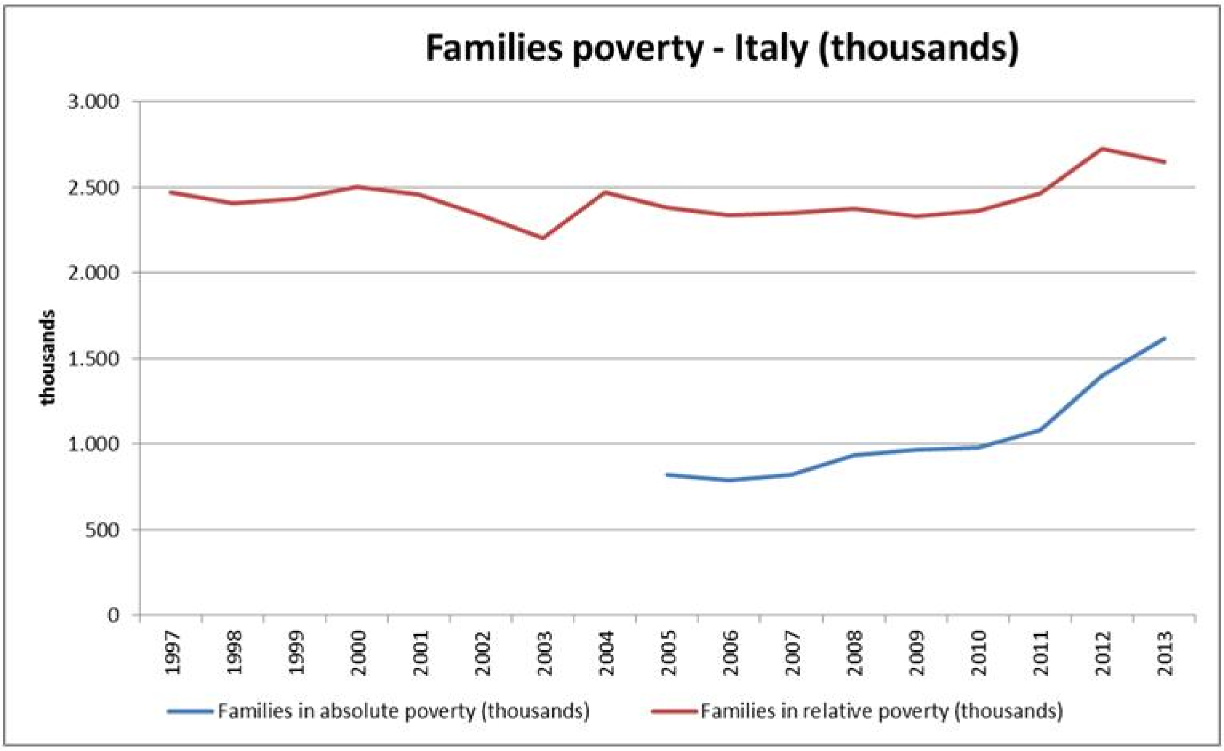

Figure 3-15: Variation of poverty level (thousand families) in Italy between 1997 and 2013

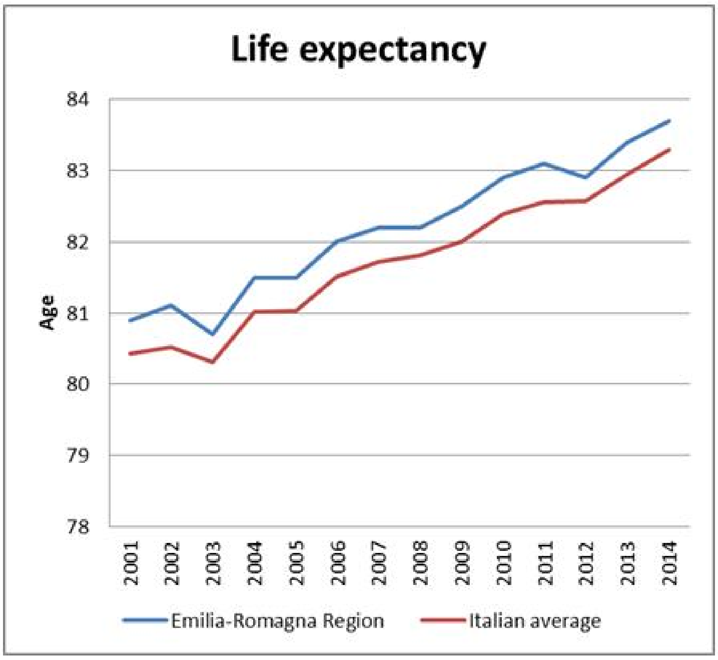

Figure 3-16: Variation of life expectancy in Emilia-Rmagna Region as well as in Italy for the period 2001-2014

In Italy, most common chronic pathologies have always been 1) arthrosis and 2) hypertension; In the last 5 years the second pathology has passed the first. There is a definite increase in allergy-related diseases (Figure 3-17)

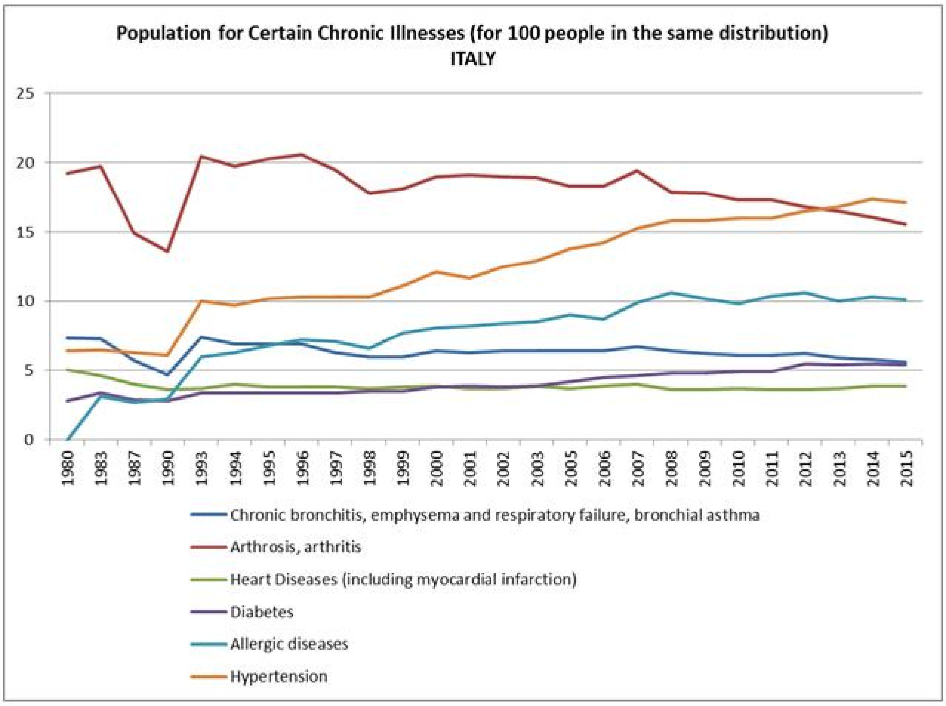

Figure 3-17: Population for certain chronic illnesses in Italy for the period 1980 – 2015.

Clinics and laboratories are the largest healthcare facilities in the country; in recent years, psychiatric care and assistance to the elderly have increased significantly, while other types of facilities have kept steady (Figure 3-18). In Emilia Romagna, the most represented structures are those for the elderly and for physically disabled people (Figure 3-19).

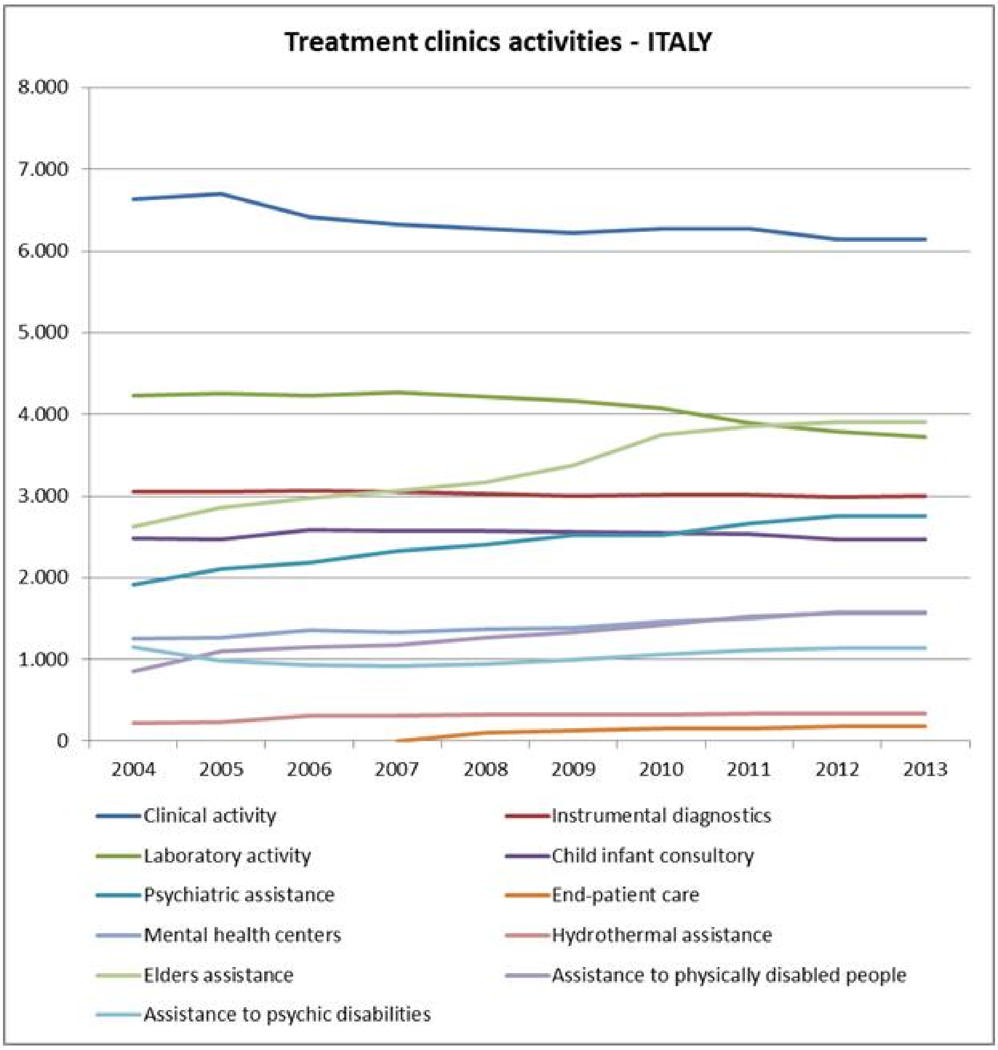

Figure 3-18: Treatment clinics activities in Italy for the period 2004 – 2013

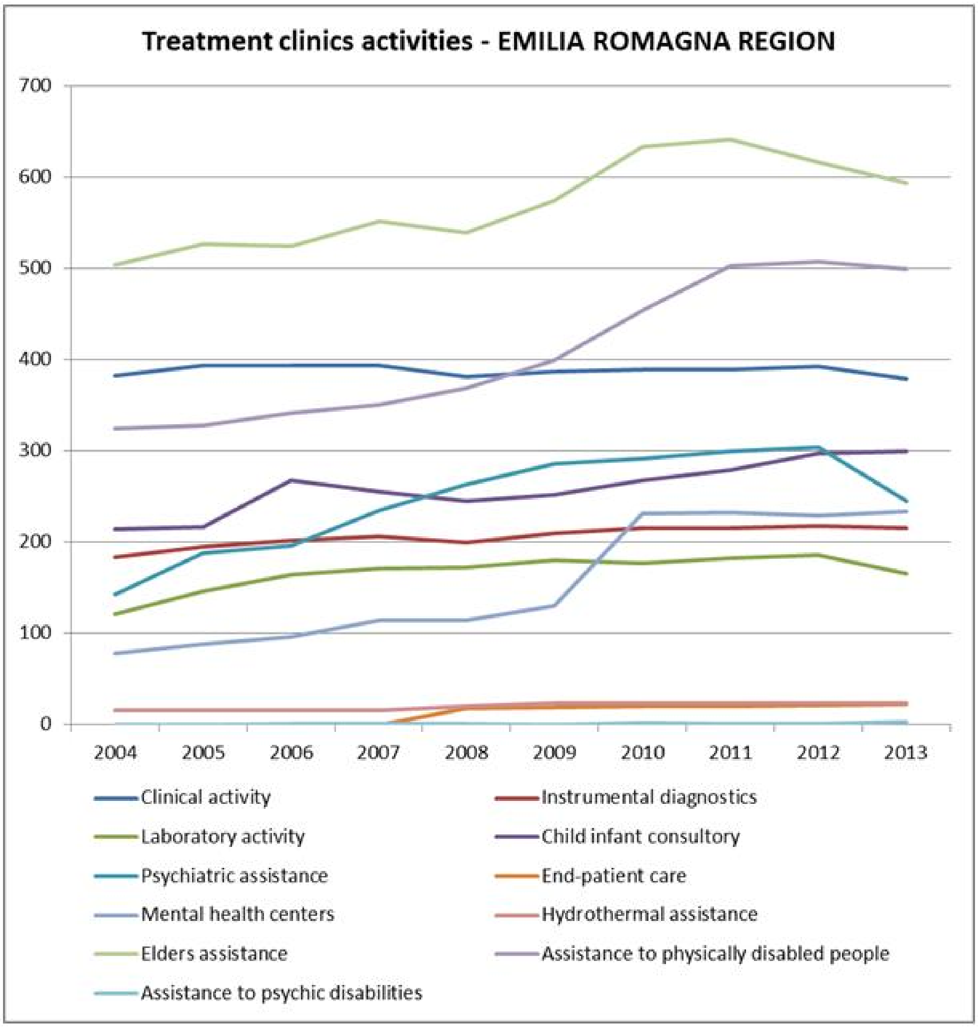

Figure 3-19: Treatment clinics activities in Emilia Romagna Regio for the period 2004 – 2013

3.3.2 Observed and expected impacts

Data proposed by Arpa Emilia Romagna (Cacciamani et al., 2010), graphed in Figure 3-20, show an increase in temperature trends from the '80s to present, estimating a +2°C in the last 40 years, that is an average of +0.5°C every ten years. In details, the last 20 years result to be the warmest of the whole series. This trend is common to every period of the year, but appears to be more marked during summer. In a previous document (Cacciamani et al. 2007) statistical and deterministic tools were employed to try to regionalize climatic data from European projects Stardex and Ensembles to derive the climate change scenarios for Emilia Romagna. From the analysis of time series regarding temperature and precipitation, some forecasting about the future were obtained: we should expect a further increase in temperature measures (both minimal and maximal), an increase in catastrophic events frequency and duration (especially heat waves in summer) and some reduction in winter's freezing frequency and duration.

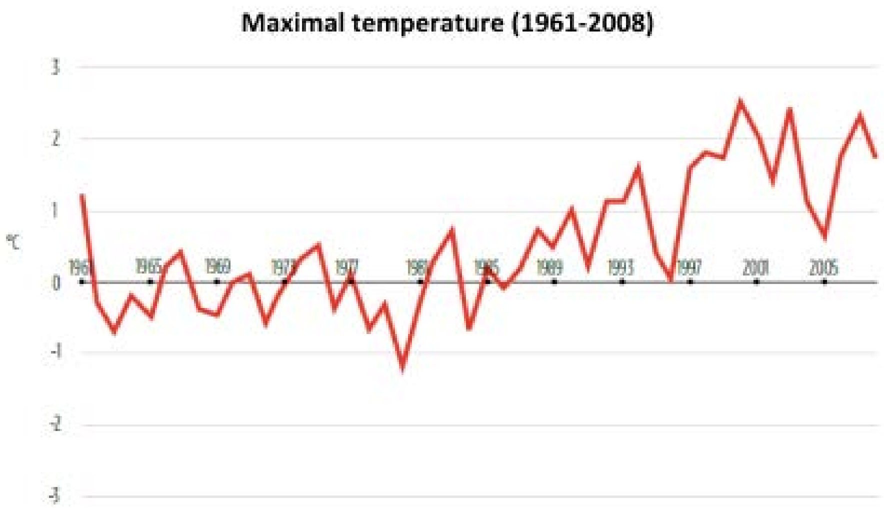

Figure 3-20: Trends in maximum daily temperature in the last 40 years.

Projections from IPCC 2007 report (IPCC, 2007) quantify the future warming by an increase of 0.2°C every ten years for a wide range of predictive models about atmospheric circulation (AOGCM), employed to define global scenarios of climate change. IPCC also notes that, for concentration of GHG and aerosol settled to levels of year 2000, there will be anyway an increment in temperature quantified in 0.1°C every ten years. Through the analysis of thermometric time series carried out in about 100 Italian meteorological stations (Brunetti, 2007), a less significant increase in temperature is deduct. Data shows an increment of 1°C every 100 years, uniformly distributed through all Italian regions. This analysis takes in exam the regional mean series instead the single stations, to make the statistical signal more solid and less prone to casual errors.

Time series shown in Figure 3-21 show a stationary trend until 1970, followed by a rapid increase leading to 2003, the warmest year of the whole series. Observing seasonal series, significant differences can be highlighted; in particular, the strong warming increase in the last part of the series is noticeable during spring and summer, but not during autumn and winter, seasons in which this trend is less marked. A preliminary study made by the "Agenzia Sanitaria Regionale" concerning the mortality in Emilia Romagna during summer 2003, reveals an increase in the mortality with respect to the period 1998-2002.

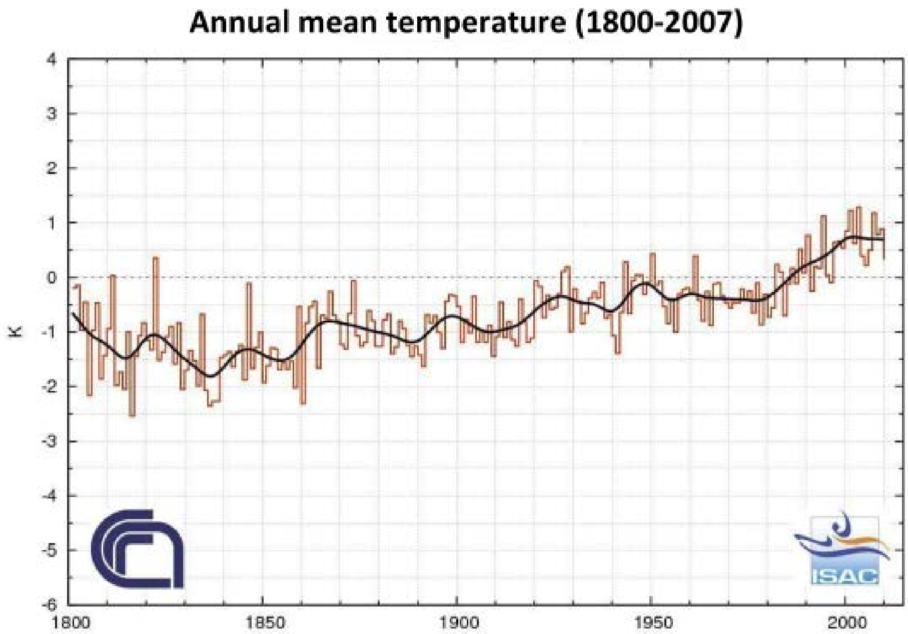

Figure 3-21: Temperature time series for the past 200 year (Brunetti, 2007)

The months with great impact on the life of the people were August and June when an increase in the mortality of around 26.3% and 14.3% respectively was recorded. These increases were especially linked to the higher mortality of older people (over 75 years). A link between daily maximum temperature and the number of deaths was also found. In addition, the Thom's discomfort index of June and August, had values typically associated with states of discomfort in each day of the above months and during the same period it frequently reached values typically associated with states of discomfort and deterioration of psychophysical conditions.

Also, humidity index - Humidex was calculated for the case of Reggio Emilia using meteorological observations from local station. The detailed results from this analysis can be found in section 3.4: "Humidex – All municipalities"

3.3.3 Non-climate related pressures

As already mention in the section "Existing Situation" families in absolute poverty have increased about 80% in 2013 compared to 2005. In addition economic crisis has forced households to consume less energy to meet their heating and cooling needs (see also Energy Section). These non-climate related pressures increase the vulnerability of health sector since they intensify the exposure of the inhabitants on the adverse effects of extreme events such as heatwaves or extreme cold.

3.3.4 Adaptation measures

Following the adoption of the European Adaptation Strategy on 16 April 2013, European countries still lacking a coordinated national adaptation vision were encouraged to develop their own national strategy. Such a strategy must necessarily be consistent with the national plans for managing the risk of natural disasters and include cross-border issues. To this end, the Ministry of the Environment and the Protection of the Territory and the Sea (MATTM) has made available at the end of 2014 three important technical and scientific documents in support of the National Climate Adaptation Strategy. Among them the report titled "Elements for a National Climate Change Adaptation Strategy" (MATTM, 2014).

The document identifies the main areas that will undergo the impacts of climate change, defines the strategic objectives and actions for mitigation of impacts. The report has been redrafted following the public consultation, in order to consider the suggestions and comments of all stakeholders. It also provides a national view on how to address the impacts of climate change in multiple socio-economic and natural systems in the future, identifying a set of actions and adaptation addresses to face these impacts on different sectors including health sector.

At a municipal level greening actions identified at Sustainable Energy Action Plan of Reggio Emilia Municipality as well as at the Municipal Structural Plan such as tree planting, installation of public water dispensers etc will reduce the discomfort due to the extreme temperature (heatwaves) in urban areas. More precisely, the Plan foresees that every new transformation area has to respect environmental parameters including mandatory planting of trees and shrubs in both productive and residential areas. In the same residential areas an index of permeability up to 60% of the territorial area covered by the intervention is envisaged. Moreover, in each residential and productive settlement, a functional breakdown is foreseen which provides a surface to be transferred to the Municipality in order to be allocated to common spaces (in particular public green areas) and a private green area with ecological value. On consolidated urban areas, if new buildings are built, there are permeability indexes to be respected.

Additionally, the General Directorate of Health and Social Policies of the Emilia Romagna Region issued in 2007 regional guidelines for intervention to mitigate the impact of possible heat waves. These guidelines provide for the activation of a "heat emergency project" locally. The Municipality of Reggio Emilia, together with the local healthcare company and many volunteers, is active every year in the project aimed in particular at the elderly population.

Finally, Reggio Emilia has approved in 2016 the implementation of the action program "Reggio Respira" ("Reggio Breaths") with the aim to improve the city's air quality through integrated actions related to the environment and mobility issues. In particular, Reggio Breaths is divided into 10 short-term projects, along with 4 medium-long-term strategic projects. Within Reggio Breaths, collaboration is also planned through the signing of a specific protocol between the municipality, Arpae Reggio Emilia, AUSL, Mobility Agency and Iren Rinnovabili, for the establishment of a Steering Cabin.

The mail actions are the following:

- Set up a steering cabin to avoid squandering and monitor the workability of the interventions.

- Increase Local Public Transport.
- Enhance the use of the taxi by increasing the number of licenses.
- Renew the current fleet of buses.
- Pedestrianize a part of the Old Town
- Encourage private choices of sustainable mobility.
- Plant 8,000 new trees by 2019
- Favor the use of electric vehicles and bicycles.
- Extension of "zones 30".
- Limiting and regulating cars in school areas.

3.4 Humidex – All municipalities

To investigate the potential current harmful impacts of climate warming on population comfort in all partner municipalities, the humidity index (Humidex) (Masterton and Richardson 1979) - a parameter employed to express the temperature perceived by people - has been examined using observational data, from local meteorological stations, extended from 1985 to 2014 for Lakatamia-Strovolos and Peristeri municipalities and from 2005 to 2014 for Reggio Emilia municipality collected within the framework of LIFE UrbanProof project.

Humidex is applied in summer and generally warm periods and describes the temperature felt by an individual exposed to heat and humidity. More specifically, the Humidex parameter (in °C) is calculated by the following equation:

$$\mathrm{T\,(h)} = \mathrm{Tmax} + {}^{5}/_{9} \times (\mathrm{e} - 10)\,,$$

Where e is the vapour pressure:

$$\mathrm{e} = 6.112 \times 10^{\left(7.5 \times {}^{\mathrm{Tmax}}/_{(237.7\,+\mathrm{Tmax})}\right)} \times {}^{\mathrm{h}}/_{100}$$

Tmax is the maximum 2m air temperature (°C) and h is the humidity (%).

Furthermore, 6 classes of Humidex ranges are established to inform the general public for discomfort conditions:

<29°C comfortable
30–34°C some discomfort
35–39°C discomfort; avoid intense exertion
40–45°C great discomfort; avoid exertion
46–53°C significant danger; avoid any activity
>54°C imminent danger; heart stroke.

The results are shown above:

Figure 3-22 depicts that in all municipalities the highest discomfort conditions are presented during summer period and more precisely during July in Reggio Emilia and during August in both Peristeri and Strovolos-Lakatamia municipalities. Cypriot municipalities present the highest discomfort conditions; humidex reaches 52°C followed by Peristeri and Reggio Emilia municipalities where humidex is about 43°C and 42°C respectively.

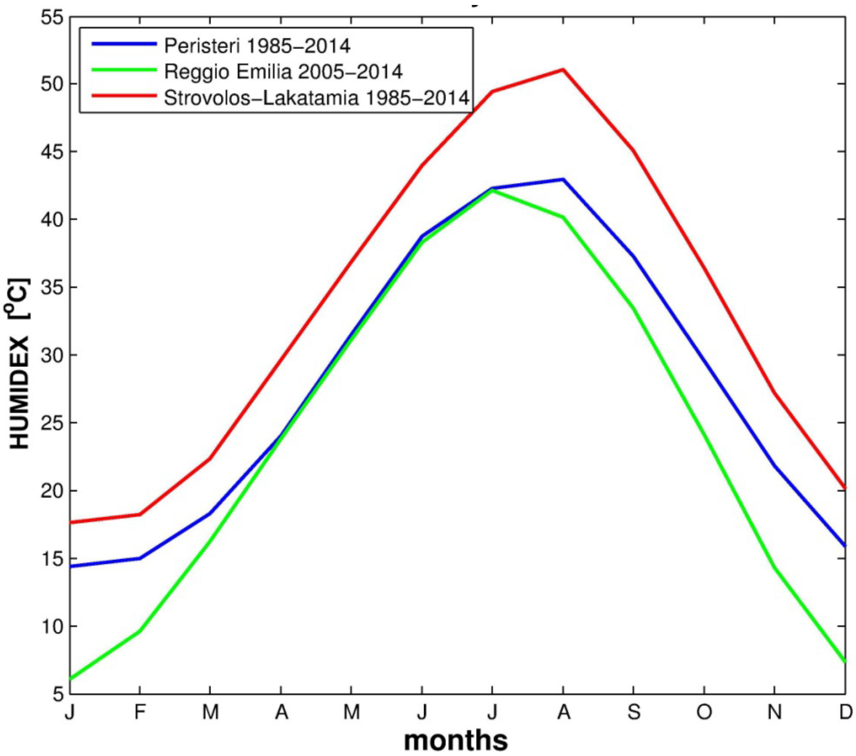

Figure 3-22: Mean monthly distribution of HUMIDEX in all partner municipalities

Figure 3-23 illustrates the number of days per year where Humidex is above 38°C, in other words the number of days with discomfort conditions for residents, for all partner municipalities. Strovolos and Lakatamia municipalities present most discomfort days (≈140 days) compared to other municipalities, followed by Peristeri (≈85 days) and Reggio Emilia (≈25 days). Similarly, Figure 3-24 shows the number of days per year where Humidex is above 40°C that is to say great discomfort conditions for residents of urban areas of all municipalities. Strovolos and Lakatamia municipalities, and in this case, present the most days of great discomfort (≈120 days), followed by Peristeri and Reggio Emilia (≈60 and 20 days respectively) municipalities. Finally, Figure 3-25 depicts the maximum consecutive discomfort days (Humidex>38°C) in all partner municipalities. As in previous cases, municipalities of Strovolos and Lakatamia show the highest number of consecutive days, about 90 days, municipality of Peristeri shows 35 days and municipality of Reggio Emilia presents 20 consecutive discomfort days.

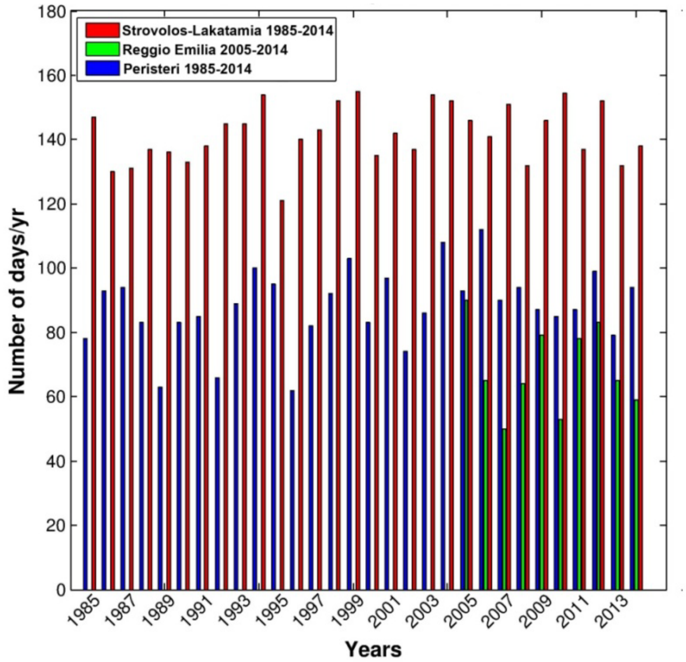

Figure 3-23: Number of days with HUMIDEX > 38°C (discomfort conditions) in all municipalities

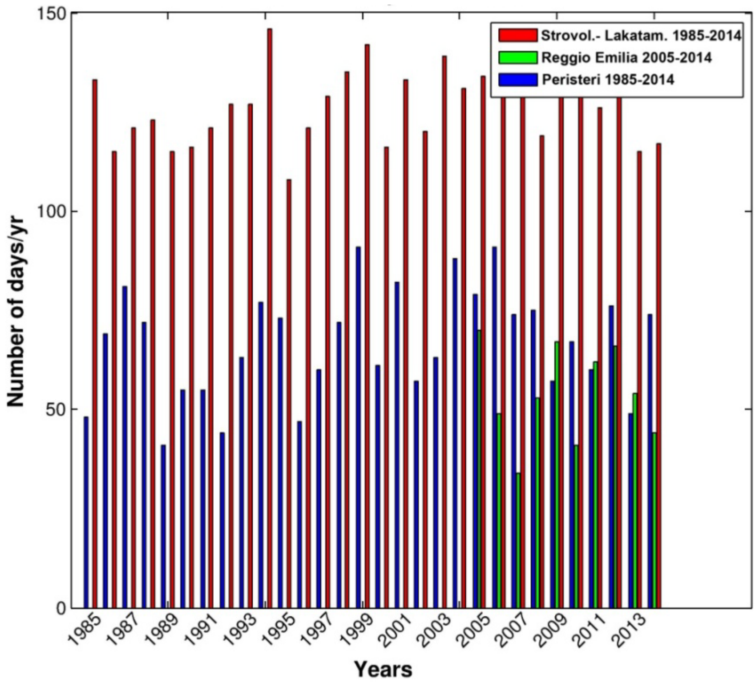

Figure 3-24: Number of days with HUMIDEX > 40°C (great discomfort conditions) in all municipalities

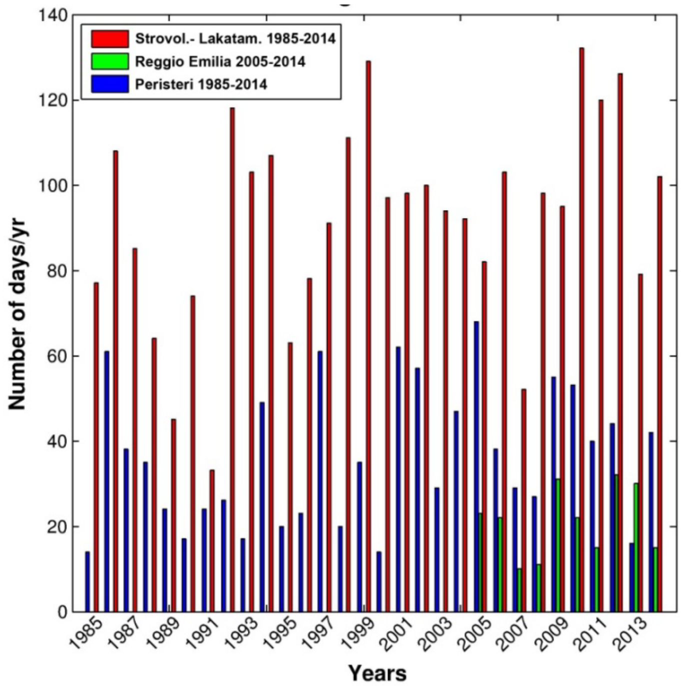

Figure 3-25: Maximum consecutive days with HUMIDEX >38°C (discomfort conditions) in all partner municipalities

As regards Humidex trend, Figure 3-26 shows that Humidex during summer presents an upward trend over recent decades in Strovolos-Lakatamia and Peristeri municipalities and a stable or even declining trend in Reggio Emilia over last decade.

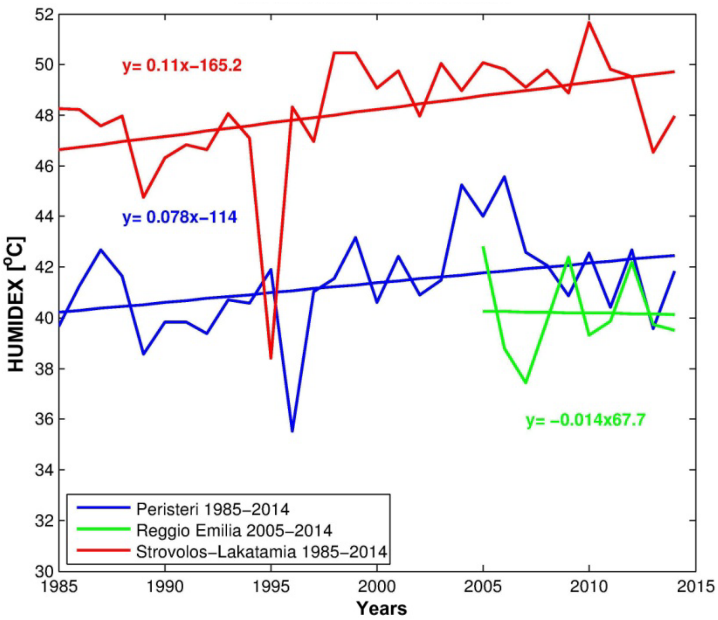

Figure 3-26: Mean summer Humidex trend in all partner municipalities

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4 INCREASE IN ENERGY DEMAND DUE TO HIGH TEMPERATURES

Built infrastructure in Europe is vulnerable to extreme weather events, including overheating of buildings (houses, hospitals, schools) during hot weather (Kovats et al., 2014). Increased temperatures in urban areas have a significant impact on the absolute energy consumption used for cooling of buildings while increases the peak and total electricity load to be delivered by electricity utilities. In parallel, higher temperatures during the winter period contribute to decrease the energy demand of buildings for heating purposes.

HDDs and CDDs (Thom, 1962) are proxies for the energy demand needed to heat or cool, respectively, a home or a business. Both variables are derived from measurements of outside air temperature. The heating and cooling requirements for a given structure at a specific location are considered, to some degree, proportional to the number of HDDs and CDDs at that location. However, they also depend on a large number of other factors, in particular building design, energy prices, income levels and behavioural aspects.

As regards trends of HDDs and CDDs from 1951 to 2014, Figure 4-1 depicts that in the first three decades, HDDs were roughly constant and CDDs declined slightly. Since the beginning of the 1980s, Europe has started experiencing a markedly declining overall trend in HDDs, and a markedly increasing trend in CDDs, pointing to a general increase in cooling needs and a general decrease in heating needs (Figure 4-1).

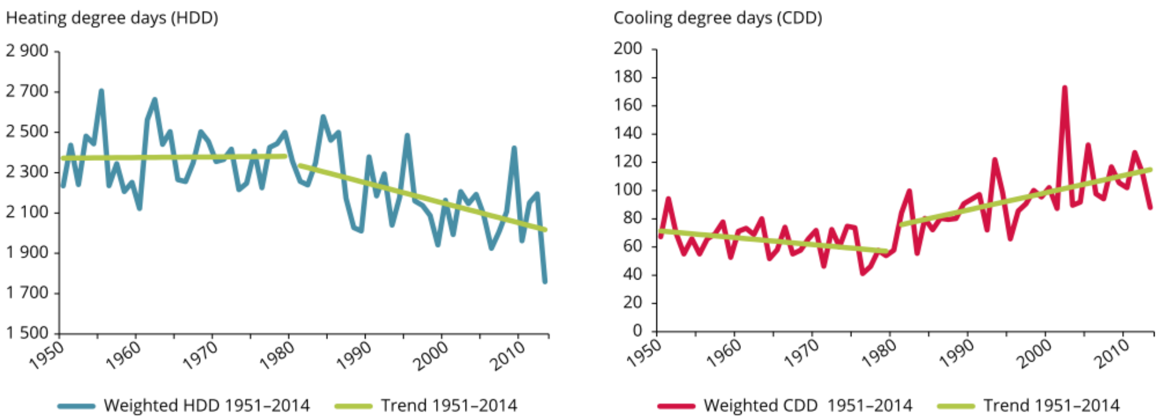

Figure 4-1: Time series of population-weighed heating and cooling degree days averaged over Europe (EEA, 2017)

In addition, Figure 4-2 shows that in the Mediterranean the decrease in HDDs is about -20 to -5 HDD/year for the period 1981-2014 while the increase in CDDs is about 1-4 CDD/year.

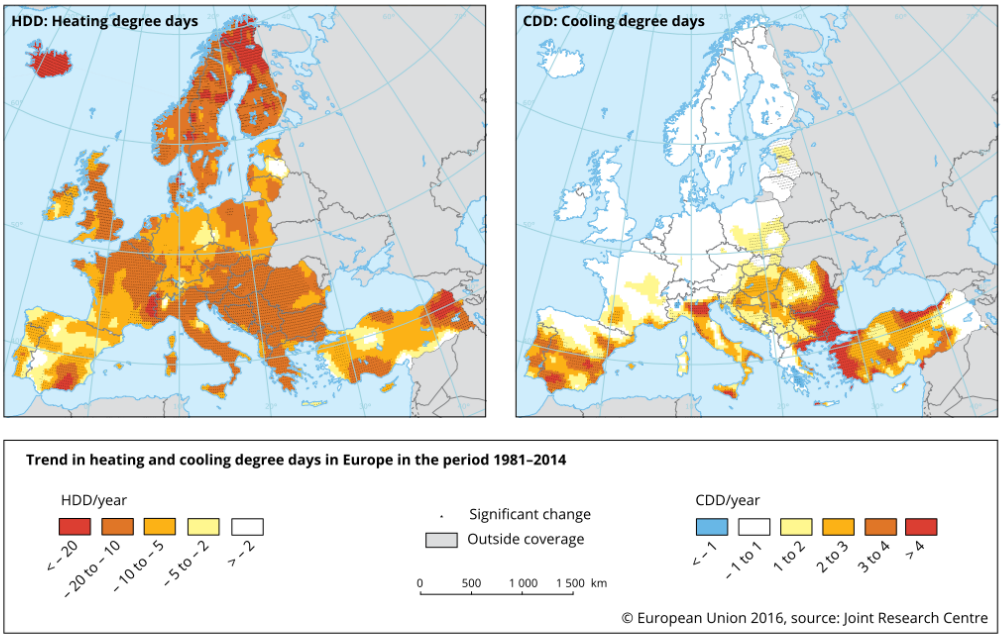

Figure 4-2: Trends in heating and cooling degree days, 1981-2014

Due to this highly dependency of energy demand on the ambient temperature, the projected climate change is expected to affect energy sector with several ways (Arent et al., 2014; Akhmat et al. 2014, Kovats et al., 2014):

- The climate change poses challenges to energy suppliers and users in terms of potential increase in the economic cost of energy use
- Rise in the average and extreme temperatures increases electricity demand for cooling
- Climate change has larger impact on the peak electricity demand than on the average monthly electricity demand
- Climate change affects the geographical pattern of renewable energy supply in the different regions of the world

More specifically, in southern Europe, cooling degree days by 2060 will increase, while heating degree days will decrease but with substantial spatial variations (Giannakopoulos et al., 2009a, b). Consequently, net annual electricity generation cost will increase in most of the Mediterranean and decrease in the rest of Europe (Mirasgedis et al., 2007; Eskeland and Mideksa, 2010; Pilli-Sihlova et al., 2010; Zachariadis, 2010).

4.1 Cyprus

4.1.1 Existing situation

In Cyprus, there are no indigenous energy resources, apart from renewable energy sources (RES). To this end, in order to meet the energy requirements of the island, the vast majority of fuels is imported, making Cyprus a highly energy dependent island. The gross inland energy consumption in 2014 was 2.22 Mtoe, a rise of about 1.4% from 2013. The energy mix pattern is dominated by oil and petroleum products, which represent 93.7% of the gross energy consumption in 2014 (EU, 2016). The contribution of renewable energy to the gross inland energy consumption has steadily increased over recent years and the renewables share has reached 5,9% in 2014 (130.000 toe).

The gross electricity generation in 2014 was 4,35 TWh, a rise of 1.4% compared to 2013. Electricity in Cyprus is generated mainly by crude oil and petroleum products. Only 7,4% of electricity is generated by renewables, despite Cyprus' remarkable potential in solar and wind. Nevertheless, wind power generation has increased about 87% compared to 2010 (EU, 2016). The National Renewable Energy Action Plan projected that by 2018 the electricity generation capacity from renewable energy sources would reach 400 MW. In 2014, the installed renewables have reached 210 MW. The installed capacity mix in Cyprus for 2014 is show in Figure 4-3.

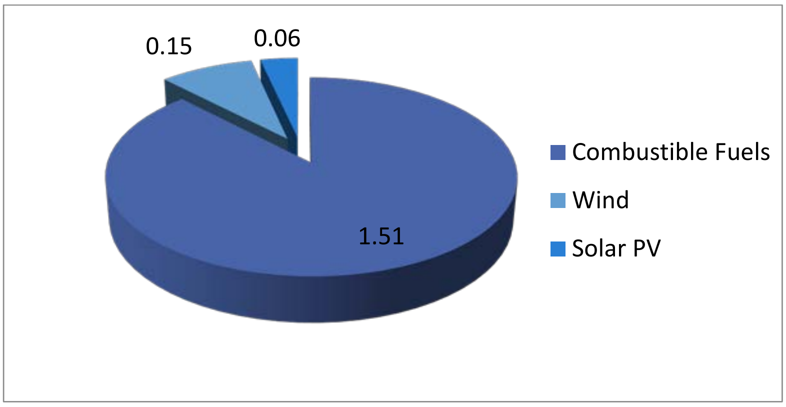

Figure 4-3: Installed Capacity (in GW) mix in Cyprus for 2014 (EU, 2016)

The final energy consumption in Cyprus totaled 1,61 Mtoe in 2014, reduced by 16,5% compared to 2010. The major energy consumers along with their contribution to the final energy consumption are given in Table 4-1

Table 4-1: Major energy consumers and their contribution to the final energy consumption of Cyprus

Energy consumers	Final Energy Consumption (Mtoe)	
	2013	2014
Industry	0.19	0.22
Transport	0.87	0.84
Households	0.30	0.29
Services	0.20	0.20
Agriculture	0.04	0.04
Other	0.02	0.02

As regards final energy consumptions of Latamia Municiplaity, Figure 4-4 depicts that the majority the energy for the period 2009-2014, is generated mainly by natural gas, diesel and electricity. However, in the total energy production, renewable energy sources (PV) have a small contribution. As shown in Figure 4-5 renewables in 2014 (550MWhr/year) have nearly fivefold compared to 2009 (120 MWhr/year). Finally, Figure 4-6 shows the major energy consumers of the municipality of Latamia. Transport is the largest consumer of energy, followed by housing and the tertiary sector (Lakatamia, 2015)

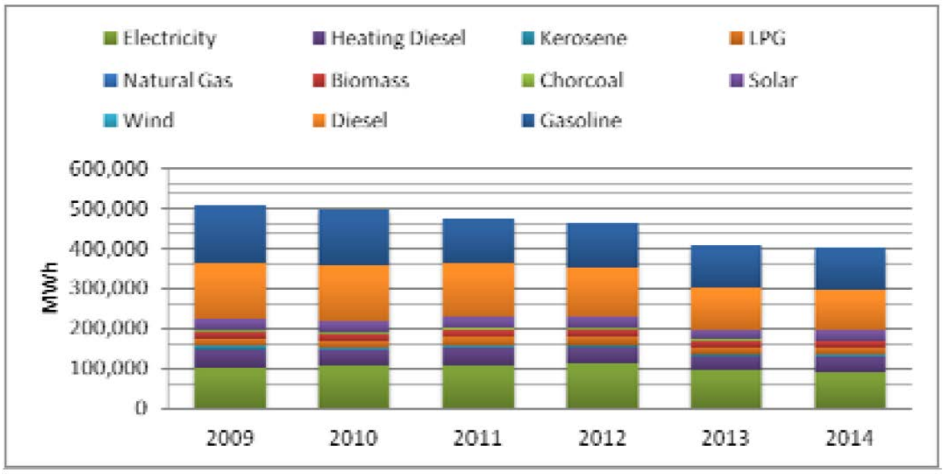

Figure 4-4: Final energy consumptions for the period 2009-2014 (by energy source) for the municipality of Lakatamia

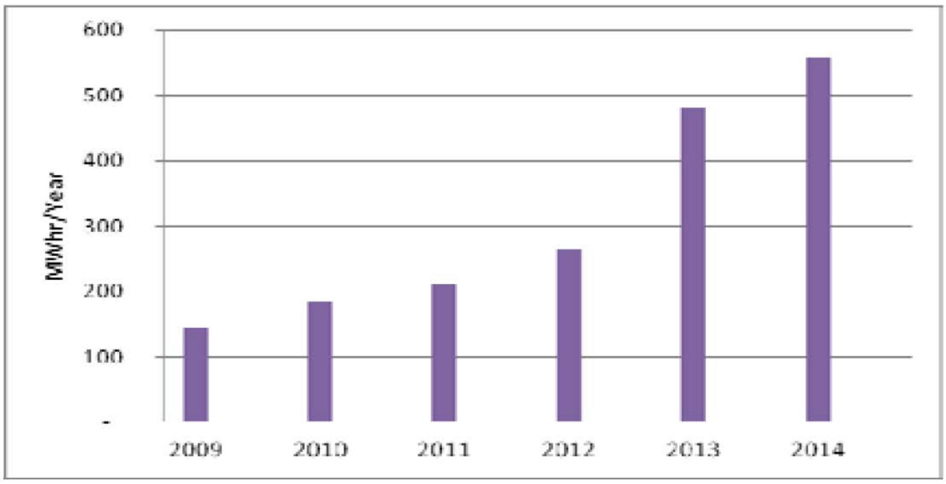

Figure 4-5: Electricity production from renewable energy sources (PV) for the period 2009 – 2014 for the municipality of Lakatamia

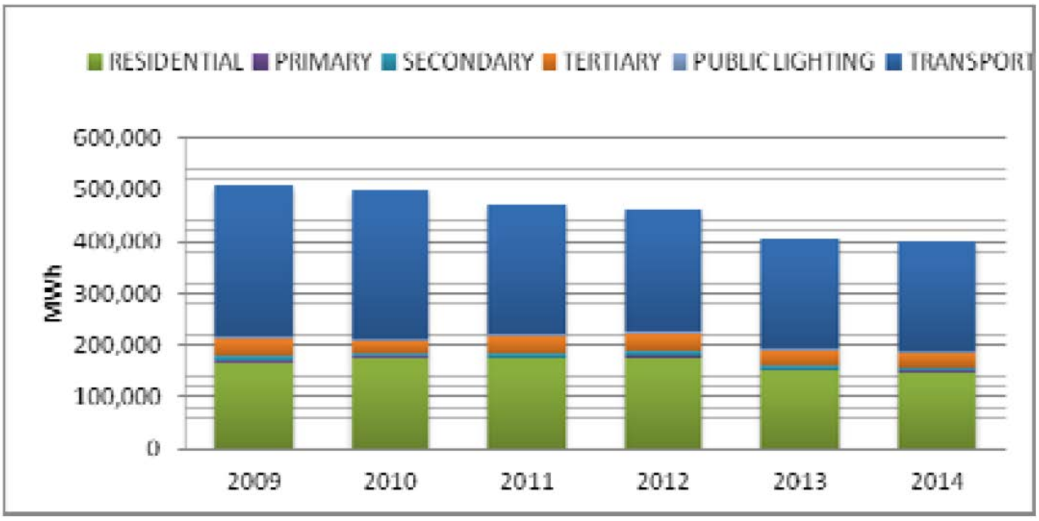

Figure 4-6: Final energy consumptions, by sector, in municipality of Lakatamia for the period 2009-2014

A similar picture to that of the Municipality of Lakatamia is also presented by the Municipality of Strovolos, to a higher degree thought due to its larger size. The consumed energy, for the period 2009-2014, was mainly generated by diesel, electricity and natural gas at almost similar rates (Figure 4-7). Electricity production from rewewable energy sources (Photovoltaics) for the period 2009-2015 is also presented in Figure 4-8. Although energy production from PV is very small, much smaller than that of the municipality of Lakatamia, however, in the past 5 years the production of electricity has increased almost six times. Finally, Figure 4-9 illustrates that the major consumer in municipality of Strovols is again the sector of transport followed by housing and tertiary sector (Strovolos, 2015).

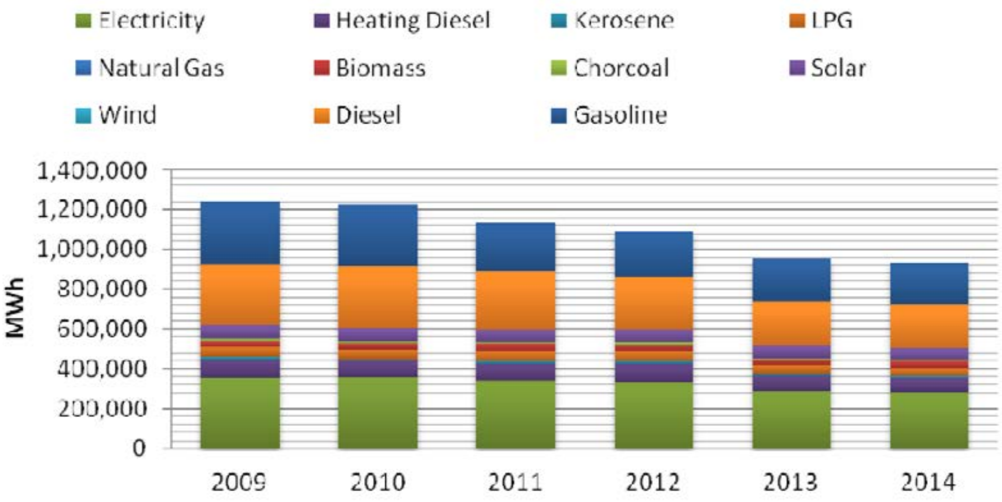

Figure 4-7: Final energy consumptions for the period 2009-2014 (by energy source) for the municipality of Strovolos

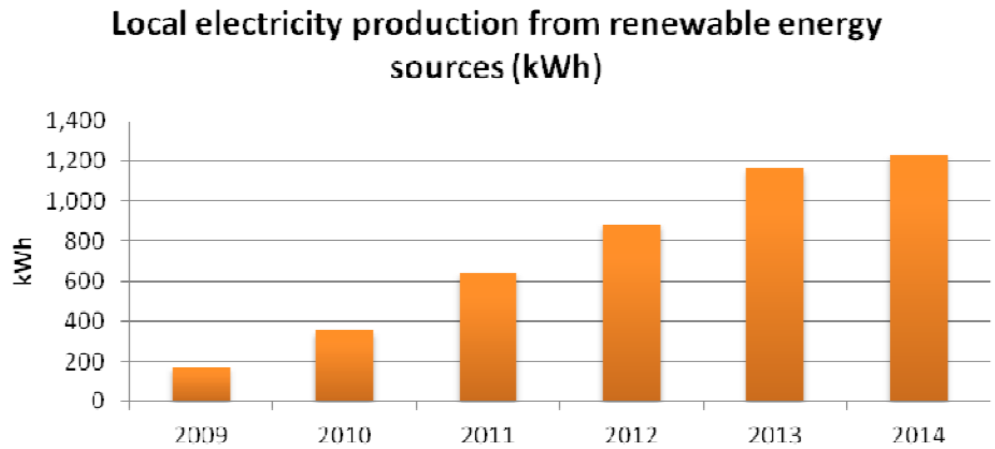

Figure 4-8: Electricity production from renewable energy sources (PV) for the period 2009 – 2014 for the municipality of Strovolos

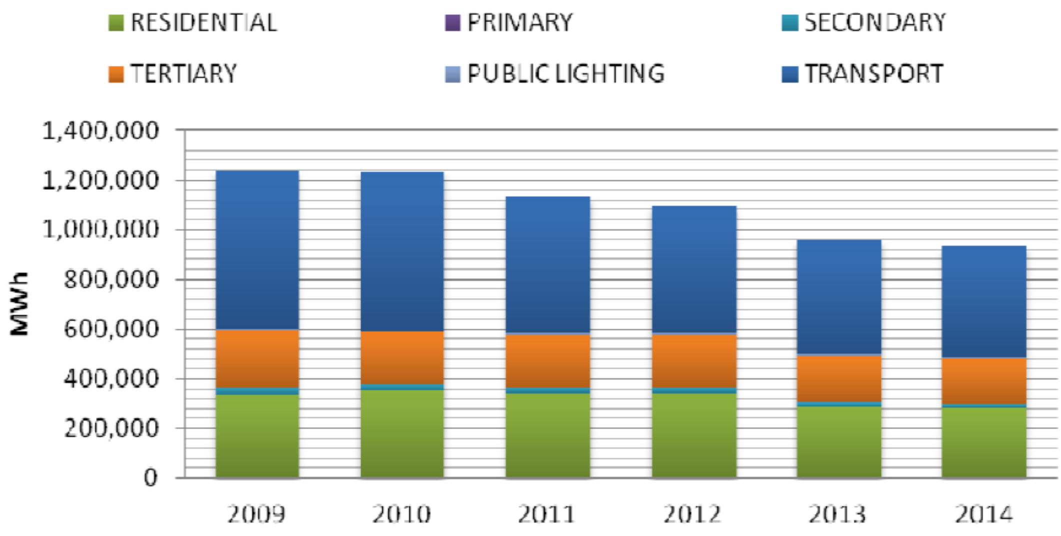

Figure 4-9: Final energy consumptions, by sector, in municipality of Strovolos for the period 2009-2014

4.1.2 Observed and expected impacts

To investigate the observed impacts of climate change on energy demand, the heating (HDD) and cooling (CDD) degree days was calculated using climatic data from local meteorological stations in Cyprus. The results concerning the meteorological station of Athalassa, the closest station to the municipalities of Lakatamia and Strovolos, are depicted in Figure 4-10 and Figure 4-11 . Figure 4-10 illustrates the downward trend of HDD for the period 1985-2014, in other words it shows that the energy demand for heating has decreased in recent years. On the other hand, Figure 4-11 shows the upward trend of CDD i.e. the increasing trend of energy demand for cooling in recent years.

