2ND REPORT ON THE NATIONAL RISK ASSESSSMENT OF THE REPUBLIC OF CYPRUS

CYPRUS CIVIL DEFENCE DEPARTMENT, MINISTRY OF INTERIOR

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CIVIL DEFENCE ACTING COMMANDER'S FORWARD

I address this 2nd edition of the Cyprus Report on National Risk Assessment with recognition of the collective work of several government departments of the Republic of Cyprus and various experts, professionals and academics, who contributed to it.

Risk assessments, as Crisis and Disaster management in general, in our modern era, are often characterized by the fact that data from past disasters may no longer be dependable for estimates concerning future catastrophes. The pace of technological development, together with the predicted climate change, are rendering the traditional scientific thought more interpretive, requiring input from a multiplicity of sciences and from multiple disciplines and perspectives for emergency planning, in a framework of democratic dialogue.

Traditional disasters in Cyprus, such as earthquakes, may pose new and more complex problems in the future, as new technology and much higher buildings are nowadays built in the most seismically prone areas of the island. New and stricter anti-seismic codes have been introduced. However, in the building stock of Cyprus there coexist modern steel and reinforced concrete structures together with traditional stone and adobe buildings. Further to that, future earthquakes may overlap with weather extremes and especially hot waves.

Taking into consideration all the up-to-date discourses of academics and practitioners of Risk and Crisis Management, regarding the spatial and temporal elements framing risks and crises, our leadership consciously keeps the National Risk Assessment Programme of Cyprus as an ongoing and continuous process. This is also due to the fact that the order of magnitude of risks that our contemporary world, in general, and Cyprus in particular, may face in the coming decades is expected to increase exponentially. With the above in mind, the Cyprus Civil Defence leadership and forces envision to incorporate modern planning, organizational and operational paradigms, which will permit a more unified and focused risk and crisis planning, so as to safeguard the socio-economic and environmental progress of our Homeland.

Loucas Hadjimichael

Cyprus Civil Defence Acting Commander

INTRODUCTION BY THE EDITOR

Since the issue of the 1st Report of December 2015, a lot of work has been done on the National Risk Assessment project. This progress is presented in this summary. This 2nd report is a collective piece of work of various contributors: Different government departments and other organizations as well as professional and academic experts. No primary research was carried out for its drafting; existing risk assessments were systematized, partly through a call of tenders awarded to ADENS CONSORTIUM, Greece. The current report strongly links certain risks with the current and expected climate change.

This summary of 170 or so pages summarizes much larger studies and excludes sensitive data, especially from such fields as cyber risk assessment. Should any researcher require further details, the editor may be contacted as to their availability.

The methodologies used are not unified and include, among others, elements from the

- Commission Staff Working Paper on Risk Assessment and Mapping Guidelines for Disaster management - 17833/10 (5 January 2011),
- International Standard IEC/ISO 31010 – 2009: Risk Management - Risk Management Techniques
- ISO 31000 – 2009: Principles and Guidelines
- British National Methodology
- Netherland's National Methodology

This report, besides providing background information about Cyprus examines the risk assessment of the following sectors: Earthquake, tsunami, floods, coastal erosion and sea level rise, forest and wild fires, human health, land desertification, water resources, biodiversity, energy supply, marine pollution and cyber risks. Risks such as high temperature, low temperature, winds and other similar have been included as horizontal subjects, into this summary, under the headings cited above.

The data given in this report refer to the government controlled part of Cyprus, for which data is available. It does not refer to the whole island that is including the Turkish occupied part of Cyprus, unless otherwise explicitly stated in the text.

This summary is publicly available on the site of the Cyprus Civil Defence. We expect that it will become a matter of public discussion, will be utilized by policy makers and that it will inspire further research into the matter. Nonetheless, this work will be renewed at frequent time intervals, as new knowledge is accumulated, new paradigms are investigated, and new experiences are gained.

ABBREVIATIONS

AMSL	Above Mean Sea Level
AOGCM	Atmosphere–Ocean General Circulation Model
APSFR	Areas of Potentially Significant Flood Risk
AROPE	At risk of poverty and social exclusion indicator
AUA	Agricultural University of Athens
BCI	Beach Climate Index
CAMP	Coastal Area Management Programme
CAP	Common Agricultural Policy
CAPEX	Capital Expenditure
CBD	Convention on Biological Diversity
CC	Climate Change
CCD	Cyprus Civil Defence (Department)
CCRA	Climate Change Risk Assessment
CDD	Cooling Degree Days
CERA	Cyprus Energy Regulation Authority
CHC	Cyprus Hydrocarbons Company
CIS	Common Implementation Strategy
CLC	Corine Land Cover
CNBS	Cyprus National Biodiversity Strategy
COSMOS	Cyprus Organization for Storage and Management of Oil Stocks
CPA	Cyprus Ports Authority
CTO	Cyprus Tourism Organization
CYSTAT	Statistical Service of Cyprus
DEFA	Natural Gas Public Company
DFMR	Department of Fisheries and Marine Research
DMP	Drought Management Plan
DoE	Department of Environment
EA	Ecosystem Approach
EAC	Electricity Authority of Cyprus
EC	European Commission
EEA	European Environment Agency
EEZ	Exclusive Economic Zone
ESA	Environmentally Sensitive Areas
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FRI	Fire Return Interval
FRMP	Flood Risk Management Plan
FTTH	Fiber-To-The Home
FWI	Fire Weather Index
GCM	Global Climate Model
GDP	Gross Domestic Product
GFS	Game Fund Service
GHG	Greenhouse Gases

GMI	Guaranteed Minimum Income
GMSLs	Global Mean Sea Levels
GMST	Global Mean Surface Temperature
GWS	Government Water System
GWW	Government Water Works
HCCVI	Habitat Climate Change Vulnerability Index
HDD	Heating Degree Days
IAS	Invasive Alien Species
IBUs	International Banking Units
ICT	Information and Communication Technology
IP	Irrigation Project
IPCC	Intergovernmental Panel on Climate Change
IR	Irrigation Divisions
IVA	Impact, Vulnerability and Adaptation
ktoe	Kilotonne of oil equivalent
LNG	Liquefied Natural Gas
MANRE	Ministry of Natural Resources and the Environment
MCA	Multi-Criteria Assessment
MCM	Million cubic meters
MEA	Millennium Ecosystem Approach
MECIT	Ministry of Energy, Commerce, Industry and Tourism
MOA	Ministry of Agriculture
MOH	Ministry of Health
MOI	Ministry of Interior
NAP	National Action Plan
NBS	National Biodiversity Strategy
NDN	Nitrification/Denitrification processes
neZEH	Nearly Zero Energy Hotels
NFD	Number of feeding days
NFP	National Forest Programme
NPP	Net Primary Productivity
NRA	National Risk Assessment
NWFPs	Non-Wood Forest Products
nZEB	Nearly Zero Energy Buildings
OA	Ocean Acidification
OPEX	Operational Expenditure
OWL	Other Wooded Land
PFRA	Preliminary Flood Risk Assessment
PGA	Peak Ground Acceleration
PM	Particulate Matter
PSMD	Potential Soil Moisture Deficit
PVE	Photovoltaic Energy
PWD	Public Works Department
RA	Risk Assessment
RACI	Responsible, Accountable, Communicated, and Informed analysis

RBD	River Basin District
RBMP	River Basin Management Plan
RCM	Regional Climate Model
RCP	Representative Concentration Pathway (scenarios)
RES	Renewable Energy Sources
SB	Sewerage Board
SLR	Sea Level Rise
SOC	Soil Organic Carbon
SPEI	Standardized Precipitation Evapotranspiration Index
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
TCI	Tourism Climate Index
TEN-T	Trans-European Transport Network
TER	Threatened Endangered and Rare (species)
THI	Temperature Humidity Index
toe	Tons of oil equivalent
TSOC	Transmission System Operator of Cyprus
UAA	Utilized Agricultural Area
UHI	Urban Heat Island
UK	United Kingdom
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WDD	Water Development Department
WE	Wind Energy
WFD	Water Framework Directive 2000/60/EC
WFPs	Wood Forest Products
WTP	Willingness to Pay
WWT	Waste Water Treatment
WWTP	Wastewater Treatment Plants
YLL	Years of life lost

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PART A- BACKGROUND INFORMATION

1. GENERAL INFORMATION ABOUT CYPRUS

Cyprus is the third largest island in the Mediterranean, after Sicily and Sardinia, with an area of 9.251 square kilometers (3.572 square miles) and it is situated at a distance of 300 Km north of Egypt, 90 Km west of Syria and 60 Km south of Turkey. Greece lies 360 Km to the north-west (Rhodes-Karpathos). Cyprus is situated at a latitude of 34°33'-35°34' North and a longitude of 32°16'-34°37' East (PIO, 2015).

The country has two mountain ranges: the Pentadaktylos range which runs along almost the entire northern coast, and the Troodos massif in the central and south-western parts of the island which culminates in the peak of Mount Olympus, 1.953 m. above sea level. Cyprus' coastal line is indented and rocky in the north with long sandy beaches in the south. Between the two ranges lies the fertile plain of Mesaoria.

The Republic of Cyprus has been a member state of the UN since its independence in 1960 and the EU since 2004. In 1974 Turkey invaded Cyprus and occupied 36,2% of its sovereign territory. As a result, the internationally recognized government of the Republic of Cyprus effectively controls only the southern 57% of the island, where the population is mostly Greek-Cypriot. The northern 36,2% is currently inaccessible due to the presence of Turkish troops since 1974 and it is mostly at present resided by Turkish-Cypriots and Turkish settlers. A 3% of the territory of the island is the buffer zone controlled by the UN's Peacekeeping Force in Cyprus (UNFICYP). Two British Sovereign Bases, one at Akrotiri / Episkopi and the other at Dhekelia, cover the rest 2,8% of the island's territory.

According to official statistics, the population of the Republic of Cyprus in December 2013 was 949.000, including 167,100 foreign nationals and workers. There are no official census statistics about the population in the occupied part of the island, however it is estimated that the number of Turkish Cypriots is 91.000 and that of Turkish settlers around 160.000 This report refers to the area under the control of the government of the Republic of Cyprus and –where data is available- to the whole island. Figure 1.1.1 exhibits an eastern Mediterranean map.

Figure 1.1.: *The Eastern Mediterranean Sea*

One of the protocols annexed to the Accession Treaty of Cyprus to the EU provides that, although Cyprus was admitted as a whole to the Union, the application of the *acquis communitaire* in the northern Turkish-occupied part of the island is suspended until a solution to the Cyprus problem is found.

The Republic of Cyprus has a presidential system of government. The constitution provides for separate executive, legislative and judicial branches of government with independent powers. The President is both Head of State and Government.

For administrative purposes Cyprus is divided into six administrative districts: Nicosia, Limassol, Pafos, Larnaka and Famagusta (in the government-controlled areas) and Kerynia (in the occupied areas).

Each district is administered by a District Officer, who is a senior civil servant answerable to the Ministry of Interior. District Officers act as coordinators and liaisons for the activities of all ministries in the districts.

Apart from their institutional role pursuant to the Communities Law of 1999, the District Administrations coordinate, guide and implement projects for the development of the communities. Furthermore, they play a significant role in the preparation, revision and modification of the local plans and policy statement, as well as in the process of the examination of objections.

The government provides administrative and technical support to most of the community councils and councils of community complexes through the civil servants serving in the District Administrations.

Moreover, there are two types of local authorities, municipalities and communities, which are governed by separate laws. In principle, municipalities constitute the form of local government in urban and tourist centers, while communities constitute the local structure in rural areas.

According to the Law, the main responsibilities of municipalities are the construction, maintenance and lighting of streets, the collection, disposal and treatment of waste products, the protection and improvement of the environment and the good appearance of the municipal areas, the construction, development and maintenance of municipal gardens and parks and the protection of public health. The Municipal Council has the authority to promote, depending on its finances, a vast range of activities and events including the arts, education, sports and social services. In addition to the Municipalities Law, there are several different laws giving important powers to municipalities, other than those already mentioned.