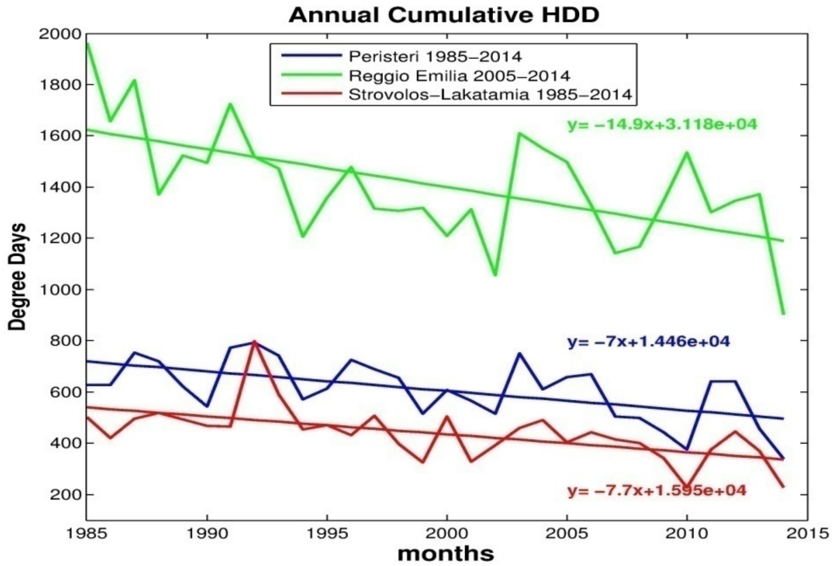

Figure 4-10: Observed changes in heating degree days between 1985 and 2014 for municipalities of Lakatamia and Strovolos (red line). Station: Athalassa

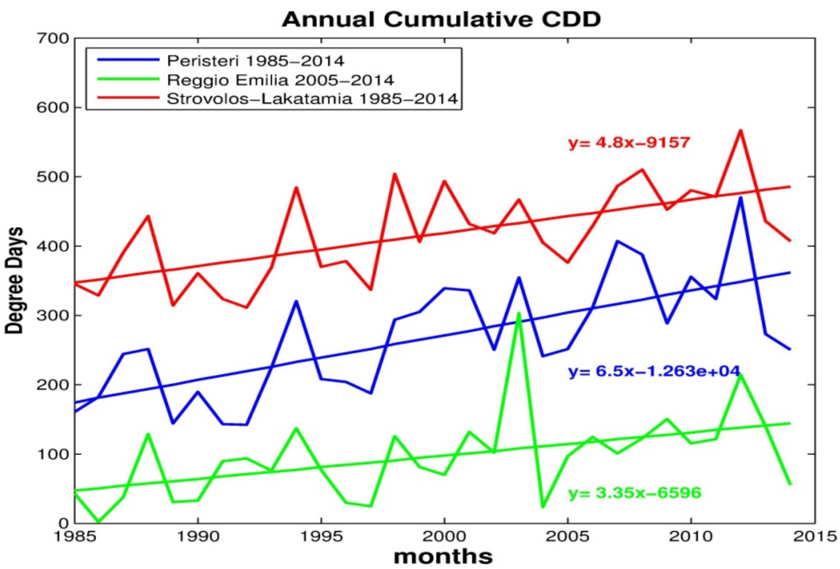

Figure 4-11: Observed changes in cooling degree days between 1985 and 2014 for municipalities of Lakatamia and Strovolos (red line). Station: Athalassa

As regards the trend of electricity consumption in Cyprus in the recent years in combination with air temperature, the Figure 4-12 shows the daily variation of these two indicators for the period 1999-2009 for Cyprus (Giannakopoulos et al, 2016). Electricity consumption shows a clearer upward trend than does air temperature. The increase in electricity consumption is largely due to economic growth and also to greater usage of air conditioners in residential and commercial situations. It is obvious that there are two components in electricity load variations: seasonal and yearly. The former is mainly influenced by the prevailing weather conditions and the latter by economic, social and demographic factors (Giannakopoulos et al, 2016).

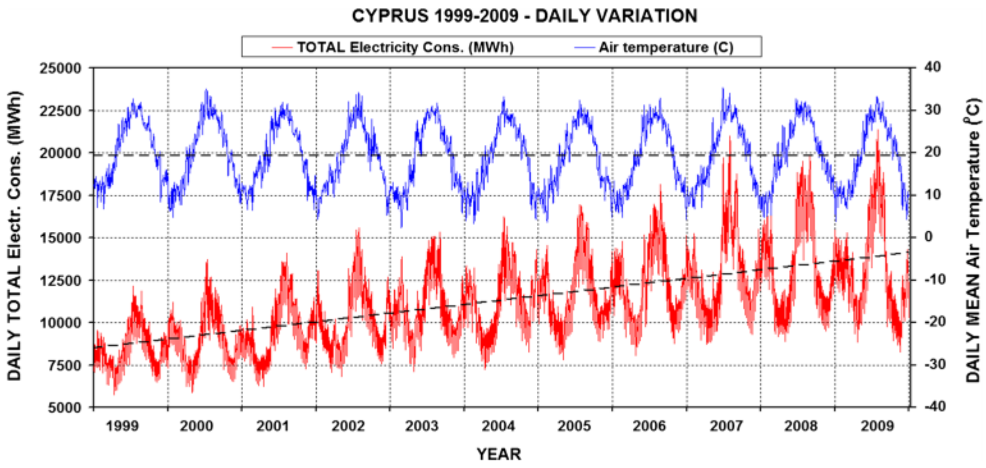

Figure 4-12: Daily variation in air temperature (°C) and electricity consumption (MWh) for the period 1999-2009 for Cyprus

To examine the future impacts of climate change on energy sector, Giannakopoulos et al. (2016) were calculated HDD and CDD using daily output from regional climate models. They identified the changes in energy demand levels by showing differences in the cumulative number of HDDs and CDDs between the reference (1961–1990) and the near future (2021–2050) period. Indicated results are shown in Figure 4-13 & Figure 4-14 for HDD and Figure 4-15 & Figure 4-16 for CDD. Figure 4-13 shows that for municipalities of Lakatamia and Strovolos, in the near future, it is expected a decrease in energy demand for heating during winter of about 60 DDs compared to the present day climate. In addition, Figure 4-14 depicts the number of days with high heating demands (HDD > 5 °C) where the municipalities of Lakatamia and Strovolos present a decrease of about 10 days. This decrease which is anticipated in energy demand for winter and spring (not shown here) can be considered as a "positive aspect" of climate change in Cyprus (Giannakopoulos et al. 2016).

Regarding energy demand for cooling in the near future in two study municipalities, Lakatamia and Strovolos, Figure 4-15 shows that it is anticipated an increase of about 200 degree-days compared to the present climate. Also, Figure 4-16 shows the number of days with high cooling demands, where municipalities of Strovolos and Lakatamia present a high increase of about 30 additional days (Giannakopoulos et al. 2016).

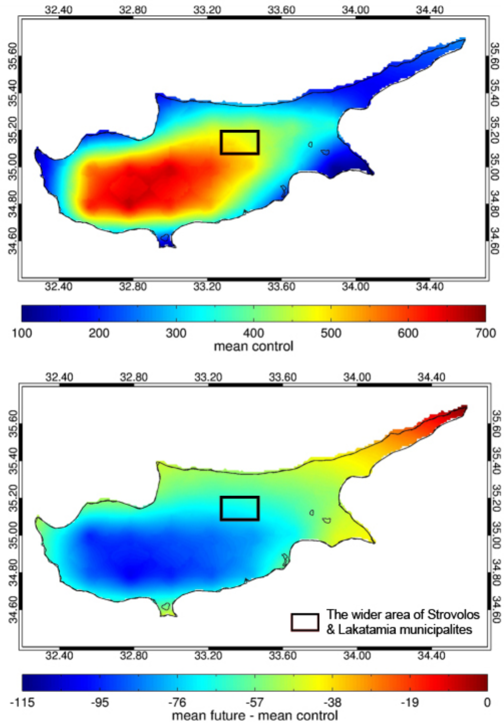

Figure 4-13: Winter cumulative HDD for control period (1960–1990) (up), and the change in winter cumulative HDD in the near future (future—control) (down) (Giannakopoulos et al. 2016)

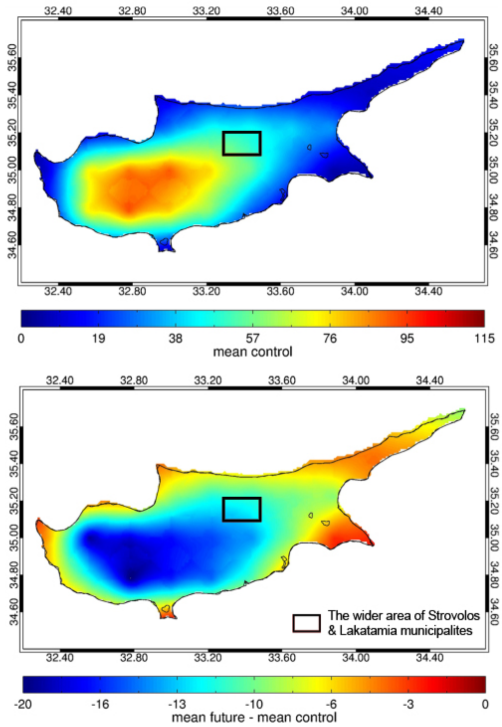

Figure 4-14: Number of days with high heating demands (HDD > 5 °C) for the control period (1960–1990) (up), and the change in the number of days with high heating demands (HDD > 5 °C) in the near future (future—control) (down) (Giannakopoulos et al. 2016)

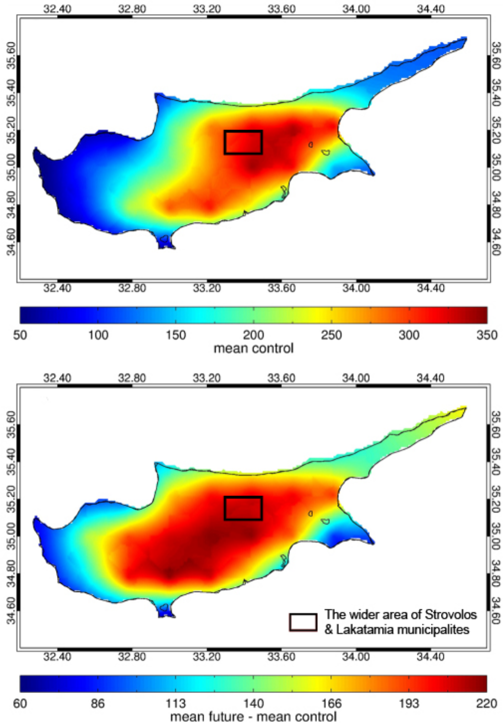

Figure 4-15: Summer cumulative CDD for the control period (1960–1990) (up), and the change in summer cumulative CDD in the near future (future-control) (down) (Giannakopoulos et al. 2016)

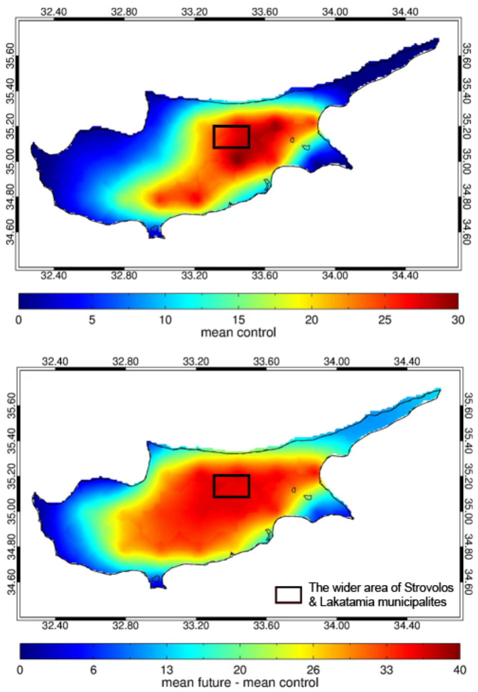

Figure 4-16: Number of days with high cooling demands (CDD > 5 °C) for the control period (1960–1990) (up), and the change in the number of days with high cooling demands (CDD > 5 °C) in the near future (future-control) (down) (Giannakopoulos et al. 2016)

Giannakopoulos et al. (2016) investigated also the future electricity consumptions in Cyprus in relation to temperature rises, using data from different regional climate models in A1B scenario. They used the period 1961-1990 as reference for comparison with the future periods 2021-2050 and 2071-2100. Moreover, they split the examined period into 'cold' (Figure 4-17) and 'warm' period (Figure 4-18). The 'cold' period covered the months November– April and the 'warm' period the months May–October. Figure 4-17a shows that the variation of electricity consumption in the 'cold' period follows a nonlinear decreasing pattern as temperature rise. Figure 4-17b presents patterns of electricity consumption related to maximum air temperature for the observations (1999–2009), the control period 1961–1990 and the future periods. For the 'cold' period of the year (November to April), a decreasing trend in electricity consumption is evident as warmer conditions dominate by 2050 and 2100. Moreover, it is clear that observations lie closer to the levels of typical consumption in the 2021–2050 than in 1961–1990, indicating that a certain degree of decrease in electricity consumption levels in the 'cold' period of the year has already occurred by 2009. There are variations among the various examined models, but the signal of decrease around 5 % compared to the control period in electricity consumption levels remains.

Regarding the 'warm' period, the variation of electricity consumption follows a nonlinear increasing trend as temperatures rise (Figure 4-18). For the 'warm' period of the year (May–October), an increasing trend in electricity consumption is evident as warmer conditions dominate by 2050 and 2100 (Figure 4-18). Moreover, it is clear that observations lie closer to the levels of consumption typical in the 2021–2050 than in 1961–1990, indicating that a certain degree of increase in electricity consumption levels in the 'warm' period of the year has already occurred by 2009. There are variations among the various examined models, but the signal of increase around 10 % compared to the control period in electricity consumption levels remains. It is evident, from the analysis of both 'cold' and 'warm' period that the electricity increase in the 'warm' period of the year is double the electricity decrease (saving) in the 'cold' period of the year (Giannakopoulos et al. 2016)

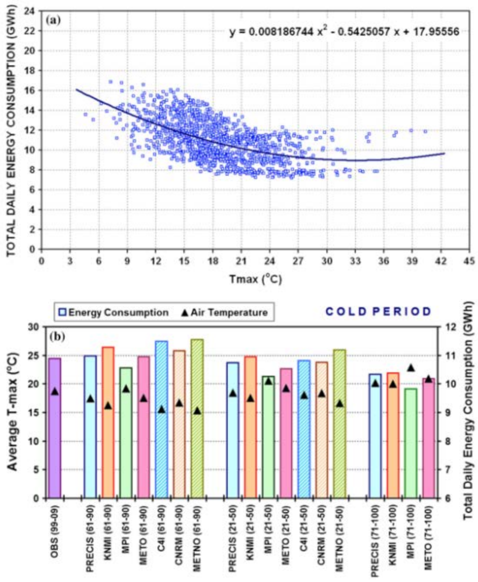

Figure 4-17: a) Relation of daily electricity consumption daily maximum air temperature for the 'cold' period of the year for the period 1999–2009 in Cyprus. b) Cyprus electricity consumption (bars, right axis) and daily maximum air temperature (triangles, left axis) for the 'cold' period of the year for the observations period 1999–2009, the various climate models for the control period 1961–1990 and the future periods 2021–2050 and 2071-2100.

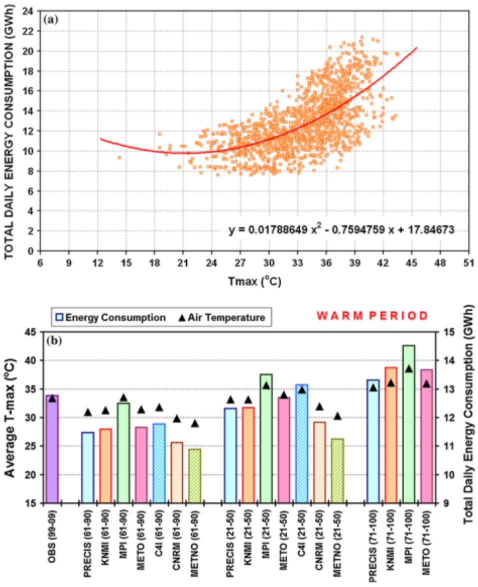

Figure 4-18: similar to Figure 4-17 but for the 'warm' period of the year

4.1.3 Non-climate related pressures

In Cyprus energy consumption has historically been growing in line with national income. After the occurrence of the economic crisis, this trend has been reversed, but fuel shares have remained essentially unchanged. There is a clear electrification trend throughout the economy of Cyprus, which would be even more pronounced if transport (that remains entirely dependent on petroleum) did not account for more than half of total final energy demand. The share of renewable energy – primarily solar thermal installations for water heating – has also risen considerably, from 2.9% in year 2000 to 5.5% in 2013. Primary and final energy intensity have fallen considerably (by more than 25%) during the last two decades. This declining trend implies both energy efficiency improvements and structural changes in the economy (Kitsios et al, 2015).

Over the period 2000-2013, the energy efficiency index for the whole economy (ODEX) decreased (i.e. improved) by 10%. A large part of this improvement came from industry, particularly from installations subject to the Emissions Trading Scheme (ETS) (cement and brick industry). Energy efficiency has also improved in the building sector in recent years, thanks to implementation of the EPBD Directive and due to financial support schemes for refurbishing the existing building stock. The transport sector, which is the largest final energy consumer, contributed the least to energy efficiency improvements (Kitsios et al, 2015).

4.1.4 Adaptation measures

According to Giannakopoulos et al. (2016), the adaptive capacity of the energy sector to changing energy demand was estimated based on the following four parameters:

- Sufficient power supply;
- Energy efficiency measures undertaken or underway;
- Use of solar energy for heating and cooling and renewable energy sources; and
- Introduction of natural gas in the energy supply.

Sufficient Existing power stations

The main adaptive capacity of the energy sector of Cyprus lies in the capacity of supplying the ever increasing demand for electricity, which is partly attributed to economic and development factors as well as to climate change (mainly temperature increase). The follow-up between supply and demand is considered sufficient, as the Electricity Authority of Cyprus (EAC) has developed a plan to guarantee the successful delivery of power in order to meet the increasing demand (increasing the adaptive capacity). Table 4-2 shows the maximum output capacity as well as the peak demand for 2014 and 2015 where is clear the adequacy of the existing power station to meet the peak demand in Cyprus (EAC, 2016). Additionally, Figure 4-19 shows the anticipated peak demand until 2018 where it is expected to be covered by the already installed electricity generation capacity.

Table 4-2: Installed electricity generation capacity and peak demand for 2014 and 2015 in Cyprus (EAC, 2016)

	2014	2015	Change (%)
Installed electricity generation capacity (MW)	1478,0	1478,0	-
Peak demand (MW)	860,0	939,0	+9,2

Energy efficiency measures

Cyprus has established a National Energy Efficiency Action Plan (NEEAP), which involves the implementation of a set of measures for improving energy efficiency until 2020. The indicative intermediate target for 2016 was set at 185,000 tonnes of oil equivalent (toe) (MCIT 2011) in other words 10% energy savings comparing to the energy consumption of the reference year. Additionally, Table 4-3 shows that the largest share of energy savings is represented by the residential sector (87.50 %) and involves measures such as thermal insulation, maintenance and inspection of heating and air-conditioning installations.

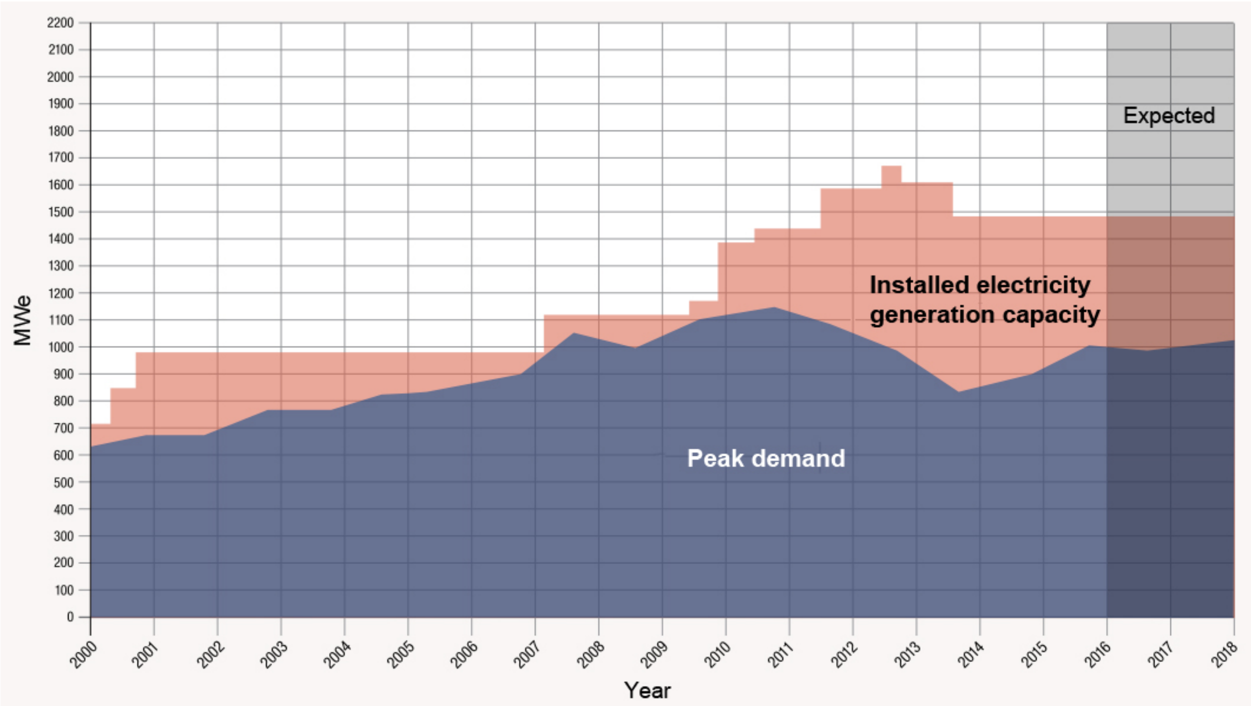

Figure 4-19: Installed electricity generation capacity, peak demand for the period 2000-2016 as well as the expected up to 2018 (EAC, 2016)

Table 4-3: Contribution by sector to the intermediate target for 2016 (MCIT, 2011)

Sector	Contribution to the intermediate target (2016)	
	Toe	%
Residential sector	161,877	87.50
Tertiary sector (public sector, general government and enterprises)	23,681	12.80
Industrial sector	1284	0.69
Transport sector	3909	2.11

Total	**190,751**	**103.1**

Use of solar energy for heating and cooling and RES

In Cyprus, solar thermal systems are widely used for generating hot water, while photovoltaic systems are increasingly used at household level therefore reducing the pressure on the energy supply sector. In addition within the framework of Directive 2009/28/EC, Cyprus' overall target is to increase 13 % the contribution from renewable energy sources (RES) in the final use of energy by 2020 (MCIT, 2010). Other sub-objectives concerning Cyprus 2020 renewable energy plan are:

- **Heating and cooling:** 23.5% of heat consumption met by renewable sources;
- **Electricity:** 16% of electricity demand met by electricity generated from renewable energy sources;
- **Transport:** 5% of energy demand met by renewable energy sources.

Natural gas introduction

On the 28th of December 2011 Noble Energy announced the discovery of natural gas at the Cyprus Block 12 prospect, offshore the Republic of Cyprus as a result of the 1st licensing round for hydrocarbon exploration in its EEZ. The Cyprus A-1 well encountered approximately 310 feet of net natural gas pay in multiple high-quality Miocene sand intervals. The discovery well was drilled to a depth of 19,225 feet in water depth of about 5,540 feet. Results from drilling, formation logs and initial evaluation work indicate an estimated gross resource range of 5 to 8 trillion cubic feet (Tcf), with a gross mean of 7 Tcf. The Cyprus Block 12 field covers approximately 40 square miles and will require additional appraisal drilling prior to development.

The discovery of indigenous gas reserves is anticipated to lead to a redesign of the gas sector structure in Cyprus and revisions of policies, political decisions and schedules would have to be done.

Since after the discovery of the natural gas field, there have been changes in the policy of the Republic of Cyprus. More particularly, even if it was initially considered to transport the natural gas to the onshore receiver terminal at Vasilikos in liquefied form, it is unclear whether this option comprises an alternative today or not.

The natural gas demand is projected to increase as shown in Figure 4-20. It is expected that the introduction of natural gas in the energy mix will provide a diversified, safer energy profile for Cyprus and that will gradually be used in the electricity production, industry and household sector making the energy sector less sensitive to increasing energy demand patterns (CYPADAPT, 2014b).

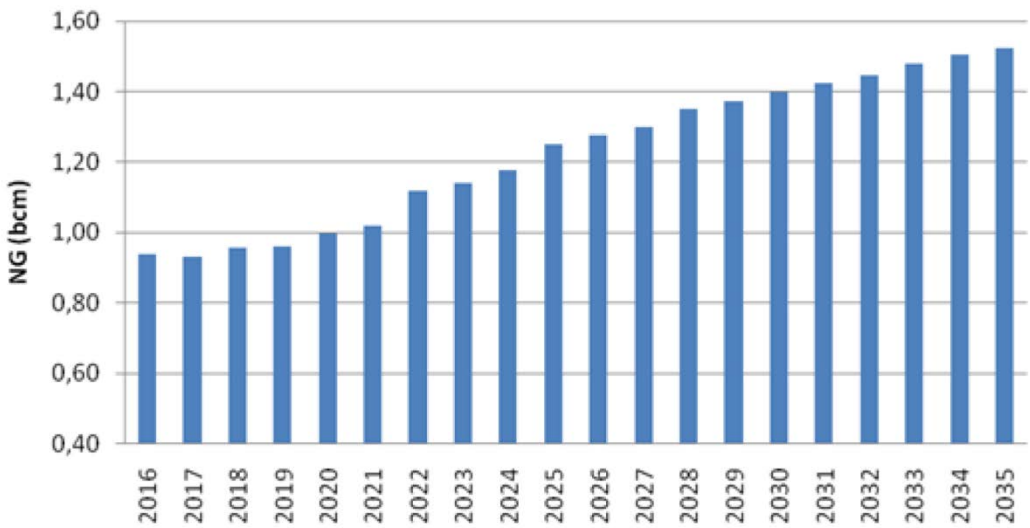

Figure 4-20: Projected natural gas demand between 2016 and 2035

4.2 Greece

4.2.1 Existing situation

Energy supply

Around 61% of Greece's energy needs are covered through imports with the remaining 39% being covered through national energy sources, mainly lignite (77%) and RES (22%). Imported energy sources are mainly petroleum products that account for 44% of total energy consumption and natural gas with a share of around 13%.

According to the Greek Electricity Market Operator (LAGIE), the total installed capacity in the Greek interconnected system at the end of 2016 accounted for almost 16,615 MW, including 3,912 MW lignite, 4,658 MW natural gas, 3,173 MW large hydro-power and 4,873 MW RES. The total electricity generation in the Greek interconnected system for the year 2016 amounted to almost 41.6 TWh. An additional 10.7 TWh of electricity was imported and 2.2 TWh were exported. Lignite accounted for 23.55% of the installed capacity in the interconnected system, natural gas for 28.4%, hydro-power for 19.10% and RES for 29.33%.

According to the Hellenic Electricity Distribution Network Operator (HEDNO), on the non-interconnected islands (NIIs), the diesel-driven generators' production was 3,604 GWh by December 2016. The renewable energy share in the electricity mix of the NII was 21.8%, corresponding to a production of 1,003 GWh and an installed capacity of 482.3 MW.

Energy demand

Figure 4-21 illustrates the trend of total electricity demand as well as the peak demand in Greece for the period 2000 – 2015. It is shown that between 2000 and 2008 there was a steady increase in total demand. Since then, as a result of the economic crisis there has been a steady decline, with the exception of 2015 where consumption was roughly 50.1 TWh (ADMIE, 2016).

In addition, Figure 4-21 shows the efficiency of the system to cover the peak demand within the period of interest

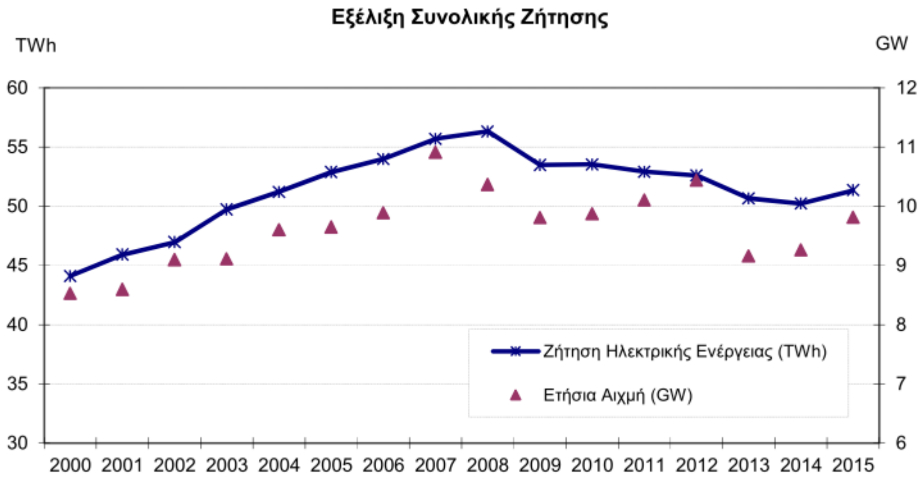

Figure 4-21: Trend of total electricity demand and peak demand in Greece for the period 2000 – 2015 (ADMIE, 2016)

Renewable energy in Greece

A national target of a 20% RES share in gross final energy consumption by 2020 has been defined under Law 3851/2010, exceeding the national target of 18% according to the EU Directive 2009/28/EC. The specific trajectory for achieving this target is presented in the National Renewable Energy Action Plan (NREAP) of 2010. Specific targets for RES electricity share (40%), RES heating and cooling share (20%), and RES transport share (10%) have been defined in order to achieve the national RES target until 2020. The overall target is therefore supposed to be achieved through a combination of measures for energy efficiency and the large-scale penetration of RES technologies in electricity production, heat supply and transport sector.

Solar Energy

Solar energy is playing an increasingly important part in the energy mix of Greece. The country has high levels of solar irradiation with an average global horizontal irradiation level of more than 1,500 kWh/m^2. With around 4.1 million m2 (2.9 GWth) of solar thermal systems installed, Greece has the second largest total capacity in Europe after Germany. It also has the third largest per capita ratio of installed collector surface after Cyprus and Austria. Around 243 000 m^2 (170.1 MWth) of solar thermal systems have been installed in 2012. The Greek market mostly consists of individual solar water heaters of the thermosiphon type. There is still a significant potential for larger solar thermal systems in the tertiary sector and in industry.

There has only been a marginal increase of 1 MW in the installed solar PV capacity in 2016 compared to the figures at the end of 2015. The total installed solar PV capacity by the end of 2016 accounted for 2,605 MWp, out of which 375 MW of small PV systems below 10 kWp have been installed under the Special Photovoltaic Rooftop Programme. During the year 2016, a total of 3,417 GWh was produced by solar PV which thus became the third most important RES in terms of generation (after large hydro-power and wind power), producing 25.4% of RES electricity and 6% of total electricity in Greece. A total of 512 GWh was produced by PV systems on rooftops which have been installed under the Special Photovoltaic Rooftop Programme.

Wind Energy

Greece has some of the most attractive sites for the use of wind energy in Europe, with average capacity factors of around 25% for the mainland and 30% for the islands. The economic wind energy potential in Greece is estimated at 10,000-12,000 MW.

The national capacity target for wind energy is 7,500 MW until 2020, including 300 MW of offshore wind energy. The installed capacity for wind energy has increased by 279 MW or almost 13.3% in 2016 compared to the figures at the end of 2015, making 2016 the second best year for the Greek wind energy sector in terms of new installations. In particular, a total capacity of 2,370 MW of wind parks was installed in Greece by December 2016 compared to 2,091 MW installed by the end of 2015. Of this, a total capacity of 323 MW of wind turbines has been installed on the NIIs, out of which almost 62% on Crete. The electricity generation from wind energy during 2016 was of 5,145 GWh, compared to 4,621 GWh by December 2015. In 2016, wind energy took the second place among RES in terms of total electricity generation, accounting for 38.3% of RES electricity and 9% of total electricity generation in Greece.

Small hydro-power

By December 2016, there has been an installed capacity of 223 MW of small hydro-power (SHP) plants in Greece. By definition, these are hydro-power stations with a capacity less than 15 MW. As all SHP plants are of the run-of-river type, most of their generation takes place during the wet season (winter and spring). There are 105 SHP projects in operation, mostly located in Epirus, Macedonia and Peloponnese. Only one SHP plant with a capacity of 300 kW is installed on the non-interconnected islands. SHP plants produced a total of 721 GWh in 2016 and generated around 5.4% of RES electricity and 1.3% of total electricity in Greece during this year.

Biomass

There are only few biomass energy projects that have been developed in Greece, mainly for the utilization of municipal wastes. The total installed capacity of biomass energy currently stands at 58 MW for a total of 12 individual projects. During 2016, biomass capacities of 6 MW have been added. There are no biomass projects installed on the non-interconnected islands. Throughout 2016, a total of 252 GWh of electricity was produced by biomass energy plants.

4.2.2 Observed and expected impacts

It is well known that peak and total electricity demand in a city depends highly on the ambient temperature levels (Santamouris & Kolokotsa, 2015). Giannakopoulos and Psiloglou (2006) found that the relation between energy demand and temperature is non-linear and that the optimum ambient temperature for low levels of energy demand is 22°C. Around this temperature, there exists an area where energy consumption shows no sensitivity to air temperature. Outside this area, energy consumption increases with an increase (due to air conditioning needs) or decrease (due to extra heating needs) of air temperature (Giannakopoulos and Psiloglou, 2006).

Analysis of the sensitivity of the electricity demand in Athens during the summer period as a result of ambient temperature increase was also performed by Santamouris et al. (2015). It was found that the increase of the total electricity demand in Athens per degree of temperature increase above 22 °C, was 4.1% of the basic electricity load, which was among the highest percentage increases reported in literature. It is pointed out that the corresponding increase for the whole country is 1.1%.

The changes in the energy consumption of urban buildings due to the impacts of urban warming were assessed by Santamouris et al. (2001). Hourly data for the year 1996, obtained from 30 stations in and around the city, were used to calculate the energy consumption of a typical office building in Athens. It was concluded that the monthly load for cooling in urban areas was about 120% higher than in the reference suburban zones. In addition, the load for heating was reduced by about 38%. Also, the peak electricity demand of the urban building was almost doubled due to urban heat island, from 13.7 kW/m^2 to 27.5 kW/m^2.

Additionally, Kapsomenakis et al. (2013) analyzed 40 year of hourly data series from nine meteorological stations in Greece in order to understand the impact of air temperature and relative humidity trends on the energy consumption of a typical office building in Greece. They found that the heating load in the Greek building sector from 1970 to 2010 has decreased by about 1 kWh/m^2 per decade, while the cooling load increased by about 5 kWh/m^2 per decade. As regard Athens, they estimated that the annual heating load has been reduced of about 20% while the annual cooling load has been increased of about 25% (Figure 4-22)

As regards climate change impacts on energy sector in Greece in 21st century, Asimakopoulos et al. (2012) projected the energy demand of the building sector in Greece by calculating energy consumption, using output data from regional climate models in different IPCC scenarios (A2, B2, A1B) up to 2100. In general, this study concluded that the energy demand of the building sector in Greece for heating is expected to decrease by about 50% while the respective energy demand for cooling is expected to increase as much as 248% until 2100. As regards Athens, the study shown that the reduction of thermal energy needs for the near future period, 2041-2050, is estimated to about 22% (A1B scenario) in relation to the current levels, while for the distant future period, 2091-2100 is estimated to about 37% in B2 scenario, 43% in A1B scenario and 55% in A2 scenario (Figure 4-23). As far as cooling energy needs are concerned, Figure 4-23 depicting that for the near future period the increase is expected to about 60% over the current situation in A1B scenario, while for the distant future period the increase is anticipated to about 96%, 112% and 156% in B2, A1B and A2 scenarios respectively.

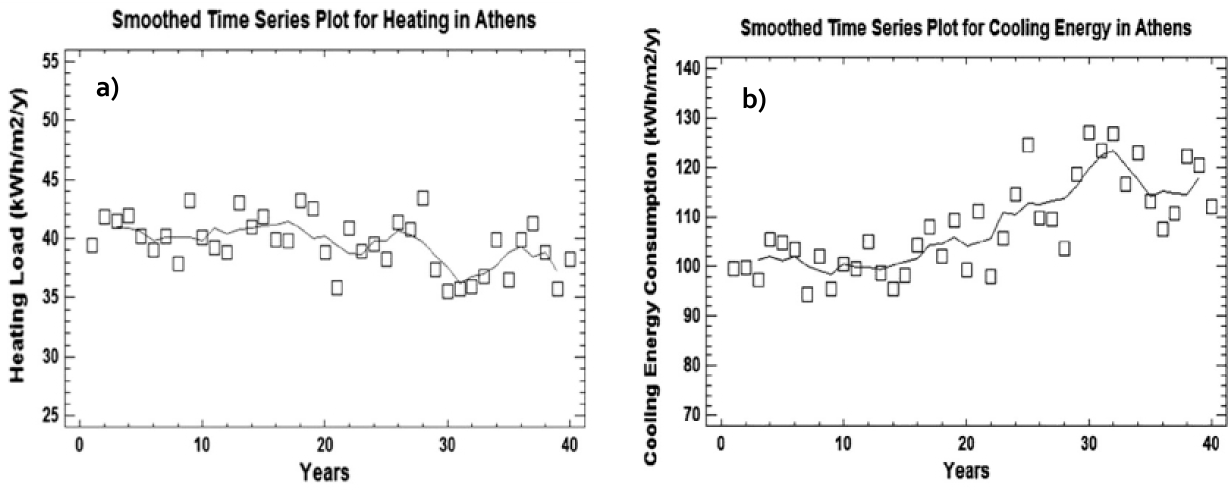

Figure 4-22: Annual variation of the heating (a) and cooling (b) load in Athens, (Kapsomenakis et al., 2013)

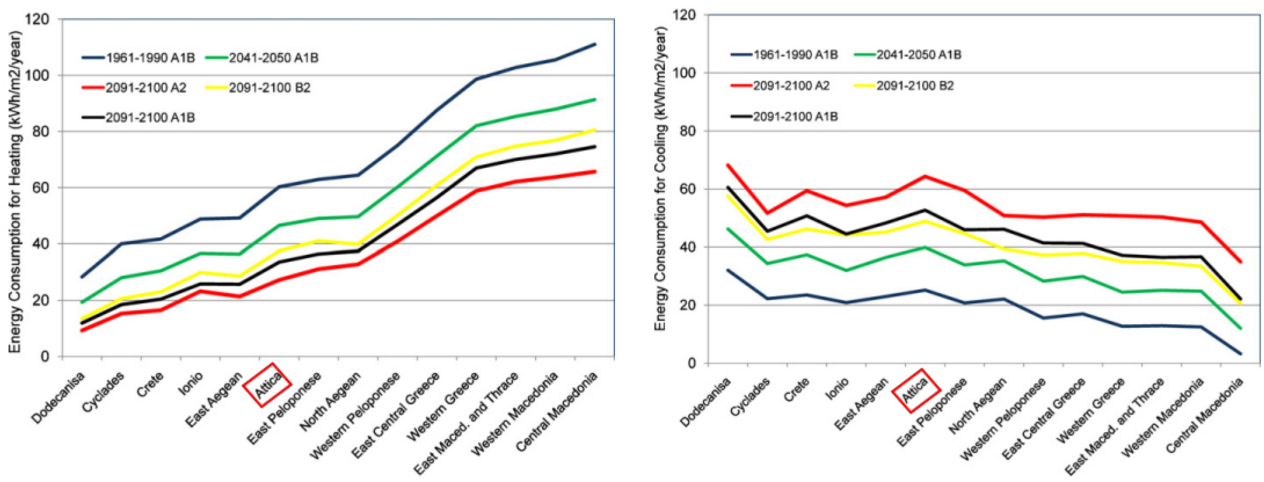

Figure 4-23: Variation of the energy demand for heating (a) and cooling (b) a conventional housing for near and distant future using three IPCC scenarios (Asimakopoulos et al. 2012)

Additionally, Asimakopoulos et al. (2012) calculated the degree-hours for air conditioning for near and distant future. As for Athens, the results are depicted in Figure 4-24. It is shown that for the period 2041-2050 the increase in degree-hours for cooling is expected about 100% over the current situation in A1B scenario, while in the distant future (2091-2100) the respective increase is expected about 200%, 277% and 327% in B2, A1B and A2 scenarios respectively.

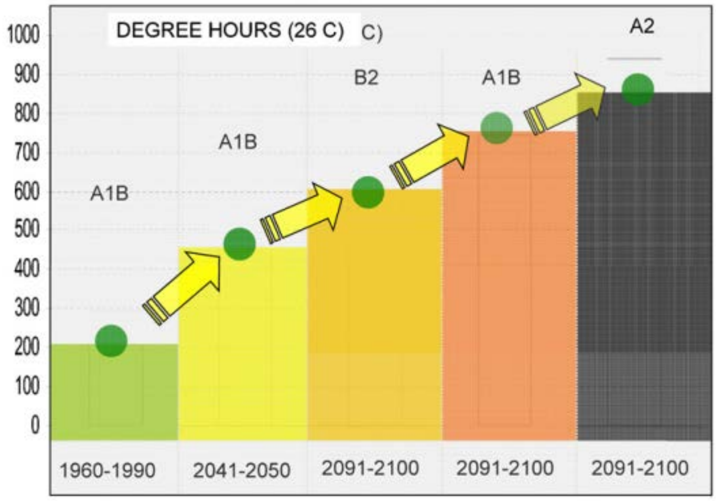

Figure 4-24: Change in degree-hours with a base of 26 °C in the region of Attica for all climatic scenarios and two future period (near and distant) (Asimakopoulos et al. 2012)

CDD and HDD are also presented in the following Figures for the case of municipality of Peristeri where the meteorological data from Thissio station (National Observatory of Athens) were used for the period between 1985 and 2014. Figure 4-25 shows the decreasing trend of HDD from 1985 to 2014, about 3 heating Degree-Days per decade. On the other hand, Figure 4-26 presents the increasing trend of the cooling Degree-Days for the same period. Energy demand for cooling has increased about 7 CCDs in 2014 compared to 1985.

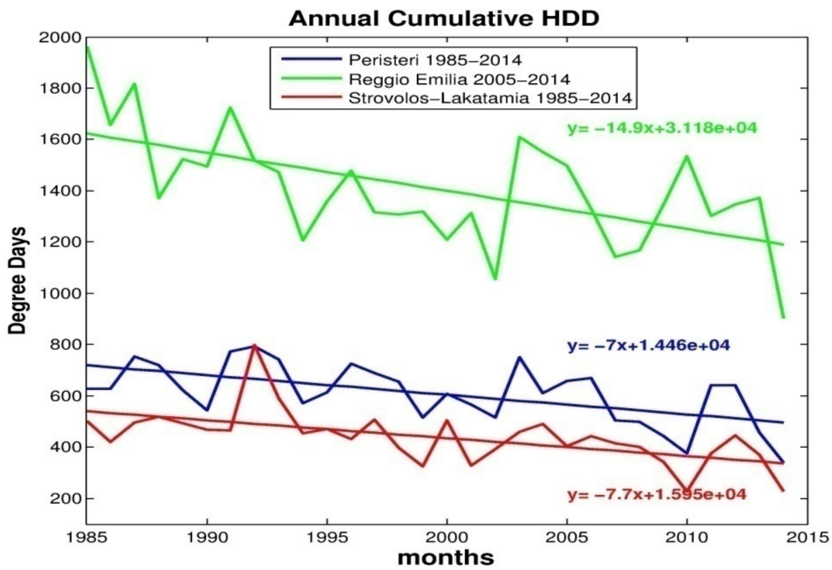

Figure 4-25: Observed changes in heating degree days between 1985 and 2014 for the municipality of Peristeri (blue line). Station: Thissio

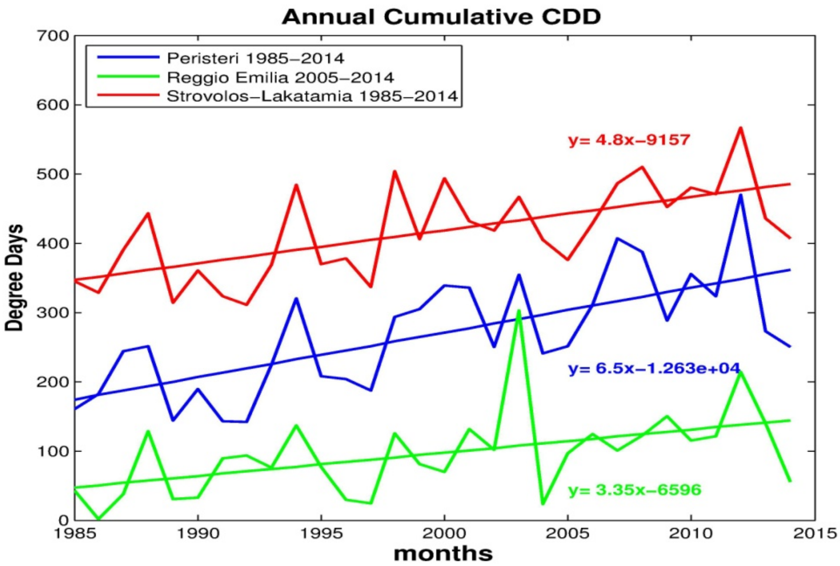

Figure 4-26: Observed changes in heating degree days between 1985 and 2014 for the municipality of Peristeri (blue line). Station: Thissio

4.2.3 Non-climate related pressures

Santamouris et al. (2013) analyzed the relation between the economic crisis and energy consumption in Greece. They investigated the energy consumption of 598 Greek household (466 in Attica Region) in 2010-2012. The results showed that poorer households had less income and lined in less energy efficient dwellings. Comparing the 2010–11 winter to the harsher winter of 2011–12 showed that inhabitants consumed less energy during the winter of 2011–12 because of the rapid economic degradation. Important conclusions were drawn regarding the energy consumption of the households which during the harsh winter 2011–12 was 37% less than expected. Also, the analysis revealed that 2% of high-income households and 14% of low-income households were below the fuel poverty threshold. The term fuel poverty has been used since the early 1980s and was defined by in 1991 as the difficulty or even inability of a family to afford the funds for proper heating at home.

4.2.4 Adaptation measures

As is known, most of the greenhouse gas emissions are carbon dioxide emitted from combustion of fossil fuels for energy purposes. In Greece, the area with the highest carbon dioxide emissions is electricity generation due to the combustion of lignite.

Climate change mitigation policies aimed to drastically reduce greenhouse gas emissions and are therefore primarily concerned with the energy sector. This would obviously aim to reduce the use of lignite in electricity generation and increase non-CO2-emitting forms of energy such as Renewable Energy Sources.

The analysis of mitigation and therefore emission reduction policies is not included in this text as it does not concern adaptation policies.

For analytical purposes, it is assumed that no mitigation policy applies or at least a policy of drastic reduction of emissions is not implemented. Therefore, in the context of adaptation policy, it is a matter of protecting certain energy facilities such as lignite stations and mines, although if a policy of drastic reduction in emissions were to be pursued, their use would be significantly reduced.

In the context of a holistic approach to the issue, a mixed adaptation and mitigation policy will be followed in practice. Then the protection of certain energy installations may not be need at least to the extent foreseen in the context of a purely adaptation policy. The analysis of combined policies is beyond the scope of the present text.

From the Greek National Adaptation Strategy to Climate Change (Bank of Greece, 2016), the adaptation measures which are proposed concerning the energy sector are classified as follows:

Action 1. Protection of the main energy infrastructures

Measure 1.1 Specific vulnerability study for existing electricity transmission / distribution networks and high voltage centers and development of investment programs in protection projects.

Measure 1.2 Examine the necessity of modifying programs of ADMIE (The Independent Power Transmission Operator of Greece) and DEDDIE (Hellenic Electricity Distribution Network Operator) for future network projects to be proactively protected, and develop a network infrastructure migration program, if required.

Measure 1.3 Specific study of the vulnerability of natural gas installations, including Revythoussa, and elaboration of a program of investments in protection projects.

Measure 1.4 Consider the need to modify DESFA (The National Natural Gas System Operator) programs for future gas projects to be proactively protected.

Measure 1.5 A specific study on the vulnerability of refineries and oil storage facilities, and the development of a program of investment in protection projects that may be required.

Measure 1.6 Examine the need to amend regulations on petroleum product safety stocks so that the storage system is preventively protected.

Action 2. Projects for the protection of coastal energy and island systems.

Measure 2.1 Specific vulnerability study for existing networks and power plants in non-interconnected islands and preparation of a program of investment in protection projects that may be required. Similarly for islands interconnection networks.

Measure 2.2 Examination of the need to modify the DEDDIE programs for non-interconnected islands so that future electricity infrastructures (units, island and islands interconnections) are preventively protected.

Measure 2.3 A specific vulnerability study for existing offshore power plants using seawater for cooling purposes, and an investment program for their protection projects.

Measure 2.4 Consideration of the necessity to amend a licensing regulation for power plants and modify existing permits so that coastal units would be preventively protected.

Action 3. Expansion and protection of water resources

Measure 3.1 A special study on the vulnerability of hydroelectric units and if need it, a development of water protection programs in conjunction with the obligations of these units for irrigation.

Measure 3.2 Specific study of the vulnerability of power plants that are cooled by installations with water resources and, if necessary, the elaboration of programs for the protection of these resources.

Action 4. Research and Development.

Measure 4.1 Research on cooling technologies for high performance heat units with regard to water resources.

Measure 4.2 Smart networks and demand management to mitigate the effects of increased electricity demand due to temperature increases.

Measure 4.3 Modern methods of protecting networks from extreme weather events.

Action 5. Horizontal and coordinated actions.