The main sources of revenue of municipalities are municipal taxes, fees and duties (professional tax, immovable property tax, hotel accommodation tax, fees for issuing permits and licenses, fees for refuse collection, fines, etc.), as well as state subsidies. Taxes, duties and fees represent the major source of revenue, while state grants and subsidies amount to only a small percentage of the income. The central government, however, usually finances major infrastructure projects undertaken by the municipalities. The yearly budgets of the municipalities are submitted to the Council of Ministers for approval and their accounts are audited annually by the Auditor General of the Republic. Municipal loans also need to be approved by the Council of Ministers.

The functions of communities are generally similar to those of municipalities, although structurally different. With the exception of some communities, which are financially better off, the Government provides essential administrative and technical assistance as well as most of the necessary services to most communities, through the office of its District Officer. The revenue of the communities consists of state subsidies as well as taxes and fees collected from the residents of the area. The Community Councils are responsible for the provision of community services, water supply, and the regulation of professional practices.

In terms of Emergency Services, these come directly under the central government, but are scattered among different Ministries; the Police and Fire Services under the Ministry of Justice and Public Order, the Medical Services under the Ministry of Health, and the Civil Defence Department under the Ministry of the Interior. Emergency Services have offices in all five districts of the Republic of Cyprus, through which they deal with their routine work independently. In case of a major incident or disaster, however, the Minister of the Interiors takes over intervention efforts, through the Civil Defence Department, according to the Civil Defence Law of 1996 and Regulations of 1997. Depending on the magnitude of the crisis at hand, an ad-hoc Ministerial Committee may also be activated.

2. POPULATION PROJECTION FOR CYPRUS

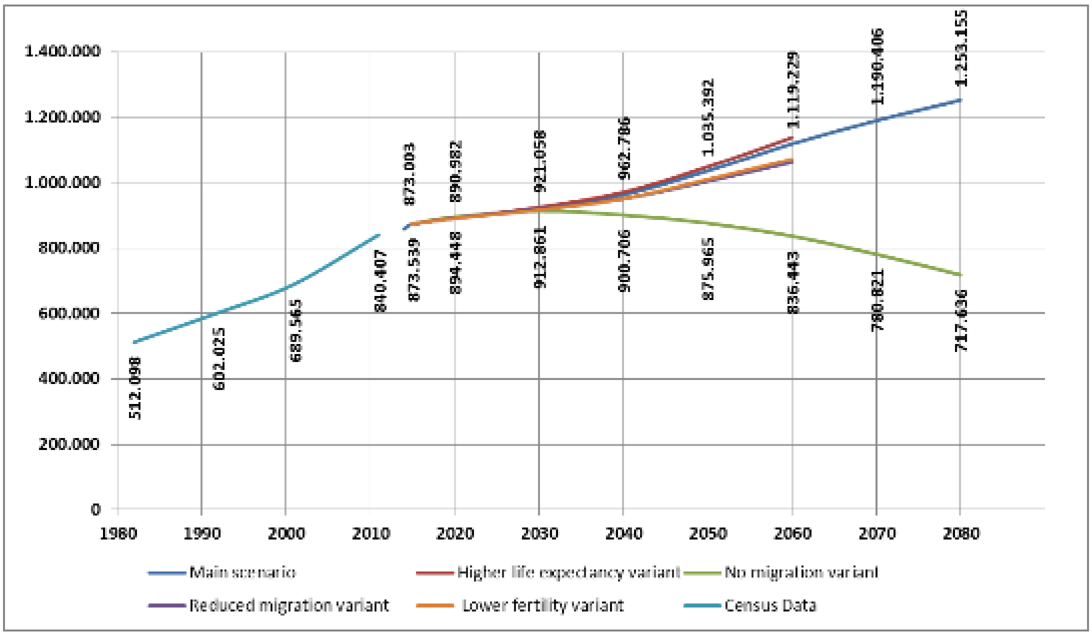


Figure 2.1: *Europop2013 Cyprus population projections and Census Data*

Figure 2.1 presents the projected changes to the population of Cyprus during the period 2014 to 2080. There is little variation between the Main scenario and the following 3 Scenarios: Higher life expectancy variant, Reduced migration variant and Lower fertility variant. According to the *main scenario*, the population of Cyprus is predicted to rise up to 20% by 2050 and 46,1% by 2080 (in comparison to 2014). The old-age dependency ratio is estimated

19,9% in 2014 and will rise to 42,3% by 2080. According to the *No migration variant Scenario,* the population is predicted to decline by -22% during the period 2015 to 2080.

A larger population overall may place greater pressure on the environment, in terms of land use and consumption of natural resources, and greater pressure on health, water, energy, transport and waste services to meet higher demands.

Projections of population and socio-economic trends are ideal for considering risks in the short and medium term (to 2050s) but are less helpful for longer term assessment. This is because the population is just one of many social and economic factors that may influence risks in the long term and other drivers cannot be quantified in the same way as population.

According to the latest demographic report released from the statistical service of the Republic of Cyprus, the population of the Government controlled area was estimated at 847.000 at the end of 2014, compared to 858.000 at the end of 2013 recording a decrease of 1,3%. The proportion of children below 15 decreased to 16,4% while the proportion of old-aged people 65 and over increased to 14,6% in 2014, compared to 25,4% and 11,0% respectively in 1992 and 25,0% and 10,8% in 1982. There was a gradual increase in the proportion of old-aged people and a decrease in the proportion of children demonstrating the ageing process. The proportion of persons aged 45-64 increased also, to 24,5% from 19,3% in 1992 and 17,6% in 1982 indicating an ageing of the working age population as well.

Given the fact that the percentage of the citizens above 65 years of age has increased from 12,7% in 2010 to 14,6% in 2013 and the crude birth rate has been reduced from 11,8 births per 1.000 population in 2010 to 10,9 births in 2014, Cyprus can be considered as a country with high aging population. This poses a serious challenge to the health and pension system of Cyprus (Table 2.1).