Measure 5.1 Incorporating preventive protection measures for the siting of energy projects (thermal units, RES units, natural gas infrastructure and oil infrastructure) and electricity networks. Preventive measures will address the avoidance of the implementation of an energy project in locations with a high vulnerability to climate change, such as coastal areas, flood risk areas and vulnerable areas to extreme weather events.

Measure 5.2 Coordination of energy measures with agriculture, water resources and interventions in the built environment.

Measure 5.3 Public and/or private investment programs for the protection of energy facilities

In the municipality level, Peristeri has not implemented yet an adaptation plant to climate change, however, the Municipality Operational Plan for the period 2015-2019 (Municipality of Peristeri, 2016) defines a series of actions and policies which may not have been developed for the purpose of adaptation to climate change, but are indirectly contributing to the reduction of vulnerability and subsequently, to adaptation of energy sector. In general these actions aimed to energy saving as well as to reducing the heat island effect which associated with the increased energy demand and the discomfort levels of the residents. Such actions are:

General Actions

1. Participation in the Environmental Association of Municipalities of Athens – Pireaus (PESYDAP).

Participation of the Municipality in PESYDAP for the protection of Mount Pikilo as well as the exploitation of its solar energy potential, etc.

2. Programmatic study for the assessment of actions aimed to the energy optimization.

Environmental protection and cost reduction of energy needs.

3. Energy saving information program.

Organizing and implementing citizens' rising awareness programs for energy-saving ways.

Urban Regeneration

4. Reformation of free spaces of the Chorafa area with bioclimatic design

Greening of the area, special bioclimatic study for its holistic reorganization. Enhancement of the infrastructures of the area

5. Bioclimatic regeneration of a wider area of 1st Playground

Reconstruction of a wider area of 1st Playground with the aim of improving environmental conditions.

6. Electrical interventions in communal areas

Improving security and lighting in communal areas, saving energy.

7. Reconstruction of Sophocles Venizelou Street of the Municipality of Peristeri

Bioclimatic regeneration of a central road axis

The objective of the Municipality of Peristeri, concerning the urban regeneration projects is to implemented ten (10) projects until 2019.

Installation of alternative energy sources in public buildings

8. Study of the installation of alternative energy sources.

Placement of alternative energy sources into municipal buildings, as well as pilot installation in selected building blocks.

The objective of this action, which is derived from the Operation Plan of the Municipality of Peristeri, is to implement five (5) project regarding placements of alternative energy sources into municipal buildings until 2019

Energy upgrading of municipal buildings

9. Formation of a green roof in the City Hall of the Municipality of Peristeri.

The creation of new green spaces helps both the energy upgrading of the building and the improvement of the quality of life of the residents

10. Energy upgrade program for public buildings.

Energy upgrading of public buildings. The objective of this action, which is derived from the Operation Plan of the Municipality of Peristeri, is to upgrade 6 public building until 2019

11. Formation of a green roof at the 11th high school of the Municipality of Peristeri.

Energy saving, aesthetic upgrading.

12. Formation of a green roof at the 13th secondary school of the Municipality of Peristeri.

Energy saving, aesthetic upgrading.

13. Formation of a green roof at the 16th secondary school of the Municipality of Peristeri.

Energy saving, aesthetic upgrading.

The objective of the Municipality of Peristeri plan regarding energy upgrading of municipal buildings is to upgrade six (6) building until 2019.

4.3 Italy

4.3.1 Existing situation

In 2014, Italy's gross inland energy consumption amounted to 151,03 Mtoe where the 23% was Italy's production and the rest was imported. Figure 4-27 depicts Italy's energy production and Figure 4-28 illustrates the net imports for 2014. 40% of gross energy consumption was derived from crude oil (60,14 Mtoe) and another 33,6% came from gas which holds second place in the energy mix (50,71 Mtoe), followed by hard coal which represents 8% of consumption (12,42 Mtoe) (EU, 2016). Figure 4-29 presents the gross inland energy consumption in 2014. Regarding final energy consumption, in 2014 it was 113,35 Mtoe (Figure 4-30) while Transport sector was the highest consumer follows by Households, Industry and Services (Figure 4-31).

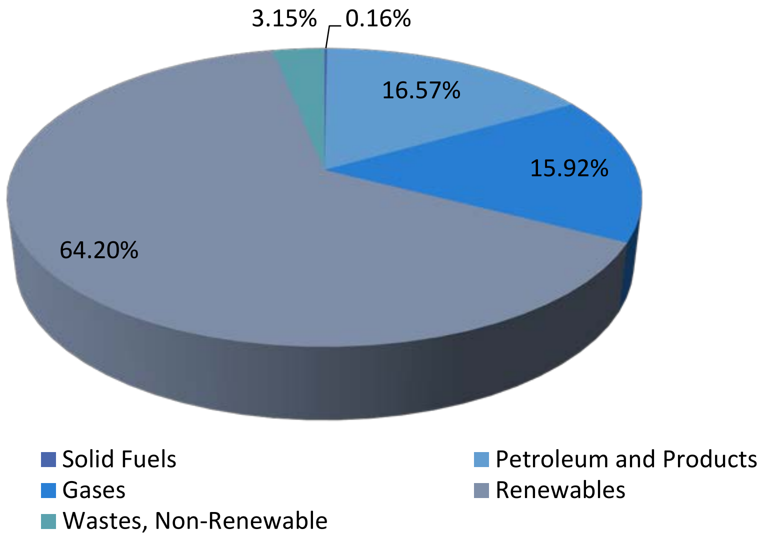

Figure 4-27: Energy production in Italy, 2014 (36,81 Mtoe)

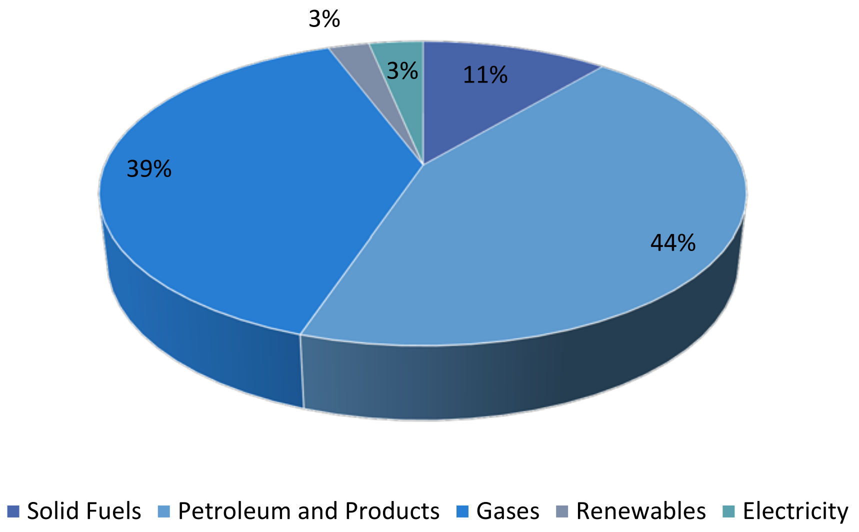

Figure 4-28: Net imports in Italy, 2014 (116,12 Mtoe)

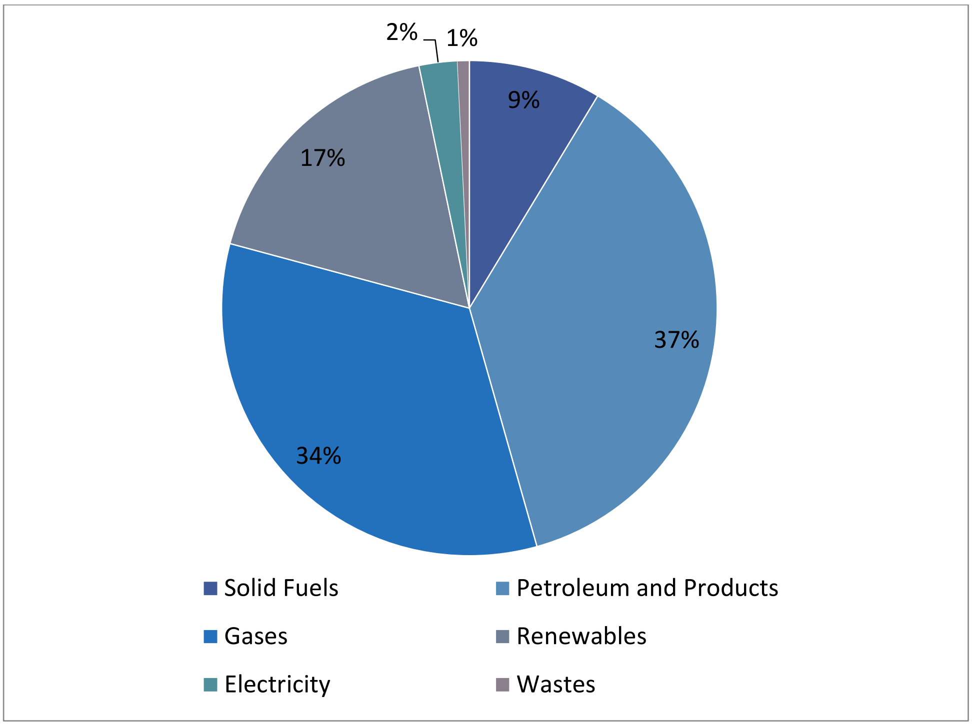

Figure 4-29: Gross inland energy consumption inItaly, 2014 (151 Mtoe)

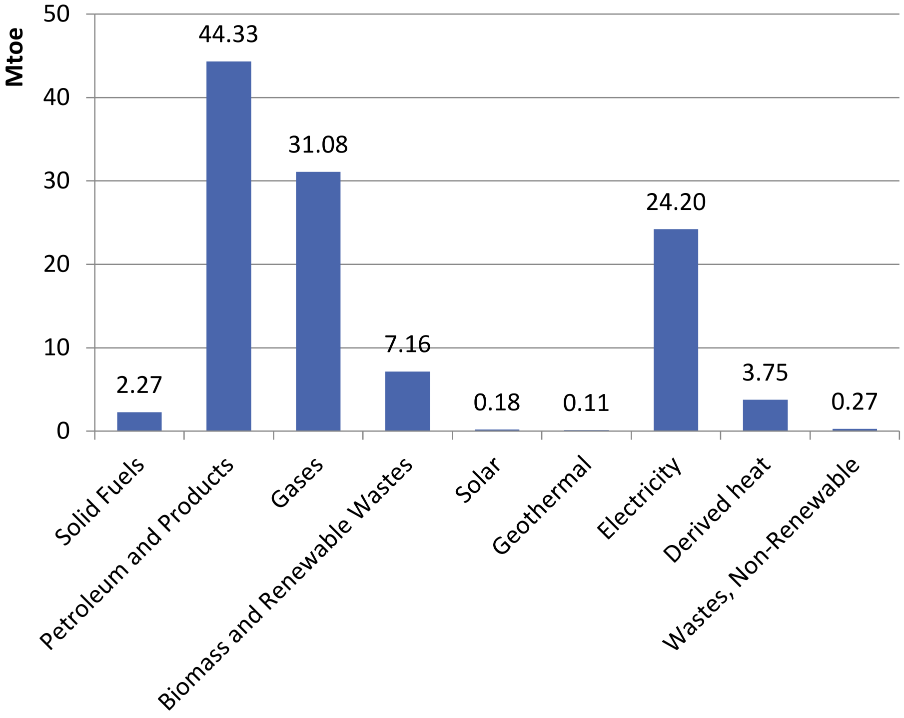

Figure 4-30: Final Energy Consumption by Fuel/Product in Italy, 2014 (113,35 Mtoe)

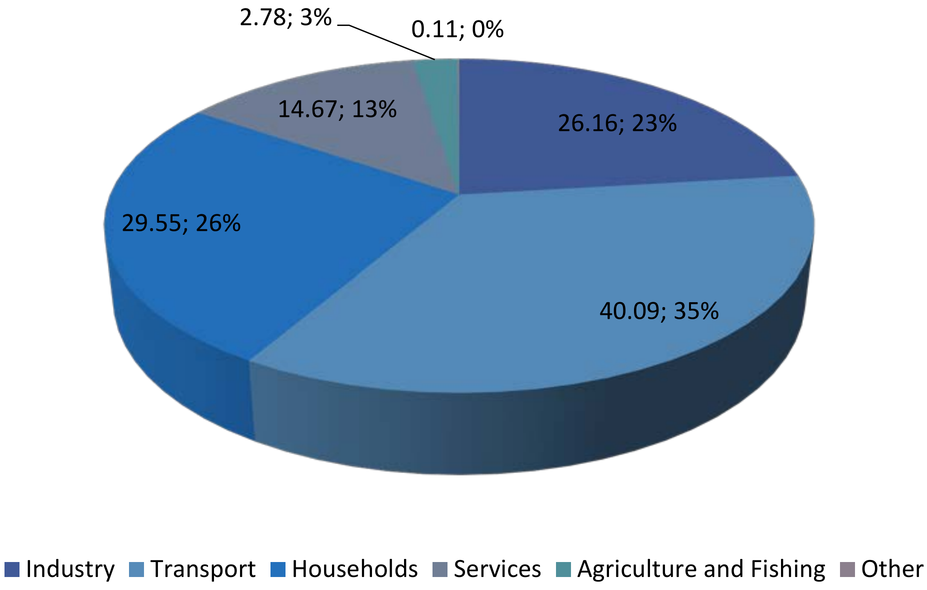

Figure 4-31: Final energy consumption by sector in Italy, 2014

4.3.2 Observed and expected impacts

Climate changes are becoming ever more evident: heatwaves and droughts, flooding and desertification, melting glaciers and permafrost are extensively observed in the world and are causing serious impacts with enormous economic, environmental and social costs (EEA Report N° 12/2012). In energy sector gradual changes in the climate and extreme weather events are likely to have adverse effects on the resilience of electricity networks and can potentially lead to interruptions of the power supply and cause extensive blackouts. The infrastructures identified as vulnerable to long-term climate impacts are:

1. Fossil power generation because of the loss of efficiency due to increased temperatures.

2. Hydroelectric generation due to a reduce water supply if periods of drought increase.

3. Renewable power generation due to increased storminess.

4. Energy distribution system as the capacity of distribution network is reduced if temperatures and precipitation storminess increase.

Beside energy supply, power demand also is linked to several weather variables, particularly to daily temperature. To examine the observed impacts of climate change on energy demand, the heating (HDD) and cooling (CDD) degree days was calculated using climatic data from the meteorological station "Ex Tribunale" in the city center of Reggio Emilia. Figure 4-32 shows the decreasing trend of HDD from 1985 to 2014, about 150 degree-days of heating per decade (green line). On the other hand, Figure 4-33 presents the increasing trend of the cooling Degree-Days for the same period which is about 33 additional degree-days per decade (green line).

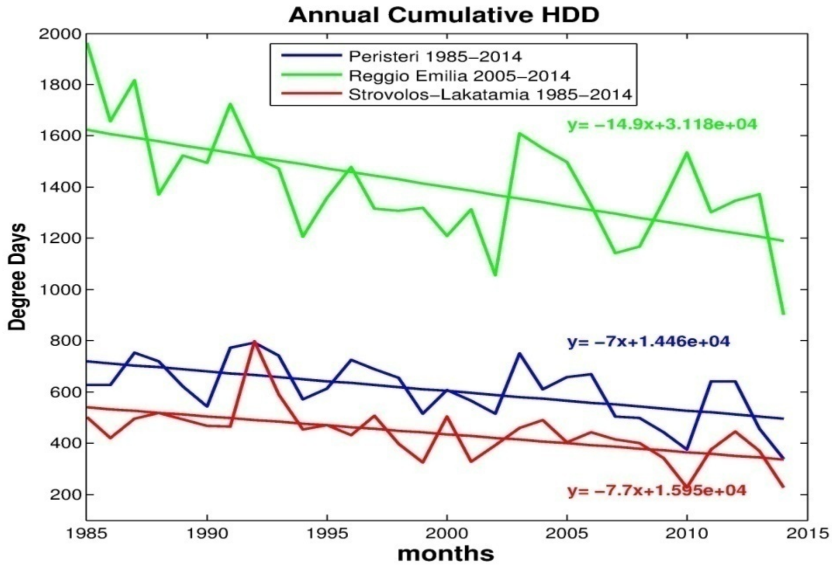

Figure 4-32: Observed changes in heating degree days between 1985 and 2014 for the municipality of Reggio Emilia (green line). Station: Ex Tribunale

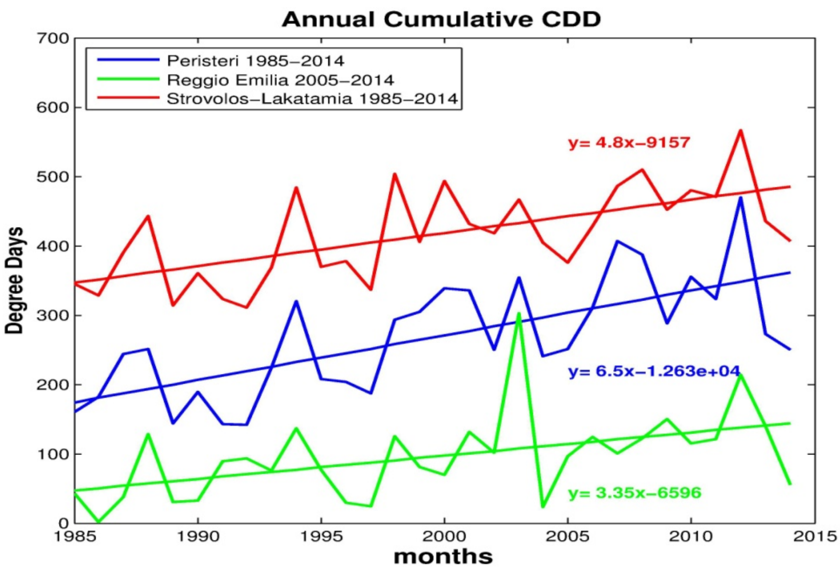

Figure 4-33: Observed changes in heating degree days between 1985 and 2014 for the municipality of Reggio Emilia (green line). Station: Ex Tribunale

To investigate future impacts on climate change on energy requirements, future projections of heating degree days (HDD) and cooling degree days (CDD) for the period 2021-2050 where performed, within the framework of ENSEMBLES Project (http://www.ensembles-eu.org). The results showed that HDD decrease substantially and CDD increase everywhere (Figure 4-34), especially in the Po Valley and in the Southern of Italy mainly during summer. This change can potentially shift the peak in energy demand to summer season with implications for the need for additional energy capacity and increased stress on water resources.

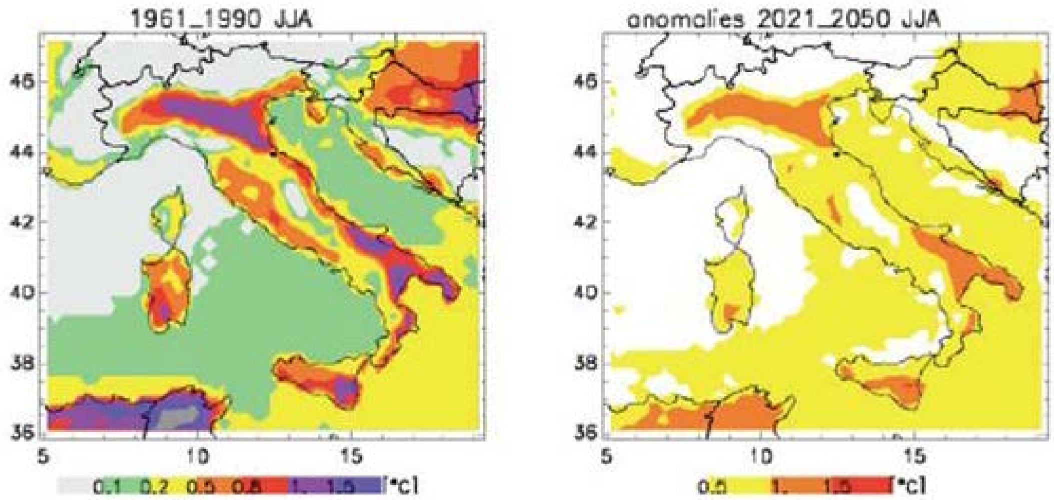

Figure 4-34: Summer CDD in reference scenario (left-hand panel) and CDD anomalies projected by 2021-2050 (right-hand panel)

Giannakopoulos et al. (2009a) also investigated the future impacts of climate change on energy requirements in the Mediterranean using the concept of degree days. The analysis was based on daily temperature outputs from several regional climate models run using the A1B emissions scenario. The reference period was selected the 1961-1990 while the future was the 2021-2050. As regards energy demand for cooling, Figure 4-35 depicts the changes of summer cumulative CDD between future and control period. It is shown that in the near future, energy demand for cooling in the municipality of Reggio Emilia, is expected to increase of about 120 degree-days during summer. In addition, Figure 4-36 shows the changes of number of days needed to cool more than 5°C (heavy cooling) between future and control period. It is clear that in the municipality of Reggio Emilia is anticipated 10-15 more days of heavy cooling in the near future (Giannakopoulos et al. 2009a).

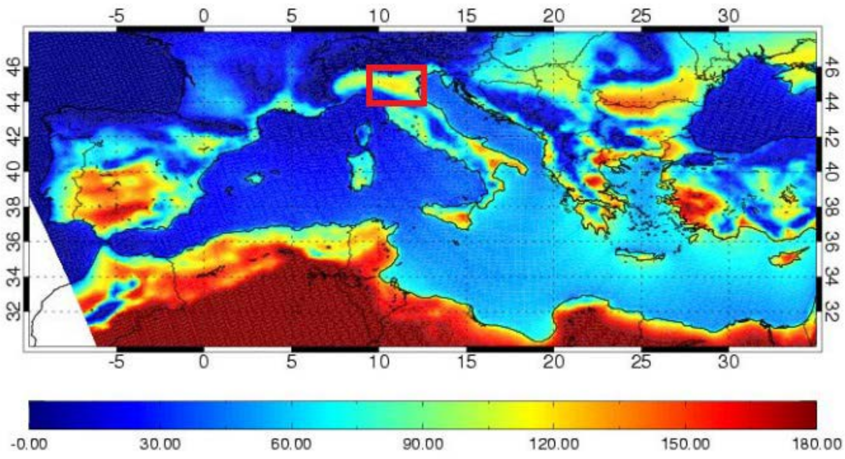

Figure 4-35: Changes in summer cumulative CDD between future and control period (Giannakopoulos et al. 2009a)

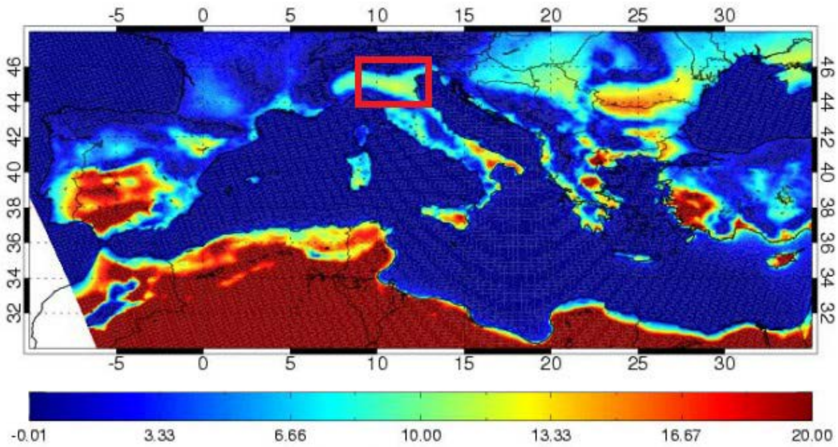

Figure 4-36: Changes in the number of days with high CDD (CDD>5) between future and control period (Giannakopoulos et al. 2009a)

Additionally, regarding heating energy requirements Figure 4-37 shows that in the area of municipality of Reggio Emilia is expected a decrease of about 130 degree-days of heating in the near future compared to the present day climate. Also, Figure 4-38 illustrates the changes in the number of days needed to heat more than 5 °C. Similarly, the municipality of Reggio Emilia presents a decrease of about 20 degree-days of heavy heating in the near future compared to current situation.

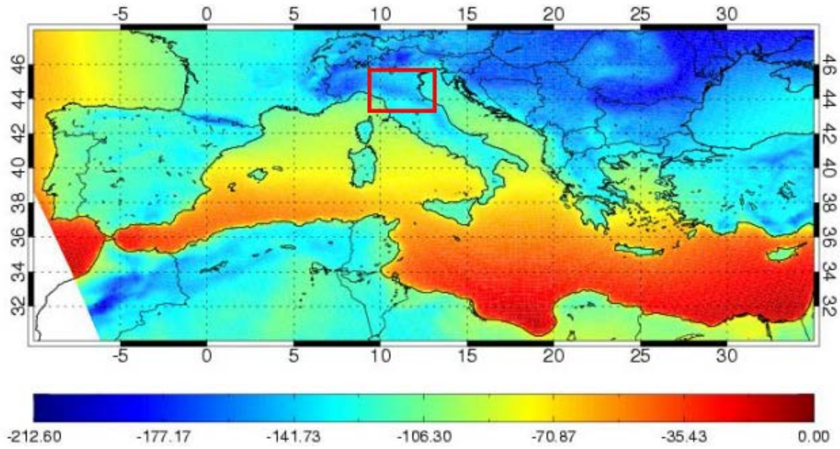

Figure 4-37: Changes in winter cumulative HDD between future and control period (Giannakopoulos et al. 2009a)

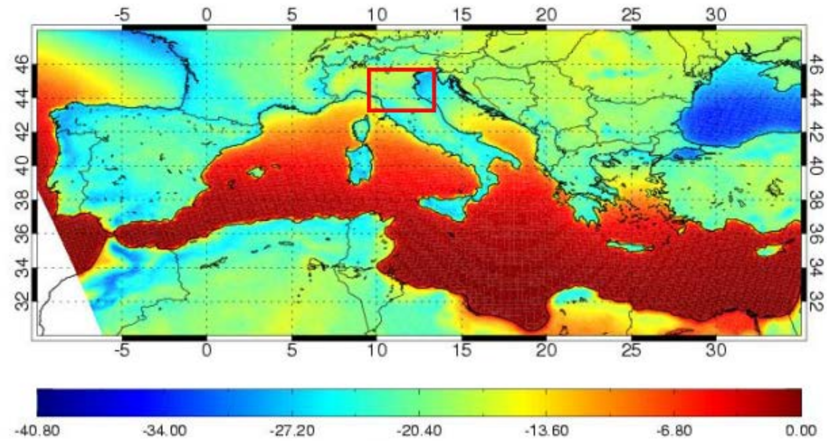

Figure 4-38: Changes in the number of days with high HDD (HDD>5) between future and control period (Giannakopoulos et al. 2009a)

4.3.3 Non-climate related pressures

Italians consume less energy than average Europeans (2,48 toe, including 4631 kWh of electricity per capita compared to 5,34 toe and 5338 kWh for the EU in 2014). This is due to several factors, such as relatively high power prices (third among EU28 for domestic consumers and first among EU28 for industrial consumers during 2015) (Figure 4-39 & Figure 4-40) and the legacy of the economic crisis, which saw electricity demand in the industrial sector fall by 16,3% between 2010 and 2014. In 2012-2013 overall electricity demand reached its record low since the market was first liberalized at the beginning of the century (Deloitte, 2015) and continues to fall in 2014 and 2015 (Figure 4-40). Additionally, energy demand in household sector decreased by 16,5% in 2014 compared to 2010.

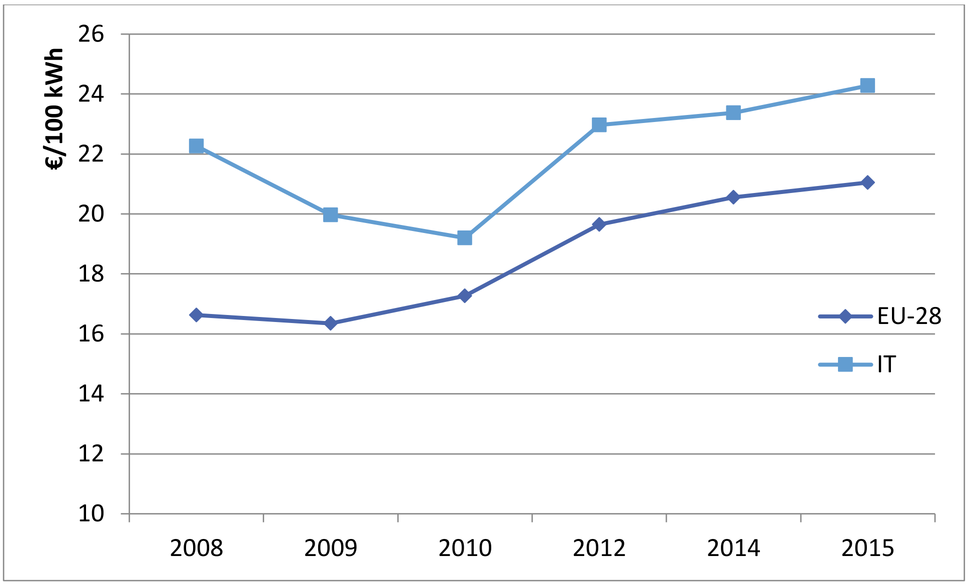

Figure 4-39: Fuel Prices for domestic consumers for electricity (€/100kWh)

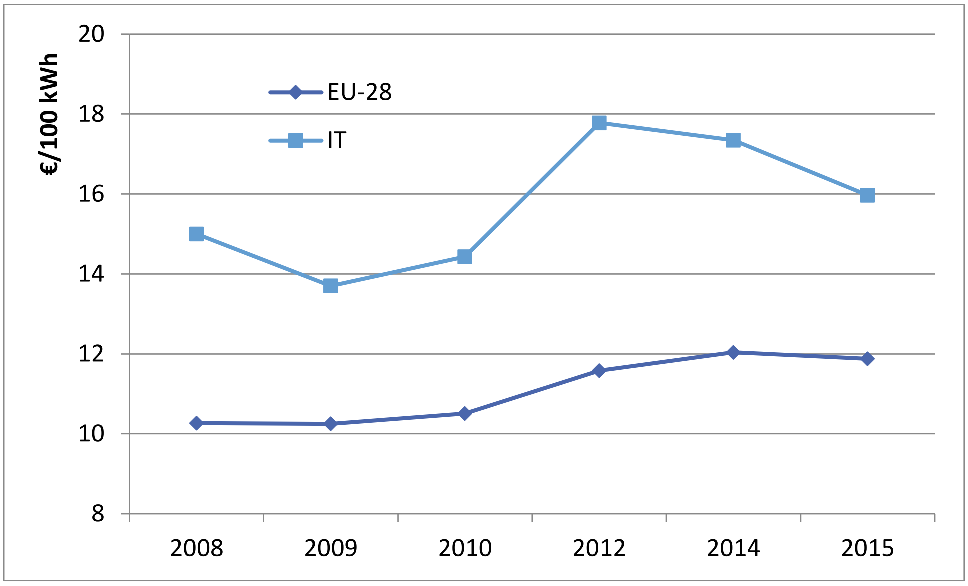

Figure 4-40: Fuel Prices for industrial consumers for electricity (€/100kWh)

4.3.4 Adaptation measures

The Sustainable Energy Action Plan of Reggio Emilia Municipality (realized in 2008) contains actions of urban greening, reduction of energy consumption, energy redevelopment of buildings, installation of photovoltaic panels, realization of cycle paths etc. with the aim of reducing CO_2. In particular, the inventory of emissions calculated for the year 2000 showed the emission of 1,169,561 tons of CO_2 (5% due to the entity). With the actions implemented from 2000 to 2007 and those foreseen from 2008 to 2020, the Municipality intends to reduce emissions by 21.9% compared to 2000. In 2014, the Municipality carried out the first monitoring of emissions: the study showed a decrease in total emissions (1,116,456 tons of CO_2) despite population growth (2000: 146,092 inhabitants; 2007: 162,290). The revision of the actions by 2020 confirmed the reduction of emissions by more than 20%. In short, the municipality will conclude emission monitoring for 2014.

Examples of actions:

- Energy efficiency promotion in renovation of public buildings
- Installation of solar panels in some Municipality facilities
- Ecoabita project (voluntary certification to assess and improve energy efficiency in houses)
- Redevelopment of public lighting (substitution of lamps, LED experimentation in traffic lights and public lighting, extension of the luminous flux regulators)
- Completion of the conversion of municipal fleet with electric vehicles and use rationalizing
- Promotion of public transport (different management of traffic lights, increased frequency, ...)
- Enhancement of the project for rental at discounted prices of commercial electric vehicles
- Mobility management for local companies
- Initiatives for the diffusion of car-sharing tool among civil servants
- Construction of bicycle paths
- Construction of some "park and ride" close to city center
- Installation of photovoltaic plants on public roofs and soils
- Installation of photovoltaic plants on private roofs and soils (residential, industrial, commercial or agricultural areas)
- Strengthening of district heating
- Tree planting
- Low impact fleet for waste collection
- Reduction of urban waste production
- Installation of public water dispensers

Additionally, the CarbonZero project of the Municipality includes compensation for CO_2 for new settlements (http://rigenerazione-strumenti.comune.re.it/carbonzero/). To achieve this prestigious goal - which the European Community has established since 2019 - it is necessary to combine a mix of solutions: making energy efficient buildings that produce all or a large part of the energy they consume from renewable or assimilated sources (photovoltaic, micro-cogeneration, etc.) and zeroing the remaining CO2 emissions through compensatory mechanisms such as plant biomass planting or reserve of funds through which the Administration will implement CO2 reduction measures. The Municipality of Reggio Emilia provides to the other Municipalities and operators the methodology implemented through an online spreadsheet. Based on the input data (expected uses, total surface area, localization, S/V ratio, standard plantings), the spreadsheet determines greenhouse gas emissions related to the thermal, electrical and waste components and provides a descriptive report of the calculation and of the compensatory proposed measures to achieve a zero CO2 balance.

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5 PERI-URBAN FIRES

Forest fires constitute a major environmental and socioeconomic issue in the Mediterranean. An average of 50,000 fires per year burn a range of 470,000 hectares annually causing, apart from ecological catastrophe, severe damages in infrastructures and, quite often, human casualties (Schmuck et al., 2011).

The destruction of forests is of great concern since it has many direct (loss of property and lives) and indirect (flash floods, soil erosion and loss of fertility) consequences. Peri-urban forest fires play a fundamental role in regulating air temperature and wind circulation in the neighboring city, and may contribute to an increase of temperature in the city during the summer months and an intensification of the urban heat island. Furthermore, if the fire reaches houses at the city edge, significant loss of property and human life can occur with an associated increase in insurance costs.

In Figure 5-1 and Figure 5-2, the average annual distribution of fire events and burnt areas in EU by province are presented. Most of the burnt areas in the EU Mediterranean region are located in Spain, Portugal and southern Italy, with smaller areas in Greece, France and Cyprus. As shown in Figures the province of Reggio Emilia depicts negligible annual fire density and burnt area, while these values are pretty high for Attica Region and the whole island of Cyprus.

Most of the burnt areas in the Mediterranean region result from fairly large fires (>50ha). They are responsible for approximately 75% - 80% of the total area burned every year (Birot, 2009). In order to analyze the impact that forest fires have in the Mediterranean, both the number of fires and burnt area were combined, forming a forest fire incidence index. This index identifies areas in which fire incidence is high because either the number of fires is high (although total burnt area may be low due to efficiency in fire prevention and preparedness), or the burnt area is high, which could be due to a high or low fire frequency (Birot, 2009). Figure 5-3 shows fire incidents in the EU by province. As shown in the figure, the province of Reggio Emilia presents low fire incidence while Attica and Cyprus high.

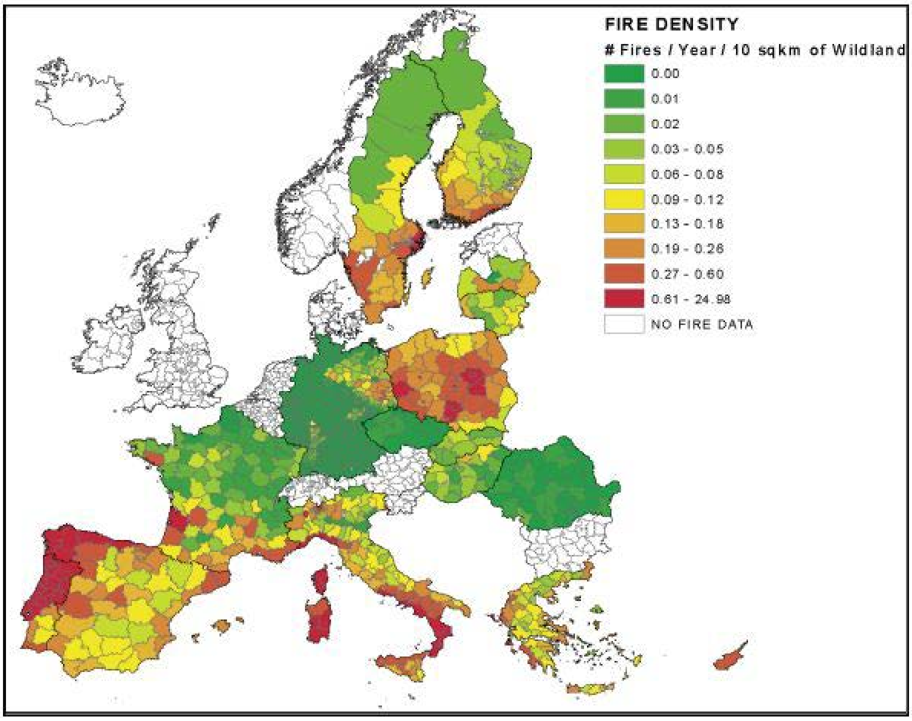


Figure 5-1: Average annual distribution of the number of fires in the EU by province.Source: EFI discussion paper 15,2009

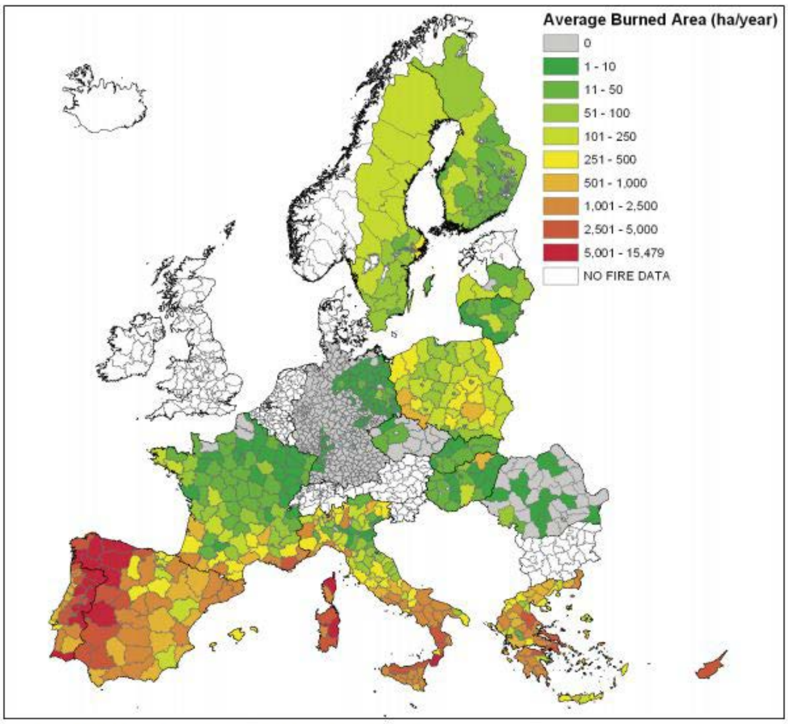


Figure 5-2: Map of burnt areas in the EU by province. Source: EFI discussion paper 15,2009.

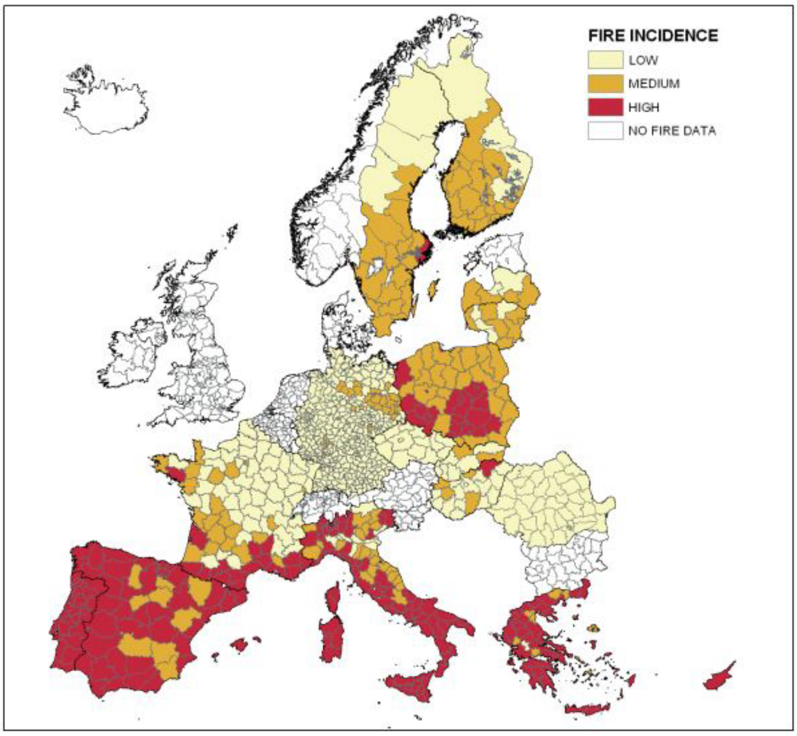


Figure 5-3: Fire incidence map for the EU.Source: EFI discussion paper 15,2009.

5.1 Cyprus

5.1.1 Existing situation

Cypriot forests and other wooded land account for 42% of the total area of Cyprus (386.166ha), constitute an important natural resource and offer many goods and services in the economic, social and environmental sector. Their protection, proper management and extension are a primary concern of the Department of Forests.

Forest fires are considered as a major and permanent threat for the forests of Cyprus.Every year, forest fires cause extensive and irreversible damages to forest ecosystems. It must be mentioned that forests consist an exceptionally important ecosystem in Cyprus which cover an areaequivalent to25% of the total areaof the island.The Cypriotforests arenaturalwith the mainforest speciesofTurkish pine(Pinus brutia),as well as Blackpine(Pinus nigra)whichmainly covers thehigherpartsof Troodos Mountain. Also found many endemic species most well known are the Golden oak (Quercus alnifolia) and Cyprus cedar (*Cedrus brevifolia) species.*

According to the Cyprus Department of Forests (2017), the highest percentage of fires in Cyprus occurs due to human negligence and not natural causes. However, regardless of what the cause of fire is, the impacts of climate change on Cyprus' forests and specifically the more intense droughts and very high temperatures during summer, can make fires even more destructive. Urbanization increases the fire hazard due to the abandonment of agricultural land and consequently the increase of flammable forest vegetation in case of fires. In Figure 5-4, the total burnt area, the number of fire events, as well as the average fire size for Cyprus for the period 2000-2015, are presented.

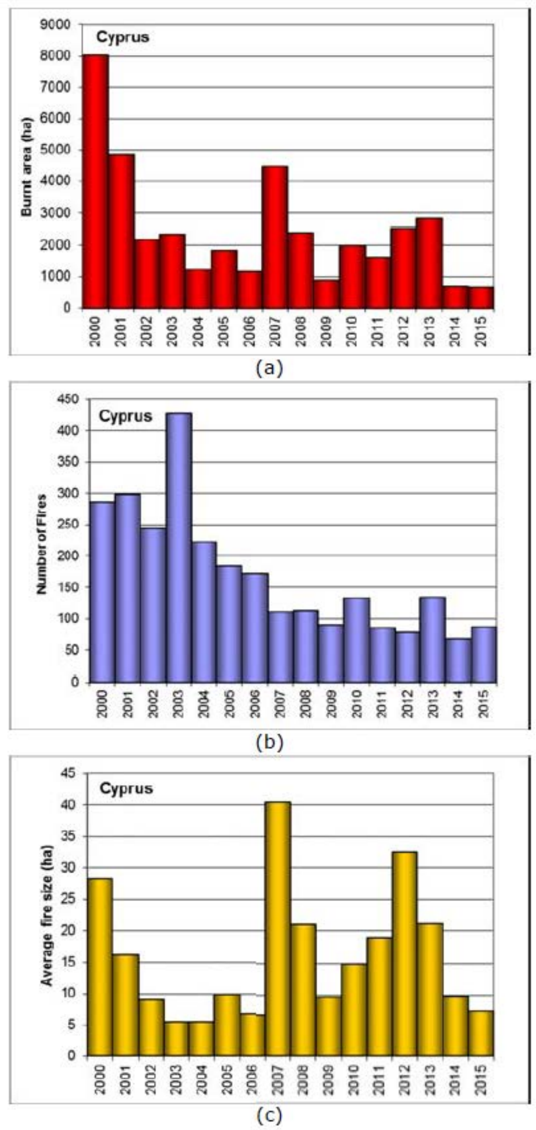


Figure 5-4:(a) Number of burnt area (ha), (b) number of fires, (c) average fire size (ha) for the period 2000-2015 for Cyprus. Source: Forest Fires in Europe, Middle East and North Africa 2015, Joint report of JRC and Directorate-General Environment 2016.

Throughout the period 2000-2012, 2,364 fires were recorded in Cyprus, while the total burnt area amounted to 23,375 hectares, 63% (14,708 hectares) of the burnt area being forests and other wooded land. The largest number of forest fires in Cyprus during the last decade was recorded in 2003 while the year with the greatest severity in forest fires in terms of total area burnt was 2007. The number of fires and burnt area for the period 2003-2012 are presented in the following table.

Table 5-1: Number of fires and burnt area in Cyprus for the period 2003-2012. Source: FAO- Forest data reporting package for 2015

Year	Total number of fires	Number of forest fires	Number of non-forest fires	Total burnt area (ha)	Forest fires (ha)		Non-forest fires
					Burnt area (ha) (Forest and other wooded land)	Burnt area (ha) (Agriculture and other artificial land)	Burnt area (Other land)
2003	427	427	n.a.	2349	921	1428	n.a.
2004	266	221	45	1250	667	551	32
2005	224	185	39	2377	962	876	539
2006	232	172	60	1228	888	272	68
2007	197	111	86	4595	3704	779	112
2008	207	114	93	2907	1997	395	515
2009	174	91	83	990	460	425	105
2010	245	133	112	2627	1559	441	627
2011	194	85	109	2008	1220	379	409
2012	198	78	120	3044	2330	201	513

Furthermore, during the period 2000-2014, an average of 181 fires burnt 2530 ha (Table 5-1). During the five year period 2010 -2014, the mean number of fire events increased while mean burnt area decreased.

Table 5-2:Mean number of fires and burnt area during 2000-2014, 2010-2014 and during the fire seasons of 2014 and 2015.

Parameter	Period	National Forest	Zone up to 2km surrounding the National Forests	Rest of the area	Total
No of fires	**2000-2014 (average)**	22	65	94	181
	2010-2014 (average)	20	90	104	214
	2014	14	96	47	157
	2015	11	132	132	275
Burnt Area (ha)	**2000-2014 (average)**	112	245	2173	2530
	2010-2014 (average)	52	258	2007	2317
	2014	2	136	635	773
	2015	2	91	970	1063
	2000-2014 (average)	5.1	3.8	23.1	14.0

Mean burnt area per fire (ha)	**2010-2014 (average)**	2.6	2.9	19.3	10.8
	2014	0.1	1.4	13.5	4.9
	2015	0.2	0.7	7.3	3.9

State owned forests, due to their free access and unique aesthetic values are central to the provision of outdoor recreational opportunities. A total of ten areas covering about 15,000 hectares have been designated as National Forest Parks and an important niche in forest recreation is filled by the four peri-urban national forest parks: Athalassa, Pedagogical Academy, Rizoelia and Polemidia (Figure 5-5). The Athalassa Forest Park is adjacent to the Strovolos Municipality, forming a green lung for the wider region.

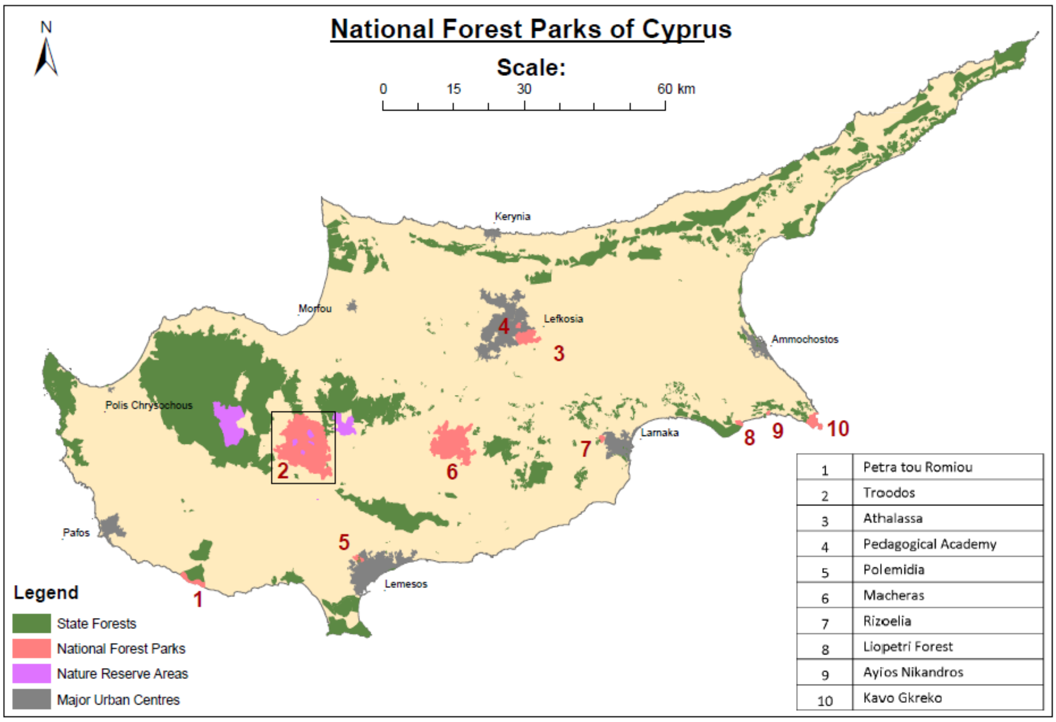


Figure 5-5: The National Forest Parks of Cyprus. Source: Department of Forests, Ministry of Agriculture, Natural Resources and Environment

In Table 5-3, the number of fire events as well as the burnt area for the period 2000-2015 for Athalassa National Forest Park according to data obtained by the Department of Forests, are presented.

Table 5-3: Number of fire events and burnt area for Athalassa National Forest Park based on data obtained by the Department of Forests.

Year	No of events	Burnt Area (ha)

2000	1	3.5
2001	1	2.5
2002	0	-
2003	2	6.5
2004	0	-
2005	0	-
2006	1	0.02
2007	0	-
2008	0	-
2009	5	11.2
2010	4	0.4
2011	2	6.1
2012	5	2.1
2013	1	0.6
2014	6	0.2
2015	8	1.1

5.1.2 Observed and expected impacts

Forests in Cyprus, like all Mediterranean forests, are exposed to high fire danger especially during the summer period because of the climatic conditions. The fire season starts in May and ends in October, but occasionally it starts in April and is extended up to November. Various climatic variables like temperature, relative humidity, and precipitation affect fuel moisture. The long, hot and dry summers that last from May until October convert the pine into a dry and very flammable fuel mass.

During the fire season the temperature fluctuates from 30° - 44°C increasing the risk of ignition to very high levels. The relative humidity, which affects considerably the fire environment, ranges between 30-65%. Rainfall during the fire season is very low and ranges between 0 and 50mm. Wind is a dominant factor of fire ignition and behavior. It is one of the hardest elements to predict due to variability of wind speed and direction and the influences of topography, vegetation, and local conditions. Winds during the fire season are mostly northwesterly or northerly (IFFN, 2005).

During the 20th century remarkable variations and trends were observed in the climate of Cyprus, particularly in the two basic climatic parameters, precipitation and temperature. According to Shoukri and Zachariadis (2012), a warming of approximately 1–1.58 °C has been observed over the twentieth century in the island. Moreover, according to the Cyprus Department of Meteorology, most of the warm years in the century have been recorded after 1990. The decrease in the amount of precipitation was also remarkable. While the average annual precipitation in the first 30-year period of the century was 559 mm, the average precipitation in the last 30-year period was 462 mm, which corresponds to a decrease of 17%.

In the framework of the current study, in order to assess the meteorological fire danger for the current climate for Strovolos and Lakatamia, the mean monthly FWI values and the number of fire and high fire danger conditions are presented (Figure 5-6).As Strovolos and Lakatamia are adjacent municipalities, the same meteorological station was chosen for the analysis. More specifically, meteorological data for the station of Athalassa (33°24' , 35°09') for the period 1983-2012 were used. As shown in the Figure, the meteorological fire danger is highest during July, which, according to the climatology of the region, is the hottest month of the year. A thorough analysis on the current climatological conditions in the Municipalities will be presented in Del.C.2. Furthermore, the number of fire risk days lies between 130 and 210 days while high fire danger conditions prevail up to 50 days per year.

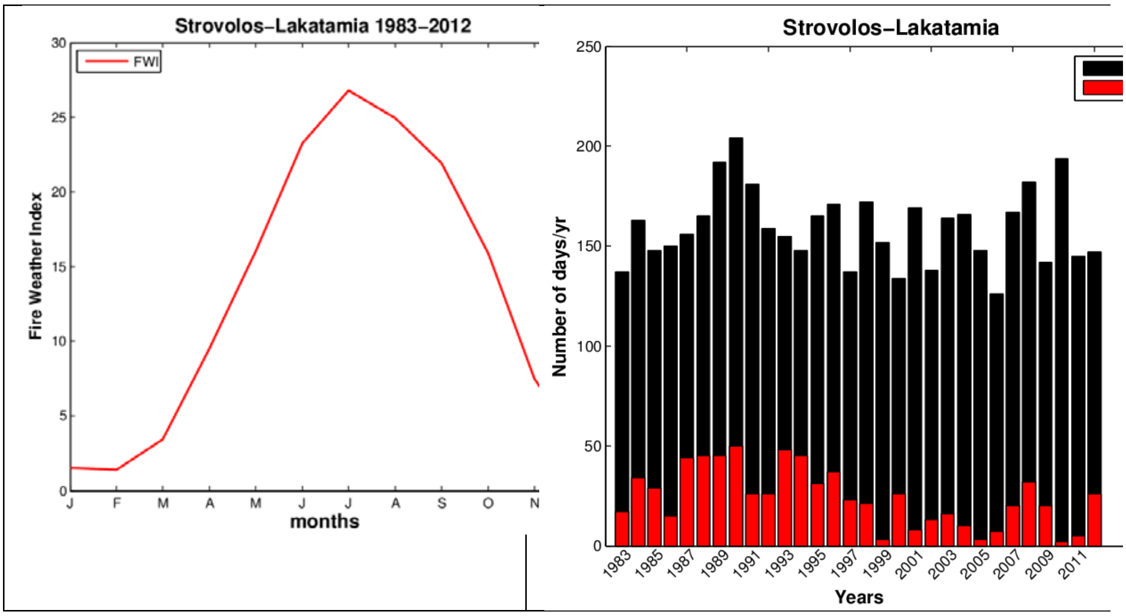


Figure 5-6: Mean monthly Fire Weather Index- FWI (left panel) and number of days per year with FWI>15,30 for Strovolos and Lakatamia for the period 1983-2012.

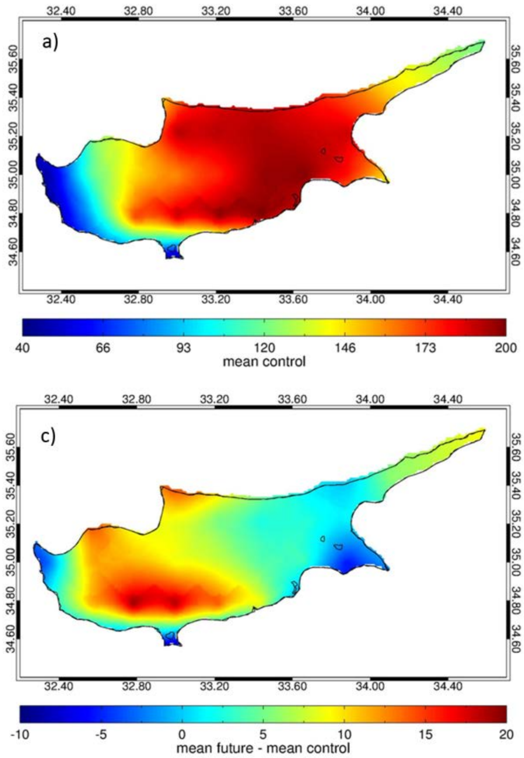


Figure 5-7: Number of days with FWI>15 for the current climate (upper panel) and the changes in the number of days with FWI>15 between the future (2021-2050) and the reference period (1961-1990) under A1B emission scenario using the PRECIS RCM.

In Figure 5-7 and Figure 5-8, the changes in the number of fire risk (FWI>15) and high fire risk days (FWI>30) between the control (1961-1990) and the future period (2021-2050) are presented. The results were obtained by the future vulnerability assessment which was conducted in the framework of CYPADAPT project (CYPADAPT, 2012) and are based on the PRECIS Regional Climate Model output. As shown in Figure 5-7, the number of days with fire risk (FWI>15) in the greater Nicosia area (Strovolos-Lakatamia) are about 175 per year, while an increase of about 7 days per year is expected. As far as the number of days with high fire risk (FWI>30) is concerned, in the current climate these are about 120 and by the end of 2050, an increase of five more days per year is expected (Figure 5-8).

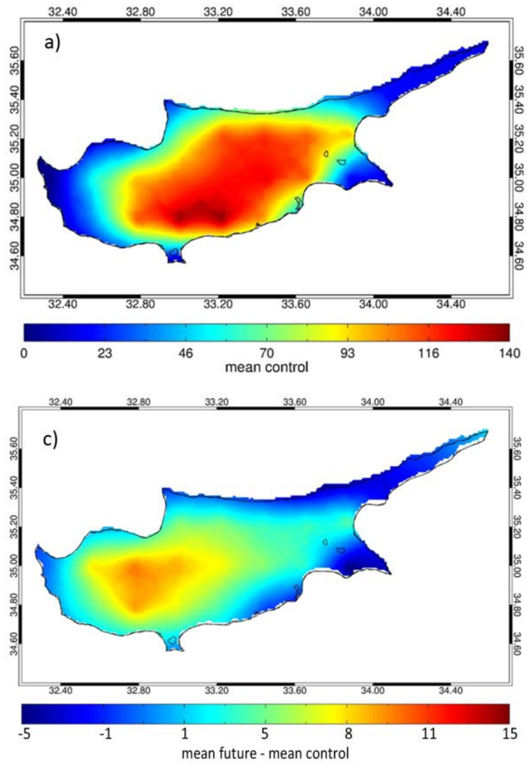


Figure 5-8: Number of days with FWI>30 for the current climate (upper panel) and the changes in the number of days with FWI>15 between the future (2021-2050) and the reference period (1961-1990) under A1B emission scenario using the PRECIS RCM.

5.1.3 Non-climate related pressures

The forests of Cyprus are under pressure from a multitude of directions and are constantly facing new challenges as a result of the changing needs and demands of society, either at the or global scale. Except from the fires and other hazards from biotic and abiotic factors, the greatest challenge comes from growth, especially from tourism, residential and industrial development (quarries, wind farms) as well as the construction of infrastructure projects.

As far as forest fires are concerned, the accumulation of biomass due to the abandonment of rural areas and the increasing tourism and exodus of city residents to forested areas, are important factors which contribute to an increased fire risk, especially during summer months (Department of Forests, 2017).

5.1.4 Adaptation measures

The mission of the Department of Forests is, inter alia, to protect and promote the sustainable management of forests, to improve green areas through the development and implementation of the Forestry Policy and Legislation and to protect forests against fires, climate change and other factors. The measures taken by the Department of Forests in order to eliminate fires according to the National Adaptation Strategy are presented, as well as awareness raising activities. Economic incentives towards fire prevention, mitigation and adaptation to climate change, on part of the EU, are also discussed.

National Adaptation Strategy

-Several measures are taken by the Forestry Department of Cyprus aiming to eliminate forest fires. These are summarized at the National Adaptation Strategy as follows:

(A) Fire Prevention measures. Fire Prevention measures include all actions and measures aimed at reducing or eliminating the potential for a fire outbreak. The main prevention measures taken are Law enforcement, Information campaigns, establishment of Picnic and camping sites, organization of patrolling and Fire danger mapping.

(B) Fire Pre-suppression measures include all actions and measures aimed at reducing the likelihood of spread of a potential fire and at facilitating the efforts of effective fire suppression. The main pre-suppression measures taken are Fire breaks, Forest roads, Forest telecommunications, Forest Stations, Silvicultural treatments, Detection and reporting of forest fires, placement of Fire lookout stations, placement of automatic fire detection system and Reporting of forest fires.

(C) Suppression measures: The suppression of forest fires is a complex, difficult and dangerous work that requires specialized knowledge, education and organization. Suppression includes all actions and measures aimed at facilitating rapid intervention and effective suppression of a potential fire. The main suppression measures taken are Forest fire fighting task force, Stand-by of forest officers, establishment of The Cyprus Forestry College, Fire engines, Personnel vehicles, Tractors, Warehouses, Fire protection systems, Water tanks and hydrants, Heliports, Aerial means and Cooperation with other agencies and the public.

Other Adaptation Supporting Policies

-The Department of Forests, in the context of public awareness raising for preservation and protection of forests, organises events and lectures on forestry issues with emphasis given on forest fire prevention, participates in radio and television broadcasts and releases informative material. It also produces daily forecasts on fire danger for the whole island which are communicated through the media for the information of the general public and public awareness.

- In the framework of the Rural Development Programme 2014-2020 of Cyprus, economic incentives are provided through Measure 8 "Investments in the development of forestry areas and in the improvement of the sustainability of forests". The main purpose of the measure is the creation and / or improvement of the existing system for the protection of forests and wooded areas from fires, the restoration of forest damage due to forest fires, the mitigation and adaptation to climate change.

The measure includes the following actions:

(i) Fire prevention. This action is limited in prevention measures and foresees the provision of financial support for: (a) the creation and maintenance of protective infrastructures, (b) management of vegetation (fuel) to reduce the risk of fire ignitions and (c) the installation and improvement of facilities and communication equipment for monitoring forest fires.

(ii) Fire restoration. This action focuses on the rehabilitation of damage to forests and wooded areas due to forest fires. It also comprises an incentive that provides support to localauthorities and owners of private forests but also to Public bodies for reforestation of burnt areas.

- In the framework of the European Regional Development Fund *(*ERDF*)* 2014-2020 of Cyprus, economic incentives are provided through Investment Priority 3, Reducing Carbon Dioxide Emissions and Adaptation to Climate Change. The CF (Cohesion Fund) contribution will seek to improve monitoring of the impacts of climate change, assessing and managing climate change risks, as well as adaptation actions related to forest protection and fire prevention.

5.2 Greece

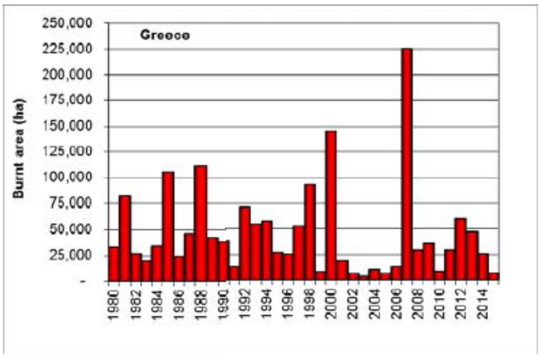
5.2.1 Existing situation

Greece is one of the European countries presenting high fire hazard (Barbosa et al., 2007), and previous studies identify Attica as one of the regions exposed to the highest fire risk (Iliadis, 2005).According to the Ministry of Environment and Energy, Attica is the most fire affected region of the country. An average of 83 fires occur every year and 43,117 acres of forest, forested land and pastures are burnt. The area of Attica covers 3,808,100 acres, of which 1,645,860 acres are forests and wooded land, 267,430 acres grassland and 1,894,810 acres other areas (inhabited areas, agricultural land, etc.). The predominant forest species in the forests of Attica are the evergreen - broadleaf (906,520 acres), Pinus halepensis (655,470 acres) and spruce (Abies) (75,070 acres), while there are 5,010 acres of Platanus, 2,090 acres of oak (Querqus) and 1,700 acres of black pine (Pinus Nigra).

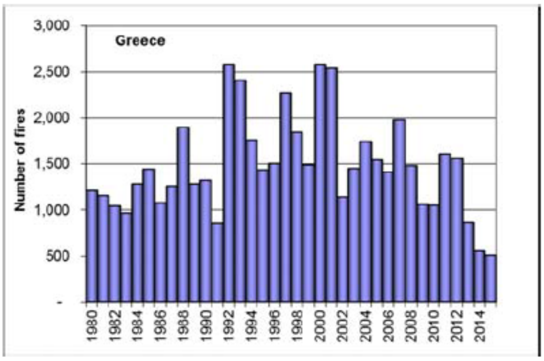
The mountainous regions of Attica are under considerable pressure from fires and from anthropogenic activities, including quarries, urban extension and a range of activities (military installations, educational institutions, casinos, telecommunication facilities, etc.). All of this leads to alteration of the landscape and ecological degradation. Forest fires are either caused by deliberate actions or accidental events. Reducing the probability of occurrence of an accidental fire is directly related to the management of forest areas of mountainous regions at all levels.

Mount Egaleo is located on the western side of the Municipality of Peristeri and is divided into two major mountain ranges, Egaleo and its extension, Mount Poikilo. It is characterized as a Regional Park and forms a single recreation, sightseeing and hiking park with two major supralocal development poles in the west and northwest gate of Athens. Undoubtedly, the Poikilo Mountain and the Mount Egaleo are two environmental treasures for the Municipality of Peristeri and all adjacent Municipalities as they host a large and important variety of flora and fauna. The main characteristics of the flora of Egaleo and Poikilo are Mediterranean vegetation of maquis, garrigue and conifers, mainly Aleppo pine. In addition, Poikilo, contributes to the modulation of the microclimate of Peristeri. Unfortunately, over time, its degradation due to fires and trespassing for residential or other use, has reduced this positive contribution, leading also to negative looming impacts due to the risk of erosion of surface soils of the mountain itself and the increased of flood risk for the Municipality.

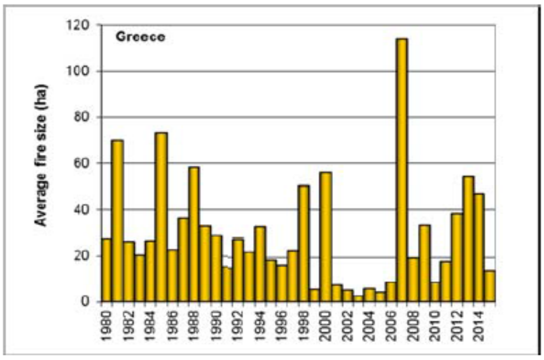
In Figure 5-9 the number of fires, total burnt area and the average fire size for the fires in Greece during the period 1980-2015 are presented. As shown in the Figure, 2007 was an extreme year as far as burnt area is concerned. Greece experienced an extreme summer and the worst natural hazard in its modern history during 2007 (Founda and Gianakopoulos, 2009). Soil dehydration, following a prolonged dry period in combination with hot and strong winds yielded favorable conditions for the ignition and spread of wildfires. Especially, during the last week of August, 55 simultaneous large fires burnt approximately 200,000 ha of vegetated land in the Peloponnese, Euboea and Attica, which corresponded to 70% of the total burnt area in the country during all years, and to 55% of the total burnt area across south Europe during 2007 (Bassi et al., 2008; European Commission, 2008; San-Miguel-Ayanz et al., 2013). During the fires of summer 2007, almost 80 civilians and fire-fighters lost their lives.



(a)



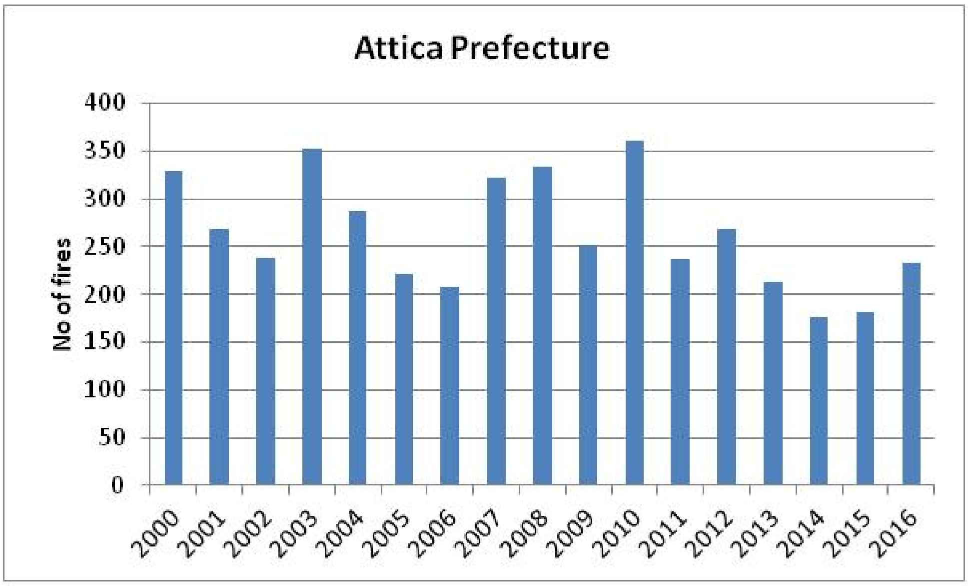
(b)



(c)

Figure 5-9: (a) Number of burnt area (ha), (b) number of fires, (c) average fire size (ha) for the period 1980-2015 for Greece. Source: Forest Fires in Europe, Middle East and North Africa 2015, Joint report of JRC and Directorate-General Environment 2016

In Figure 5-10, the number of fire events and the total burnt area for Attica Prefecture for the period 2000-2016, according to the data obtained by the Hellenic Fire Service, are presented. As shown in the Figure, the year 2009 was the most severe as far as burnt area is concerned followed by 2000, 2007 and 2012.



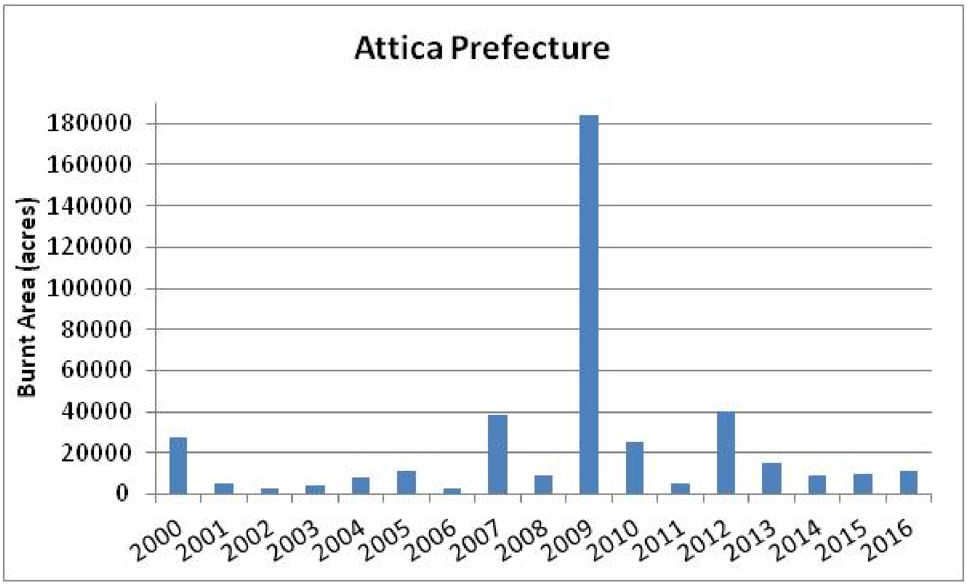


Figure 5-10: Number of fires and total burnt area for the period 2000-2016 for Attica Region.

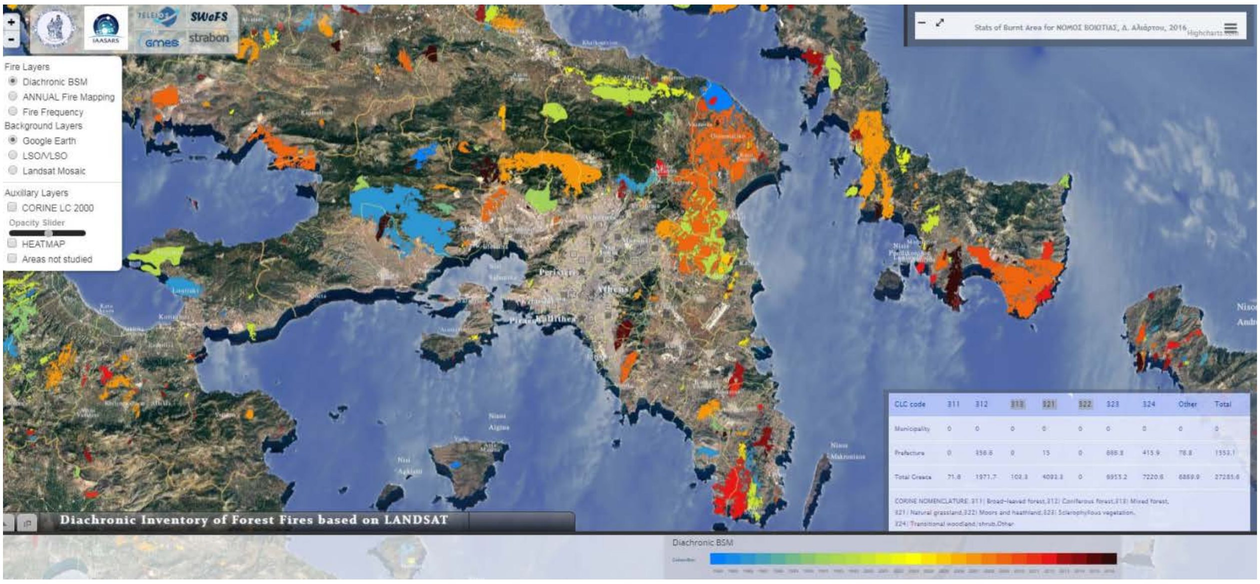


Figure 5-11: Diachronic Inventory of forest fires based on LANDSAT images. Source: http://ocean.space.noa.gr/diachronic_bsm/

In Figure 5-11, the diachronic inventory of forest fires, depicting the results of the mapping of burned areas over Attica for the last 32 years (1984 to 2016) based on LANDSAT images, is presented. Each color represents a different year. For every year since 1984, more than one fire has occurred in the greater Athens area.

In Table 5-4, the number of fires for the period 2009-2016 in Poikilo Mountain, as well as the burnt area per event, according to the Hellenic Fire Service, are presented. As shown in the Table, 26 events burnt 110 acres in total during the past 8 years.

Table 5-4: Number of fire events and burnt area in Poikilo Mountain for the period 2009-2016.

Year	No of events	Burnt Area (Acres)
2009	2	2.0
2010	5	19.0
2011	4	20.0
2012	4	2.0
2013	1	3.0
2014	1	40.0
2015	4	14.0
2016	5	10.0

5.2.2 Observed and expected impacts

Greece, being part of the eastern Mediterranean basin, is an area particularly vulnerable to climatic change regarding temperature rise and increased fire risk (Giannakopoulos et al., 2011). According to Founda et al. (2004), since the mid-1970s most regions of Greece experience significant positive temperature trends that are more pronounced in summer, while at the same time, Greece entered a prolonged period of drought (e.g. Dalezios et al., 2000; Pnevmatikos and Katsoulis, 2006) that led to a significantly high number of fires and burnt area (Dimitrakopoulos et al., 2011).

According to an extensive study that was conducted by the Forest Research Institute of Athens of the National Agricultural Research Foundation, based on the records from the National Forest Services and the Hellenic Fire Brigade (Tsagari et al., 2011), in the Prefecture of Attica for the period 1983-2005, more than 1,200 fires resulted in a total of 755,619 acres of burnt areas. More than 45% of the recorded fires occur in dry conditions (relative humidity <40%). These fires are responsible for the major disasters in the prefecture. However, fires that correspond to the 60-80% humidity class, with an average intensity of 761 acres of burned area per incident are more severe, while the corresponding average intensity in dry atmosphere (relative humidity <40%) is quite high and reaches about 690 acres of burned area per incident (Tsagari et al., 2011).

According to the same study, most of the incidents of fires (~400), which have caused the greatest disasters (358,400 acres), which account for 57% of the total, appear at high temperatures (30-35 oC). Fewer recordings (80) refer to very high temperatures (> 35 ° C), although the corresponding area losses (77,635 ha) are quite high compared to the number of incidents that caused them. Thus, the more destructive fires occur at high temperatures (> 35 ° C), with an average intensity of 970 acres burned per incident. Smaller average values show fires at temperatures of 20-25 ° C and below 20 ° C, with values of 102 and 198 acres of burned area per incident, respectively. Fires under wind conditions from 4,1 to 7,0 BF, have caused the greatest disasters in the prefecture. However, fires occur more frequently under moderate winds (1.1-4.0 BF), with a total of 661 records. In very strong winds (7,1-9,0 BF), 25 incidents were reported, while the disasters are 107,282 ha and their value is considered quite high compared to the corresponding number of incidents. Generally, the severity of fires appears decreasing with the reduction in wind intensity, displaying a minimum in no wind conditions, which reaches 30 acres of burned area per incident.

In order to assess fire danger conditions for the current climate for Peristeri, the annual variability of Fire Weather Index as well as the number of days with FWI greater than 15 and 30 have been calculated for the period 1958-2014 (Figure 5-12). Because the station of Peristeri has only five year of meteorological data available, the urban station of Thissio-

Athens (23°43′, 38 °00′) was used in the current study. As shown in the Figure, maximum fire danger conditions are found during July and August when higher temperatures and high wind speed are present. A thorough analysis on the current climatological conditions in the Municipality will be presented in Del.C.2. Furthermore, the number of days with fire risk for the current climate, range between 110 and 230 per year, and up to 120 days of high fire danger conditions for the same period.

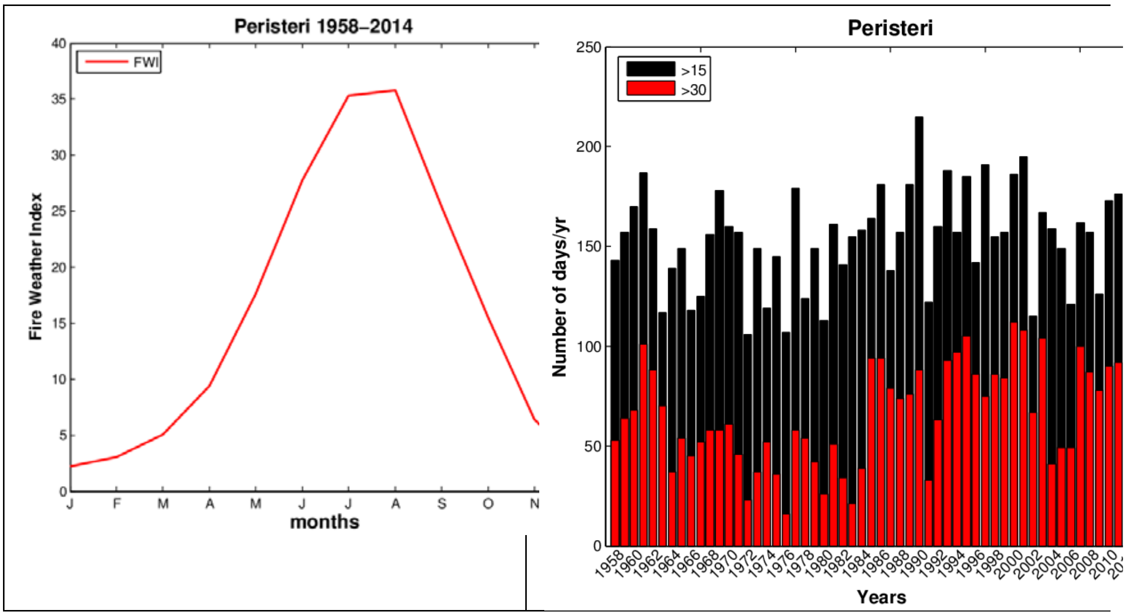


Figure 5-12: Mean monthly Fire Weather Index- FWI (left panel) and number of days per year with FWI>15,30 for Peristeri for the period 1958-2014.

It has also to be noted that, during a serious peri-urban forest fire event, air quality within the city may significantly deteriorate leading to an increase of respiratory problems for the inhabitants. According to a recent study for Attica, medium sized fires (100-300 ha) are associated with an increase of 4.9% in the daily total number of deaths, 6.0% in the number of cardiovascular deaths and 16.2% in the number of respiratory deaths. Cardiovascular effects are larger in those aged <75 years, while respiratory effects are larger in older people (Analitis et al., 2012).

The findings of the EU project CLIMRUN, which aims to support forest stakeholders and policymakers and to inform the general public, and in particular the projected changes in the number of extreme fire danger days are presented in Figure 5-13. Present and future model output from the Regional Climate Model RACMO2 were used in order to estimate FWI. This model was developed within the framework of the EU ENSEMBLES project (www.ensembles-eu.org), by the Royal Netherlands Meteorological Institute (KNMI), running at 25km horizontal resolution. As shown in Figure 5-13, Attica will face fire danger conditions up to 160 days per year in the near future (2021-2050), while by the end of the century thisnumber will increase by 30 more days. The number of days with high fire danger (FWI>30) is expected to reach 85 and 110 days per year in Attica for the near and distant future, respectively.

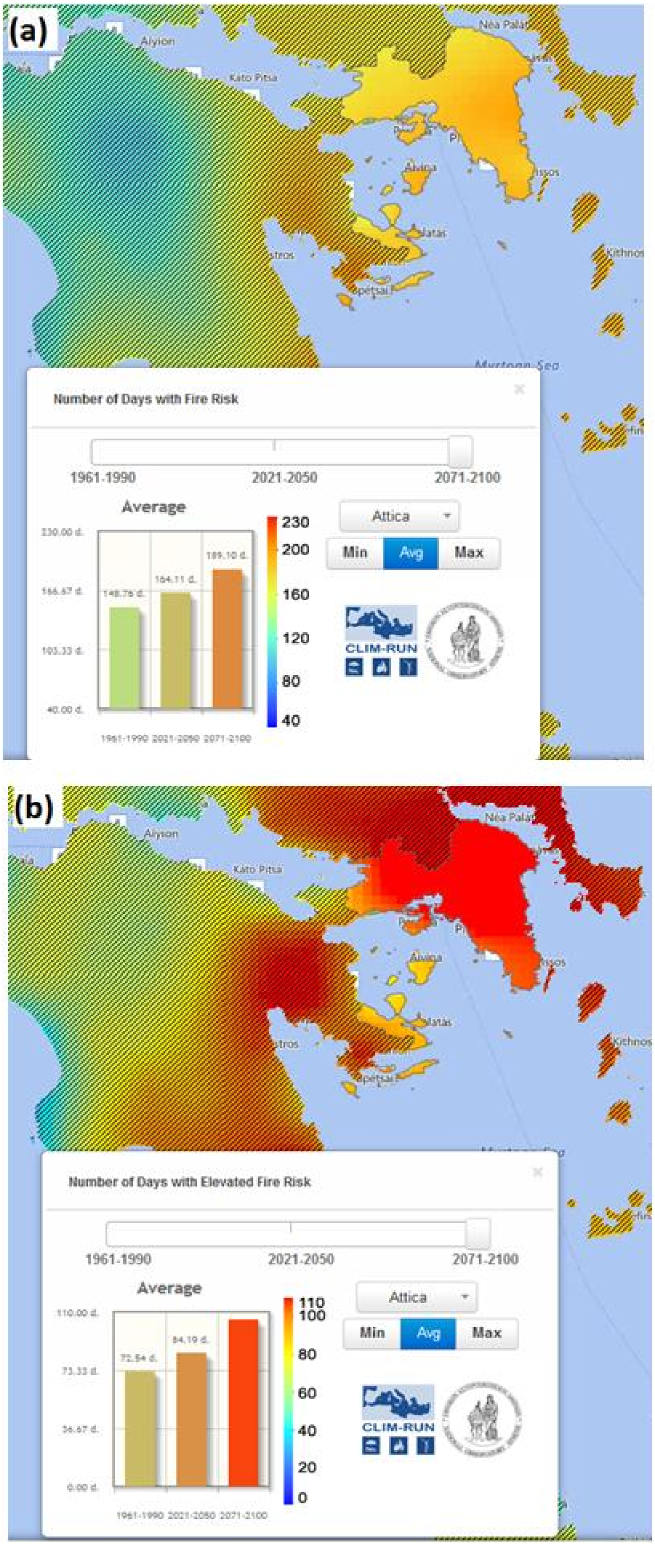


Figure 5-13: (a) Number of days with FWI>15 and (b)number of days with FWI>30 for Attica for the period 2071-2100 based on IPCC SRES A1B scenario.

5.2.3 Non-climate related pressures

Although weather is considered an important factor that controls, to some extent, fire occurrence in Greece (Dimitrakopoulos et al., 2011; Koutsias et al., 2013), especially in the years with extreme climate conditions (Founda and Giannakopoulos, 2009), the fire regime is largely influenced by factors beyond those directly related to weather conditions such as socio-economic factors (Moreira et al., 2011).

While human factors caused more than half of the fires in the northern Mediterranean region (Leone et al., 2003), the amount of human-induced fires in Greece was estimated ranging between 40% and 90%. These values include the events with unknown causes that may be attributed to arson (Kailidis and Karanikola, 2004). Another relevant socioeconomic factor to consider is the rural exodus to urban areas. This leaded to the concentration of population in main towns, that in several cases caused a strong growth of urban/forest interfaces, and the unmanaged vegetation in the surrounding of the wildland–urban interface areas (Koutsias et al. 2010; Moreira et al. 2011).

According to Salvati et al. (2015) fire patterns in Attica changed during the last 12 yearsreflecting the urban transition driven by the 2004 Olympic Games and the subsequent economic crisis.Their results indicate that a significant increase in fire size occurred during the period 2008–2011 in Athens peri-urban area, while fire size decreased in rural areas. At the same time, the proportion offorest land burnt in each fire decreased.

5.2.4 Adaptation measures

As Greek forest ecosystems are vital for almost all sectors of production and they help in the mitigation of the effects of climate change on both the physical and built environment, several measures focusing on the reduction of forest fires are proposed in the framework of the National Adaptation Strategy and are presented below. Actions taken by the local authorities in Peristeri, mainly related to awareness raising and economic incentives provided by the EU financial instruments towards fire prevention and adaptation of forest ecosystems to climate change are also presented.

National Adaptation Strategy

-According to the National Adaptation Strategy the measures to be taken for the reduction of forest fires are the following:

Measure 1: Establishment of a forest registry (registration of land uses, vegetation composition and ownership status) that will also reduce the fires related to public land violation.

Measure 2: Modernization of the legal framework for the prevention, restoration of damage caused directly by fires and also their suppression.

Measure 3: Ensuring that within a maximum of 10 days following the fire, the areas most prone to erosion are sowed with graminaceous plants so that in the first critical post-fire period the soil isprotected and stabilized. This intervention restricts the need for costly hydro-geomorphicprojects, prevents erosion and floods and improves the useable water equilibrium.

Measure 4: Emphasis on prevention, which is also more economical, by ensuring accessibility, limiting fuel by cultivation interventions and controlled grazing.

Measure 5: Modernization of fire-fighting equipment, installation of warning systems and software for rapid and uninterrupted evacuation of areas, training to avoid human casualties and restoration of natural ecosystems.

Measure 6: Forestry growing techniques, combined with controlled grazing to contain flammable surface fuels which play a major role in the ignition and expansion of a fire.

Other Adaptation Supporting Policies

-The General Secretariat for Civil Protection as the Central Administrator, with the main task of coordinating the actors involved in the whole range of disaster risk management, provides a map of fire risk forecast for the whole country (http://civilprotection.gr/el) on a daily basis.

- In the Municipality of Peristeri, an Independent Office for Civil Protection has been established, which is responsible for formulating planning suggestions, coordinating actions for prevention, treatment and restoration of disasters in the area of the Municipality. According to the Operational Plan of the Municipality for the period 2015-2019 on the axis for the *Environment and the Quality of Life*, it is suggested that the Municipality be activated in the Environmental Association for the Protection of the Poikilo Mountain (PESYDAP). Additionally, in the *Civil Protection and Crisis Management* axis, it is proposed to strengthen volunteer action and organize volunteer networks, for the horizontal communication of citizens and for highlighting the effectiveness of voluntary organizations.

- In the framework of the Partnership Agreement for the Development Frameworkfor the period 2014-2020 of Greece, economic incentives will be provided through the Thematic Objective 5, *Promote adaptation to climate change and risk prevention*. As far as forests are concerned, the European Agricultural Fund for Rural Development (EARFD) will intervene with actions to prevent forest fires and rehabilitate forests and forested land, in particular with a view to creating conditions for adapting to climate change, investments that improve the resilience and environmental value of forest ecosystems while at the same time informing and raising awareness of the value of protecting forest resources and preventing forest fires.

- The National Observatory of Forest Fires research program funded by the Green Fund is ongoing, with a main aim to create services related to the prevention and impact assessment of fires, which can be used operationally by the competent authorities in the management of forest fires.

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6 OZONE EXCEEDANCES

Ground-level (tropospheric) ozone (O_3) is not directly emitted into the atmosphere. Instead, it forms in the atmosphere from a chain of chemical reactions following emissions of certain precursor gases: NOx, carbon monoxide (CO) and NMVOCs and methane (CH_4). Ozone levels typically become particularly high in regions where considerable emissions of these gases combine with stagnant meteorological conditions, high levels of solar radiation and high temperatures during the summer. Elevated levels of ozone can cause respiratory health problems, including decreased lung function, aggravation of asthma, and other lung diseases. It can also lead to premature mortality.

Emissions of the main air pollutants in Europe have declined since 1990. Over the past decade, this reduction in emissions has resulted – for some of the pollutants – in improved air quality across the region. However, due to the complex links between emissions and air quality, emission reductions do not always produce a corresponding drop in atmospheric concentrations, especially for O_3. For example, while reductions of O_3-forming substances (i.e. O_3 precursor gases) have been substantial in Europe, O_3 concentrations in Europe have remained stable. Concentration levels depend on year-by-year variations in weather conditions including sunlight; natural emissions of ozone precursor substances by vegetation; the increase in global background ozone concentrations; and transportation of ozone and of ozone precursor substances from source areas outside Europe. All these contributing factors mean that European emission reductions of pollutants contributing to the formation of ozone may not result in equivalent reductions of ozone concentrations (Royal Society 2008; EEA 2015).

Urban air environment O_3 concentrations are mostly controlled by the presence of NOx ($NO+NO_2$) emissions. At elevated NOx levels, typical of the polluted urban environment, O_3 levels can be severely depleted locally due to a direct reaction with emitted NO. This is known as the 'NOX titration effect'.

$$NO + O_3 \rightarrow NO_2 + O_2$$

However, because O_3 is produced following the photolysis of NO_2 via reactions

$$NO_2 + hv \rightarrow NO + O$$

$$O + O_2 + M \rightarrow O_3 + M$$

These reactions constitute a well-established chemical null cycle which couples the chemistry of O_3, NO and NO_2 on a comparatively short timescale (Leighton 1961)

Moreover O_3 pollution episodes occur as a result of unfavorable meteorological conditions (Lalas, Katsoulis, & Petrakis, 1979). These unfavorable atmospheric conditions may reduce the ability of the atmosphere to disperse air pollutants, transport them from other source areas, or may be a combination of both situations (Seinfeld, 1986).

A number of meteorological variables have been found to influence ozone concentration in terms of correlation coefficients such as temperature, morning solar radiation, number of days since the last frontal passage, humidity and the frequency of summertime mid latitude cyclones as the closest associated with ozone (Ordonez et al., 2005; Wise and Comrie, 2005; Camalier et al., 2007; Leibensperger et al., 2008). However, the majority of the observational studies identify temperature as the most important meteorological factor in driving both the mean and the extreme O_3 production [e.g. Camalier et al., 2007; Pusede et al., 2015 and references therein; Otero et al., 2016 and references therein; Shen et al., 2016 and references therein]. In addition, recent regional air-quality modeling studies in Europe indicate that increased future temperatures, as projected by climate models, lead to increases in mean future ozone concentrations when anthropogenic emissions are kept constant at current levels [Langner et al., 2005; Meleux et al., 2007; Hedegaard et al., 2008; Katragkou et al., 2011; Langner et al., 2012, Varotsos et al., 2013].

According to EEA (2015) between 2003 and 2012, there was no clear trend in the annual mean of the daily maximum eight hour average ozone concentrations, recorded at different types of station (traffic, urban, rural and other, mainly industrial), for the EU-28 as a whole (Figure 32).

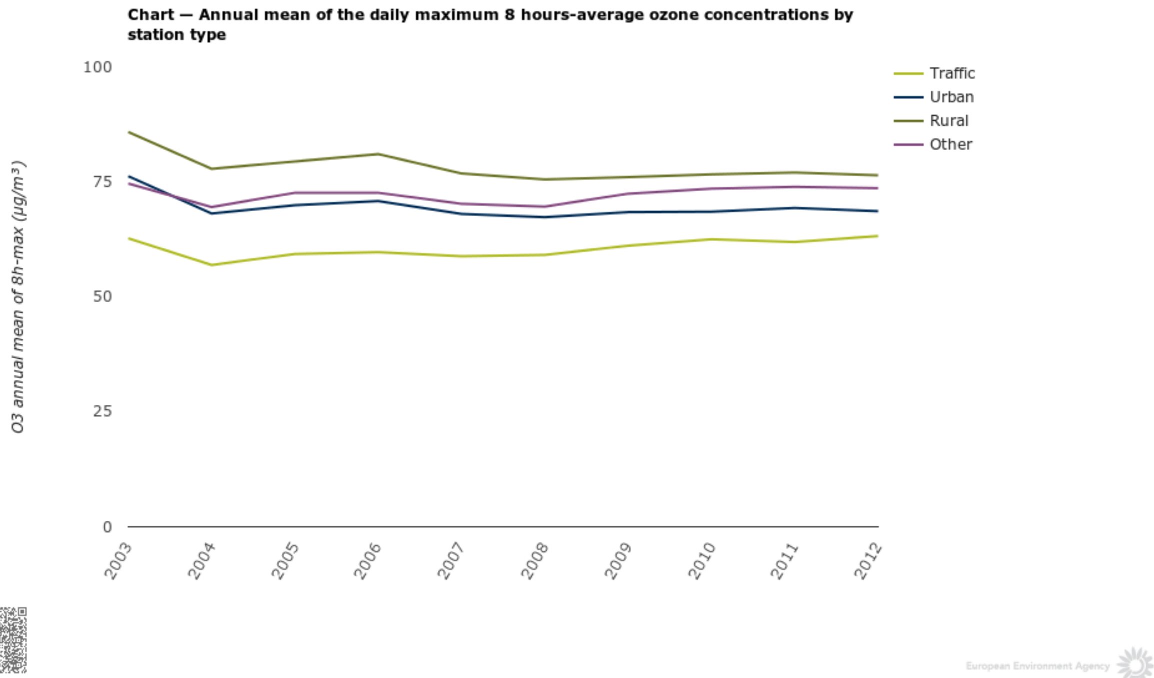

Figure 6-1: Annual mean of the daily maximum 8 hours-average ozone concentrations by station type

(Source EEA 2015)

Meteorological variability and climate change, as well as increasing emissions of biogenic non-methane volatile organic compounds (NMVOCs) during wildfires, could play a role in this lack of trends. Increasing intercontinental transport of ozone and its precursors in the northern Hemisphere also needs to be considered (EEA, 2010a, 2010b). The formation of tropospheric ozone from increased concentrations of methane (CH_4) may also contribute to the sustained ozone levels in Europe (EEA, 2012). The relative contributions of local or regional emissions reduction measures, specific meteorological conditions (such as heat waves), the hemispheric transport of air pollution and emissions from natural sources (such as wildfires), on overall ozone concentrations is difficult to estimate. Temperature plays a role in various processes that directly affect the formation of ozone, such as the emission of biogenic NMVOCs i.e. isoprene, and the photo-dissociation of nitrogen dioxide (NO_2). According to the EEA indicator 'Exceedance of air quality limit values in urban areas' between 2000 and 2013, a significant proportion of the urban population in the EU-28 was exposed to ambient ozone concentrations above the European Union target value for the protection of human health. The maximum was registered in 2003 (58 %) and the minimum in 2012 (14 %).

The numbers of people exposed are higher in relation to the more stringent World Health Organization (WHO) guidelines, where they have been in the range of 93 – 99 %, with no discernible change over time.

Hourly ozone concentrations data from the three urban stations in the partner municipalities are used. Due to the different period of operation for each station we opt not to implement the same year range for all stations in our analysis. For the purposes of the analysis the daily maximum 8 h averages are used [EU Directive 2008/50/EC, 2008]. We also examine the relationship of daily maximum 8-hour average ozone concentrations with daily maximum temperature. The historical O_3-T relationship will be used to estimate the future ozone exceedance days in the partner municipalities. The O_3 -T relationship is analyzed using the Pearson correlation coefficient (r), while the slopes (m) are obtained by the reduced major axis [Smith et al., 2009].

6.1 Cyprus

6.1.1 Existing situation

The Department of Labour Inspection operates a network of nine monitoring stations for the measurement of Ozone, Nitric Oxide, Nitrogen Dioxide, Nitrogen Oxides, Sulphur Dioxide, Carbon Monoxide, BTEX, Particulate Matter (PM), and meteorological parameters and four mini stations for the measurement of Ozone, Nitric Oxide, Nitrogen Dioxide, Nitrogen Oxides and PM. Most of the air pollutants do not exceed the limits, with the exception of ozone and PM10 (EEA, 2015). The ozone exceedances observed mainly in non-urban areas, are primarily due to transboundary pollution and due to climate conditions prevailing in the Mediterranean area.

6.1.2 Observed and expected impacts

In Strovolos-Lakatamia the data cover the period 2010-2016. From Figure 1 it is shown a low year to year variability with the average number of ozone exceedances about 60 days/yr and the minimum and the maximum number of days found in the years 2013 (39 days) and 2016 (109 days) respectively. Regarding the ozone-temperature relationship the correlation coefficient is higher than 0.7 while the slope reaches about 2.6 $ugm^{-3}/ ^{o}C$.

Figure 6-2: Number of ozone exceedance days/yr for Strovolos-Lakatamia (left) and the relationship of the daily maximum 8hr average ozone concentrations with daily maximum temperatures (right) for the years 2010-2016.

Regarding the future climate change impacts the majority of the studies show small (~1ppbV) or non statistical significant changes in the average daily maximum ozone concentrations for the near future (2050) (e.g. Langner et al., 2012, Figure 6-3).

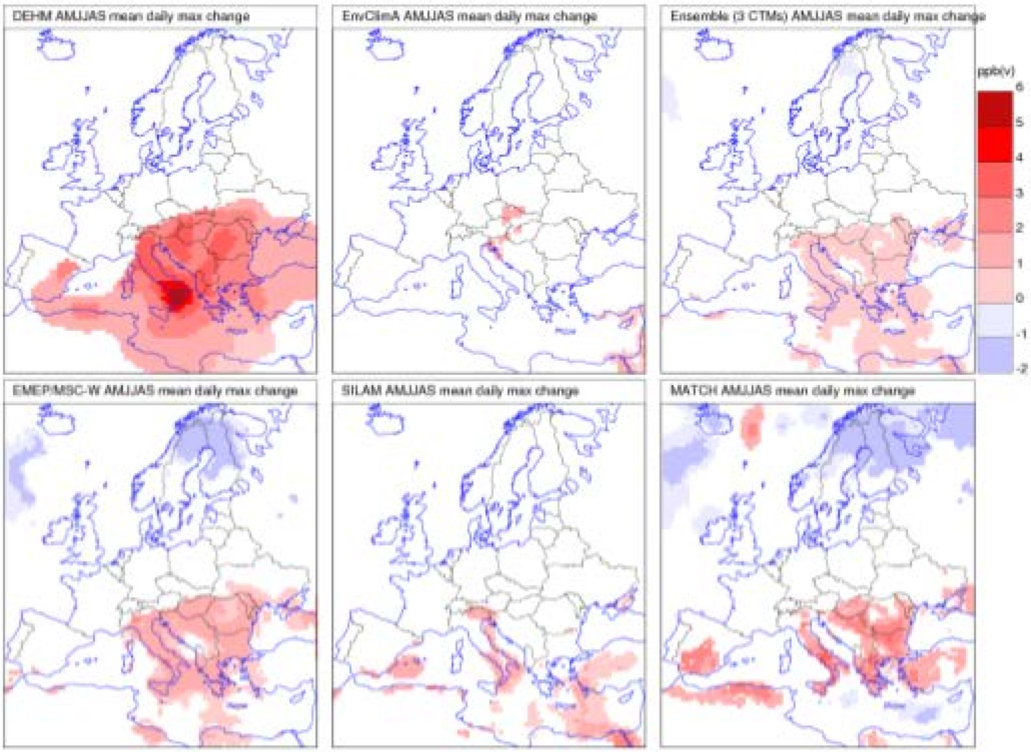

Figure 6-3: Simulated April–September change 2000–2009 to 2040–2049 in average daily maximum O3 concentration at the first model level for five different models. Only changes that are statistically significant at the 95 % level are plotted. Units ppb(v). (Source Langner et al., 2012)

6.1.3 Non-climate related pressures

Wildfires are a source of tropospheric O_3. The link exists due to the increased emissions of biogenic non-methane volatile organic compounds (NMVOCs) during wildfires which is an important precursor emission of O_3 (Real et al., 2007; Oltmans et al.,2010). More information about the observed wildfires in Cyprus can be found in Chapter 5.

6.1.4 Adaptation measures

Increases in ground level ozone (tropospheric ozone) pollution levels due to climate change may make it more difficult to attain or maintain ozone standards. This will need to be taken into account when designing effective ozone precursor emission control program. The adaptation plans regarding surface ozone concentrations are under the broader air-quality umbrella of adaption plans including emissions and particulate matter. However due the non linear relationships of ozone with its precursor emissions the impact of reduced emissions on ozone needs to be addressed more thoroughly.

For Cyprus on the national level the following adaptation measures have been recommended (Zachariades 2012). More specifically,

-data must be collected and an inventory must be completed.

-the implementation of measures for air quality improvement in urban areas must be enhanced.

-air quality must be monitored and strict inspections in service industry must be applied.

6.2 Greece

6.2.1 Existing situation

Vrekousis et al. (2013) found that during the years of economic crises (from 2008 onward) NO2 columns over Athens have been significantly reduced in the range 30–40%. This decline was further supported by surface measurements of atmospheric NO 2 mixing ratios. Additionally, the declining local concentrations of NO, CO, and SO2 are associated with an increase in ozone due to reduced titration by NO.

6.2.2 Observed and expected impacts

InFigure 6-4a non-statistically significant trend in the ozone exceedance days (days with daily maximum 8hour average concentrations > 120 ugm^{-3}) during the 2000-2014 period is shown. The year to year variability, with the exception of first years of the timeseries, is low. The average number of ozone exceedances during the period 2000-2014 is about 70 days/yr with the minimum and the maximum number of days found in the years 2003 (49 days) and 2002 (111 days) respectively. In addition the daily maximum 8hr average ozone concentrations exhibit a high correlation coefficient (r=0.7) with the daily maximum temperature while the slope is about 4 ugm^{-3}/ °C which according to previous studies is typical foe urban environments (Coates et al., 2016).

Figure 6-4: Number of ozone exceedance days/yr for the Peristeri station (left) and the relationship of the daily maximum 8hr average ozone concentrations with daily maximum temperatures (right) for the years 2000-2014.

Regarding the near future ozone concentrations, the increases in the average daily maximum concentration range from non statistically significant to about 2-3 ppbV depending on the model (Fig.1). Varotsos et al. (2011) examined the impact of climate change and more specifically the impact of increasing temperatures on ozone concentrations in Athens. The results indicated that a probable increase in the higher centiles of temperature less than 0.65 ◦C in the 2021–2050 period compared to the observed could lead to an increase of about 8 ozone exccedance days per year respectively

6.2.3 Non-climate related pressures

Wildfires are a source of tropospheric O_3. The link exists due to the increased emissions of biogenic non-methane volatile organic compounds (NMVOCs) during wildfires which is an important precursor emission of O_3 (Real et al., 2007; Oltmans et al.,2010). More information about the observed wildfires in Greece can be found in Chapter 5.

6.2.4 Adaptation measures

According to the National Adaptation Strategy (2016) the air enrichment with pollutants, such as tropospheric ozone, with confirmed negative health effects, requires

action by Health Professionals (EH) and more specifically:

- Cooperation with operators (installation of monitoring systems for ozone).
- Actions in areas of the Health Sector (preparation of facilities and staff).
- Self-protection measures (avoidance of external activities, on early morning exercise or in days with high levels of pollution)

6.3 Italy

6.3.1 Existing situation

The EpiAir2 (Gandini et al., 2013) project in Italy revealed that during the years 2001-2010 in 25 cities in Italy particulate matter concentrations have decreased in most of the cities during the study period, while concentrations of NO_2 and ozone do not show a similar clear trend.