Table 2.1: *General Demographic Indicators of Cyprus*

Population at the end of the year (000's)	**2010**	**2011**	**2012**	**2013**	**2014**
Total	839,8	862,0	865,9	858,0	847,0
Males	408,8	419,0	421,0	417,5	411,8
Females	431,0	443,0	444,9	440,5	435,2
Population distribution by age (%)	**2010**	**2011**	**2012**	**2013**	**2014**
0-14 years	16,8	16,5	16,4	16,3	16,4
15-64 years	70,5	70,7	70,4	69,8	69,0
65+	12,7	12,8	13,2	13,9	14,6
Life expectancy at birth (years)	**2010**	**2011**	**2012**	**2013**	**2014**
Men	79,0	79,3	78,8	80,0	80,7
Women	83,7	83,0	83,2	84,8	84,5
Population change	**2010**	**2011**	**2012**	**2013**	**2014**
Annual growth rate (end year) %	2,5	2,6	0,5	-,0.9	1,3
Natural increase rate (per 1.000 population)	5,7	4,9	5,2	4,9	4,7
Net migration (number)	15.913	18.142	-629	-12.078	-15.000
Fertility	**2010**	**2011**	**2012**	**2013**	**2014**
Live births (number)	9.801	9.622	10.161	9.341	9.258
Crude birth rate (per 1.000 population)	11,8	11,3	11,8	10,8	10,9
Total fertility rate	1,44	1,35	1,39	1,30	1,31
Mortality	**2010**	**2011**	**2012**	**2013**	**2014**
Deaths (number)	5.103	5.504	5.665	5.141	5.250
Crude death rate (per 1.000 population)	6,2	6,5	6,6	6,0	6,2
Infant mortality rate (per 1.000 live births)	3,2	3,1	3,5	1,6	1,4

According to Eurostat, in 2014, 122,3 million people, or 24,4 % of the population in the European Union (28 countries) were at risk of poverty or social exclusion, compared with 24.5 % in 2013. This means that these people were at least in one of the following conditions:

- at-risk-of-poverty after social transfers (income poverty);
- severely materially deprived or
- living in households with very low work intensity.

In Cyprus, this number rose to 234.000 people or 27,4% of the population.

With a rate of 27,8 % in the EU-28, children were at greater risk of poverty or social exclusion in 2014 than the rest of the population in 20 of the 28 EU Member States. The situation was relatively better for children than adults in Cyprus (24,7%). The elderly faced a lower risk of poverty or social exclusion in 2014 than the overall population both at EU-28 level (17,8 % as opposed to 24,4 %) and in 23 out of the 28 EU Member States. The risk of poverty or social exclusion faced by people aged 65 or more in 2014 ranged from 6,4 % in Luxembourg to 47,8 % in Bulgaria. In Cyprus, this risk rose to 27,2% (1,5 times the EU-28). These differences in the relative situation of the elderly, at EU-28 level, depend on a number of factors including the features of the pension systems for current pensioners and the age and gender structure of the elderly population, since elderly women and the very old tend to face much higher risks in some countries. In Cyprus, Andreou and Pashardes (2009) attribute this to the insufficient pension system of the private sector.

Table 2.2: *People at risk of poverty or social exclusion by age and sex, % of total population.*

Year	Total			Less than 18 years			From 18 to 64 years			65 years or over		
	EU-28	EU-27	Cyprus	EU-28	EU-27	Cyprus	EU-28	EU-27	Cyprus	EU-28	EU-27	Cyprus
2006	:	25,3	25,4	:	27,5	21,3	:	24,8	21,4	:	24,7	55,6
2007	:	24,4	25,2	:	26,4	20,8	:	23,8	21,1	:	24,4	55,6
2008	:	23,7	23,3	:	26,4	21,5	:	23,0	18,9	:	23,3	49,3
2009	:	23,3	23,5	:	26,5	20,2	:	22,8	19,9	:	21,7	48,6
2010	23,8	23,7	24,6	27,5	27,5	21,8	23,6	23,6	22,1	20,1	19,9	42,6
2011	24,3	24,2	24,6	27,2	27,2	23,4	24,4	24,4	22,1	20,4	20,3	39,8
2012	24,7	24,7	27,1	28,0	27,9	27,5	25,3	25,2	25,8	19,3	19,2	33,4
2013	24,6	24,5	27,8	27,7	27,7	27,7	25,4	25,4	28,2	18,2	18,1	26,1
2014	24,4	24,4	27,4	27,8	27,7	24,7	25,4	25,3	28,3	17,8	17,7	27,2

3. PROJECTED CLIMATE CHANGE FOR CYPRUS

The climate in Cyprus is generally characterized by mild rainy winters, occasional droughts, and long, hot and dry summers. Recent studies on present and future climate have shown that the Eastern Mediterranean is among the most vulnerable regions to climate change, as it is expected to be relatively strongly affected by the projected warming and related changes due to man-made forcing by increased greenhouse gases (GHG). A key aspect of the broader climate change expected in the future is the expansion of the tropics and, consequently, the subtropical dry zones that lie to the south of the Mediterranean. Therefore, Cyprus is likely to face increases in the frequency and intensity of droughts and hot weather conditions in the near future. Since the region is diverse and extreme climate conditions are already common, the impacts may be disproportional.

Gradients and contrasts are characteristic for Cyprus, not only in climatic conditions, but also in social and economic aspects, access to natural resources, as well as cultural and religious traditions. This diversity is a regional attribute, but can also be associated with political tensions. Since the region is a primary climate change "hot spot", there is concern about the future state of the environment and societal consequences.

In this report, three time periods, namely the reference, present-day period (2000), the mid-century period (2050), and the late-century period (2080) were examined, using output data from regional climate model (RCM) simulations driven by the two different Representative Concentration Pathway scenarios (RCPs), used in the latest Assessment Report of the IPCC (AR5).