6.3.2 Observed and expected impacts

In Figure 6-4the results of the analysis are shown for Reggio Emilia for the years 2000-2014. In contrast to Pesristeri in Reggio-Emilia the trend exhibits a decrease of about 3 days/decade. The average number of ozone exceedances during the period 2000-2014 is about 90 days/yr with the minimum and the maximum number of days found in the years 2014 (48 days) and 2000 (132 days) respectively. Moreover, from the Figure it is also evident a high year to year variability. Regarding the ozone-temperature relationship both the correlation coefficient and the slope between the two variables exhibit high values reaching 0.85 and 4.81 ugm^{-3}/ °C respectively.

Figure 6-5: Number of ozone exceedance days/yr for Reggio Emilia (left) and the relationship of the daily maximum 8hr average ozone concentrations with daily maximum temperatures (right) for the years 2000-2014.

Regarding the near future ozone concentrations the increases in the average daily maximum concentration range from 1 to 4 ppbV depending on the model (Figure 6-5).

6.3.3 Non-climate related pressures

Forest fires do not seem to constitute a danger in the Province of Reggio Emilia (Municipality of Reggio Emilia) (Chapter 4).

6.3.4 Adaptation measures

In Reggio Emilia a number of strategic plans have been approved that could help the improvement of the local ozone air-quality. These are:

- The Regional Integrated Air Plan (PAIR2020). which has a strategic reference horizon for 2020, envisages 94 measures to improve air quality in order to reduce pollutant levels in the regional territory and to fall within the limit values set by Directive 2008/50 / EC and by Legislative Decree 155/2010.

- The Reggio Respira ("Reggio Breaths") which aim to improve the city's air quality through integrated actions related to the environment and mobility issues.

In addition they are working on the new Sustainable Mobility Urban Plan (PUMS), a strategic tool that affects urban quality and transport, the culture of sustainability and respect for the environment, road safety and traffic in general.

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7 SOCIO-ECONOMIC CHARACTERISTICS RELATED TO CLIMATE CHANGE

7.1 Cyprus

7.1.1 Demographic indicators

7.1.1.1 Total permanent and seasonal population

Data regarding population and several social parameters are provided by the Statistical Service of Cyprus. In this context, the permanent population for all 19 Municipalities of Cyprus are provided in the Appendix. Based on the following diagram (Diagram 7-1), it is highlighted that the most populated Municipalities are capital (i.e. Nicosia) and near the capital Municipalities, such as Strovolos and Lakatamia Municipalities, as well as the main coastal tourist resorts, namely Limassol, Larnaka and Pafos Municipalities.

Diagram 7-1: Permanent population distribution per Municipality for Cyprus

In terms of seasonal population, data from the Statistical Service of Cyprusdoes not publish any relevant information. To this end, data were retrieved regarding the number of arrivals and overnight stays at the main tourist resorts of Cyprus. All the relevant data are provided in the Appendix. In order to present an overview of the population visiting Cyprus, data were analysed considering the number of arrivals and the mean length of stay. The latter is provided by dividing the overnight stays with the number of arrivals. The figures provided in Diagram 7-2 depict the decrease of the mean length of stay in Nicosia and Larnaka, an assumption that is consistent with the effects of the economic crisis. However, Lemesos, which has been traditionally the most famous touristic area of the island, shows signs of a modest recovery after 2011.

Arrivals and mean length of stay at the accommodation establishments in the main tourist resorts of Larnaka, Lemesos and Nicosia Municipalities of Cyprus from 2001 to 2015

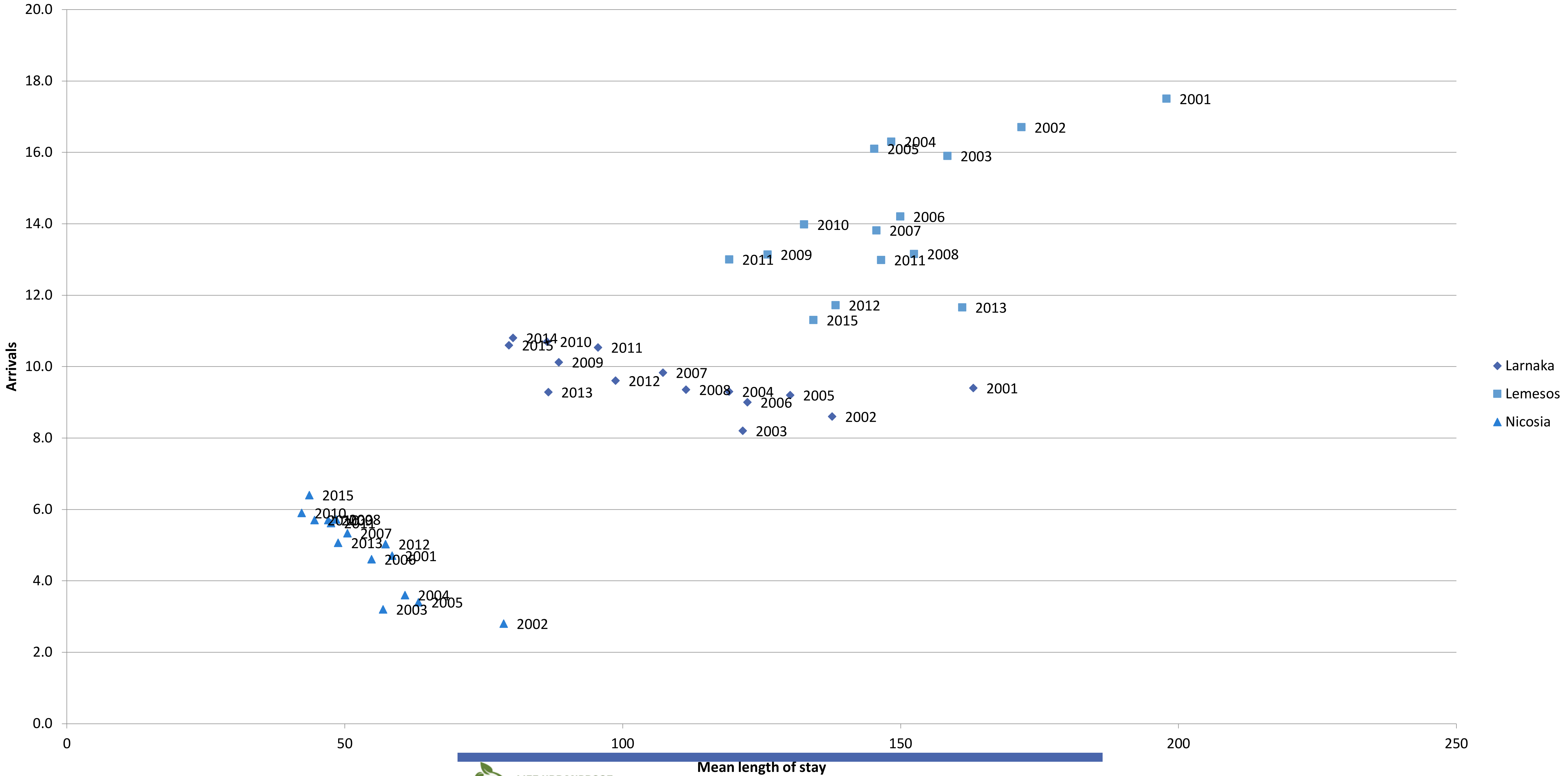

Diagram 7-2: Arrivals and mean length of stay at the accommodation establishments in the main tourist resorts of Larnaka, Lemesos and Nicosia Municipalities of Cyprus for time period 2001-2015

7.1.1.2 Population projection

Sustainable urban growth depends on the driving forces of population growth. To this end, population growth is an important parameter to assess in order to evaluate urban resilience against climate change. In this framework, data were retrieved from Eurostat, since the Statistical Service of Cyprus does not provide such kind of information. However, scenarios providing information about the likely future population size and structure have been conducted based on fertility, mortality and migration indicators by Eurostat (cohort-component method, population reference to the 1/1 population per year of reference). Based on the aforementioned, population projection for all the Municipalities of Cyprus shows a moderate growth trend.

Table 7-1: Population projection for Cyprus

Time	2015	2020	2030	2040	2050	2060	2070	2080
Population projection for Cyprus	847,008	869,041	919,997	954,320	984,402	1,011,947	1,019,473	1,004,870

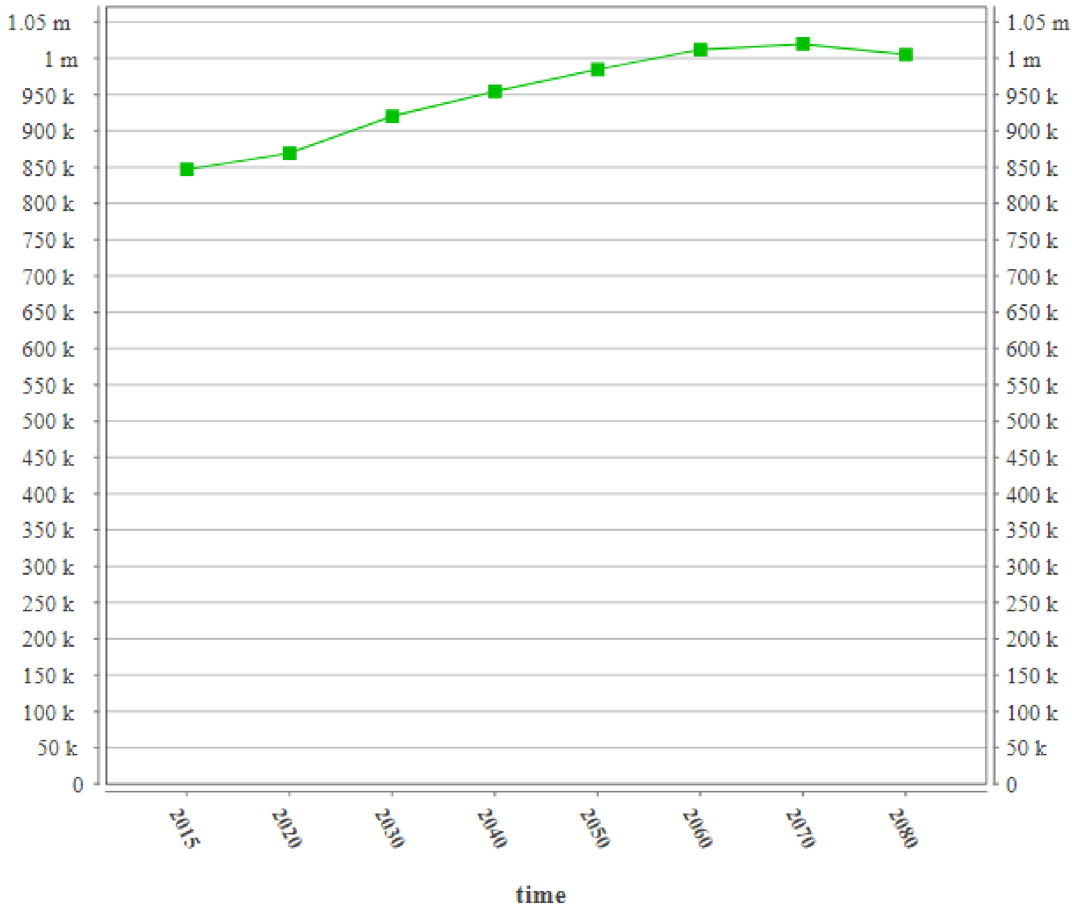

Figure 3-1: Population projection for Cyprus

Source: Eurostat

7.1.1.3 Distribution of population per age group, level of education, citizenship

Distribution of population per age group

Demographic data regarding population structure with reference to age of the permanent population were retrieved from the Statistical Service of Cyprus. Based on the data provided, the age classes with reference to young people include (i) 0-4 years old, (ii) 5-9 years old, (iii) 10-14 years old and (iv) 15-19 years old. The age groups with reference to the workforce age from 20 to 69 years old with age groups of four (4) years. The same age period is used for presenting age from 70 till 80+ years old. According to the data provided (Diagram 7-3, Diagram 7-4 and Diagram 7-5), the Municipalities of Strovolos and Lakatamia bear small differences compared to the total population of the country. More specifically, Strovolos Municipality shows a peak in ages of 25-29 years old followed by a decrease until the age group of 35-39, while the relevant peak for Lakatamia Municipality is presented more evenly for the aforementioned age groups. In all three cases presented in the following diagrams (Diagram 7-3 - Diagram 7-5) the largest percentage of the population is concentrated in the younger age groups.

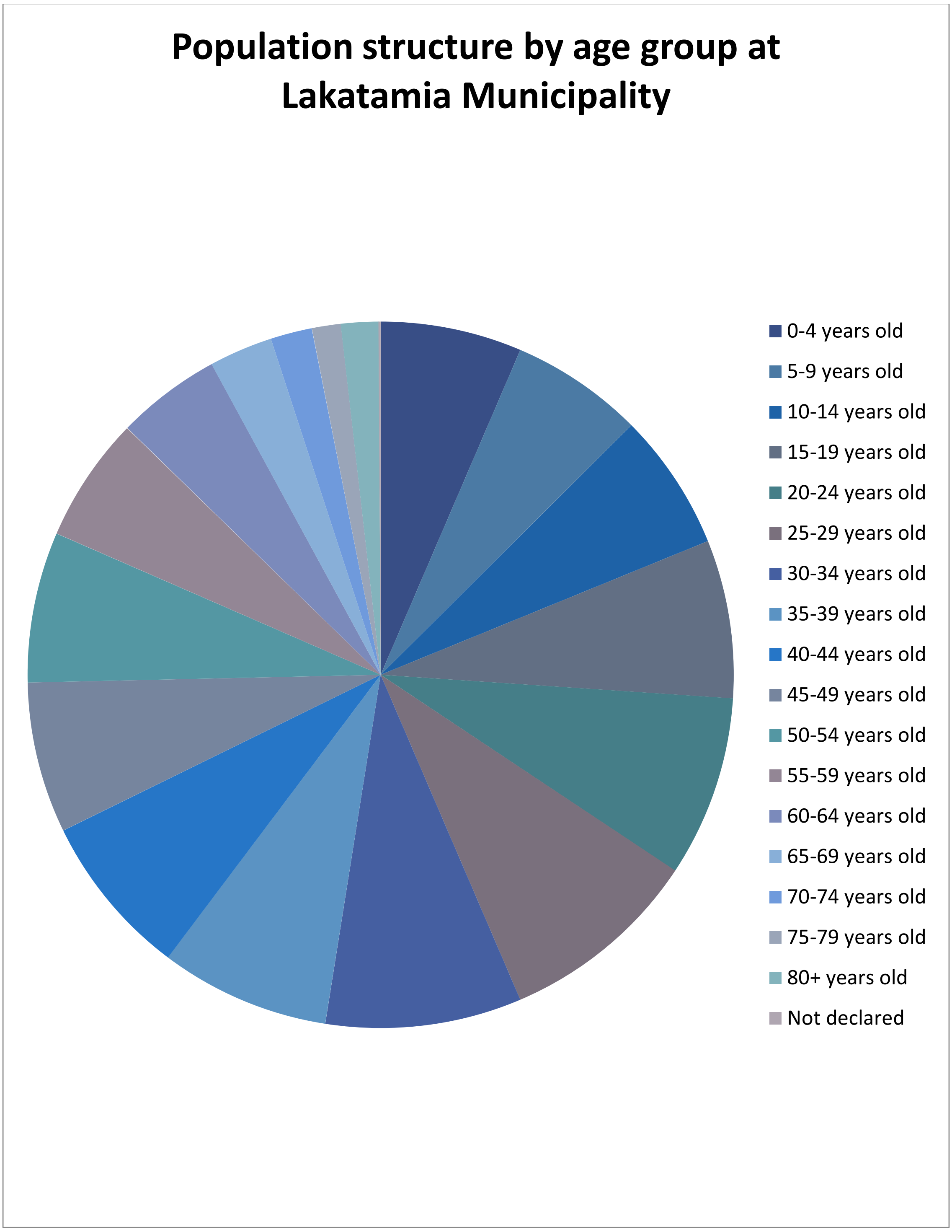

Diagram 7-3: Population structure by age group at Lakatamia Municipality

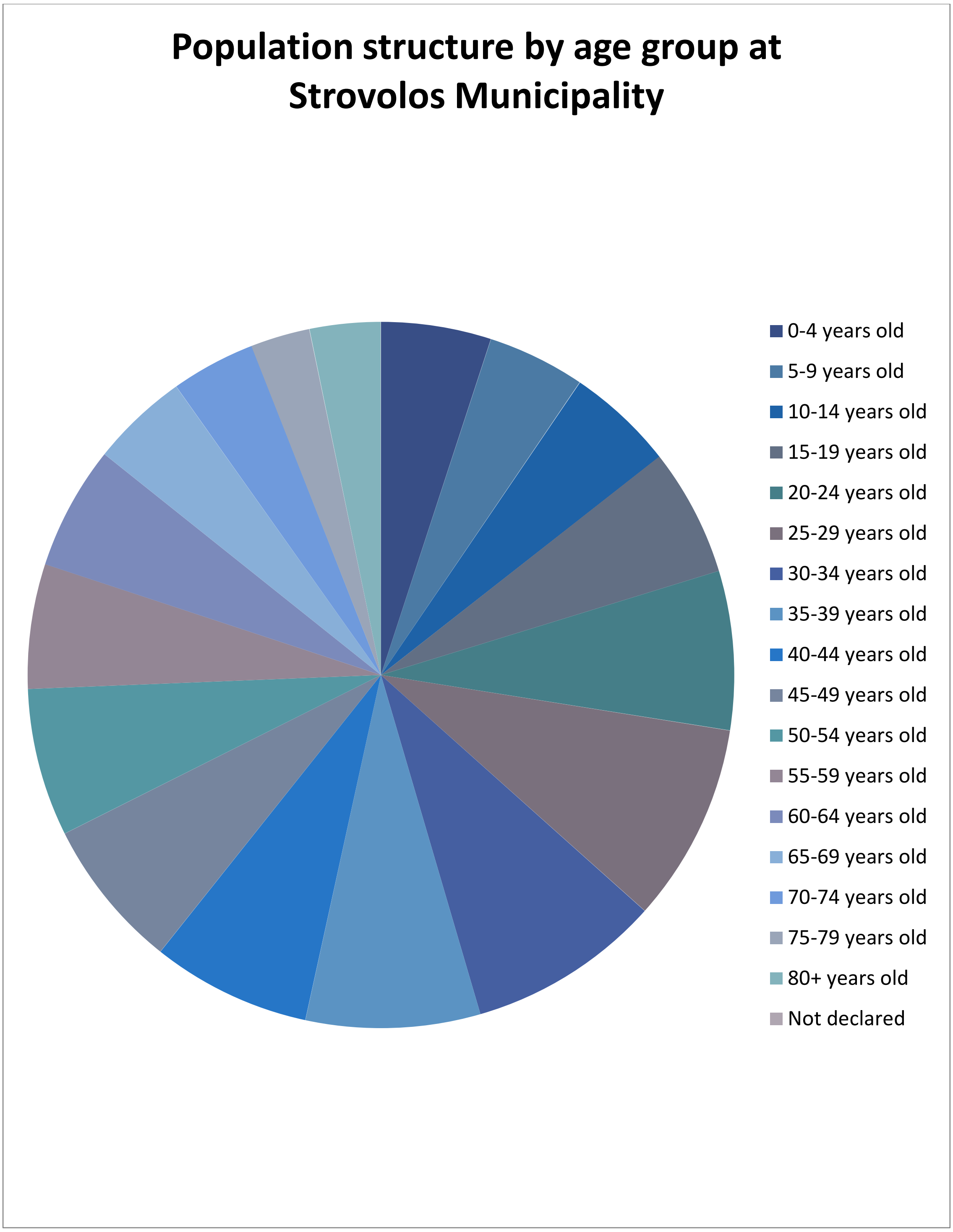

Diagram 7-4: Population structure by age group at Strovolos Municipality

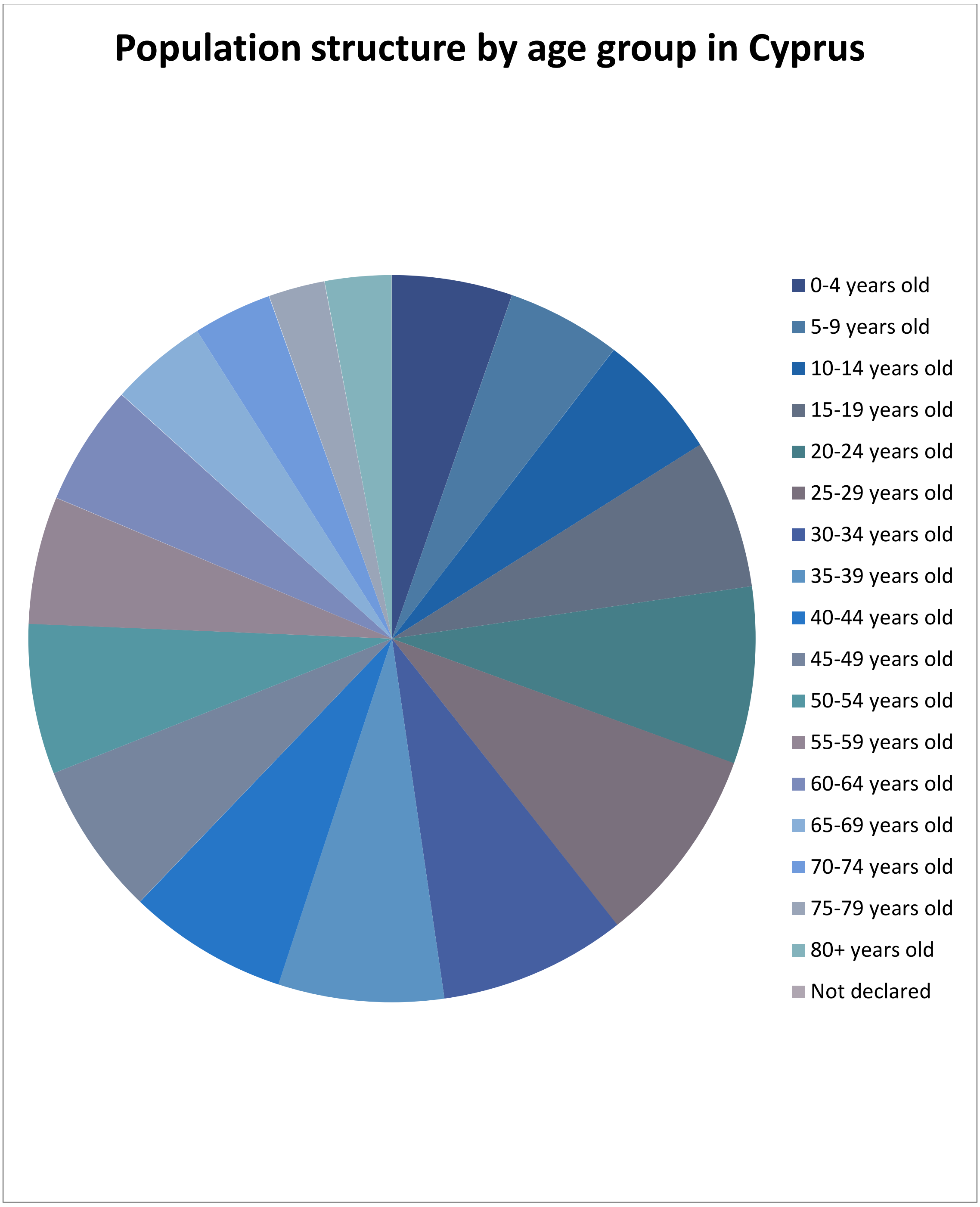

Diagram 7-5: Population structureby age group in Greece

Distribution of population per education level

Data regarding the educational system of Cyprus were provided by the Statistical Service of Cyprus. The Educational System of Cyprus consists of the following tiers (ΥπουργείοΠαδείαςκαιΠολιτισμού):

(i) Pre-school education: One-year pre-school education is compulsory for all children aged 4 8/12 to 5 8/12 years old. Children over 3 (three) years of age are also admitted.
(ii) Primary Education: Primary education is compulsory for all children aged 5 to 8/12 and has duration of 6 years.
(iii) Secondary education: Secondary General Education is offered in two triennial cycles, Lower Secondary Education and High School (Upper Secondary Education) for students aged 12-18. As far as upper secondary education is concerned, students have the choice instead of attending high school to study in secondary technical and vocational education.
(iv) Post-Graduate Vocational Education and Training: Post-Graduate Vocational Education and Training offers specialized vocational education and training to graduates of secondary education who wish to acquire technical and professional knowledge and skills in specific programs or disciplines.
(v) Higher education: Public and private higher education institutions are operating in Cyprus at university and non-university level. Public universities offer 1-3 year vocational programmes of study. Private Schools of Higher Education: 40 Private Higher Education Institutions operate in Cyprus. These institutions do not have university status but offer both academic and professional courses at undergraduate and postgraduate levels.

The data regarding the population distribution per education level are provided for the workforce of Cyprus in the Appendix. Timeseries were provided for the time period 1999-2016. Based on the Diagram 7-6, it is highlighted that the percentage of the active economically population attending higher education has increased, while people that have reached secondary education has a downward trend.

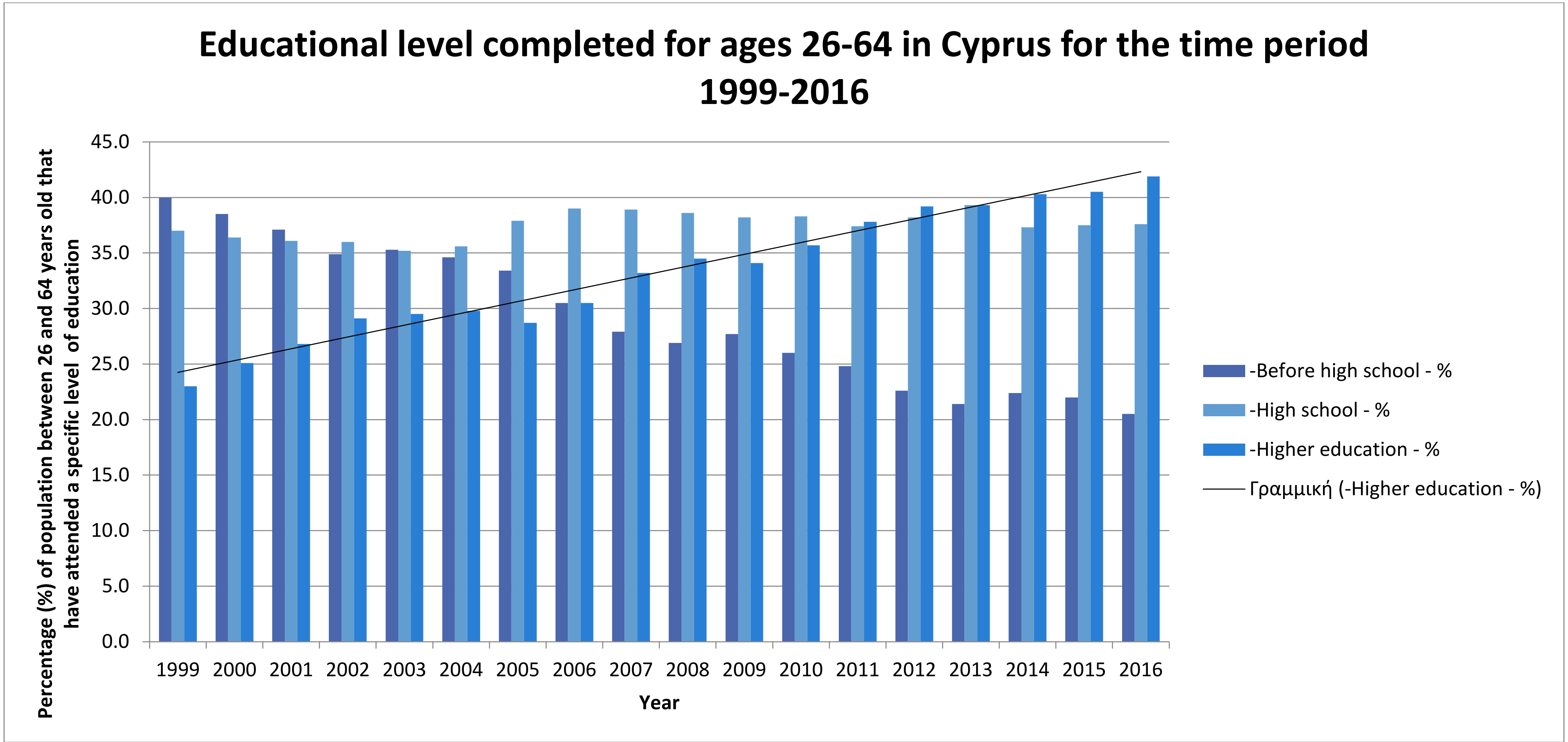
Educational level completed for ages 26-64 in Cyprus for the time period 1999-2016
Percentage (%) of population between 26 and 64 years old that have attended a specific level of education
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Year
-Before high school - %
-High school - %
-Higher education - %
Γραμμική (-Higher education - %)

Diagram 7-6: Educational level completed for ages 26-64 in Cyprus for the time period 1999-2016

Distribution of population per citizenship

Environmental, political and social factors have resulted in global migration flows. In Cyprus, 13% of the residents are European Union holders, while 8% refer to nationals of other countries. More specifically, Strovolos and Lakatamia Municipalities hold lower percentages in European Union holders and nationals of other countries. Based on Diagram 7-7, population of another nationality is mainly observed in the most tourist Municipalities on the coast of the country.

Distribution of population per citizenship for the Municipalities of Cyprus

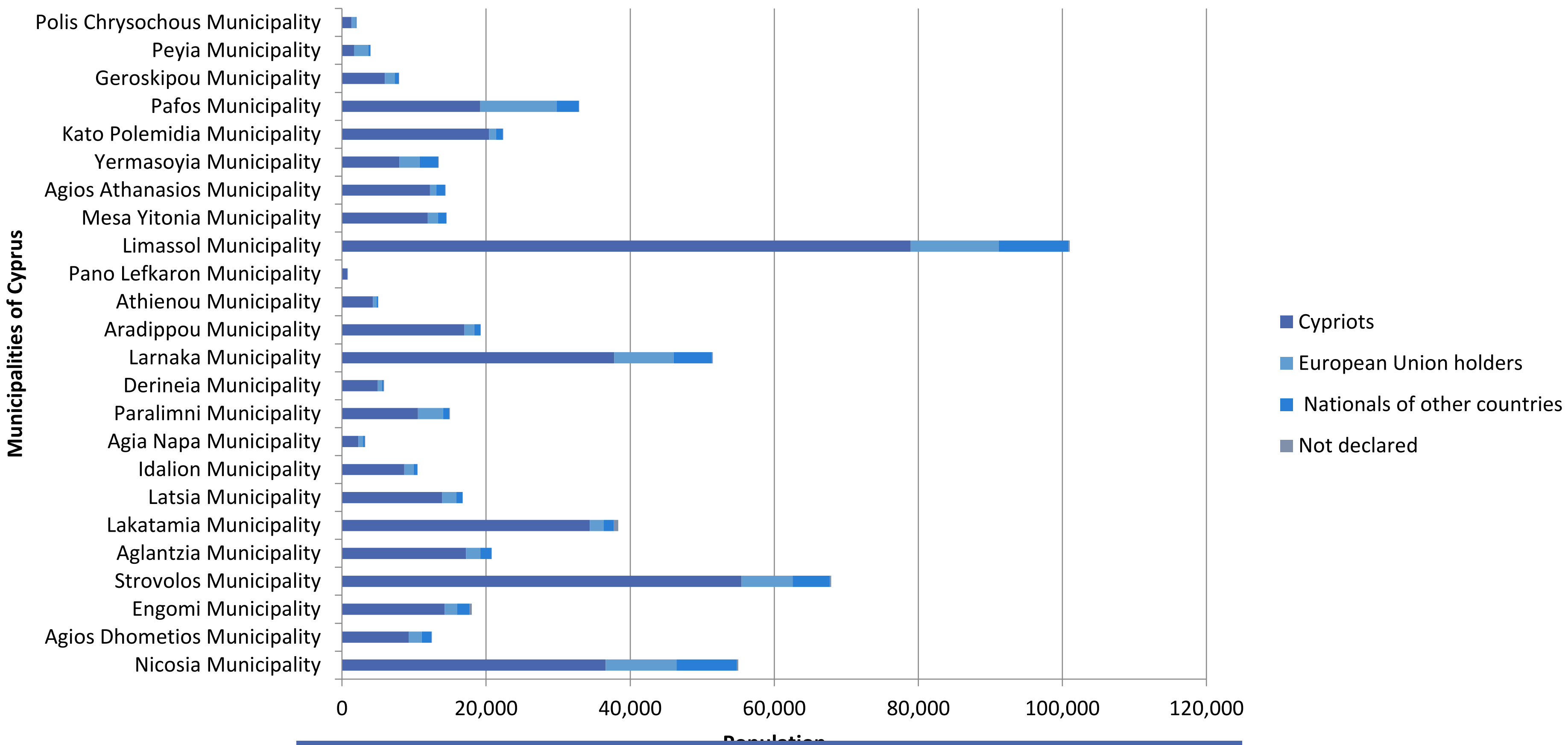

Diagram 7-7: Distribution of population per citizenship at the Municipalities of Cyprus

7.1.1.4 Population density

Population density is an indicator provided by the annual average population and the land area. In terms of the land area, the total area should be used excluding the inland waters wherever possible. In different case, the total area including the inland waters is considered for the calculation of the indicator. In this context, population density for all the Cypriot Municipalities is provided in Diagram 7-8. Municipalities such as Mesa Yitonia, Limassol, Strovolos, Engomi and Larnaka are amongst the densely populated areas. Lakatamia Municipality is also above the average.

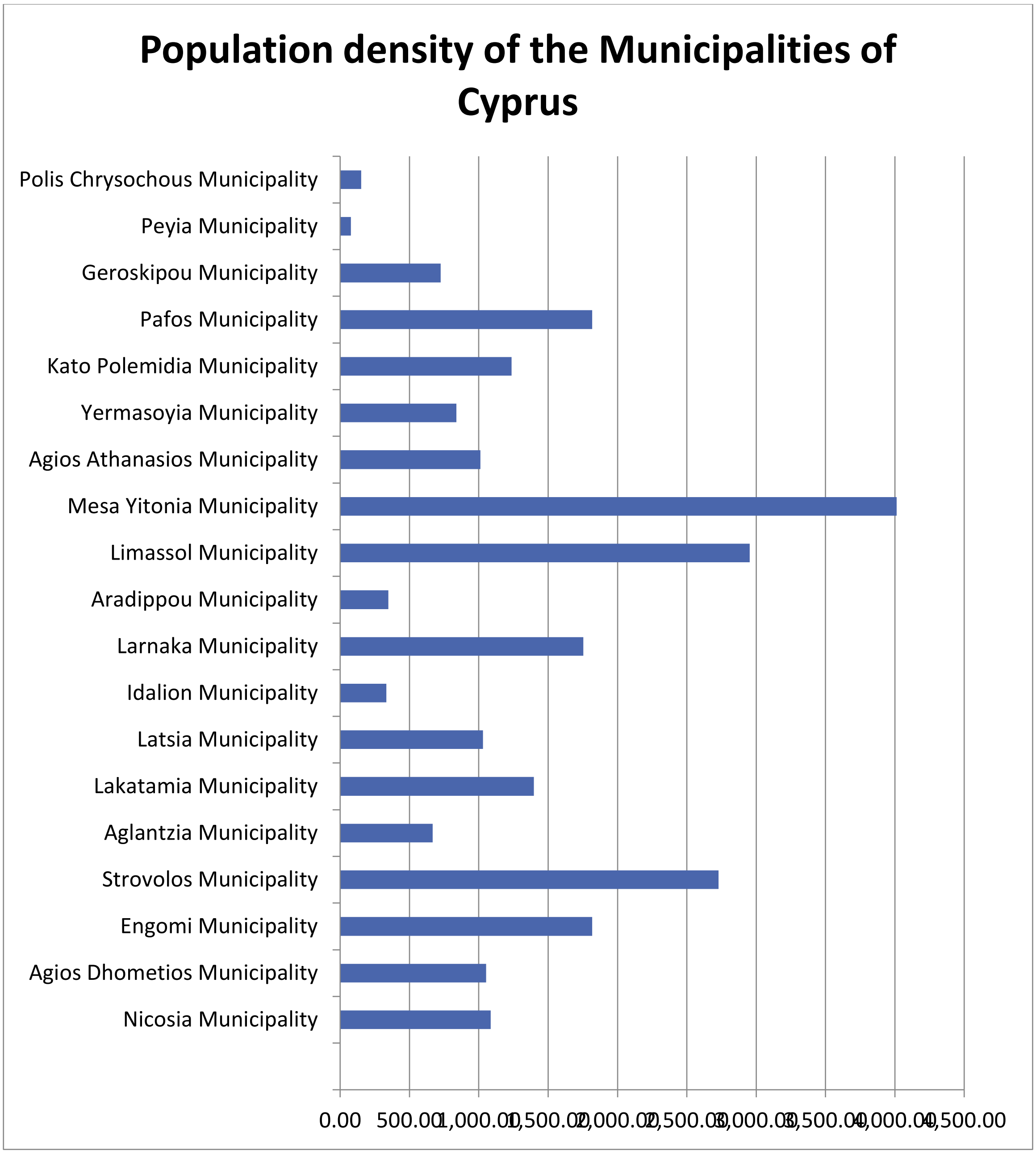

Diagram 7-8: Population density of the Municipalities of Cyprus

7.1.2 Economic indicators:

7.1.2.1 Economically active population

The economic active population (including employed, as well as unemployed people) refers to the people for the production of economic goods and services. Pre-school and school children, students and pensioners are not included in this group. To this end, data regarding the labour force of the Cypriot Municipalities are provided in the Appendix. Based on Diagram 7-9, urban cities near the capital of Cyprus, as well as the main coastal tourist resorts offer more job opportunities, thus most of the country's workforce is located in the areas.

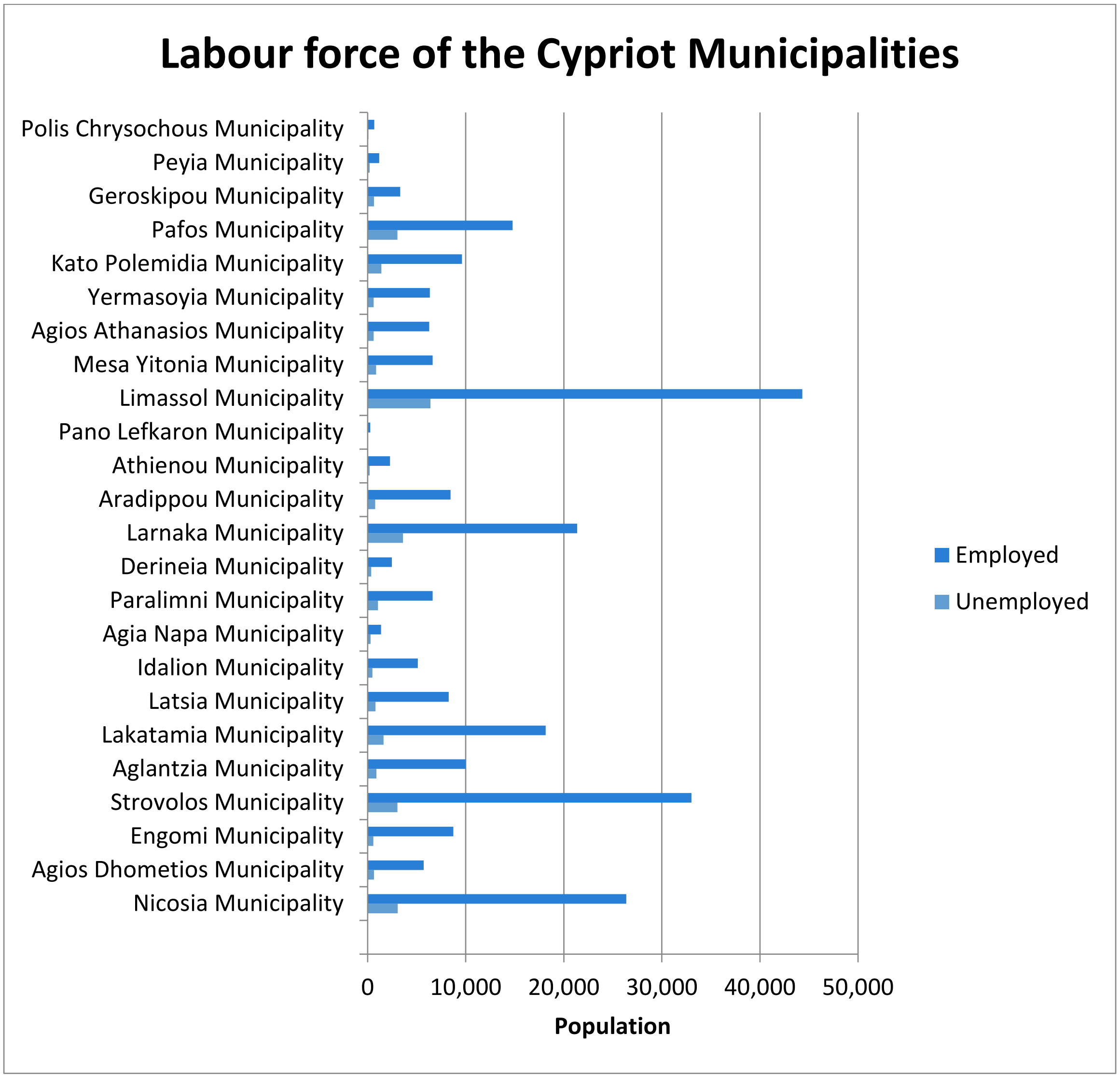

Diagram 7-9: Workforce of the Cypriot Municipalities

7.1.2.2 Distribution of population per employment status and poverty risk

Based on the data of Statistical Service of Cyprus, the economically active population of Cyprus is 417,180 people out of the total population (i.e. 840.407 people). In this context, 49,64% of the total population belongs to the workforce of the country. This percentage is almost similar to most of the Cypriot

Municipalities. However, municipalities in isolated areas have reached lower percentages 34-37%. Populated municipalities bear percentages similar to the total population, except for Limassol and Larnaka Municipalities where the economically non-active population is higher than the active (Diagram 7-10).

Population distribution per employment status at the Municipalities of Cyprus

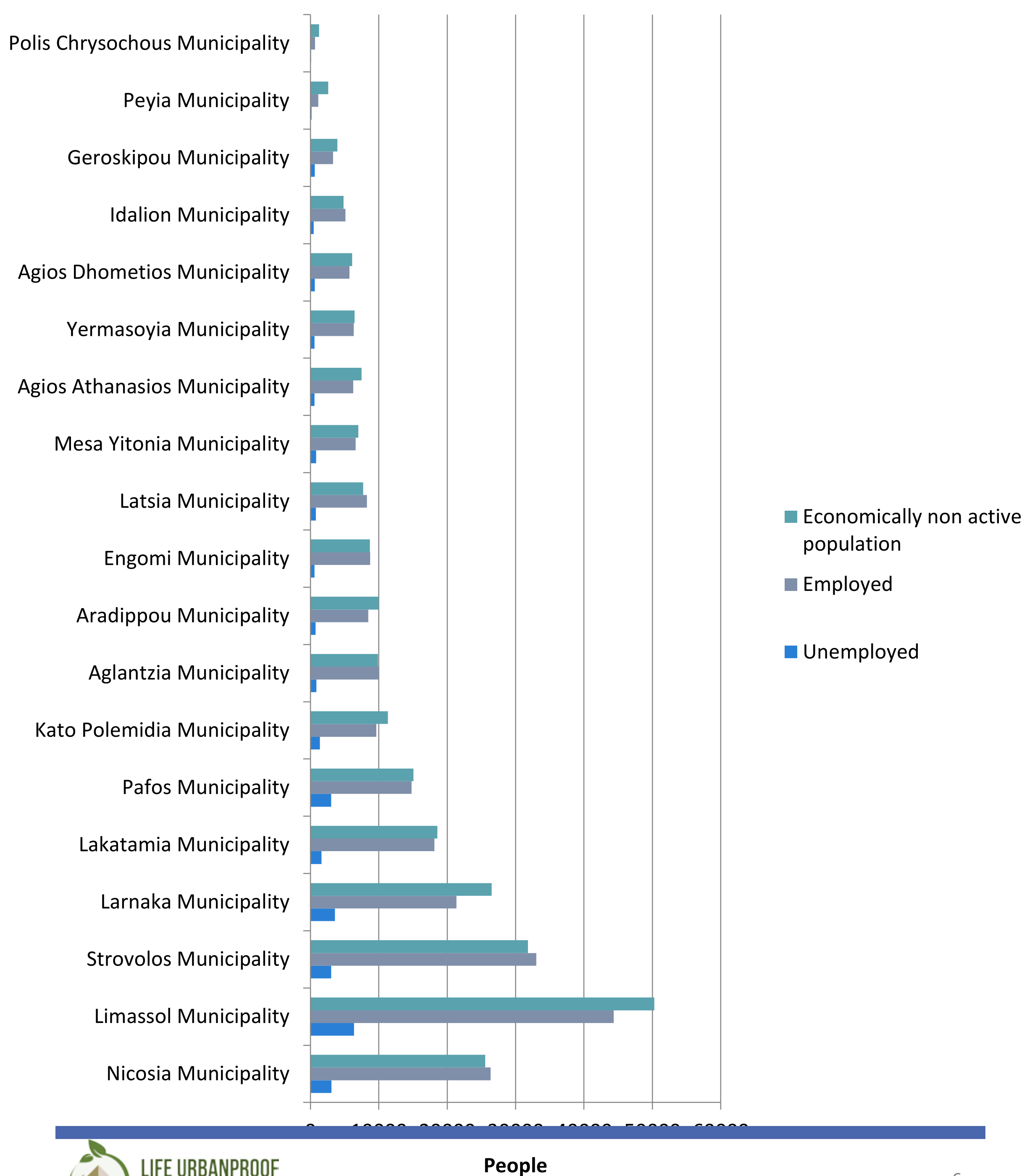

Diagram 7-10: Population distribution per employment status at the Municipalities of Cyprus

Based on the results of the Income and Living Survey 2015, the risk of poverty or social exclusion accounted for 28.9% of the population. Consequently, 28.9% of the population of Cyprus in 2015 lived at least one of the following conditions: living below the poverty risk threshold (16.2%) (income poverty), living in a household severely materially deprived (15.4 %) or living in a household with a very low labor intensity index (10.9%). In 2008, the risk of poverty or social exclusion was 23.3%, with the percentages respectively: 15.9%, 9.1% and 4.5%. Finally, it has to be noted that the poverty threshold was reduced to € 8,276in 2015 compared to € 9,614 in 2008.

7.1.3 Health indicators:

7.1.3.1 Life expectancy

Indicators for evaluating healthy life at the European Union are presented at theEuropean Information System on Healthy Life Years and Life Expectancy (EHLEIS). The project is supported by the Hellenic Statistical Authority, European Joint Action and the National Institute of Health and the Medical Research (ISERM). Life expectancyis calculated based on the average number of remaining years in good or bad health. To this end, timeseries regarding life expectancy by sex and age for Cyprus for the time period 1995-2014 are provided in the Appendix (data provided do not include institutions). Based on the data provided, life expectancy at birth was estimated at 79.8 years for men and 83.5 years for women (Diagram 7-11).

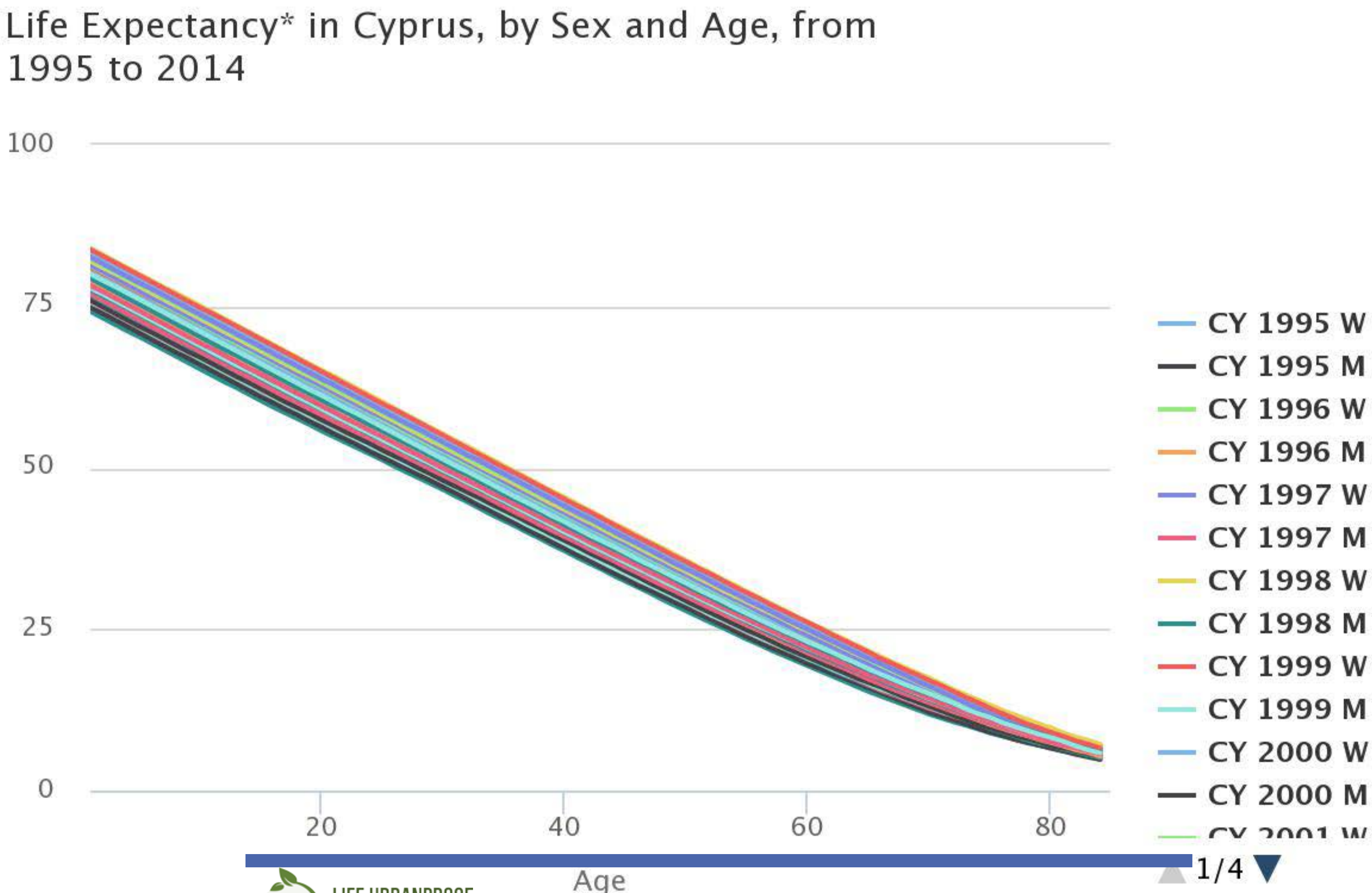
Life Expectancy* in Cyprus, by Sex and Age, from 1995 to 2014
100
75
50
25
0
20
40
60
80
Age
CY 1995 W
CY 1995 M
CY 1996 W
CY 1996 M
CY 1997 W
CY 1997 M
CY 1998 W
CY 1998 M
CY 1999 W
CY 1999 M
CY 2000 W
CY 2000 M
1/4

Diagram 7-11: Life expectancy for both men and women by age in Cyprus from 1995 to 2014

Source: [3]

[3] http://www.eurohex.eu/IS/web/app.php/Ehleis/LifeGeographic?Typ=Life&SubTyp=None

7.1.3.2 Distribution of population with chronic diseases/health problems per type of disease/health problem

The increase of the number of years spent in good health is one the main goals for the 2020 Strategy. Chronic diseases limit the years of healthy life despite the increase of the average life expectancy in the EU Member States. To this end, population distribution with chronic diseases or health problems is a critical factor for evaluation in terms of the urban resilience against climate change. Based pm the European Health Survey that was conducted on 2014 (Υπουργείο Οικονομικών και Στατιστική Υπηρεσία Κύπρου, 2016), 33.1% of the population declared having some of the diseases listed (Diagram 7-29) in during the last 12 months. The highest incidence of hypertension is reported by 14.5% of respondents, followed by middle-aged or other chronic problems (back pain-discopathy) with 10.8%, neck or other chronic neck problems with 6.2%, allergies (excluding allergic asthma) with 5.7%, diabetes (5.1%), osteoarthritis (4.3%), asthma (4.1%), osteoporosis and joint disease excluding arthritis (3.5%). Finally, based on the (Diagram 7-29), it is shown that men have higher rates than women in hypertension, diabetes, cardiac infarction, or chronic stroke, kidney problems, coronary artery disease and/or angina (chest pain) and stroke or chronic old stroke effects, while women have higher percentages than men.

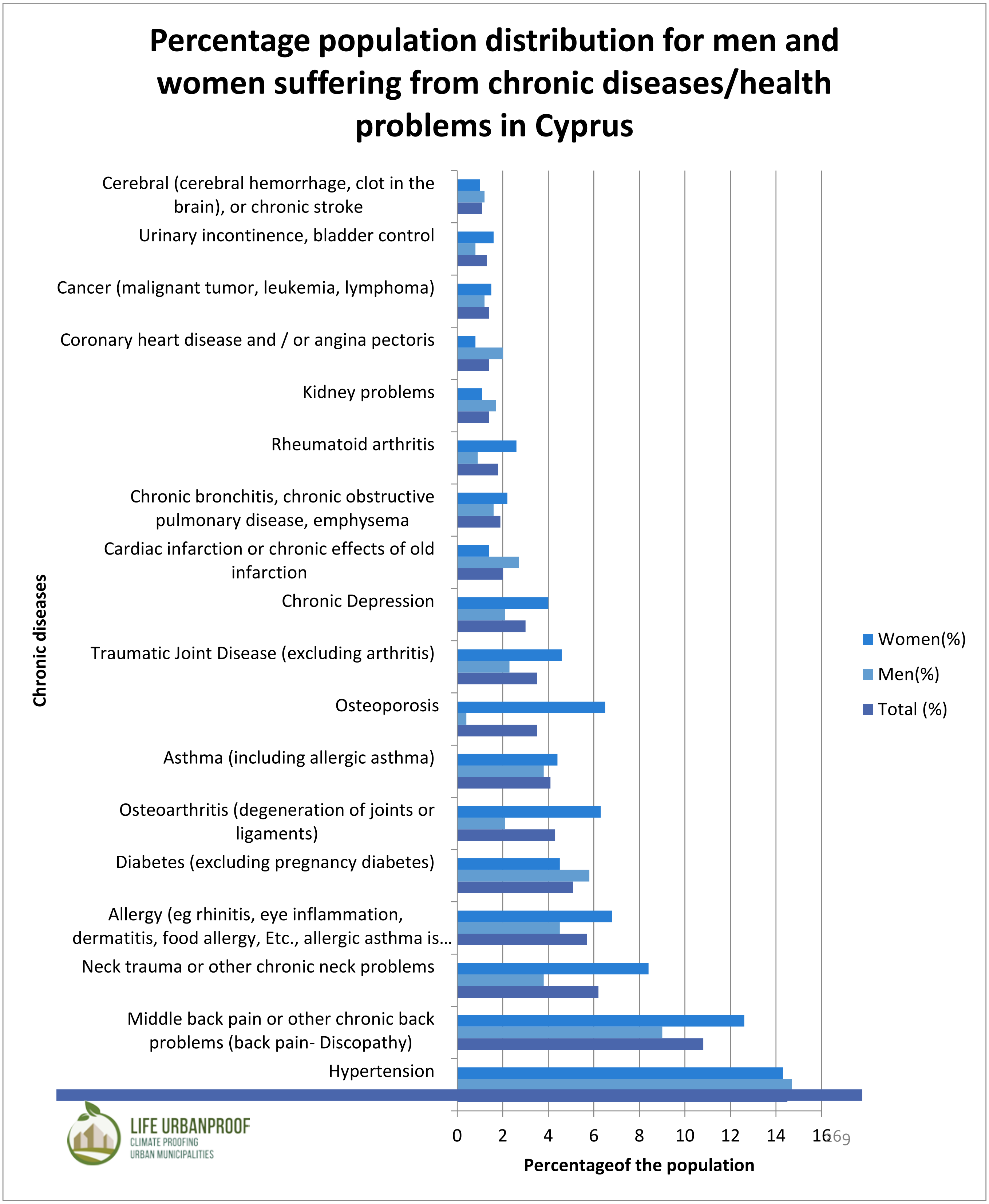
Percentage population distribution for men and women suffering from chronic diseases/health problems in Cyprus
Chronic diseases
Cerebral (cerebral hemorrhage, clot in the brain), or chronic stroke
Urinary incontinence, bladder control
Cancer (malignant tumor, leukemia, lymphoma)
Coronary heart disease and / or angina pectoris
Kidney problems
Rheumatoid arthritis
Chronic bronchitis, chronic obstructive pulmonary disease, emphysema
Cardiac infarction or chronic effects of old infarction
Chronic Depression
Traumatic Joint Disease (excluding arthritis)
Osteoporosis
Asthma (including allergic asthma)
Osteoarthritis (degeneration of joints or ligaments)
Diabetes (excluding pregnancy diabetes)
Allergy (eg rhinitis, eye inflammation, dermatitis, food allergy, Etc., allergic asthma is...
Neck trauma or other chronic neck problems
Middle back pain or other chronic back problems (back pain- Discopathy)
Hypertension
Women(%)
Men(%)
Total (%)
0
2
4
6
8
10
12
14
16
Percentageof the population
LIFE URBANPROOF
CLIMATE PROOFING
URBAN MUNICIPALITIES

Diagram 7-12: Percentage population distribution for men and women suffering from chronic diseases/health problems in Cyprus

7.1.3.3 Number of hospitals/health clinics per type (expertise) of hospital/clinic

Public and private health services are available for medical care in Cyprus. Based on the 2015 census, the most frequent specialties with regard to outpatient visits in General Hospitals are General Medicine, Special Pathology, Cardiology, Pediatrics and Gynecology-Obstetrics. To this end, the major urban centres of Cyprus have provided a larger number of beds (Diagram 7-30). A sufficient number of beds are available in private clinics (Diagram 7-31).

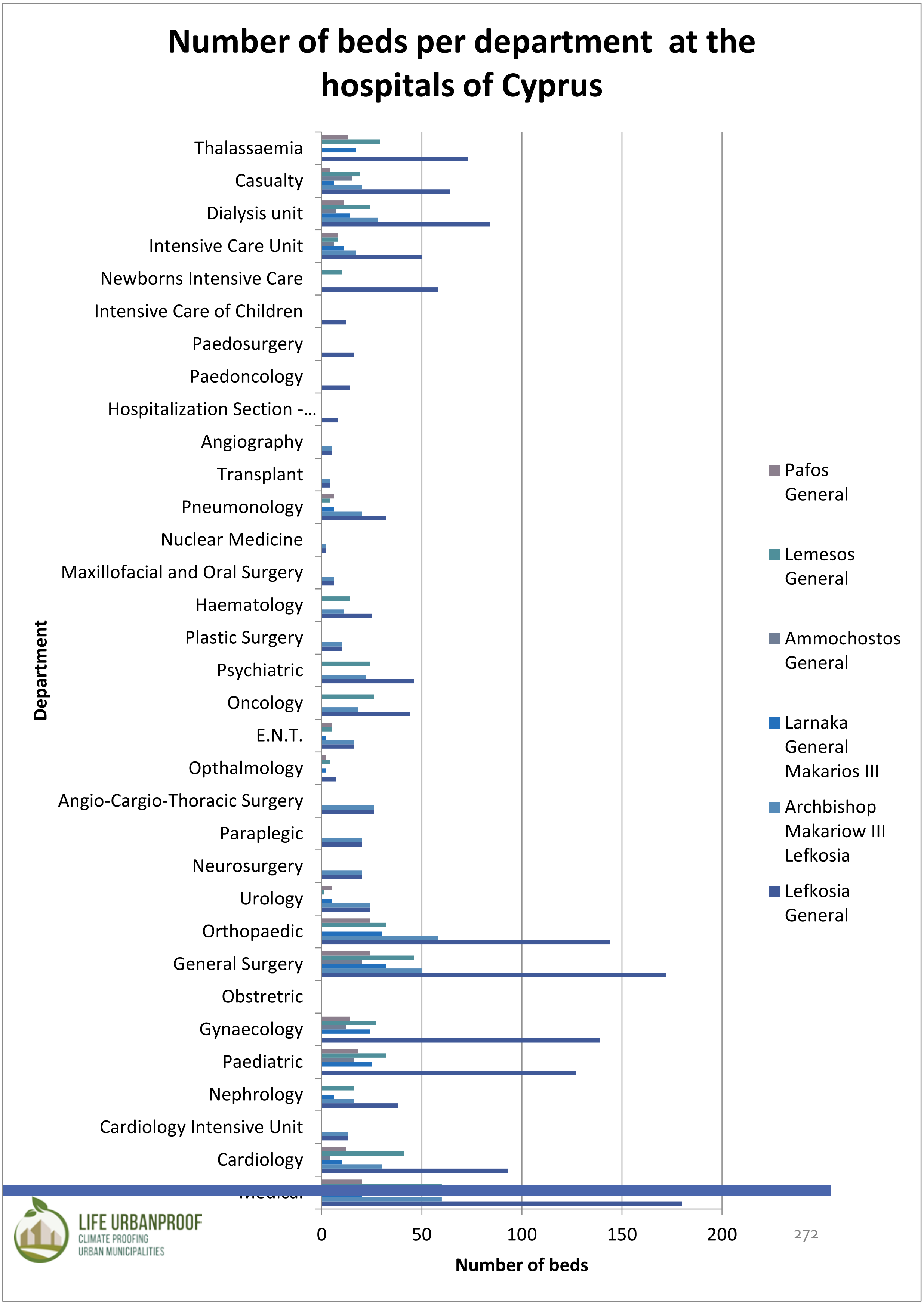
Number of beds per department at the hospitals of Cyprus
Thalassaemia
Casualty
Dialysis unit
Intensive Care Unit
Newborns Intensive Care
Intensive Care of Children
Paedosurgery
Paedoncology
Hospitalization Section -...
Angiography
Transplant
Pneumonology
Nuclear Medicine
Maxillofacial and Oral Surgery
Haematology
Plastic Surgery
Psychiatric
Oncology
E.N.T.
Opthalmology
Angio-Cargio-Thoracic Surgery
Paraplegic
Neurosurgery
Urology
Orthopaedic
General Surgery
Obstretric
Gynaecology
Paediatric
Nephrology
Cardiology Intensive Unit
Cardiology
Department
0
50
100
150
200
Number of beds
Pafos General
Lemesos General
Ammochostos General
Larnaka General Makarios III
Archbishop Makariow III Lefkosia
Lefkosia General

Diagram 7-13: Hospitals per type of expertise and number of beds in Cyprus

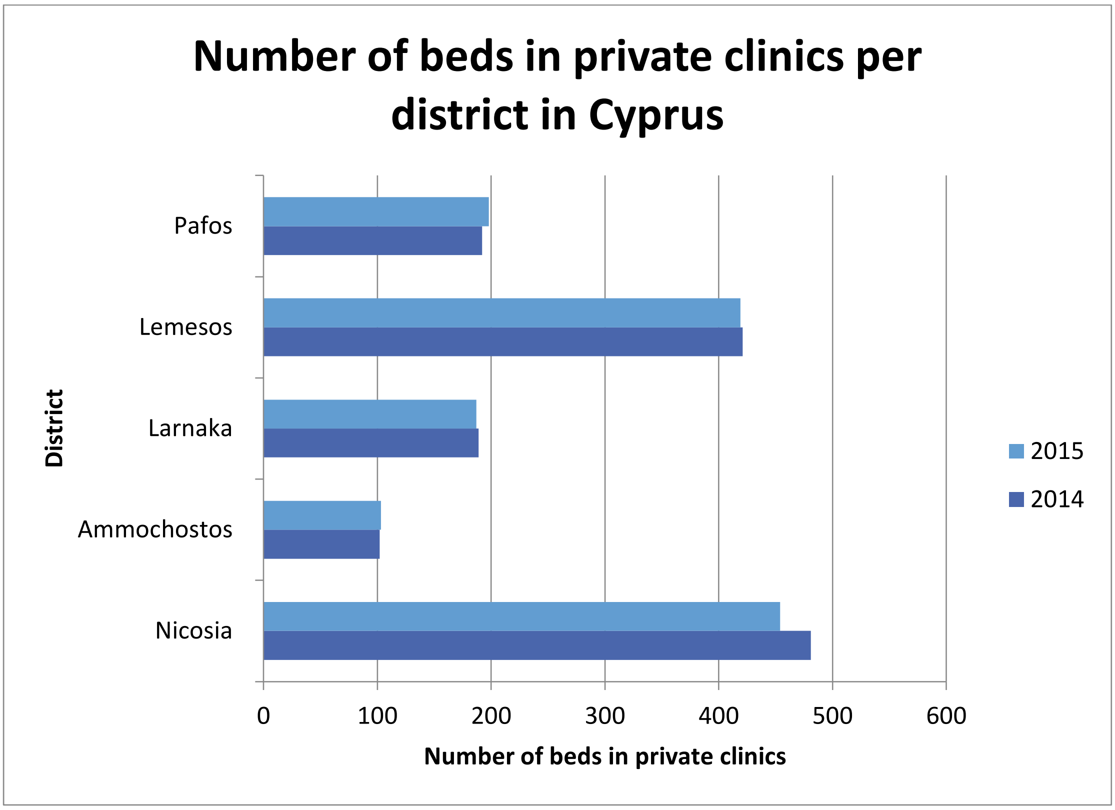

Diagram 7-14: Number of beds in private clinics of Cyprus for 2014-2015

7.2 Greece

7.2.1 Demographic indicators

7.2.1.1 Total permanent and seasonal population

The Hellenic Statistical Authority provides data regarding the population and social conditions of Greece. In this framework, data regarding the permanent population of the Municipalities of Greece were retrieved, and have been included in the Appendix. To this end, a general description based on the upper administrative division (i.e. regional units) is provided in the following diagram (Diagram 7-15) due to the significant number of the Greek Municipalities. The permanent population distribution reveals the degree of urbanization in Greece, where city centres are overpopulated compared to the islands and remote areas inland.

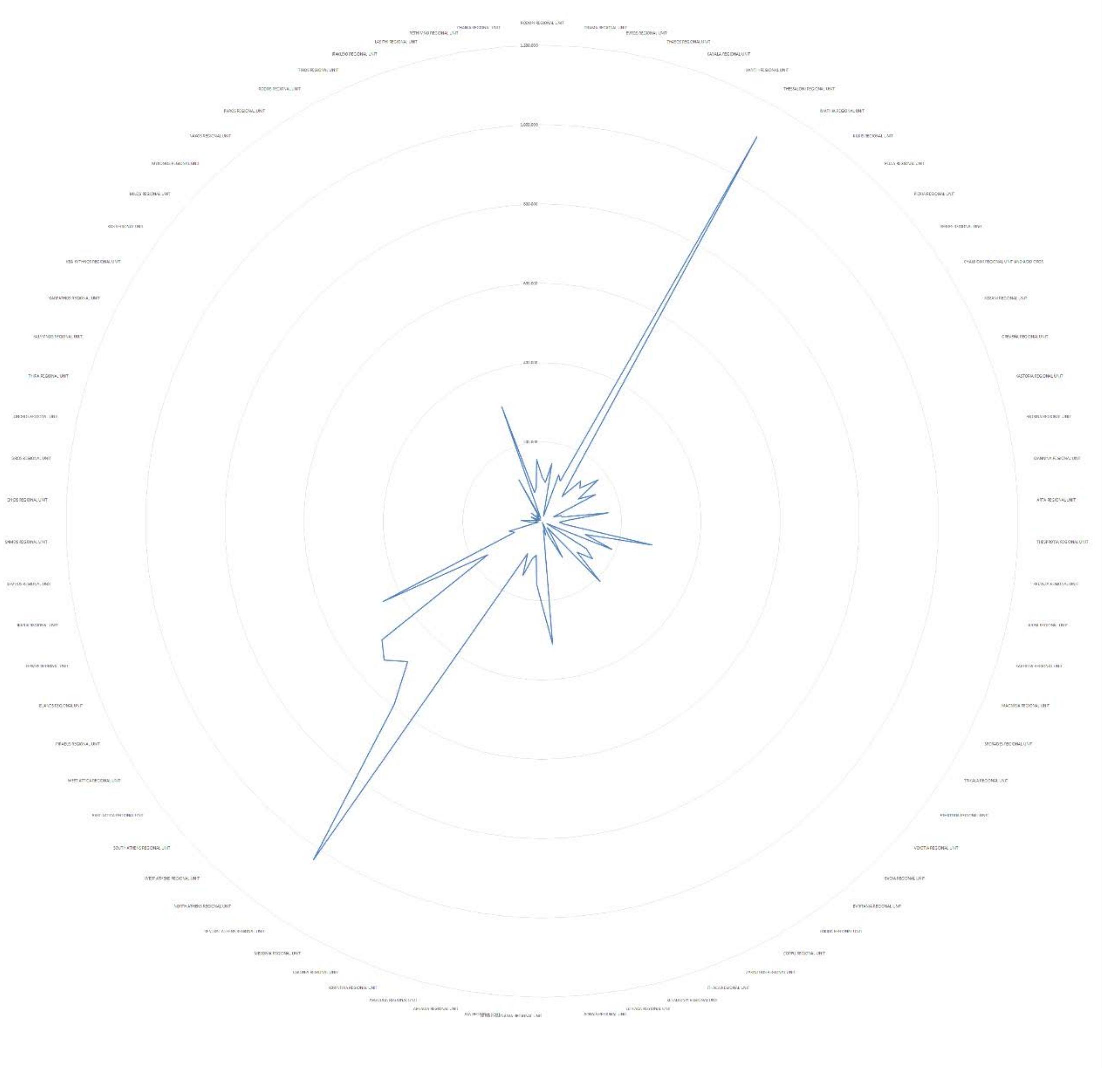

Diagram 7-15: Permanent population distribution per regional unit for Greece

In addition, data from the Hellenic Statistical Authority were also used in order to calculate the seasonal population of the Municipalities, in Greece. More particularly, the seasonal population refers to the population using tourist accommodation establishments in a specific area. In this framework, according to Eurostat, a tourist accommodation establishment is defined by every kind of accommodation provision regardless of being their primary or secondary activity of the enterprise to which the establishment belongs to. Therefore, a classification of tourism accommodation establishments is available for the collection of tourism statistics, namely:

- *NACE Group 55.1: hotels and similar accommodation (this includes accommodation provided by hotels, resort hotels, suite/apartment hotels, motels);*
- *NACE Group 55.2: holiday and other short-stay accommodation (this includes holiday homes, visitor flats and bungalows, cottages and cabins without housekeeping services, youth hostels and mountain refuges);*
- *NACE Group 55.3: camping grounds, recreational vehicle parks and trailer parks — otherwise referred to as campsites (this includes the provision of accommodation in campgrounds, trailer parks, recreational camps and fishing and hunting camps for short stay visitors, and the provision of space and facilities for recreational vehicles, protective shelters or plain bivouac facilities for placing tents and/or sleeping bags).*

Based on the abovementioned, data were retrieved about the number of arrivals and overnight stays at tourist accommodations per Municipality (all data are provided in the Appendix). Specifically, the key indicator of overnight stays highlights the length of stay, as well as the number of visitors. However, since there is a number of dwellings for tourist use without having a certification by the Greek National Tourism Organisation, all the figures provided in the following diagram (Diagram 7-16) should be adjusted considering a 10% increase. In specific for the case of the Municipality of Peristeri, it has to be noted that there has been no seasonal population recorded by the Hellenic Statistical Authority.

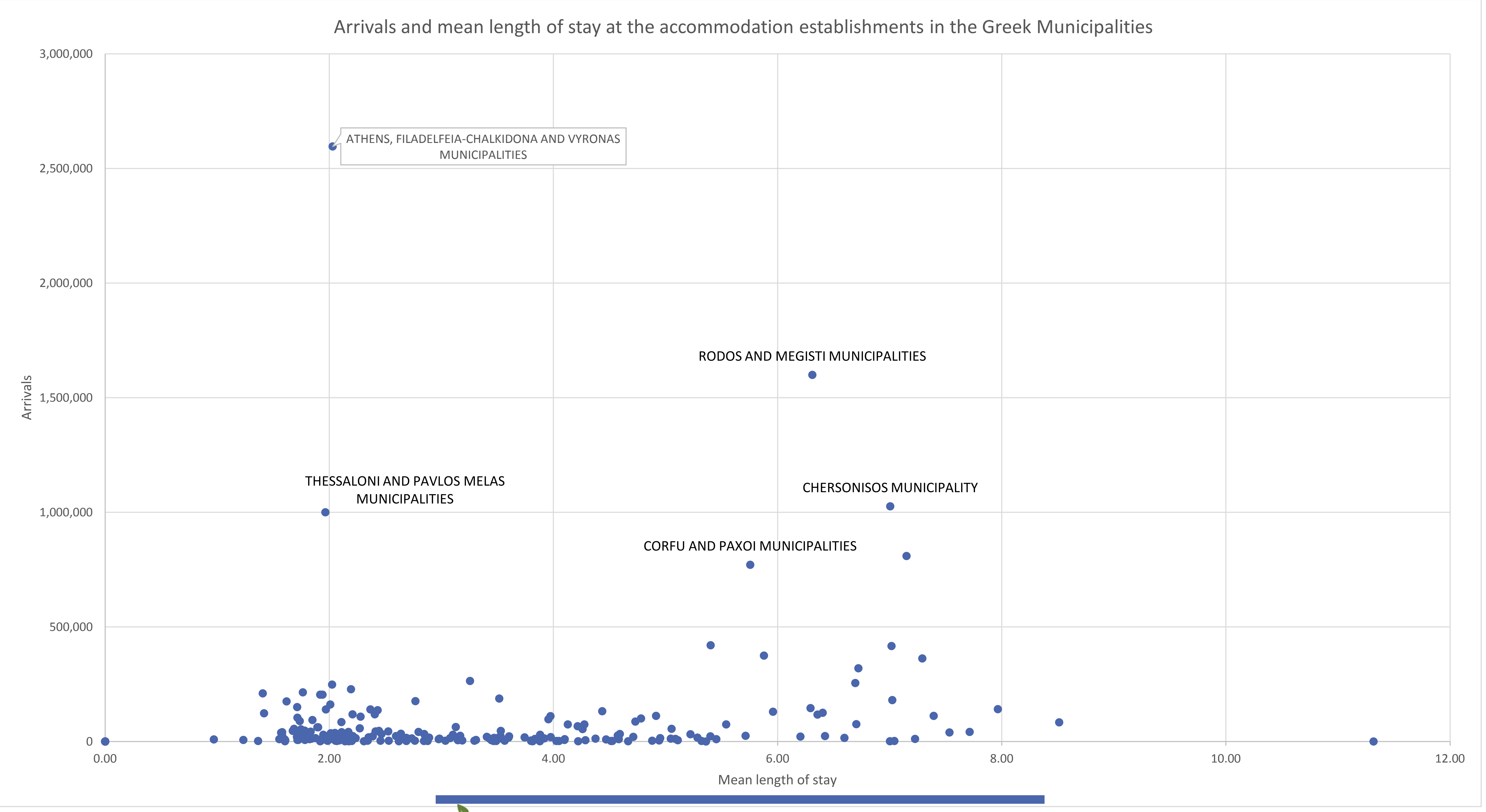
Arrivals and mean length of stay at the accommodation establishments in the Greek Municipalities
Arrivals
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Mean length of stay
ATHENS, FILADELFEIA-CHALKIDONA AND VYRONAS MUNICIPALITIES
RODOS AND MEGISTI MUNICIPALITIES
THESSALONI AND PAVLOS MELAS MUNICIPALITIES
CHERSONISOS MUNICIPALITY
CORFU AND PAXOI MUNICIPALITIES

Diagram 7-16: Arrivals and mean length of stay at the accommodation establishments in the Greek Municipalities

7.2.1.2 Population projection

Population growth is one of the indicative features for evaluating urban resilience to climate change. In specific, the driving forces of population growth in urban areas are interrelated to the causes for undesirable patterns or processes of urban growth considering the current trends in population change. Therefore, a trendline in population figures contributes to an evaluation towards achieving sustainable urban growth. To this end, official data were retrieved by the Hellenic Statistical Authority regarding population projection of Greece. Based on the aforementioned,population projections were plotted considering three (3) demographic parameters, namely (i) fertility, (ii) mortality and (iii) migration. Three (3) scenarios (i.e. low, medium, high) based on specified assumptions were also conducted for each one of the aforementioned parameters. In general, based on the scenarios referring to the fertility rate, it is expected that fertility rate shall reach 1.66 (medium scenario). In addition, with reference to mortality, an increase in life expectancy is foreseen in all three scenarios. However, different results are expected for the three migration scenarios, where a gradual decrease is foreseen in the low scenario compared to an increase at the high scenario.Based on the aforementioned, Greek population is expected in the framework of the medium scenario to reach 11.500.000 people, by 2050. All the relevant data are included in the Appendix. In order to obtain data comparability amongst social indicators, some additional data regarding population projections have been included. More specifically, data regarding population projection at municipal level have been retrieved from official databases (i.e. Greek universities) that have used input data from the Hellenic Statistical Authority. In this framework, a database including population projection figures of the main Greek cities (i.e. 66 Municipalities in Attica region, have been included (Appendix).

7.2.1.3 Distribution of population per age group, level of education, citizenship

Distribution of population per age group

Demographic data regarding population structure refer to the age groups of the permanent population. The age classes with reference to young people include (i) 0-9 years old and (ii) 10-19 years old. The proportion of people of working age incorporate age groups of (i) 20-29 years old, (ii) 30-39 years old, (iii) 40-49 years old, (iv) 40-49 years old, (v) 60-69 years old and another age group of 70+ years old. It has to be noted that Greece holds one of the highest shares of young people (20.9%) in the total population across the EU member states, in 2005. All data regarding population structure at municipal level are included in Appendix. Based on the population structures depicted in Diagrams Diagram 7-17, Diagram 7-18 and Diagram 7-19, one may assume that Peristeri Municipality does not present a large deviation from Attica region, as well as the whole country.

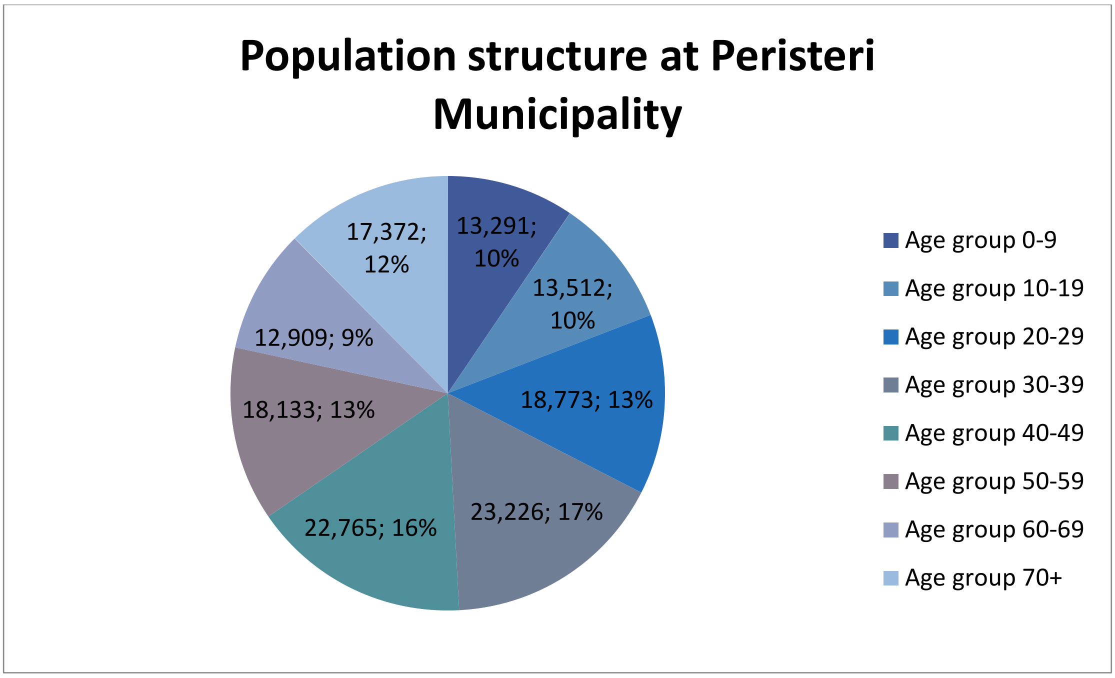

Diagram 7-17: Population structure at Peristeri Municipality

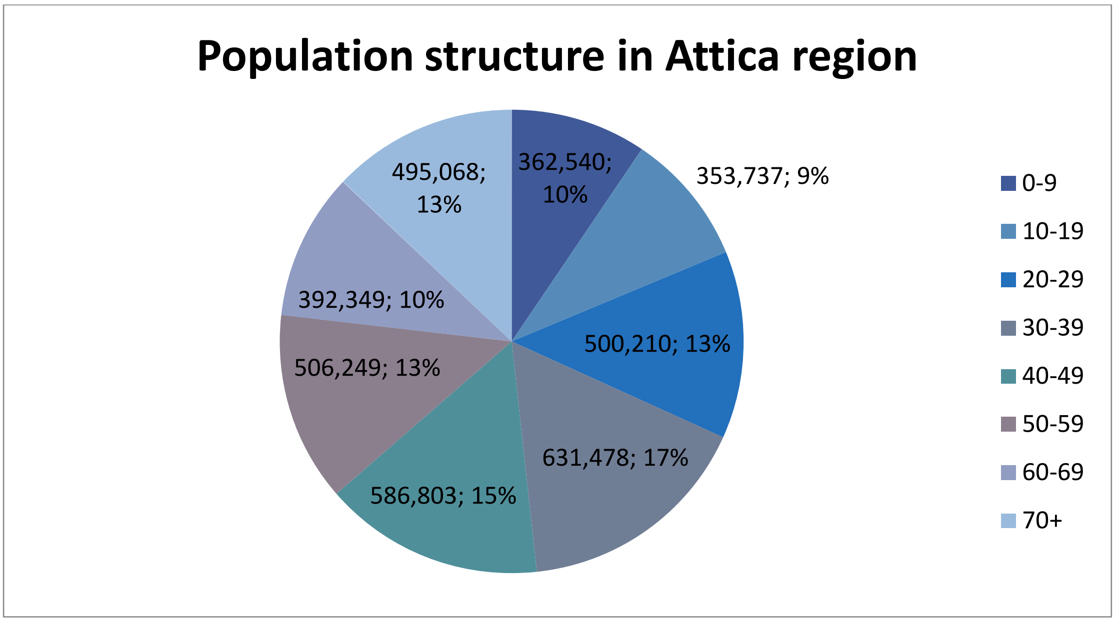

Diagram 7-18: Population structure in Attica region

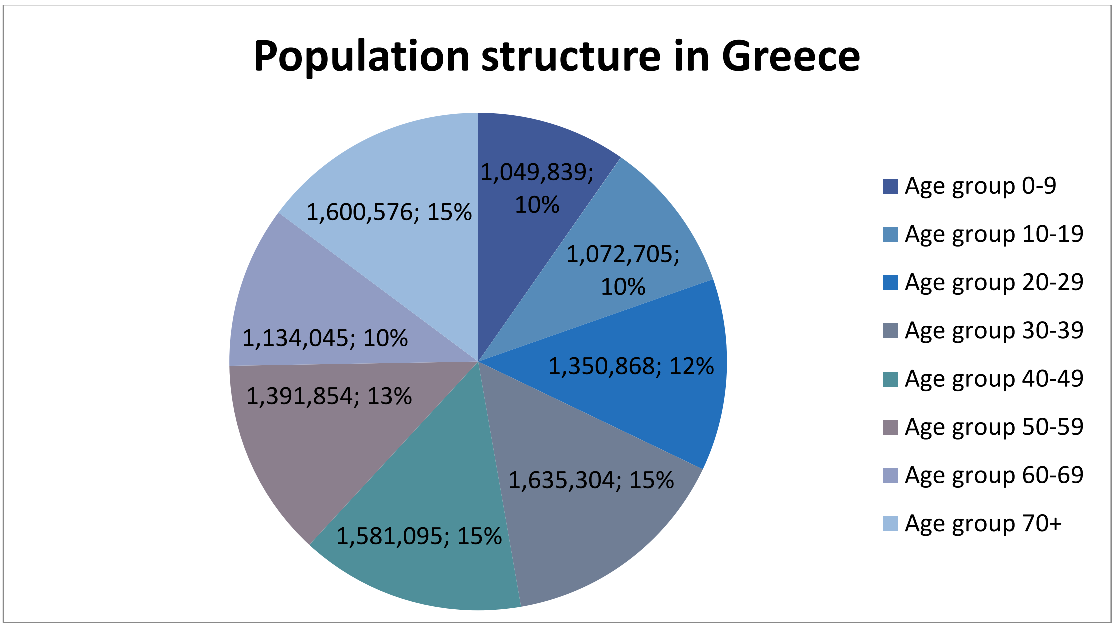

Diagram 7-19: Population structure in Greece

Distribution of population per education level

The social data regarding the educational level provided for the Greek population are based on the census that was conducted in 2011. It has to be noted that the Greek educational system has three main levels of education, i.e. primary, secondary and tertiary. However, there are several more educational structures that operate alongside the state educational system providing some kind of recognition at a specific issue. To this end, the educational attainment statistics provided by the Hellenic Statistical Authority have been based on the International Standard Classification of education (ISCED) in order to achieve comparability of education statistics across EU member states.

Table 7-2: Educational level classification

Educational level
Doctoral or postgraduate degree holders/University graduates-Polytechnic, Higher Technological Educational Institute, School of Pedagogical and Technological Education, higher professional and equivalent schools
Graduates of Post-Secondary Education (Institute of Vocational Training, Colleges, etc.)
High School Graduates (General, Ecclesiastical, Professional, etc.)
Graduates of third grade High School and graduates of vocational schools
Graduates of Primary School

Individuals that abandoned Primary School, but have writing and reading skills/Individuals that have completed pre-school education/Individuals that cannot write and read
Non-classified (individuals born after 1/1/2005)

The data regarding the population distribution per education level are provided for each one of the Greek municipalities in the Appendix. However, considering the fact that Greece is consisted of 325 municipalities and one (1) autonomous state, certain data are about to be highlighted in the following diagram (Diagram 7-20). More specifically, it has to be noted that the administrative divisions of Greece include two main levels, i.e. (i) regions, (ii) municipalities. Therefore, the population distribution per educational level at the 13 Greek administrative regions depicts in a more comprehensive approach the existing educational level in Greece. Following, the large concentration of population in the capital, individuals with higher educational levels are also found at the Attica region (Diagram 7-21). In particular for the Municipality of Peristeri, the population distribution per educational level does not have major differences than the average value of the 66 Municipalities located at the Attica region (Diagram 7-22 and Diagram 7-23).

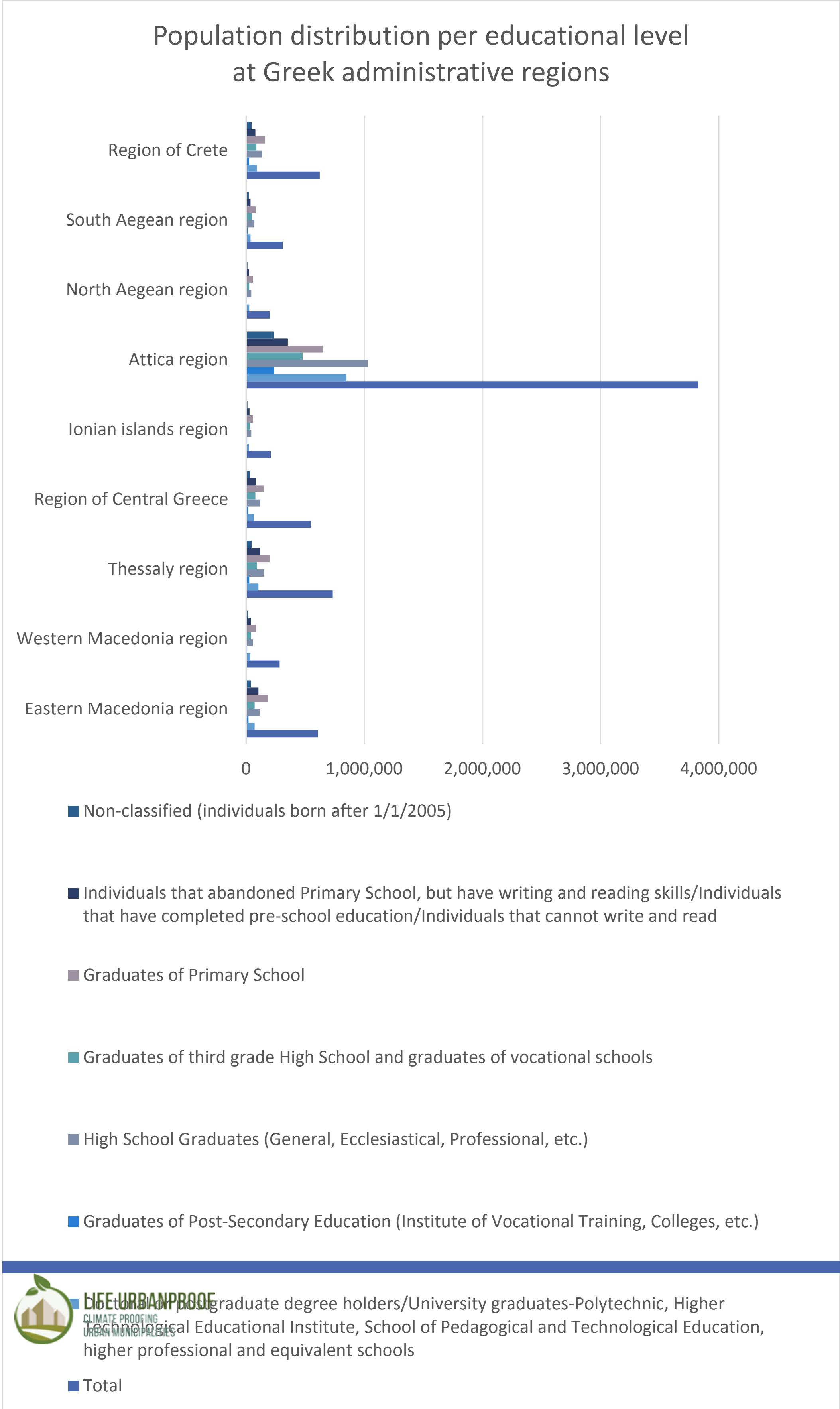
Population distribution per educational level
at Greek administrative regions
Region of Crete
South Aegean region
North Aegean region
Attica region
Ionian islands region
Region of Central Greece
Thessaly region
Western Macedonia region
Eastern Macedonia region
0
1,000,000
2,000,000
3,000,000
4,000,000
Non-classified (individuals born after 1/1/2005)
Individuals that abandoned Primary School, but have writing and reading skills/Individuals that have completed pre-school education/Individuals that cannot write and read
Graduates of Primary School
Graduates of third grade High School and graduates of vocational schools
High School Graduates (General, Ecclesiastical, Professional, etc.)
Graduates of Post-Secondary Education (Institute of Vocational Training, Colleges, etc.)
Doctoral or postgraduate degree holders/University graduates-Polytechnic, Higher Technological Educational Institute, School of Pedagogical and Technological Education, higher professional and equivalent schools
Total

Diagram 7-20: Population distribution per educational level at the 13 Greek regions

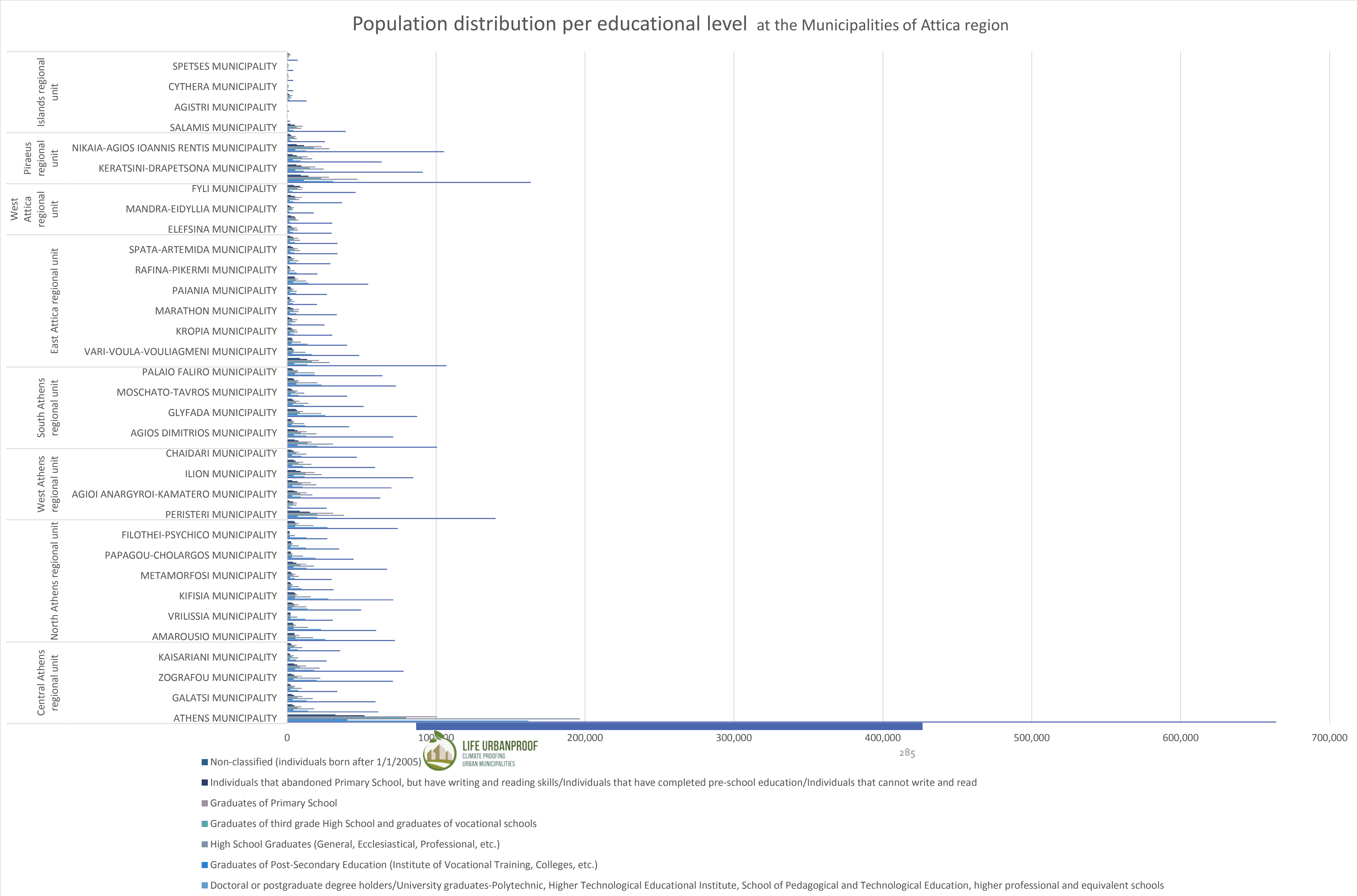
Population distribution per educational level at the Municipalities of Attica region
Islands regional unit
SPETSES MUNICIPALITY
CYTHERA MUNICIPALITY
AGISTRI MUNICIPALITY
SALAMIS MUNICIPALITY
Piraeus regional unit
NIKAIA-AGIOS IOANNIS RENTIS MUNICIPALITY
KERATSINI-DRAPETSONA MUNICIPALITY
West Attica regional unit
FYLI MUNICIPALITY
MANDRA-EIDYLLIA MUNICIPALITY
ELEFSINA MUNICIPALITY
East Attica regional unit
SPATA-ARTEMIDA MUNICIPALITY
RAFINA-PIKERMI MUNICIPALITY
PAIANIA MUNICIPALITY
MARATHON MUNICIPALITY
KROPIA MUNICIPALITY
VARI-VOULA-VOULIAGMENI MUNICIPALITY
South Athens regional unit
PALAIO FALIRO MUNICIPALITY
MOSCHATO-TAVROS MUNICIPALITY
GLYFADA MUNICIPALITY
AGIOS DIMITRIOS MUNICIPALITY
West Athens regional unit
CHAIDARI MUNICIPALITY
ILION MUNICIPALITY
AGIOI ANARGYROI-KAMATERO MUNICIPALITY
PERISTERI MUNICIPALITY
North Athens regional unit
FILOTHEI-PSYCHICO MUNICIPALITY
PAPAGOU-CHOLARGOS MUNICIPALITY
METAMORFOSI MUNICIPALITY
KIFISIA MUNICIPALITY
VRILISSIA MUNICIPALITY
AMAROUSIO MUNICIPALITY
Central Athens regional unit
KAISARIANI MUNICIPALITY
ZOGRAFOU MUNICIPALITY
GALATSI MUNICIPALITY
ATHENS MUNICIPALITY
0
100,000
200,000
300,000
400,000
500,000
600,000
700,000
Non-classified (individuals born after 1/1/2005)
Individuals that abandoned Primary School, but have writing and reading skills/Individuals that have completed pre-school education/Individuals that cannot write and read
Graduates of Primary School
Graduates of third grade High School and graduates of vocational schools
High School Graduates (General, Ecclesiastical, Professional, etc.)
Graduates of Post-Secondary Education (Institute of Vocational Training, Colleges, etc.)
Doctoral or postgraduate degree holders/University graduates-Polytechnic, Higher Technological Educational Institute, School of Pedagogical and Technological Education, higher professional and equivalent schools

Diagram 7-21: Population distribution per educational level at the 66 Municipalities of Attica region

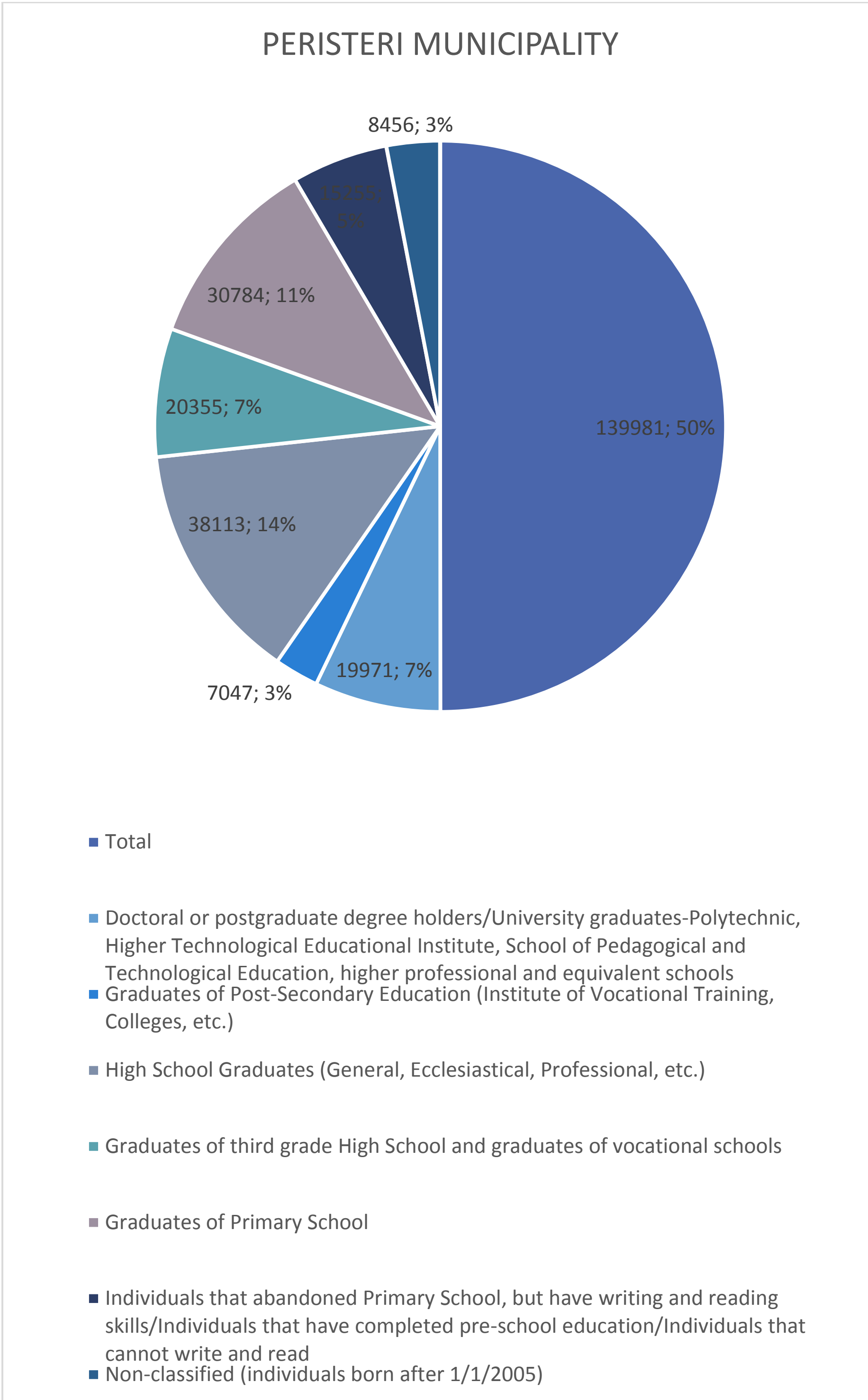
PERISTERI MUNICIPALITY
8456; 3%
15255; 5%
30784; 11%
20355; 7%
139981; 50%
38113; 14%
19971; 7%
7047; 3%
Total
Doctoral or postgraduate degree holders/University graduates-Polytechnic, Higher Technological Educational Institute, School of Pedagogical and Technological Education, higher professional and equivalent schools
Graduates of Post-Secondary Education (Institute of Vocational Training, Colleges, etc.)
High School Graduates (General, Ecclesiastical, Professional, etc.)
Graduates of third grade High School and graduates of vocational schools
Graduates of Primary School
Individuals that abandoned Primary School, but have writing and reading skills/Individuals that have completed pre-school education/Individuals that cannot write and read
Non-classified (individuals born after 1/1/2005)

Diagram 7-22: Population distribution per educational level at the Municipality of Peristeri

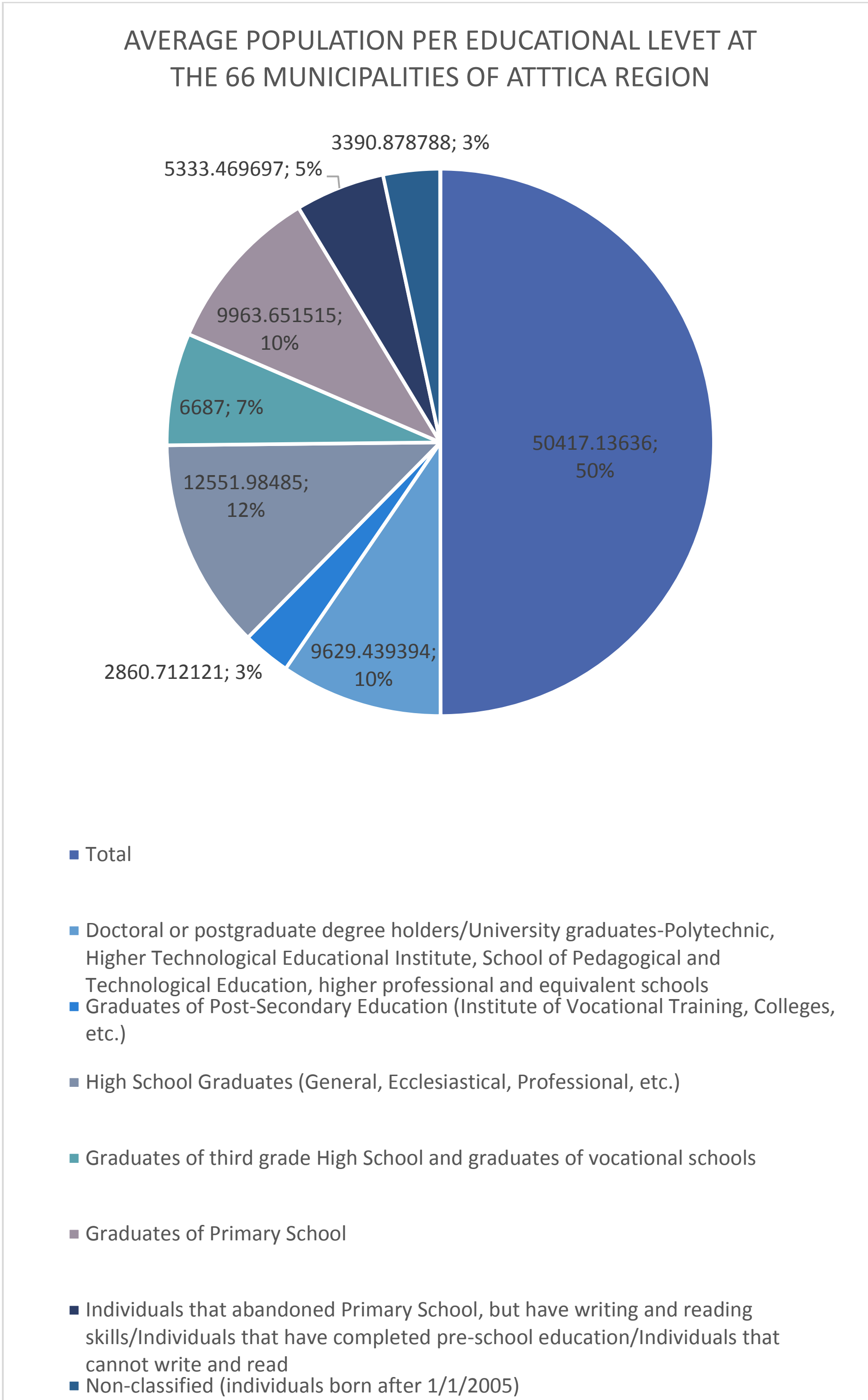
AVERAGE POPULATION PER EDUCATIONAL LEVET AT THE 66 MUNICIPALITIES OF ATTTICA REGION
3390.878788; 3%
5333.469697; 5%
9963.651515; 10%
6687; 7%
50417.13636; 50%
12551.98485; 12%
2860.712121; 3%
9629.439394; 10%
Total
Doctoral or postgraduate degree holders/University graduates-Polytechnic, Higher Technological Educational Institute, School of Pedagogical and Technological Education, higher professional and equivalent schools
Graduates of Post-Secondary Education (Institute of Vocational Training, Colleges, etc.)
High School Graduates (General, Ecclesiastical, Professional, etc.)
Graduates of third grade High School and graduates of vocational schools
Graduates of Primary School
Individuals that abandoned Primary School, but have writing and reading skills/Individuals that have completed pre-school education/Individuals that cannot write and read
Non-classified (individuals born after 1/1/2005)

Diagram 7-23: Average population distribution per educational level

Distribution of population per citizenship

In the former years environmental, political and social factors in combination with economic crisis have resulted in global migration flows. Foreign populations in Greece cover 8% of the total population in the country. In addition, it has to be noted that in a country with a negative population growth, foreign populations have contributed significantly to the population increase overall. In particular, migrants of the Municipality of Peristeri make up 7.37% of the total permanent population (Diagram 7-24). This percentage does not differ from the average percentage referring to the whole country, but is has a significant difference compared to the migrant population of Athens Municipality (22.84%).