The present-day was taken to be for conditions around the year 2000. To ensure good signal-to-noise ratio, averages for a 20-year period centred around 2000, i.e. 1991-2010, were used. Differences in various meteorological parameters over Cyprus between the present-day, i.e. the period 1991-2010 (reference period), and the relatively near future, i.e. 2050 (averages of 2041-2060) as well as the more distant future, i.e. 2080 (averages of 2071-2090) were produced. Changes in indices of climate extremes between these two periods were also examined. Examining the very near future (e.g. 2020) was avoided, as the signals of climate change for such a short timescale are very uncertain, especially on regional scales.

The specific scenarios that were used were the RCP4.5 and RCP8.5 scenarios, which represent a moderate and a more pessimistic climate change scenario, respectively. In the RCP4.5, the global mean radiative forcing in 2100 relative to pre-industrial times is 4,5 Wm^{-2}, while in RCP8.5 it is 8,5 W m^{-2}. The more optimistic RCP2.6 scenario was not used, since it is less likely to occur and there are considerably fewer simulations in EURO-CORDEX/MED-CORDEX available with RCP2.6.

The main purpose of the present study was to present a comprehensive regional climate assessment in Cyprus, using the recently established CORDEX (Coordinated Regional Climate Downscaling Experiment; http://www.meteo.unican.es/en/projects/CORDEX) - specifically its European component - and the associated Mediterranean sub-project, namely MED-CORDEX (https://www.medcordex.eu/). Two MED-CORDEX models were used, that have performed

12 km (0,11 degree) horizontal resolution simulations, and three EURO-CORDEX models with the same resolution.

Data were acquired from EURO-CORDEX RCMs that performed 12 km simulations (three versions of SMHI).

The regional climate models used were:

- RegCM, version 4 called RegCM4 of the International Centre of Theoretical Physics (ICTP), driven by the Hadley Centre Global Environmental Model version 2 Earth System called HadGEM-ES. Hereafter referred as ICTP (MED-CORDEX).
- ALADIN, version 5.2 of the Meteo-France Institute (CNRM) driven by the CNRM-CM5 global climate model. Hereafter referred as CNRM (MED-CORDEX).
- RCA4 of the Swedish Meteorological and Hydrological Institute (SMHI) (Stranberg et al., 2014 and references therein) driven by 3 different global climate models: a) the CNRM-CM5 hereafter SMHI-CNRM (EURO-CORDEX), b) the Hadley Centre Global Environmental Model version 2 Earth System called HadGEM-ES of the Met Office Hadley Centre (MOHC) hereafter SMHI-MOHC (EURO-CORDEX) and, c) the Max Planck Institute for Meteorology model MPI-ESM-LR hereafter SMHI-MPI (EURO-CORDEX).

The three last EURO-CORDEX models are basically the SMHI regional model with boundary conditions from three different global models (CNRM, MOHC, and MPI), which makes the combined modelling systems substantially diverse so as to be considered as different models.

All the models generally showed a good skill in capturing daily minimum and maximum temperature in the different parts of Cyprus. Precipitation was modelled satisfactorily, though with substantial overestimates in most of the models, mainly in the high elevation stations. Nevertheless, the performance of the models was judged to overall be very good, with the top performing models being ICTP and SMHI. SMHI had an absolutely complete availability of data for all the scenarios, periods, and variables of interest, whereas for ICTP there were a few gaps. Between the three different SMHI models available (SMHI-CNRM, SMHI-MOHC, and SMHI-MPI), the SMHI-MOHC model was found to represent best the multi-model mean, following a test performed for the most important/basic parameters (seasonal mean temperature, seasonal mean precipitation) in the present-day.

Before examining changes in the future, the present-day climate of Cyprus as simulated by the models was examined. Temperatures were found to have a negative tendency from low to high altitudes, though with coastal areas being somewhat cooler than the inland low elevation areas in spring, summer, and autumn but warmer in the winter. The island generally features a high number of summer hot and very hot days, as well as tropical nights, with the continental lowland areas being the most susceptible to such conditions. Frost can occur throughout the island, but its frequency is higher in high elevation and in continental lowland areas. Precipitation is, as in most Mediterranean areas, highest during winter, and lowest during summer in most of the areas, except for the continental lowland areas that experience more rain in the autumn and spring. The wettest parts of the island are the high elevation areas, followed by the western coastal areas. The driest parts of the island are the continental lowland areas and the southern coastal areas. Extreme rainfall is more likely over the high elevation areas, followed by the western coastal areas. Extreme winds are more likely to occur in the coastal areas, especially in the west and the south.

Based on the future simulations, temperature is expected to steadily increase throughout the island in the coming decades, in agreement with what has been predicted or suggested by past studies. The future estimates of temperature have low uncertainty and are therefore highly probable. For the mid-21st century (2050), increases from the present-day in both the daily minimum and the daily maximum temperature range from around 1°C (~2°C in high elevation areas in the summer) in the intermediate severity (RCP4.5) future scenario to around 1.5-2°C (~3°C in high elevation areas in the summer) in the high severity (RCP8.5) scenario. The season with the lowest temperature increases in general is the winter, and the season with the largest increases is the summer. The regions with the smallest increases are the western coastal areas, while those with the largest increases are the continental lowland and the high elevation areas. On average, daily minimum temperatures increase slightly more than the daily maximum temperatures.

For the late-21st century (2080), the geographical and seasonal characteristics of temperature increases are similar to those for mid-century, except that the eastern coastal areas are predicted to experience similarly large changes with the lowland continental and the high elevation areas. The magnitude of changes is larger in 2080 than in 2050, with changes ranging from around 2°C (~2.5°C in high elevation areas in the summer) in RCP4.5 to around 3.5°C in RCP8.5 (~4.5°C in high elevation areas in the summer).

All the extreme high temperature indices show increases in the future for all regions, seasons, and scenarios, with high confidence. The strongest changes by the end of the century are found in the RCP8.5 scenario, in which the models predict from 23 (western and southern coastal areas) to 56 (continental lowland areas) more very hot days per year, and from 2 (eastern coastal areas) to 15 (high elevation areas) less frost nights per year.

Precipitation predictions for the future have lower confidence, due to the more uncertain nature of hydrological responses to radiative forcing, but nevertheless, there are some significant conclusions that can be drawn from analysing the precipitation output. Apart from varying between models, precipitation changes also vary substantially between different seasons, regions, and scenarios. By 2050, there is a tendency for winter precipitation increases in most regions, in both scenarios. For the rest of the year, there is a mixture of signals depending on the region and season. The most significant feature is the decrease in precipitation in high elevation areas in the spring, summer and autumn; especially for the RCP8.5 scenario (maximum change is -35 mm for high elevation areas in the summer in RCP8.5).

Towards the end of the century (2080), there is a dominance of negative precipitation changes, especially in RCP8.5. The strongest changes are found in high elevation areas, where decreases exceed 30 mm in most seasons in RCP8.5.

When it comes to precipitation extreme indices (e.g. rainfall over short amounts of time), the strongest changes occur in the high elevation areas by 2080 in the RCP8.5 scenario, with e.g. the number of wet days decreasing by 16 and the maximum length of wet spell decreasing by

1 day. For the rest of the cases, the changes are somewhat smaller, but they also generally follow the patterns of changes in mean precipitation. Based on one model's results, the number of dry days is also found to change substantially, with the maximum increases (>25 days) found in high elevation areas.

Future changes in the winds over the island are challenging to the model, but there is some hint (low certainty) from multi-model results that the number of windy days is generally going to decrease, possibly due to the general prevalence of more stagnant conditions in the Eastern Mediterranean in the future. In particular, for the RCP8.5 scenario, the models show that by 2080 the number of days with average wind speed higher than 5 m/s will decrease in all regions, with the maximum change (9 days) found for the western coastal areas.

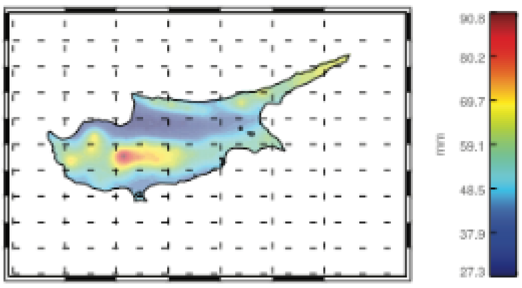
Future relative humidity mostly shows negative changes over the island. The changes are generally not large, but the most pronounced decreases (~ -5%) are found for spring, summer and autumn over high elevation areas, in 2080, for the RCP8.5 scenario.

Finally, sea level is also an uncertain parameter with relatively low confidence in its possible future changes. Some projections that have been performed as part of other studies have suggested that it may be expected that the Eastern Mediterranean will experience about 0,5 m of increase by 2050 and 1 m by 2100. These projections were considered as a pessimistic CC scenario, since reports argue that vertical land movement is counteracting this potential effect and this phenomenon hasn't been taken into account in this NRA. It is noted that the coastline is already subject to erosion, as a result of human activities such as sand mining, dams, illegal breakwater construction and urbanisation. Climate change impacts could deteriorate this erosion.

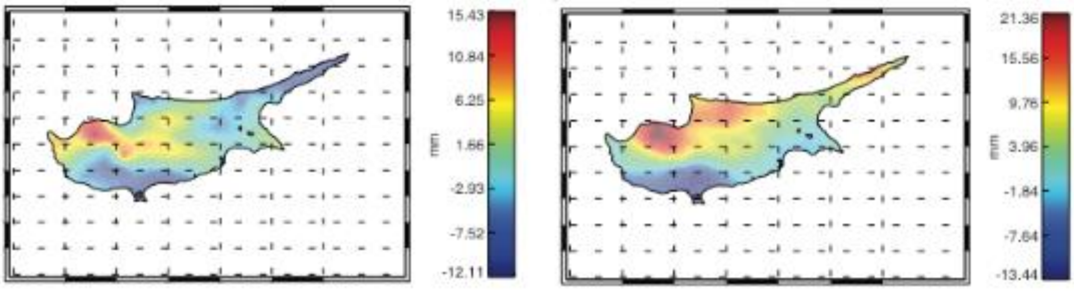
Specifically concerning precipitation, the purpose of this step is to understand the sensitivity (according to the available evidence) of the selected metrics to changing climate conditions. It was based on a review and synthesis of existing research outputs and government analyses and included recording key assumptions and uncertainties related to the assessment. Selected metrics were developed as a means of capturing key issues and enabling risk assessment.

For each metric, suitable datasets were sought from publicly available sources (either government analyses or wider published research); this will provide the basis for consistency in the delivery of future risk assessments.

In accordance with the climate prediction for year 2050 (Figure 3.1), the rainfall intensity increases in the north-western part of the island and decreases in the southern areas.



(a) Present day scenario



(b) Difference of indices from present day

RCP4.5 scenario

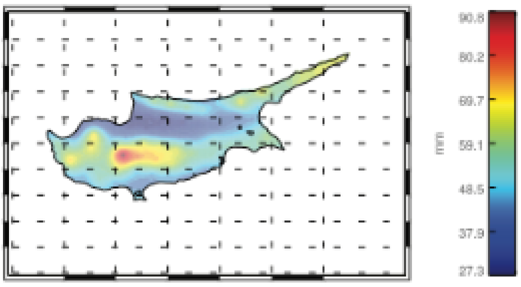
(c) Difference of indices from present day

RCP8.5 scenario

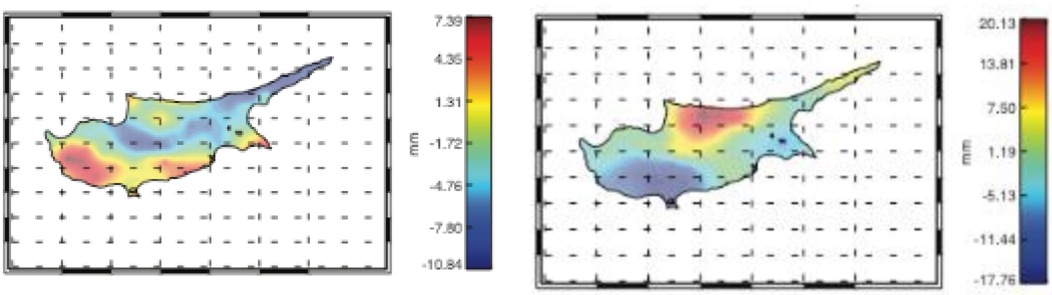
Figure 3.1 *Precipitation extremes between 2050 (i.e. 2041-2060 average) and the reference period (present-day, i.e. 1990-2010 average) annual maximum rainfall (in mm) over 1 day*

The overall trend for the whole of the island is that extreme precipitation increases by about 3% by 2050 for the RCP4.5 scenario (intermediate) and by about 7% for the RCP8.5 scenario compared to present day.