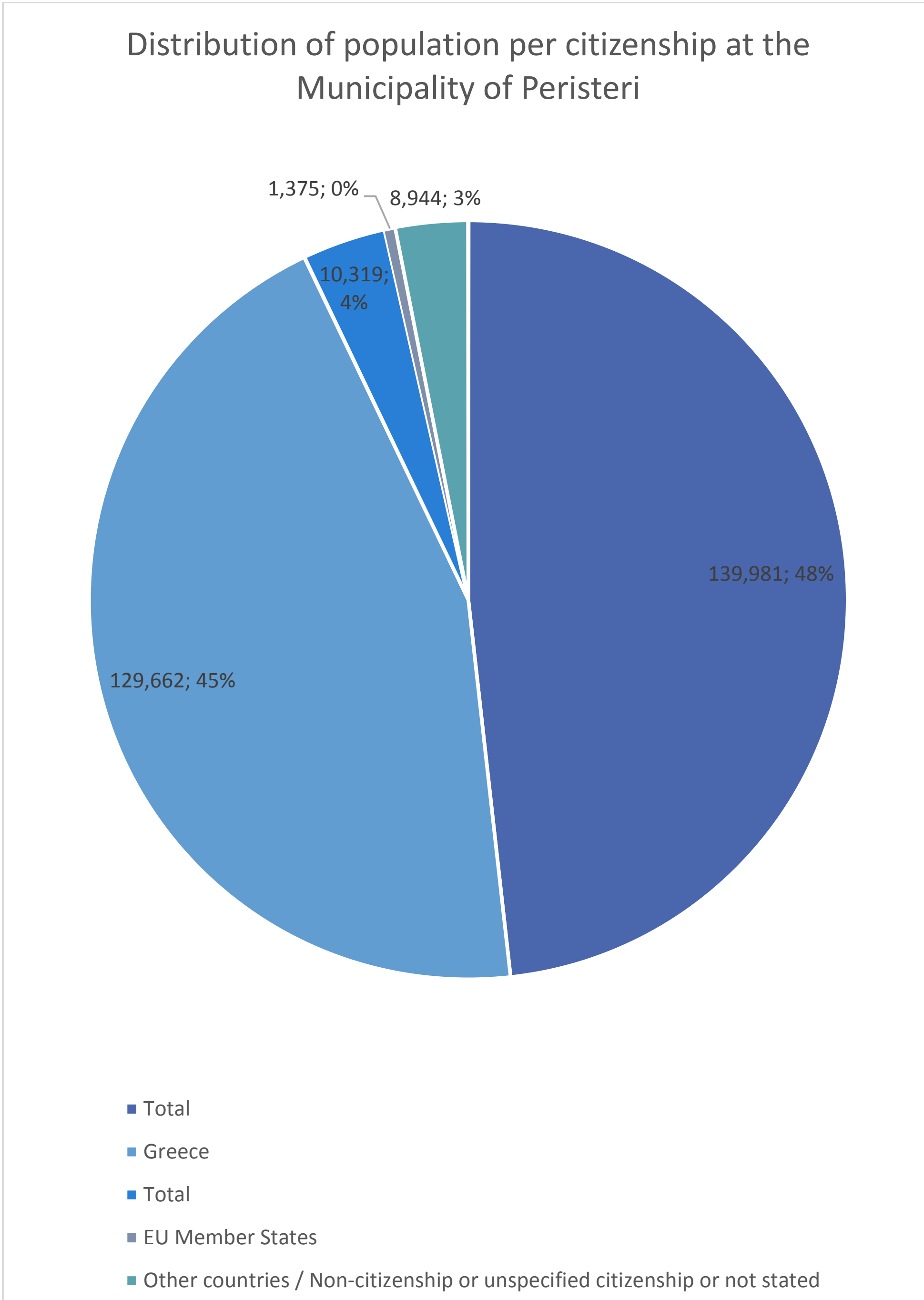

Diagram 7-24:Distribution of population per citizenship at the Municipality of Peristeri

7.2.1.4 Population density

The surface area is used to calculate population density in each region. Data are available by NUTS 3 level, total area (including inland water and excluding coastal water) and land area (excluding inland and coastal water). Data availability is subject to the completeness of reporting by the countries, thus for the case of the Greek Municipalities the total permanent population per municipality, as well as the surface area along with the inland waters area have been adapted by the Hellenic Statistical Authority (Census 2011).In this framework, population density for all the Greek Municipalities was compiled by authors.

Considering the main outcomes of data processing, the average population density refers to 316 residents per square kilometers, with 3,708.37 standard deviation. Based on the abovementioned, only 47 Municipalities are above average, while 268 are below average. The Municipality of Peristeri belongs to the above average group (Diagram 7-25), as one of the urban municipalities closely located to the city center.

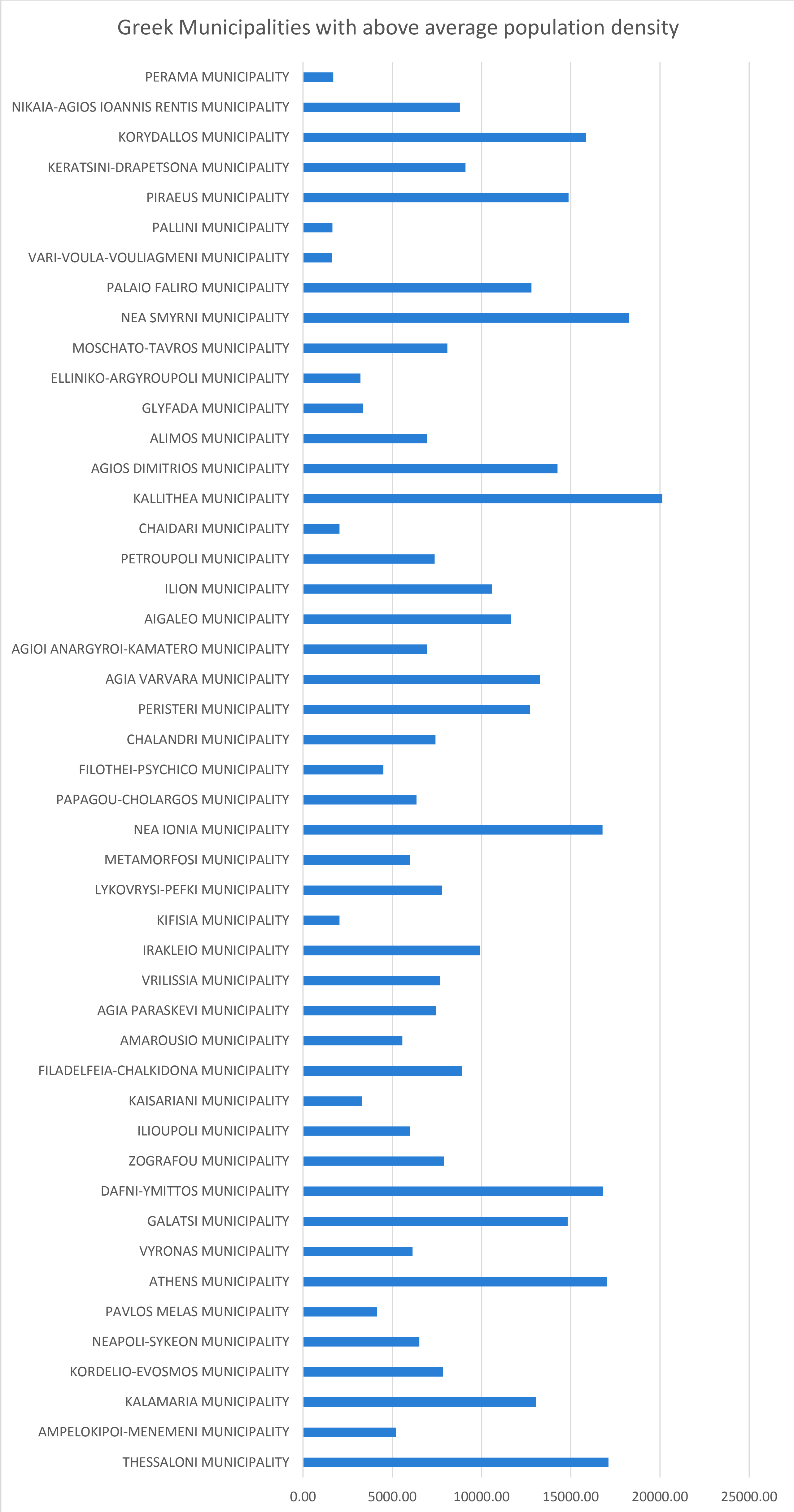

Diagram 7-25: Greek Municipalities with above average population density

7.2.2 Economic indicators:

7.2.2.1 Economically active population

Labour force (i.e. economically active population) -with reference to both employed and unemployed people for the production of economic goods and services- does not include pre-school and school chindren, students, as well as pensioners. In this framework, the Appendix lists all 325 Greek Municipalities' workforce data entries. In specific, the economically active population of Greece is 4,586,636 (i.e. 42.4% of the total resident population). Data processing highlighted that 61.7% of the employed population of the five (5) biggest Greek Municipalities (i.e. Municipalities of Athens, Thessaloniki, Patra, Iraklio and Piraeus) work at the Municipality of their residency (Diagram 7-26). However, based on the data presented in Section 7.2.1.1, it is evident that the aforementioned Municipalities are the most populated. As a result, the workforce of Greece seems to have been gathered at the major city centres of the country (i.e. another aspect that highlights the urbanization phenomenon).

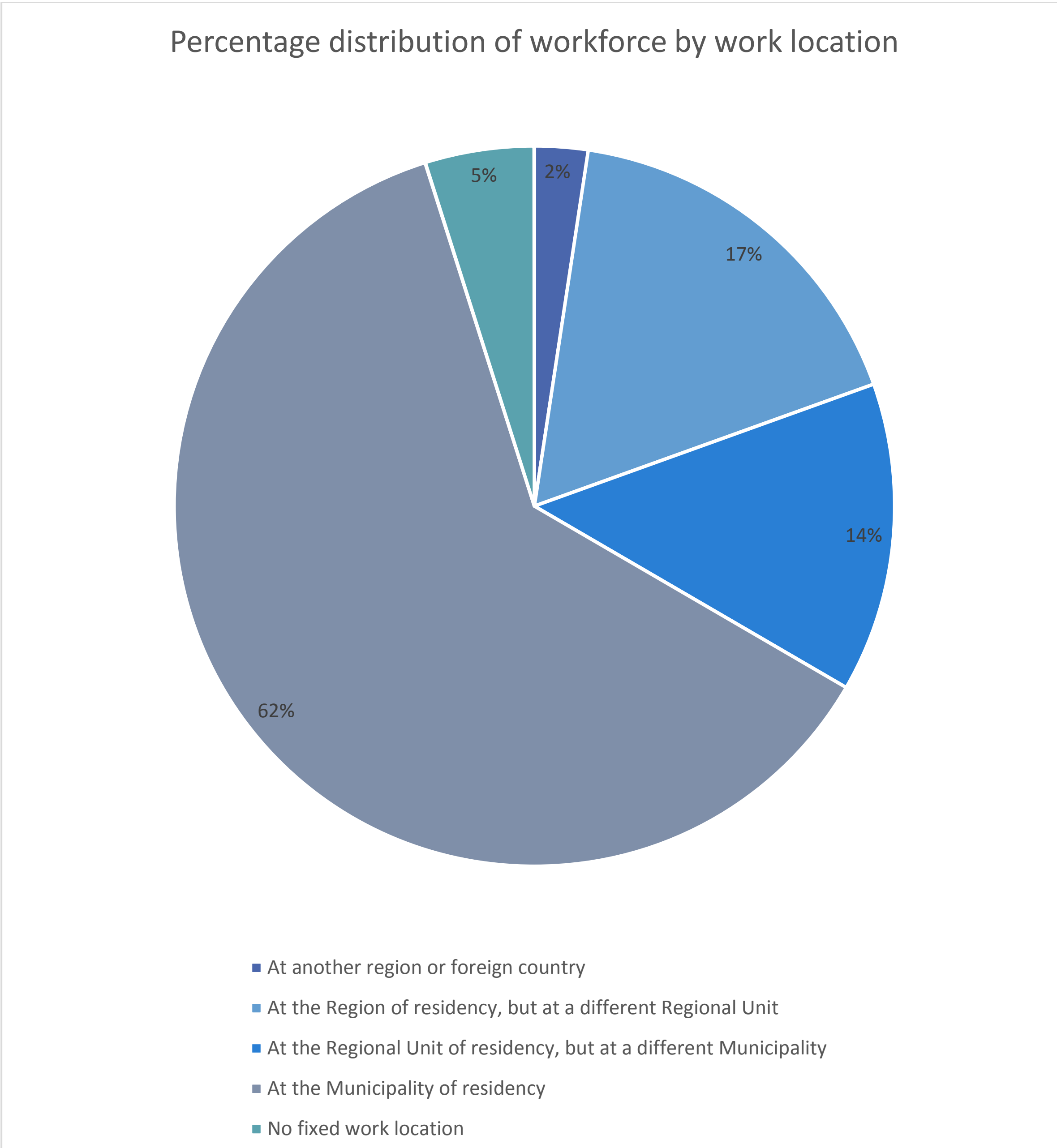

Diagram 7-26:Percentage distribution of workforce by work location

Source: [4]

7.2.2.2 Distribution of population per employment status andpoverty risk

Based on the 2011 Census, the economically active population of Greece was 4,586,636 (42.4% of the total resident population) while the number for the inactive reachedthe 6,229,650 people (57.6% of the total resident population)[5]. 3,727,633 people out of the total economically active population declared that they are employed, while the rest declared "unemployed". Some more numbers for the population distribution per employment status refer to an average number of 0.9 employed people per household[6], highlighting the existing economic crisis. All data regarding the population distribution per employment status for all Greek Municipalities have been included in Appendix. In particular for the Municipality of Peristeri, ~55% of the total resident population belongs to the economically non-active population, while 9.67% declared unemployed, thus leaving a 37.37% to the "employed category" (Diagram 7-27).

[4] http://www.statistics.gr/en/statistics?p_p_id=documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN&p_p_lifecycle=2&p_p_state=normal&p_p_mode=view&p_p_cacheability=cacheLevelPage&p_p_col_id=column-2&p_p_col_count=4&p_p_col_pos=1&_documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN_javax.faces.resource=document&_documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN_ln=downloadResources&_documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN_documentID=230501&_documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN_locale=en

[5] https://www.statistics.gr/documents/20181/1210503/A1602_SAM04_DT_DC_00_2011_01_F_GR.pdf/2aa7132a-a7db-41fb-88f6-b6061d29dd13

[6] https://www.statistics.gr/documents/20181/1215267/A1602_SAM04_DT_DC_00_2011_01_F_EN.pdf/4b5473f2-86de-45e1-a8f2-c49de19c6947

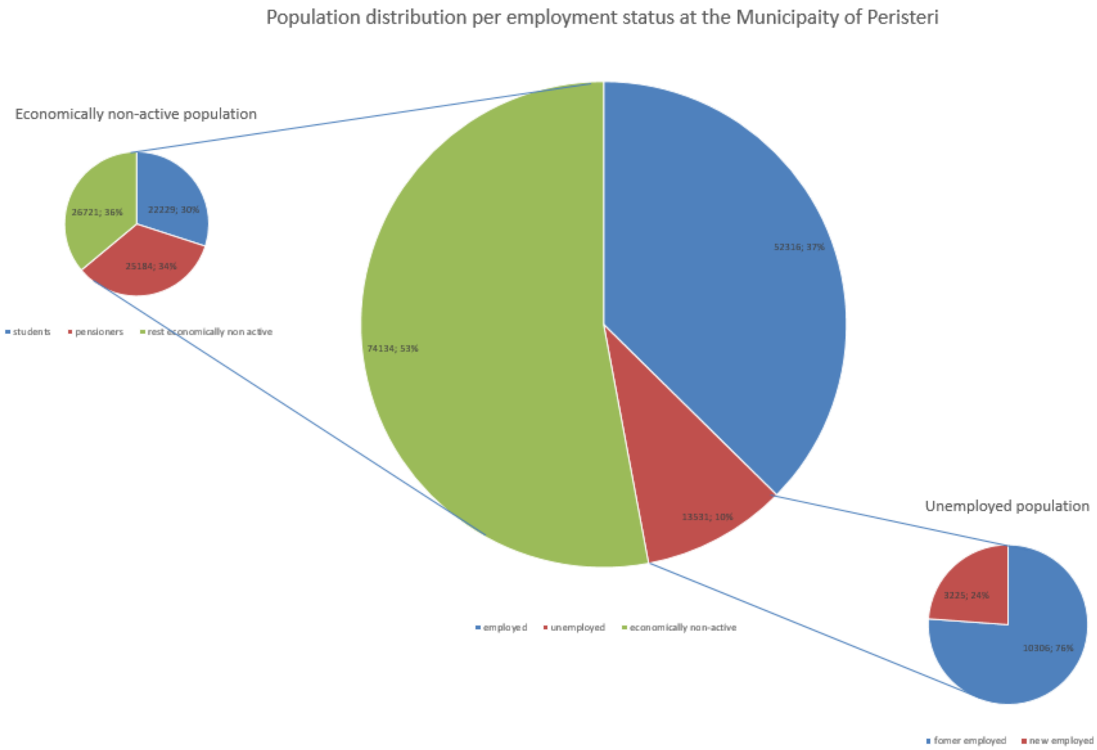

Diagram 7-27: Population distribution per employment status at the Municipality of Peristeri

With reference to poverty risk indicator, the Hellenic Statistical Authority has conducted a survey on income and living conditions of households (EU-SILC) based on 2015 reference income period for the total population of the country (it has to be noted that the exact survey with reference the income period the year 2016, shall be provided on 22 June, 2018). Based on the results announced in the aforementioned survey, 35.6% of the total population of the country i.e. 3,789.300 people are at risk of poverty and social exclusion. The aforementioned percentage hasn't decreased only but recently, and in particular between the years 2015 and 2016 (Diagram 7-28). The age groups most affected are persons between 18-64 years old (i.e. holding 39.7% of the population at risk of poverty)[7].

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[7]http://www.statistics.gr/en/statistics?p_p_id=documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN&p_p_lifecycle=2&p_p_state=normal&p_p_mode=view&p_p_cacheability=cacheLevelPage&p_p_col_id=column-2&p_p_col_count=4&p_p_col_pos=1&_documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN_javax.faces.resource=document&_documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN_ln=downloadResources

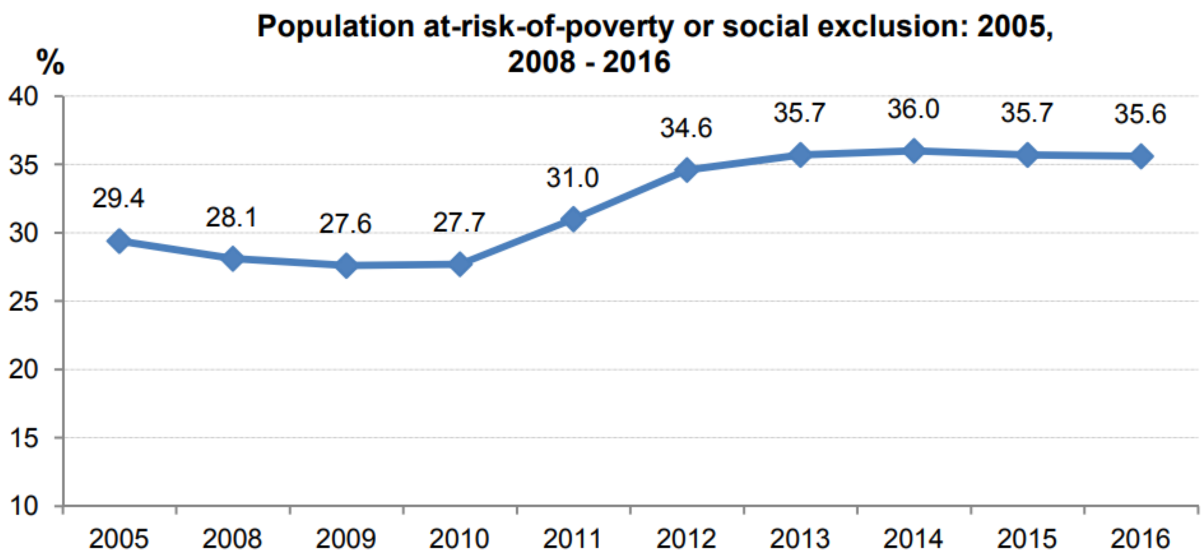


Diagram 7-28: Population at-risk-of-poverty or social exclusion for the time period 2005-2016

7.2.3 Health indicators:

7.2.3.1 Life expectancy

Life expectancy, as well as a number of indicators regarding monitoring a healthy life at the EU Member States are evaluated at theEuropean Information System on Healthy Life Years and Life Expectancy (EHLEIS), which is supported by the Hellenic Statistical Authority, European Joint Action and the National Institute of Health and Medical Research (ISERM). In this framework, data regarding mortality, as well as

& documents WAR publicationsportlet INSTANCE qDQ8fBKKo4lN documentID=253786& documents WAR publicationsportlet INSTANCE qDQ8fBKKo4lN locale=en results of the Minimum European Health Module are processed for the indicator of life and health expectancy. In specific, health expectancy indicator is determined by the average number of remaining years in good or bad health (i.e. life expectancy is distinguished in good or bad perceived health).

Data regarding life expectancy by sex and age for the time period 1995-2014 for the total population of Greece were retrieved by the European health expectancies (eurhex) database[8], computed with the EUROSTAT method, and are attached at the Appendix. However, it should be noted that the survey population does not include people in institutions. Therefore, based on the data provided, life expectancy in Greece for the year 2013 (one of the first years of the Greek economic crisis) has been increased by 1.8 years since 2004 (Diagram 7-30).

[8] http://www.eurohex.eu/IS/web/app.php/Ehleis/LifeGeographic?Typ=Life&SubTyp=None

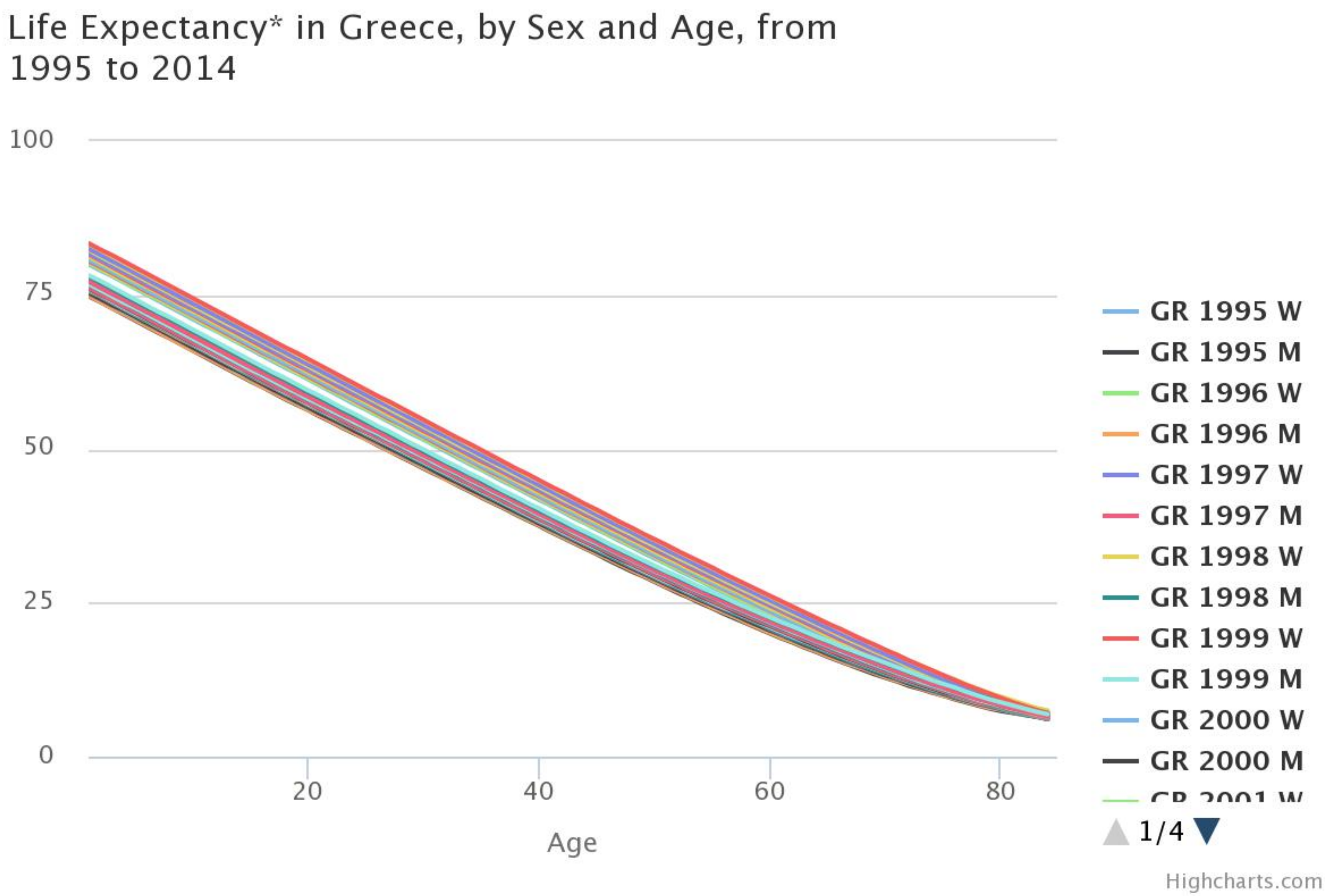

Life Expectancy* in Greece, by Sex and Age, from 1995 to 2014
100
75
50
25
0
20
40
60
80
Age
GR 1995 W
GR 1995 M
GR 1996 W
GR 1996 M
GR 1997 W
GR 1997 M
GR 1998 W
GR 1998 M
GR 1999 W
GR 1999 M
GR 2000 W
GR 2000 M
1/4
Highcharts.com

Diagram 7-29: Life expectancy for both men and women by age in Greece from 1995 to 2014

Source:European health & life expectancy information system

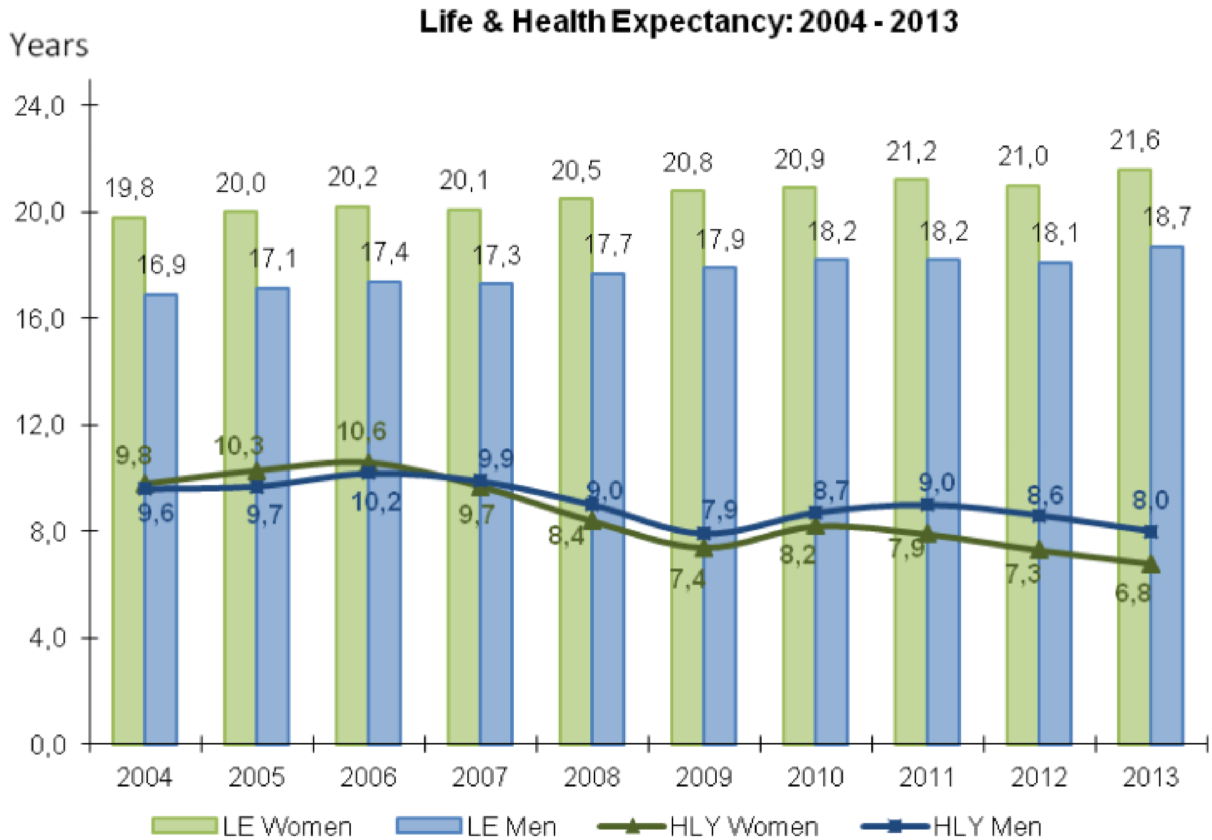


Diagram 7-30: Life and health expectancy for the time period 2004-2013

Source:1. Hellenic Statistical Authority, 2016

Another crucial question is whether extra years of life gained through increased longevity are spent in good or bad health. Since life expectancy at birth is not able to fully answer this question, indicators of health expectancies, such as healthy life years (also called disability-free life expectancy) have been developed. These focus on the quality of life spent in a healthy state, rather than the quantity of life — as measured by life expectancy.Diagram 7-30 highlights the healthy years of men and women in Greece at age 65 for the period 2004-2013. Based on this diagram, the remaining years that a person is expected to live healthy have decreased by 1.6 years for men and 3.0 years for women.

7.2.3.2 Distribution of population with chronic diseases/health problems per type of disease/health problem

In general, the average life expectancy of the residents of EU member states has increased over the last few decades (approximately 0.25 years annually until 2012) (RIVM, 2012). However, the number of healthy life years, i.e. the years that people spend in good health, remained unchanged in recent years until 2012. Chronic diseases are the main reason for the aforementioned number of years spent in healthy life, and are also one of the greatest EU challenges for increasing this number by two (2) years until 2020.

The population distribution with chronic diseases for the case of Greece is only provided in regards to the total population of the country above 15 years old (see also Appendix). In this framework, 44.8% of the men in Greece suffer from chronic diseases, while the percentage is higher for women (54.1%). The prevalence of chronic diseases and health problems per age group is depicted in the following diagram (Diagram 7-31).

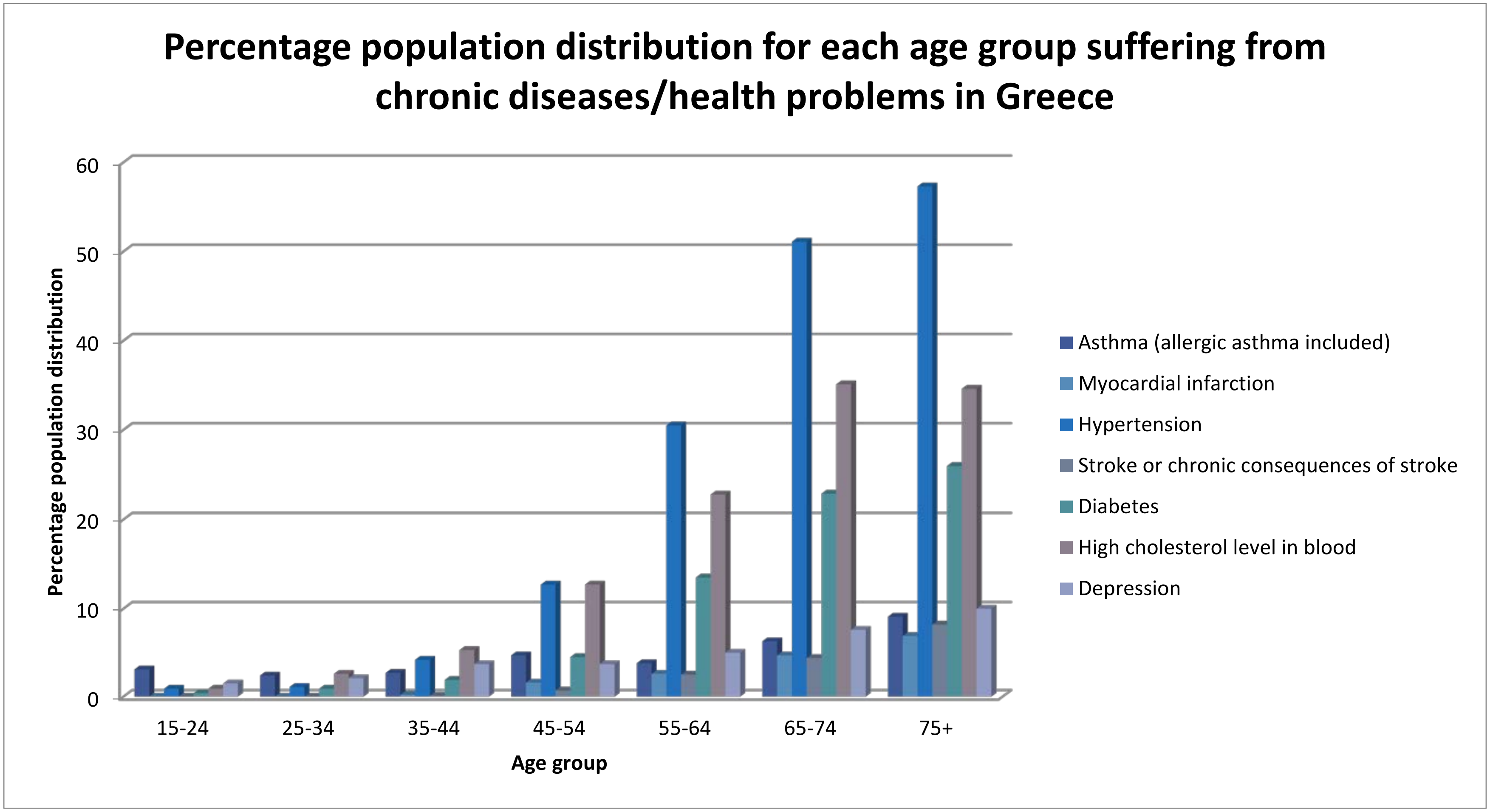


Diagram 7-31: Percentage population distribution per age group suffering from chronic diseases/health problems in Greece

7.2.3.3 Number of hospitals/health clinics per type (expertise) of hospital/clinic

Based on the 2015 census, the number of hospitals in Greece is 283 as in 2014, after the recording of 4.0% decrease during the period 2013-2012 and 2.4% during 2014-2013. 54.8% of the hospitals are private while the rest are health care units of legal entities of public law (Hellenic Statistical Authority, 2015a) (see also the Appendix). The majority of the existing hospitals are the general domain of expertise, while the lion's share of specialized hospitals belongs to neuropsychiatric (by 17.7%) and Obstetrical-Gynecologal (by 8.8%) hospitals (Diagram 7-32). 34.3% of the total number of hospitals in Greece are located in Attica region (Diagram 7-33). In addition, there are also 205 health centres, the number of which remained the same during 2012-2015. 17 health centres are located in Attica region (Hellenic Statistical Authority, 2015a) (Diagram 7-34).

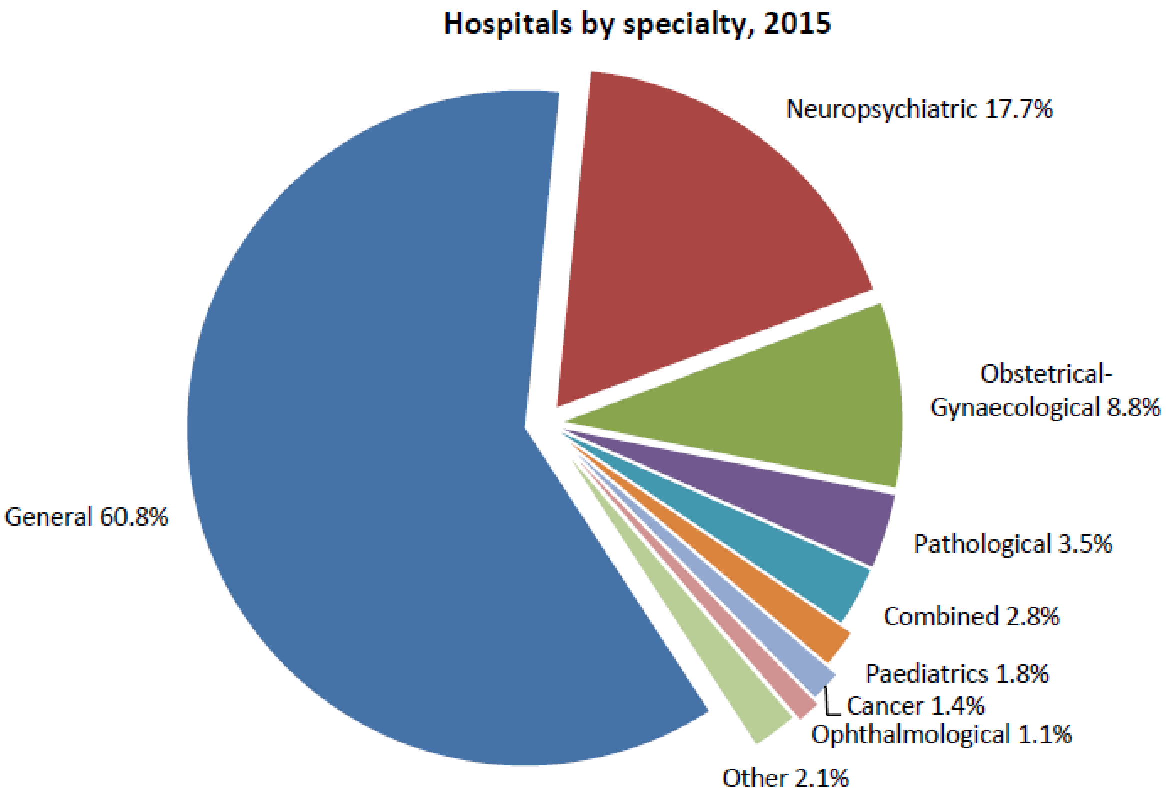


Diagram 7-32: Hospitals per type of expertise in Greece

Source: Hellenic Statistical Authority, 2015a

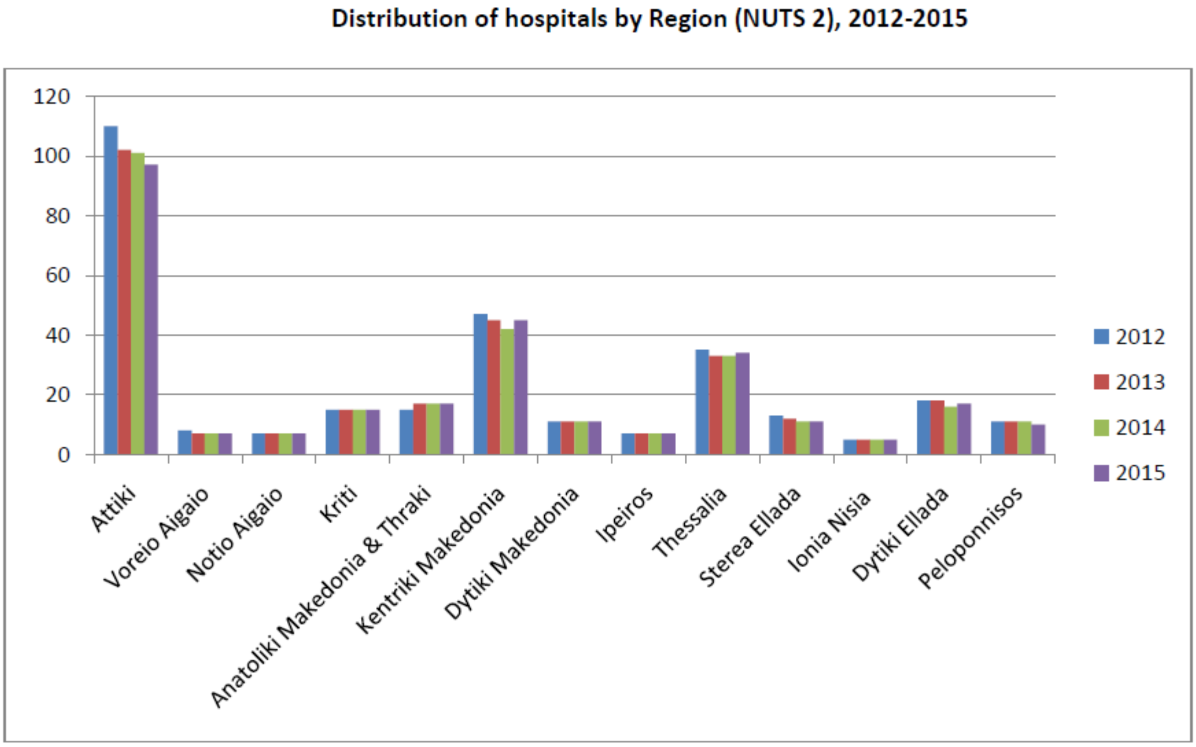


Diagram 7-33: Distribution of hospitals by region during 2012-2015

Source: Hellenic Statistical Authority, 2015a

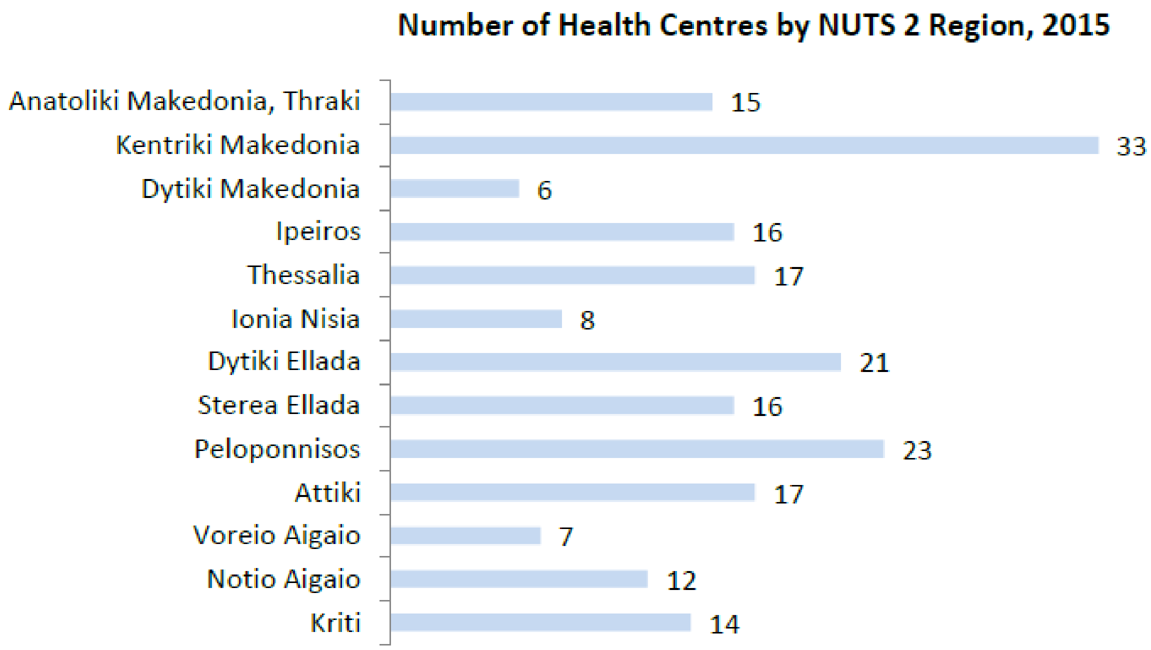


Diagram 7-34: Number of Health Centres per region, 2015

Source: Hellenic Statistical Authority, 2015a

7.3 Italy

7.3.1 Demographic indicators

7.3.1.1 Total permanent and seasonal population

Data regarding population and several social parameters are provided by the National Institute for Statistics of Italy. In this context, the resident population for Reggio Emilia Municipality, Emilia Romagna Region and Italy are provided in the following diagrams (Diagrams7-36, 7-37 and 7-38) highlighting an increasing trend.

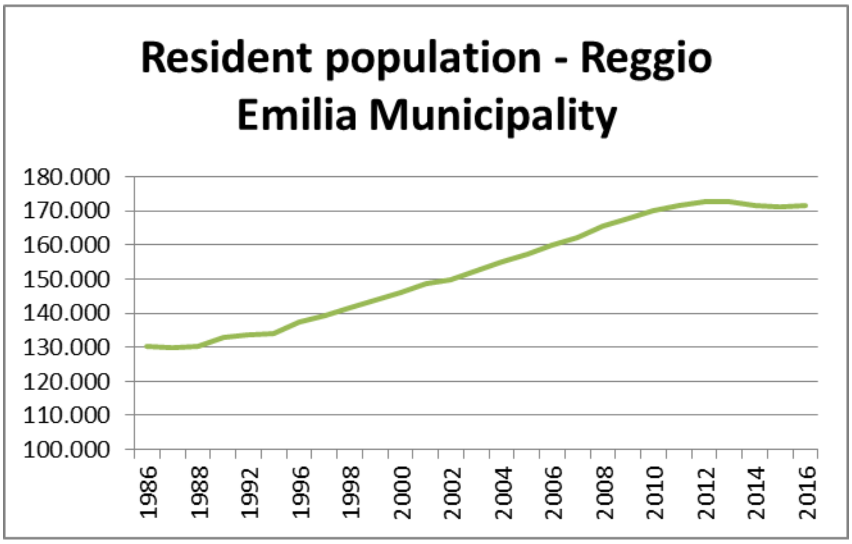


Diagram 7-35: Resident population distribution in Reggio Emilia Municipality

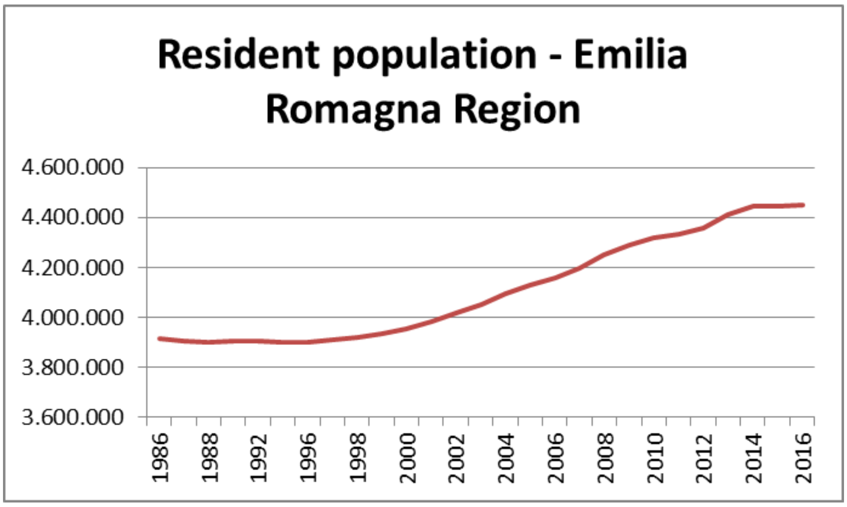


Diagram 7-36: Resident population distribution in Emilia Romagna Region

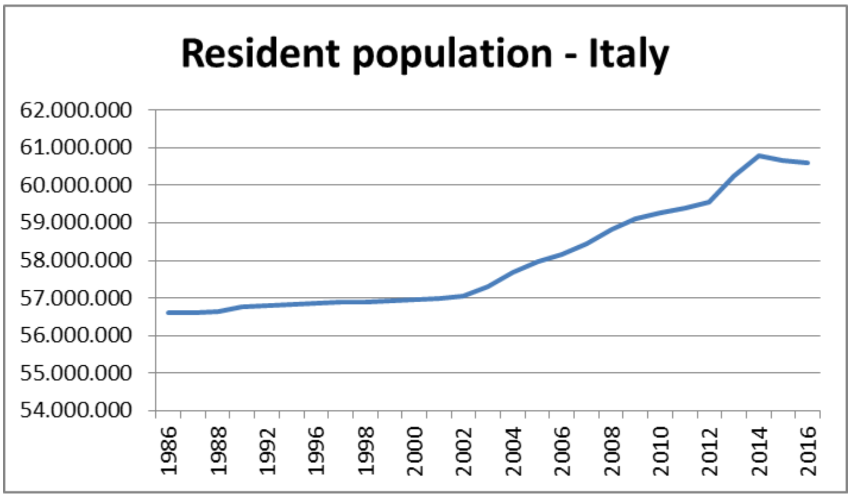


Diagram 7-37: Resident population distribution in Italy

In terms of seasonal population, data from the National Institute for Statistics of Italy National Institute for Statistics of Italy does not publish any relevant information. To this end, data were retrieved regarding the number of arrivals and presences at the main tourist resorts of Reggio Emilia and Emilia Romagna Region, as depicted in the following diagrams.