For the year 2080 the predictions (Figure 3.2) the rainfall intensity increases in the western and southern parts of the island and decreases in the central and north-east parts.



(a) Present day scenario



(b) Difference of indices from present day

RCP4.5 scenario

(c) Difference of indices from present day

RCP8.5 scenario

Figure 3.2 *Precipitation extremes between 2080 (i.e. 2071-2090 average) and the reference period (present-day, i.e. 1990-2010 average) annual maximum rainfall (in mm) over 1 day*

PART B – RISK ASSESSMENT

1. EARTHQUAKE

1.1. TECTONIC SETTING AND REGIONAL SEISMICITY

Cyprus lies within the Alpine-Himalayan zone, in which about 15% of the world earthquakes occur. The seismicity of Cyprus is thought to be due to the "Cyprus Arc", which constitutes the tectonic boundary between the African and Eurasian in the eastern Mediterranean region. The African plate moves northwards, colliding with the Eurasian plate. As a result it is being subducted (pushed under) the Anatolian microplate, which marks southern end of the Eurasian plate (Figure 1.1).

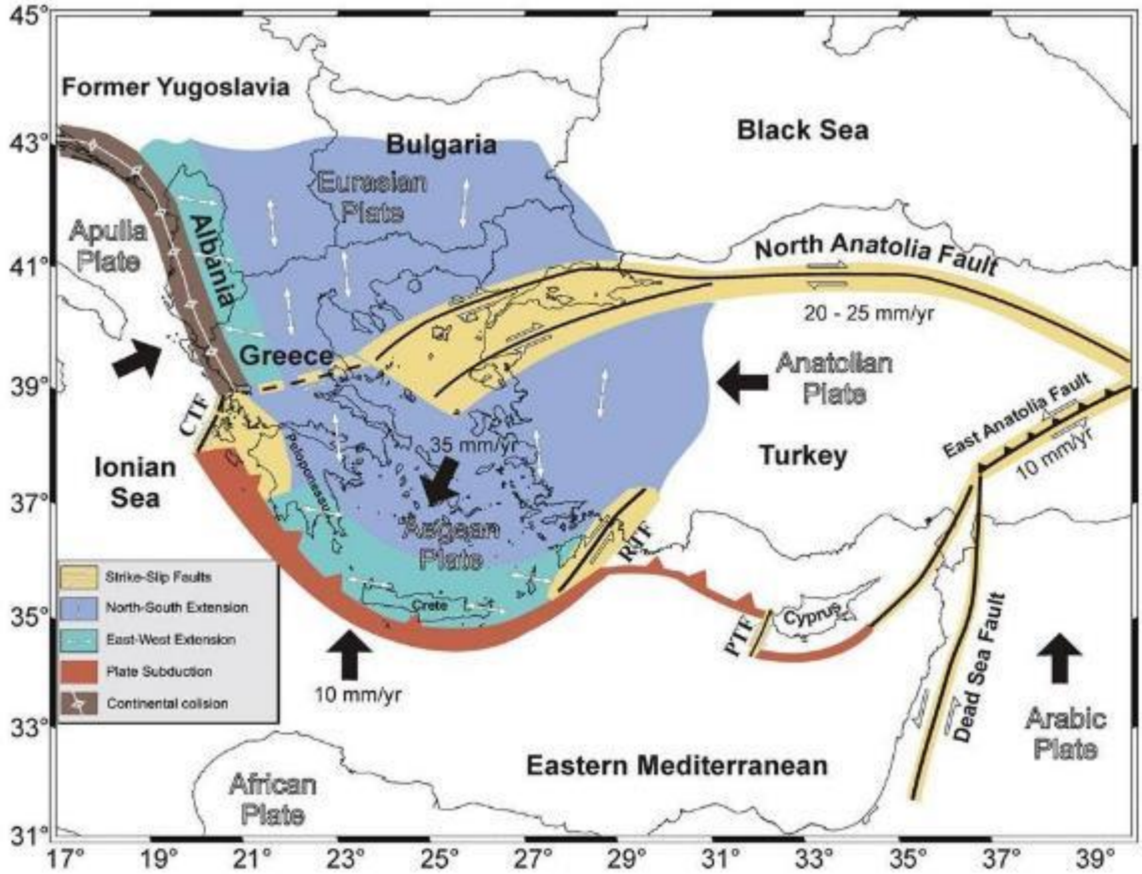


Figure 1.1: Schematic map of the principal tectonic setting in the Eastern Mediterranean in a Eurasia fixed reference frame, (PTF: Paphos Transform Fault.) After Papazachos et al, 2003.