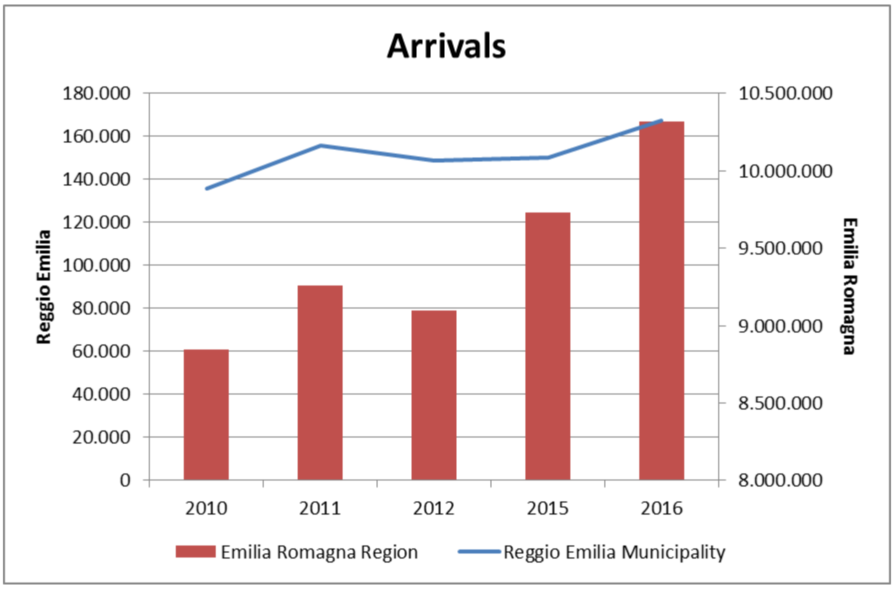


Diagram 7-38: Arrivals in Reggio Emilia and Emilia Romagna Region tourist structures

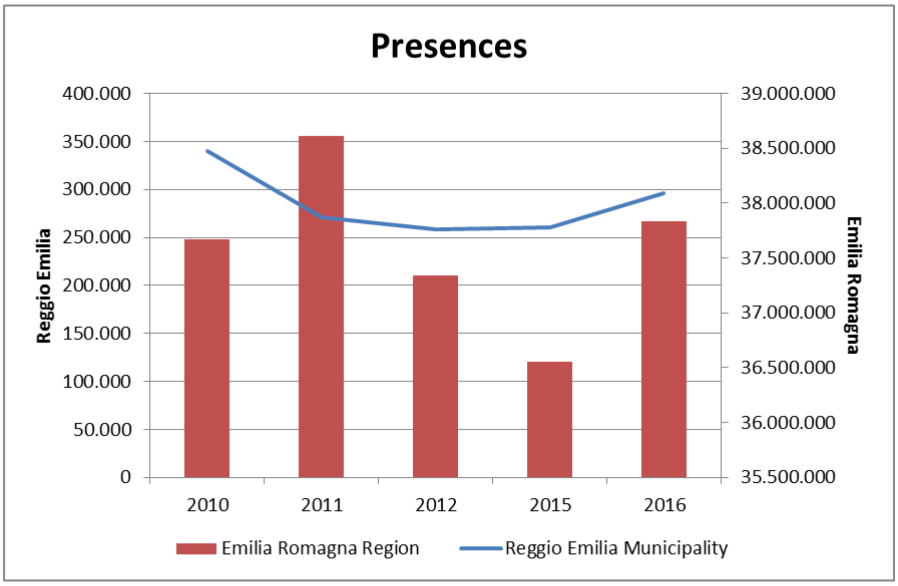


Diagram 7-39: Presences in Reggio Emilia and Emilia Romagna Region tourist structures

Table 7-3: Arrivals and presences in Italian Regions tourist structures

	2014		2015	
Regions	**Arrivals**	**Presences**	**Arrivals**	**Presences**
Veneto	10.597.803	41.306.004	11.213.267	42.213.738
Trentino Alto Adige	5.479.355	26.242.808	5.682.800v	26.763.957
Toscana	6.821.947	23.154.147	7.062.693	23.947.505
Lombardia	7.297.664	19.677.303	8.129.895	21.733.272
Lazio	6.758.348	20.675.157	7.053.862	19.655.212
Emilia-Romagna	2.524.689	9.822.981	2.619.025	9.612.200
Campania	1.949.634	8.176.727	2.318.535	8.672.439
Sicilia	2.042.506	7.107.368	2.007.547	6.967.871
Piemonte	1.570.864	5.151.959	1.883.866	5.994.857
Sardegna	1.095.489	5.316.299	1.208.724	5.838.536
Liguria	1.808.941	5.321.684	1.967.660	5.737.319
Friuli-Venezia Giulia	1.049.572	4.132.771	1.104.118	4.304.970
Puglia	663.713	2.547.305	730.122	2.675.795
Marche	399.459	2.065.448	405.249	2.292.704
Umbria	687.215	2.136.726	709.031	2.177.649
Calabria	241.268	1.618.710	247.205	1.646.288
Valle d'Aosta	377.245	1.211.654	409.652	1.283.293
Abruzzo	174.171	870.288	171.265	814.265
Basilicata	81.576	215.011	95.797	228.961
Molise	14.041	42.157	13.369	47.099
TOTAL	**51.635.500**	**186.792.507**	**55.033.682**	**192.607.930**

7.3.1.2 Population projection

Data regarding the population projection in Reggio Emilia, Emillia Romagna Region and Italy were retrieved. Based on the following diagrams (Diagram 7-40, 7-41 and 7-42), it is obvious that population in Reggio Emilia is expected to have a steady increase compared to the total population of the country.

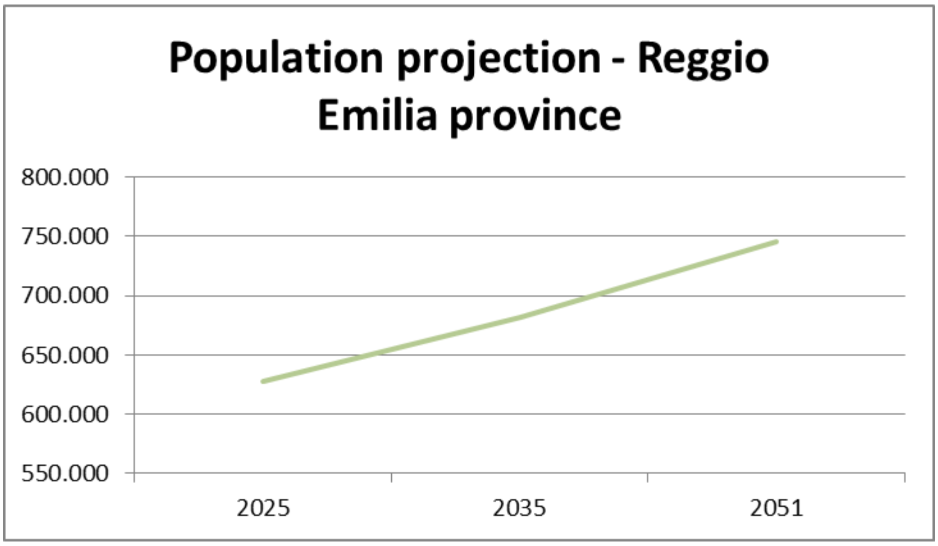


Diagram 7-40: Population projection for Reggio Emilia

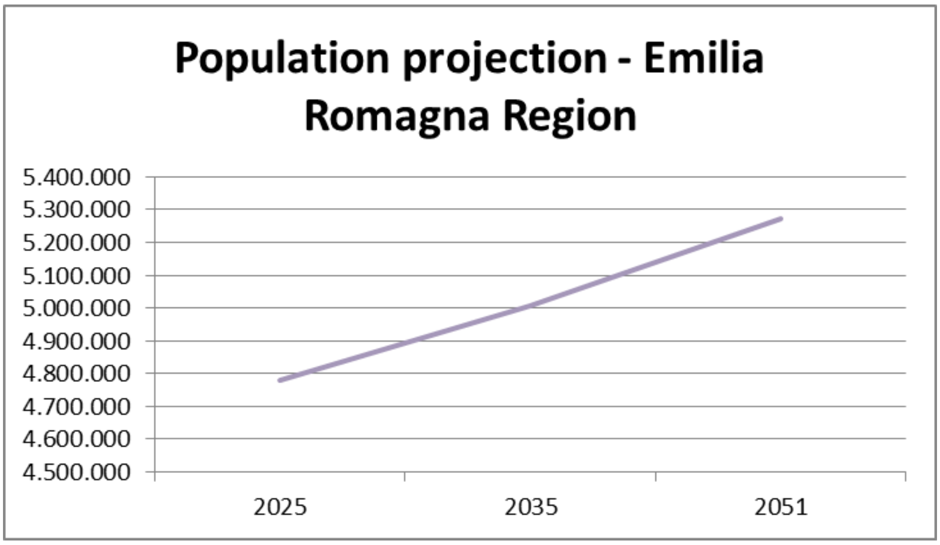


Diagram 7-41: Population projection for Emilia Romagna Region

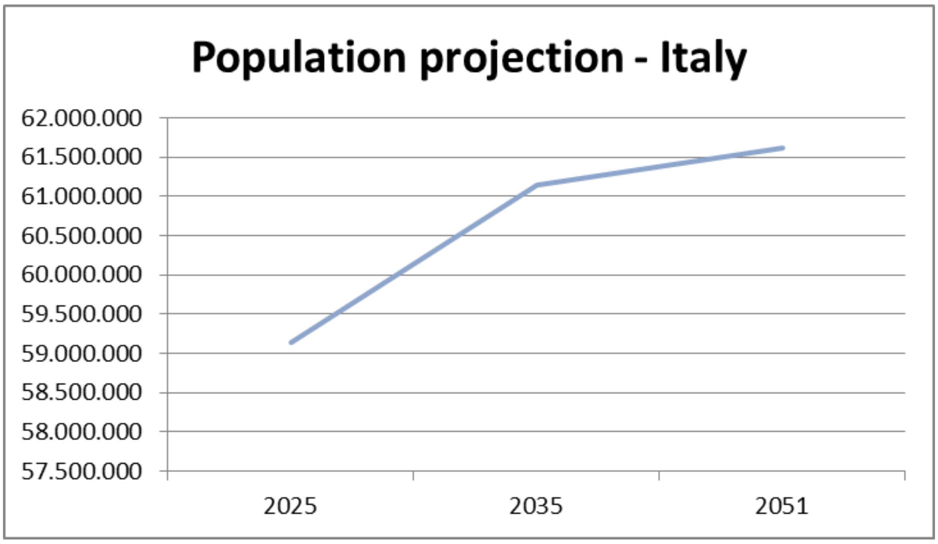


Diagram 7-42: Population projection for Italy

7.3.1.3 Distribution of population per age group, level of education, citizenship

Distribution of population per age group

Demographic data regarding population structure with reference to age of the permanent population were retrieved. Based on the data provided, the age classes with reference to young people include (i) 0-4 years old, (ii) 5-9 years old, (iii) 10-14 years old and (iv) 15-19 years old. The age groups with reference to the workforce age from 20 to 69 years old with age groups of four (4) years. The same age period is used for presenting age from 70 till 80+ years old. According to the data provided (Diagram 7-44, Diagram 7-45 and Diagram 7-46), workforce age is more populated compared to other age groups.

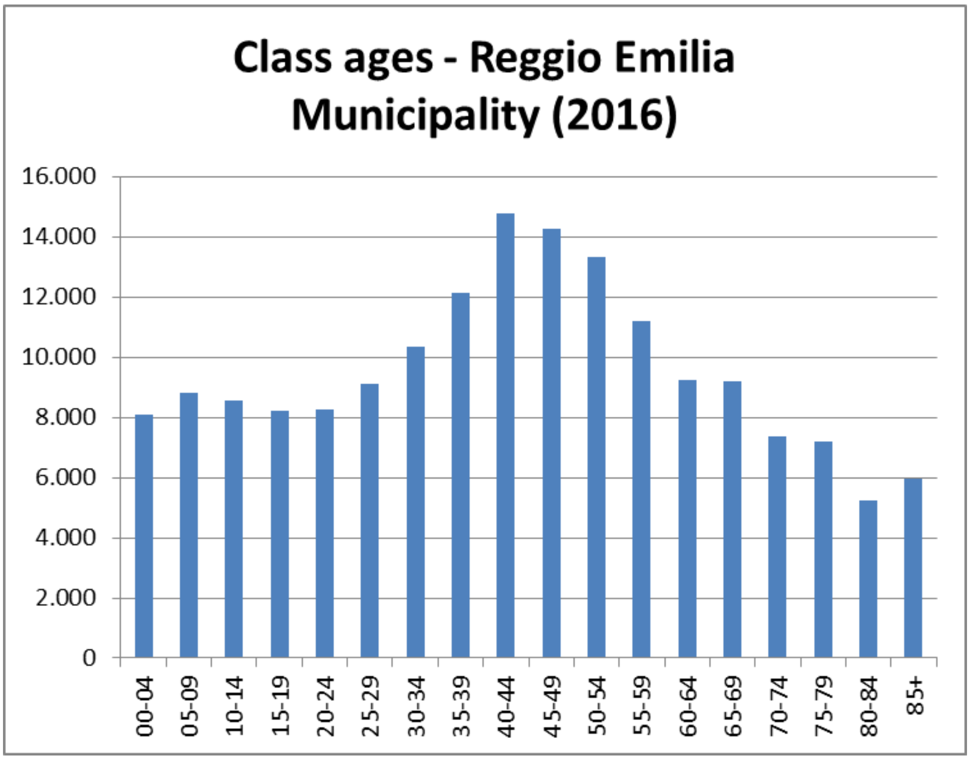


Diagram 7-43: Distribution of population per age group for Reggio Emilia in 2016

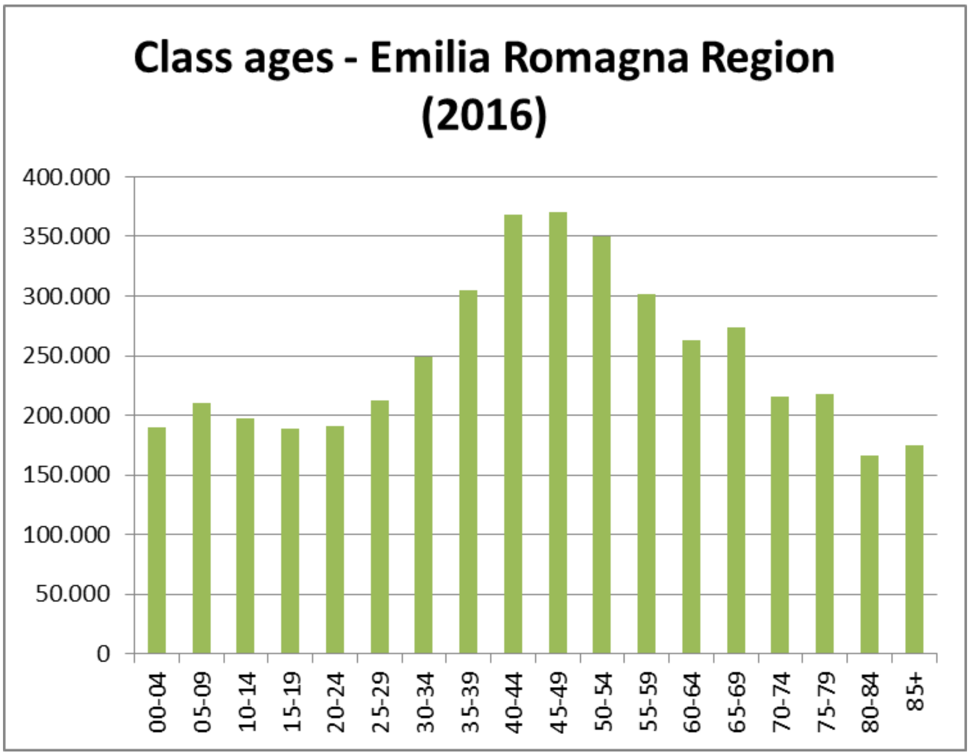


Diagram 7-44: Distribution of population per age group for Emilia Romagna Regionin 2016

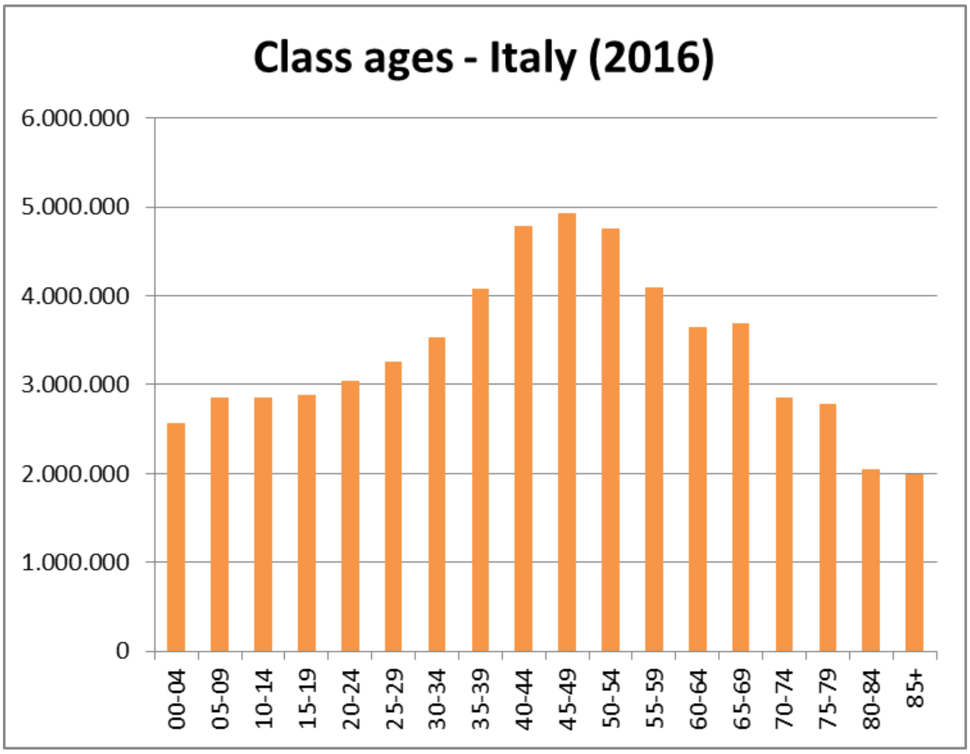


Diagram 7-45: Distribution of population per age group for Italyin 2016

Population of Reggio Emilia Municipality, Emilia Romagna Region and Italy divided in class ages (2016)

Distribution of population per education level

Data regarding the educational system of Italy were retrieved and are depicted in the following diagram (Diagram 7-46). The majority of the residents have attended junior high school and high school.

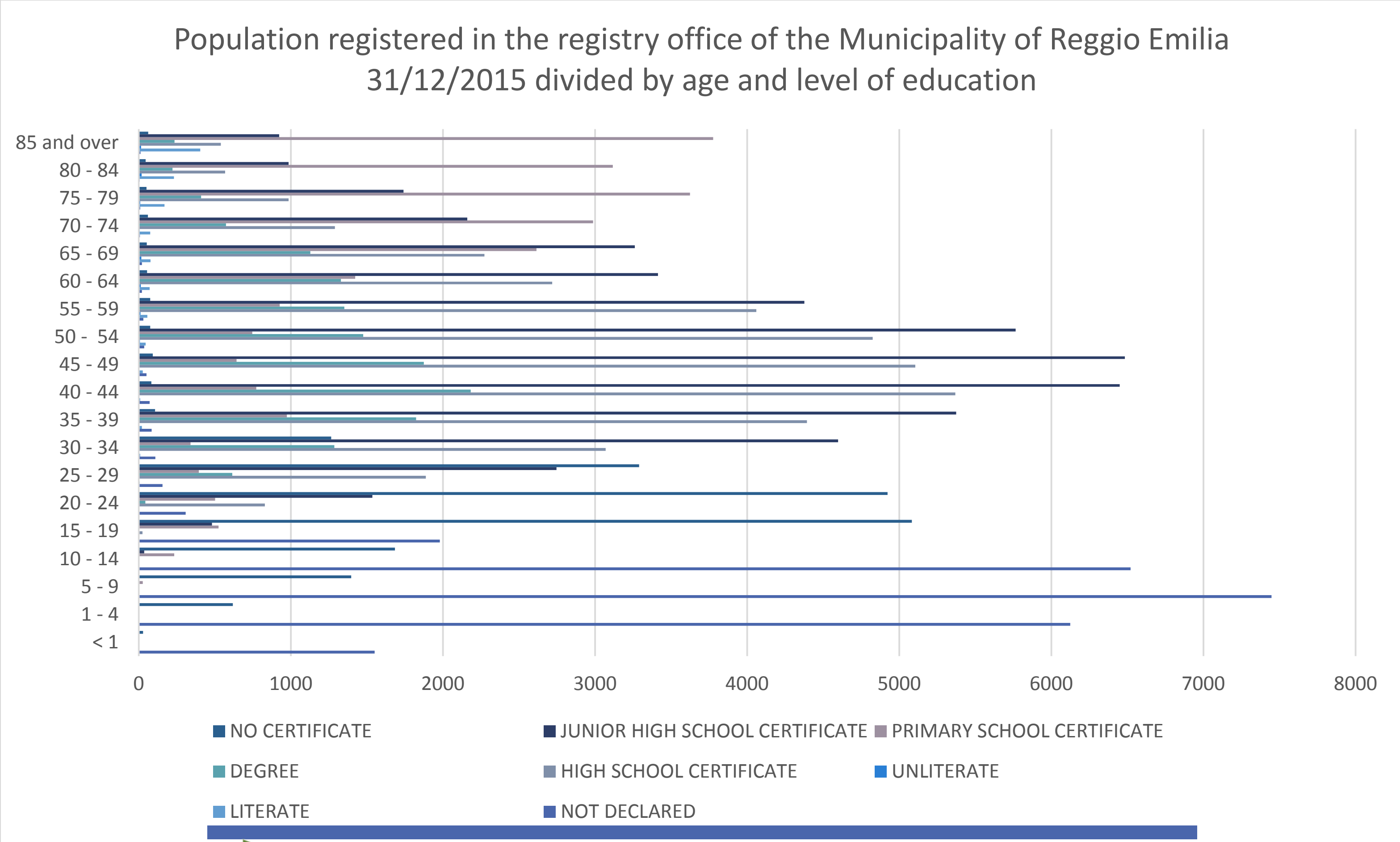
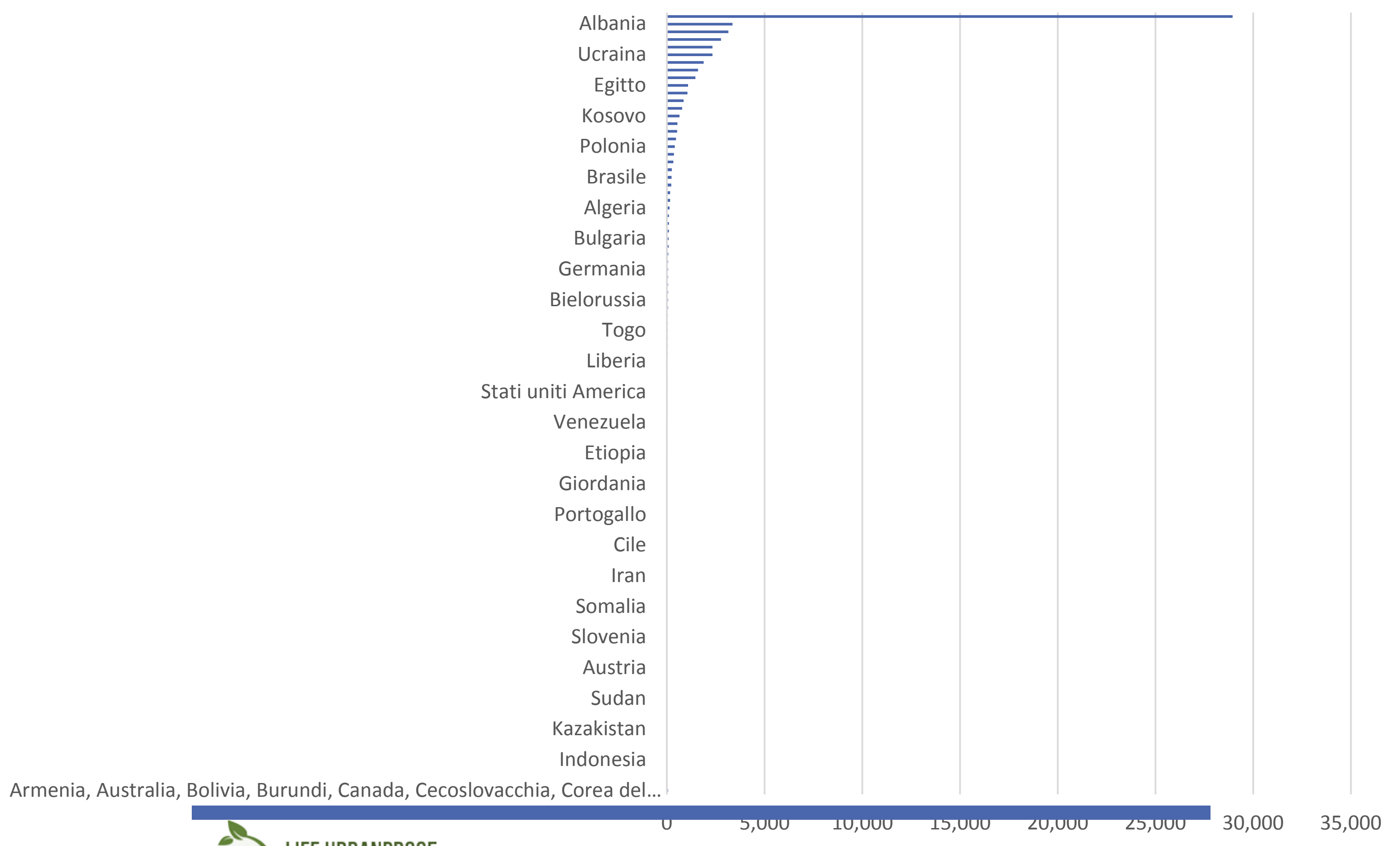

Population registered in the registry office of the Municipality of Reggio Emilia 31/12/2015 divided by age and level of education
85 and over
80 - 84
75 - 79
70 - 74
65 - 69
60 - 64
55 - 59
50 - 54
45 - 49
40 - 44
35 - 39
30 - 34
25 - 29
20 - 24
15 - 19
10 - 14
5 - 9
1 - 4
< 1
0
1000
2000
3000
4000
5000
6000
7000
8000
NO CERTIFICATE
JUNIOR HIGH SCHOOL CERTIFICATE
PRIMARY SCHOOL CERTIFICATE
DEGREE
HIGH SCHOOL CERTIFICATE
UNLITERATE
LITERATE
NOT DECLARED

Diagram 7-46: Population registered in the registry office of the Municipality of Reggio Emilia 31/12/2015 divided by age and level of education

Distribution of population per citizenship

Environmental, political and social factors have resulted in global migration flows. ForReggio Emilia, the structure of the foreign population is provided in the following diagram (Diagram 7-47).



Registered foreign population (Municipality of Reggio Emilia 31/12/2015)

Diagram 7-47: Registered foreign population (Municipality of Reggio Emilia 31/12/2015)

7.3.1.4 Population density

Population density is an indicator provided by the annual average population and the land area. Campania, Lazio and Lombardia are the Italian Regions with the highest density of population, probably because they host respectively cities such as Naples, Rome and Milan. Emilia Romagna is the Region with the most similar density to the Italian average.

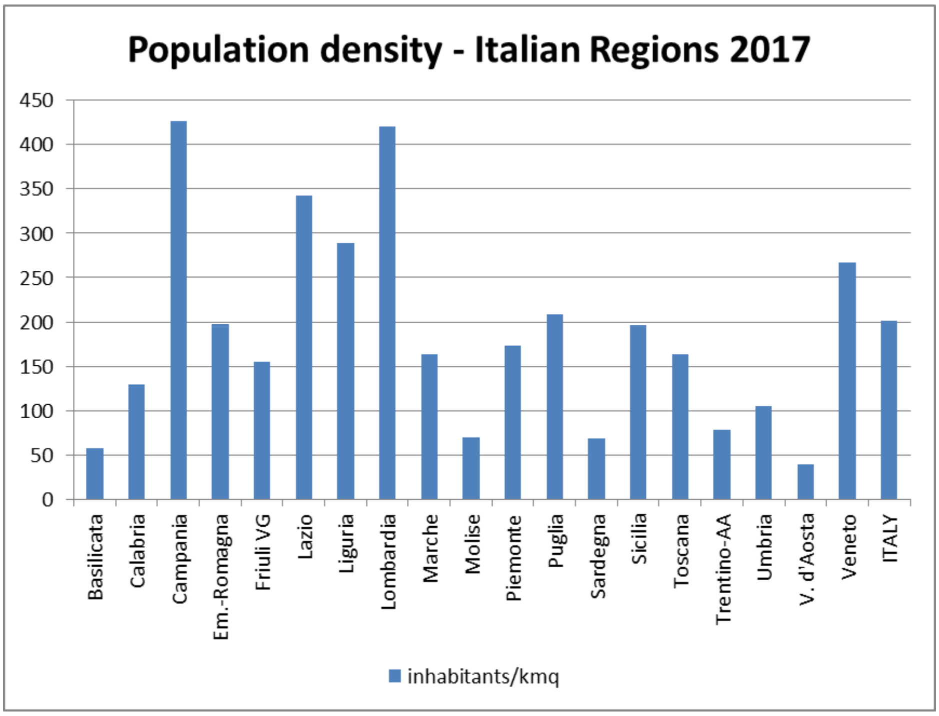


Diagram 7-48: Population density in Italian regions for 2017

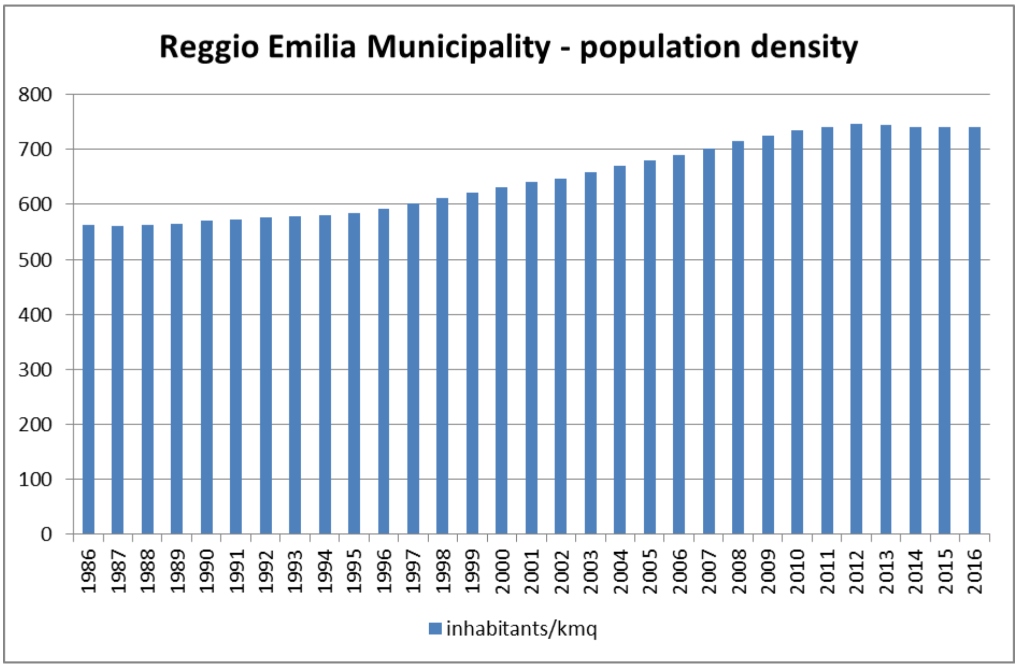


Diagram 7-49:Population density in Reggio Emilia

7.3.2 Economic indicators:

7.3.2.1 Economically active population

The economic active population (including employed, as well as unemployed people) refers to the people for the production of economic goods and services. Based on Diagram 7-50, economically active population has increased in Italy through the years.

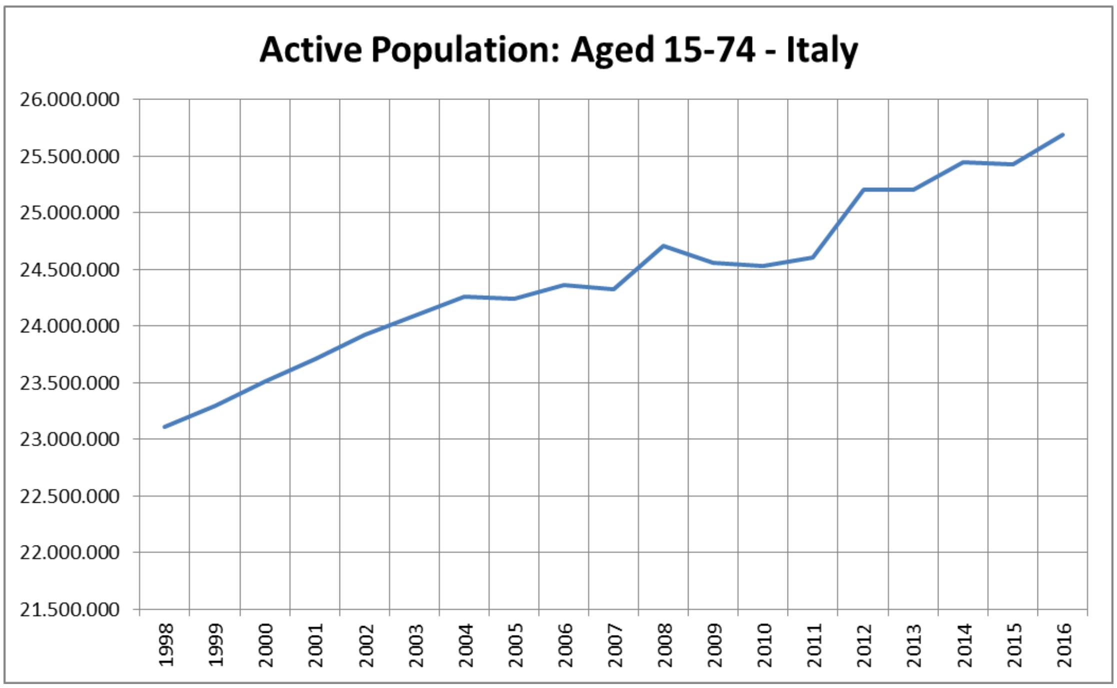


Diagram 7-50: Workforce of Italy

7.3.2.2 Distribution of population per employment status and poverty risk

Based on the data provided in Diagram 7-51 and Diagram 7-52, unemployment rate exceeds employment following almost the same trend for Italy, Emilia Romagna Region and Reggio Emilia.

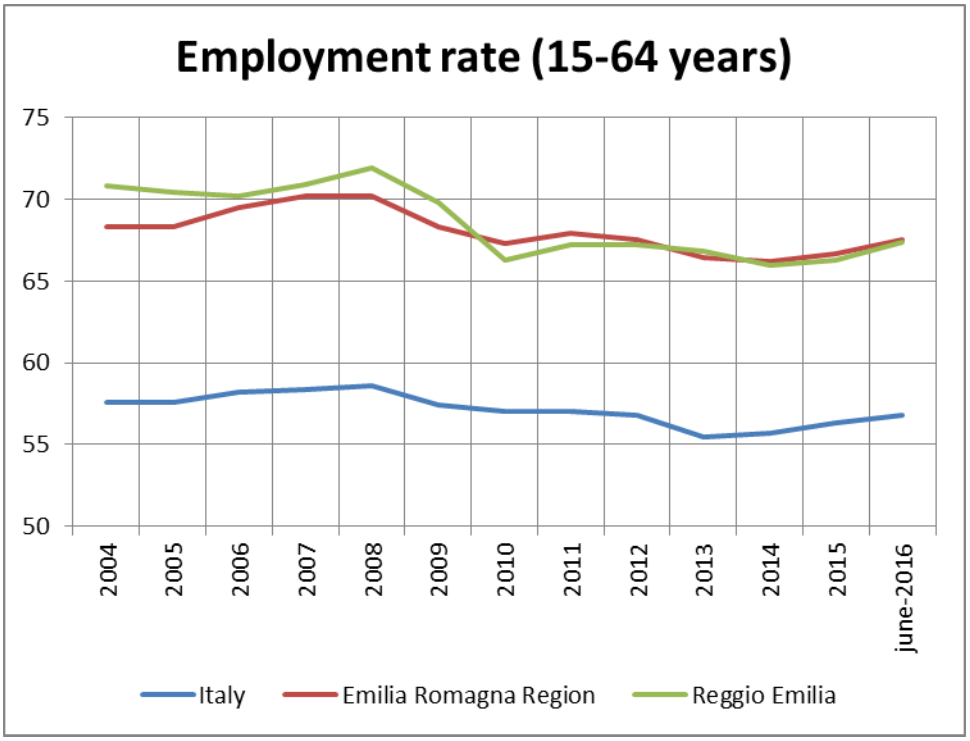


Diagram 7-51: Employment rate in Italy, Emilia Romagna Region and Reggio Emilia

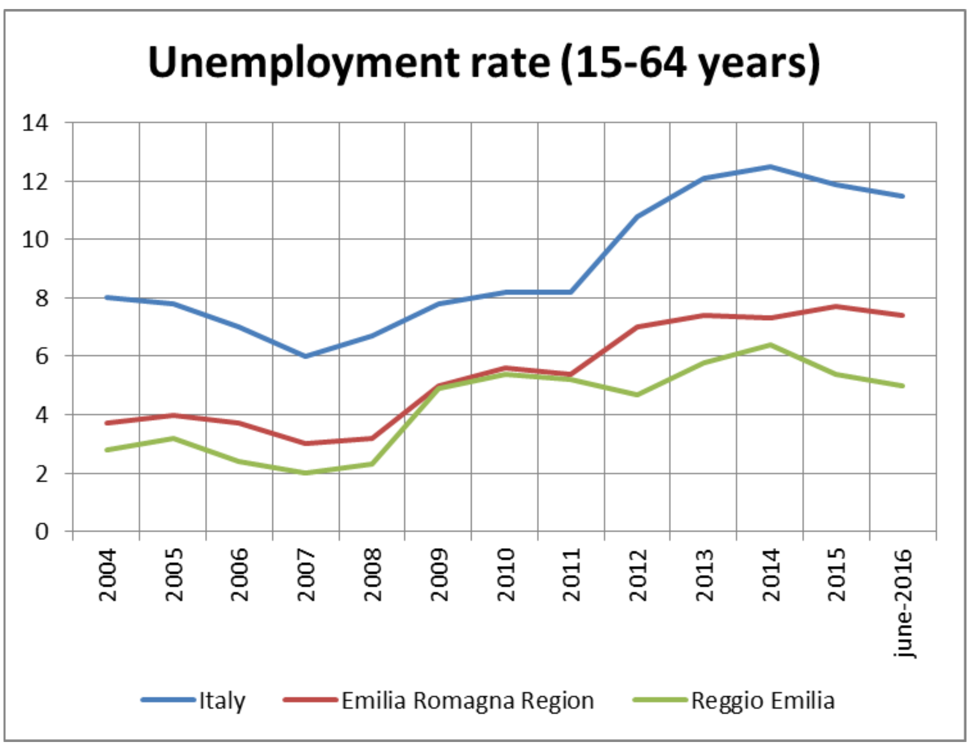


Diagram 7-52:Unemployment rate in Italy, Emilia Romagna Region and Reggio Emilia

Finally, it has to be noted that families with relative poverty have a steady trend, with an increase in 2012, while families with absolute poverty have significantly increased especially in recent years (Diagram 7-53).

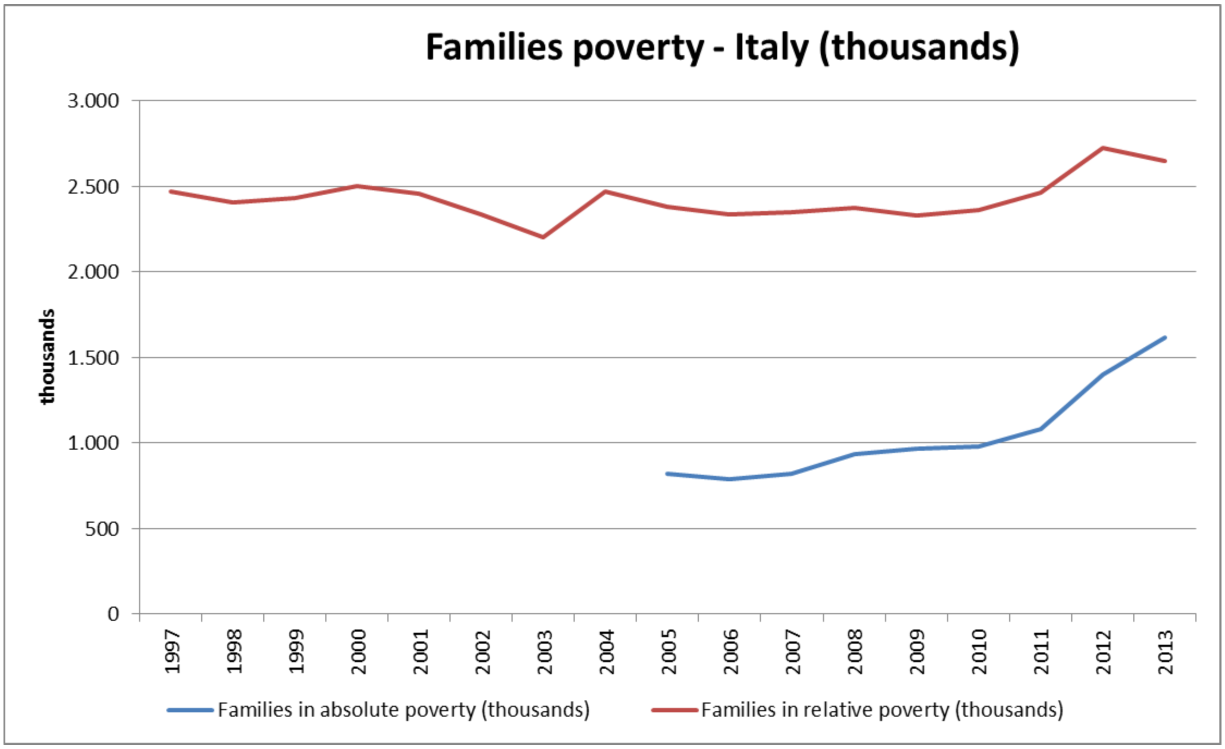


Diagram 7-53: Families in absolute and relative poverty in Italy

7.3.3 Health indicators:

7.3.3.1 Life expectancy

Life expectancy in Italy and Emilia Romagna have the same trend since 2001, but the values of Emilia Romagna are higher than the national average (Diagram 7-54).

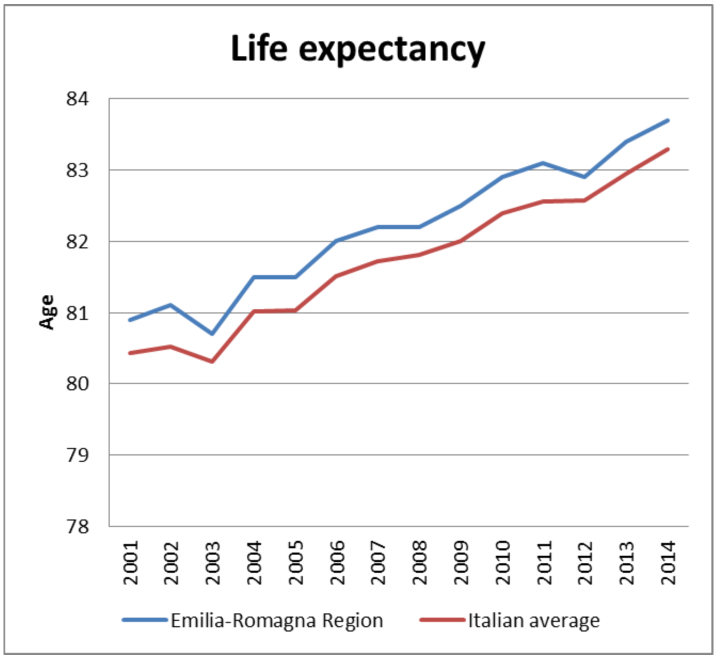


Diagram 7-54: Life expectancy in Emilia Romagna Region and Italy, from 2001 to 2014

7.3.3.2 Distribution of population with chronic diseases/health problems per type of disease/health problem

In Italy, most common chronic pathologies have always been 1) arthrosis and 2) hypertension; In the last 5 years the second pathology has passed the first. There is a definite increase in allergy-related diseases (Diagram 7-55).

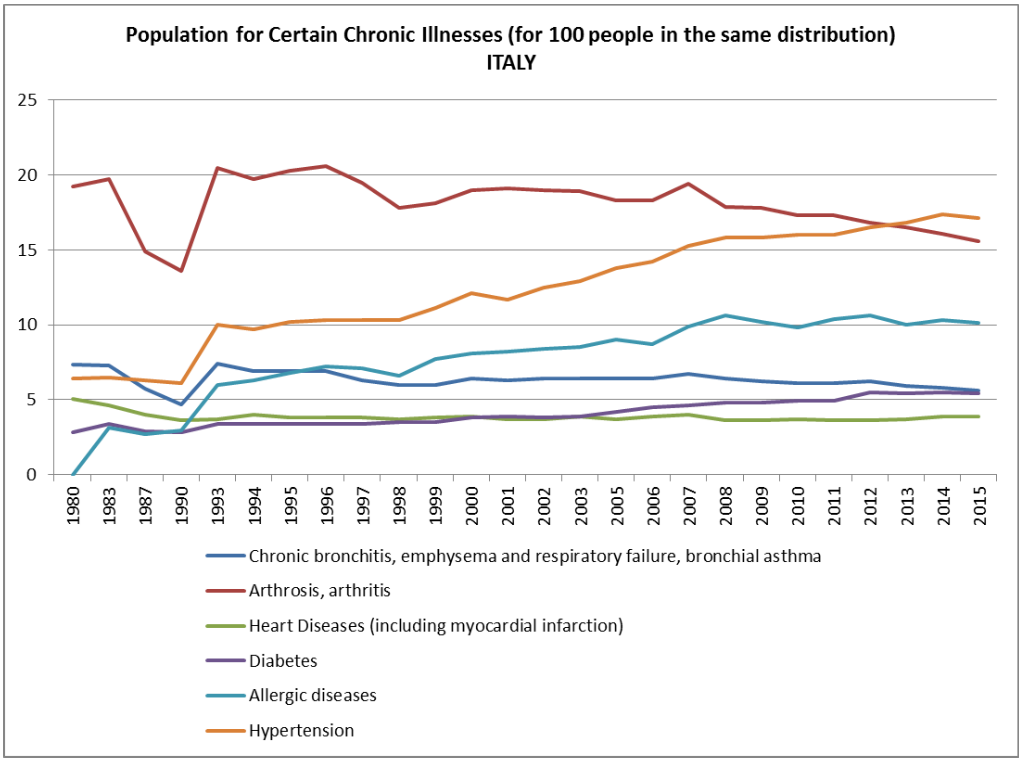


Diagram 7-55:Population for certain chronic illnesses in Italy

7.3.3.3 Number of hospitals/health clinics per type (expertise) of hospital/clinic

Clinics and laboratories are the largest healthcare facilities in the country; in recent years, psychiatric care and assistance to the elderly have increased significantly, while other types of facilities have kept steady. In Emilia Romagna, the most represented structures are those for the elderly and for physically disabled people (Diagram 7-56 and Diagram 7-57).

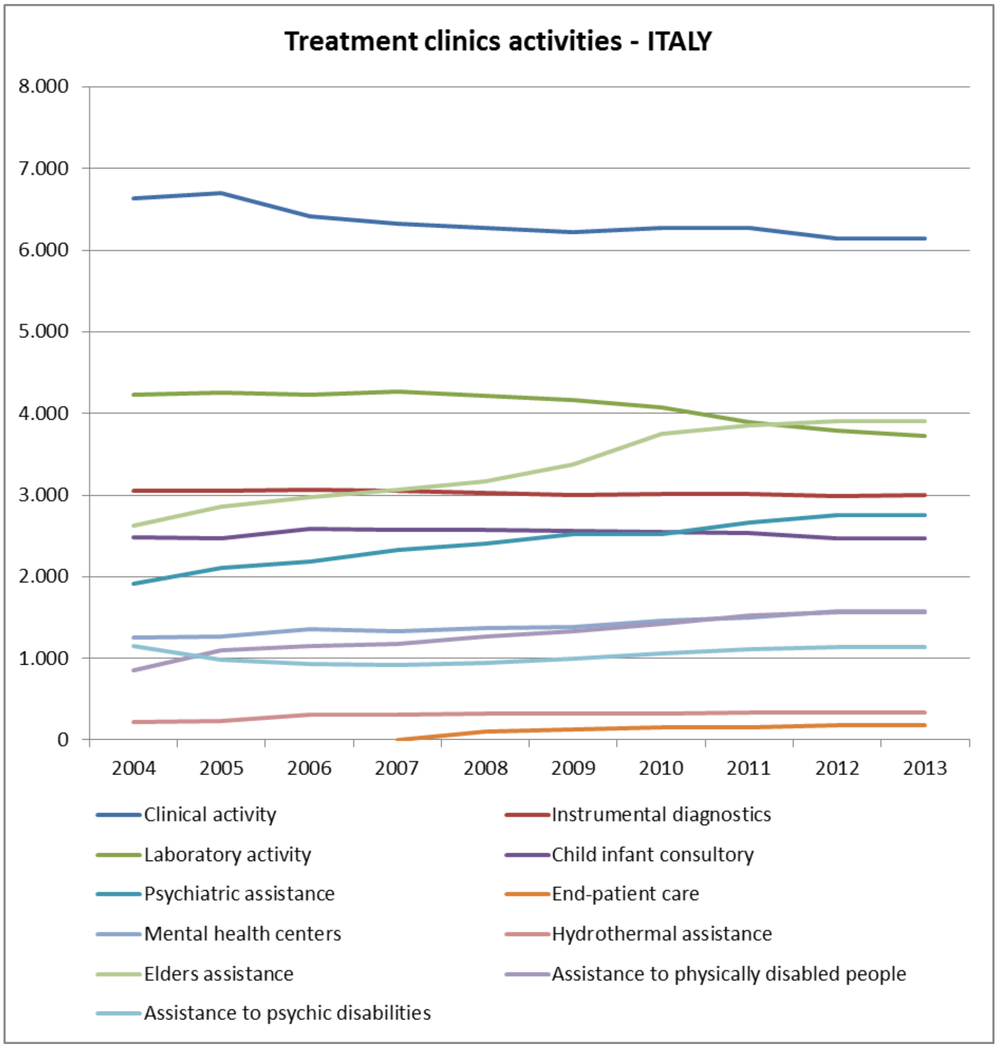


Diagram 7-56: Treatment clinics in Italy

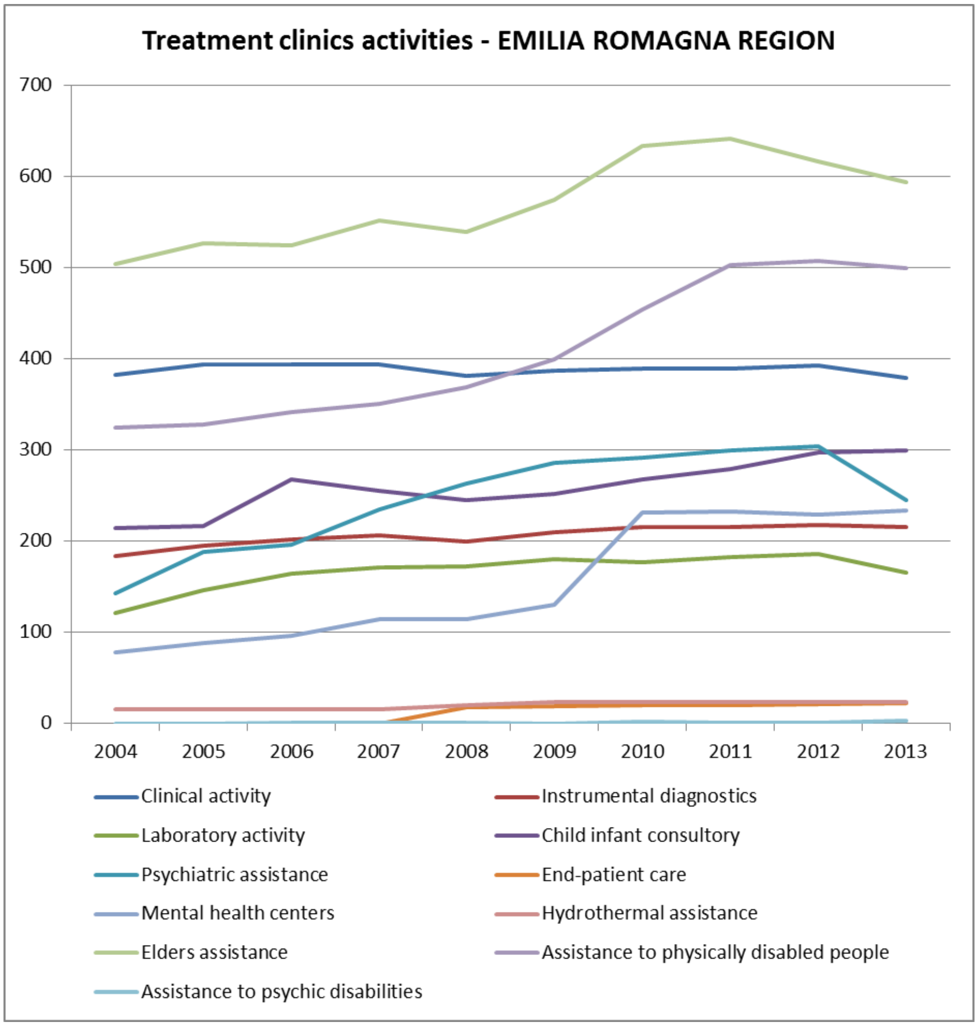


Diagram 7-57: Treatment clinics in Emilia Romagna Region

7.4 References

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