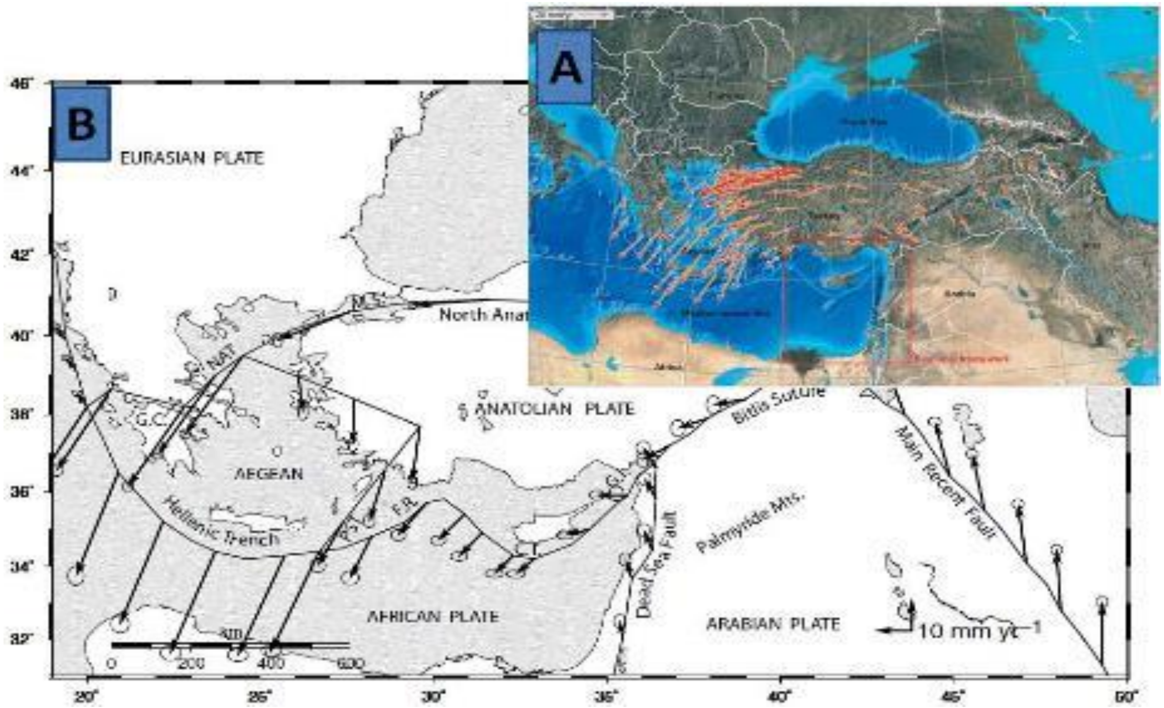


Figure 1.2: GPS horizontal velocities map of Eastern Mediterranean in a Eurasia fixed reference frame. (B) Relative motions and 95% confidence ellipses on schematic plate boundaries in the Eastern Mediterranean derived from Euler vectors. Motions along the boundaries of the Anatolian Plate show Anatolian motion with respect to bordering plates (except the border with the Aegean). After McClusky et al., 2003, 2000.

Cyprus is moving to the north-northwest, as Anatolian plate, at a rate of 8 mm/year relatively to Eurasia (Figure 1.2). The relative motion between Anatolia and Africa changes from being arc-perpendicular in the western part of the Cyprus Arc (rate: 10 mm/year), to being almost arc-parallel in the eastern part (rate: 5 mm/year).

The detailed seismotectonic nature of the Cyprus Arc has been long debated. Ongoing research shows more and more evidence which supports the hypothesis that Cyprus is located in the middle of a transition from subduction to continental collision, mainly along the west part of the Cyprus Arc, probably related to a tear in the subduction system.

The smaller differential motion between the African and Anatolian plates (Cyprus Arc) as compared to the African and Aegean plates (Hellenic Arc) has a direct impact on the seismicity of the two arcs: The Cyprus Arc is less active than the Hellenic Arc.

The Cyprus Arc can be divided into three main segments based on the characteristics of the seismic activity:

(1) The western part, which extends from the Antalya gulf (where it joins the Hellenic Arc) to the west of Cyprus, and exhibits high seismic activity with medium depth (up to 135 km) earthquakes near the Antalya gulf.

(2) The central part, which extends between the south-west coast of Cyprus to the south-east (north of Eratosthenes seamount all along), also exhibits high seismic activity with both shallow and medium depth earthquakes.
(3) The eastern part, which extends further north-eastwards ending at the Africa-Anatolia-Arabia triple junction, is an area of low seismic activity and the absence of medium depth earthquakes.

1.2. LOCAL SEISMICITY

Historical references and archaeological findings reveal that strong earthquakes struck Cyprus in the past, which on several occasions destroyed its towns. Historical data show that 20 destructive earthquakes with an intensity of at least V on the modified Mercalli scale occurred between 26 BC and 1900 AD (Table 1.1).

Table 1.1: The historic earthquakes of Cyprus.

DATE	PLACE (INTENSITY)	EPICENTER
26 BC	Pafos (VII), Egypt (IV)	South-West of Cyprus
15 BC	Pafos (IX), Kourion (IX) and other towns in Cyprus (VIII)	South-West of Pafos
76 AD	Salamis (X), Pafos (IX), Larnaca (IX)	South-East of Cyprus
332-333 AD	Salamis (VII)	East of Cyprus
342 AD	Pafos (X)	South-West coast, Cyprus
365 AD	Kourion (VII), Akrotiri (VII), south coasts of Cyprus (VIII)	South-West of Cyprus
394 AD	Pafos (VII), Salamis (VII)	East of Cyprus
1144	Pafos (VII)	West of Cyprus
1183	Pafos (VIII)	Near Pafos
1202-1203	Cyprus (VI)	South-West of Cyprus
3/5/1222	Pafos (IX), Lemesos (VIII)	South-West of Cyprus
7-8/8/1303	Nicosia (V), Lemesos (V)	South of Cyprus
3/5/1481	Paphos (VI), Nicosia (VI)	West of Cyprus
25/4/1491	Mesaoria valley (IX), Nicosia (VIII), Lemesos (VII)	Cyprus
1546	Nicosia, Famagusta (VI)	Cyprus
25/4/1567	Lemesos (VII), Nicosia, Famagusta (V)	South of Cyprus
28/1/1577	Kourion (VI), Nicosia, Salamis (V)	South of Cyprus
10/12/1735	Famagusta (VIII)	Near Famagusta
1741	Famagusta (VI)	Near Famagusta
28/6/1896	Akrotiri (VIII), Lemesos (VIII)	190 Km South of Cyprus

More accurate data of earthquakes occurring in the Cyprus region have been collected since 1896, when seismological stations were put in operation in neighboring countries. The situation has improved considerably since the mid-1980s, with the establishment of local seismological stations in Cyprus. Today, since 2014, an 11-station broadband seismic network is in operation in Cyprus, closely monitoring the local and regional seismic activity.

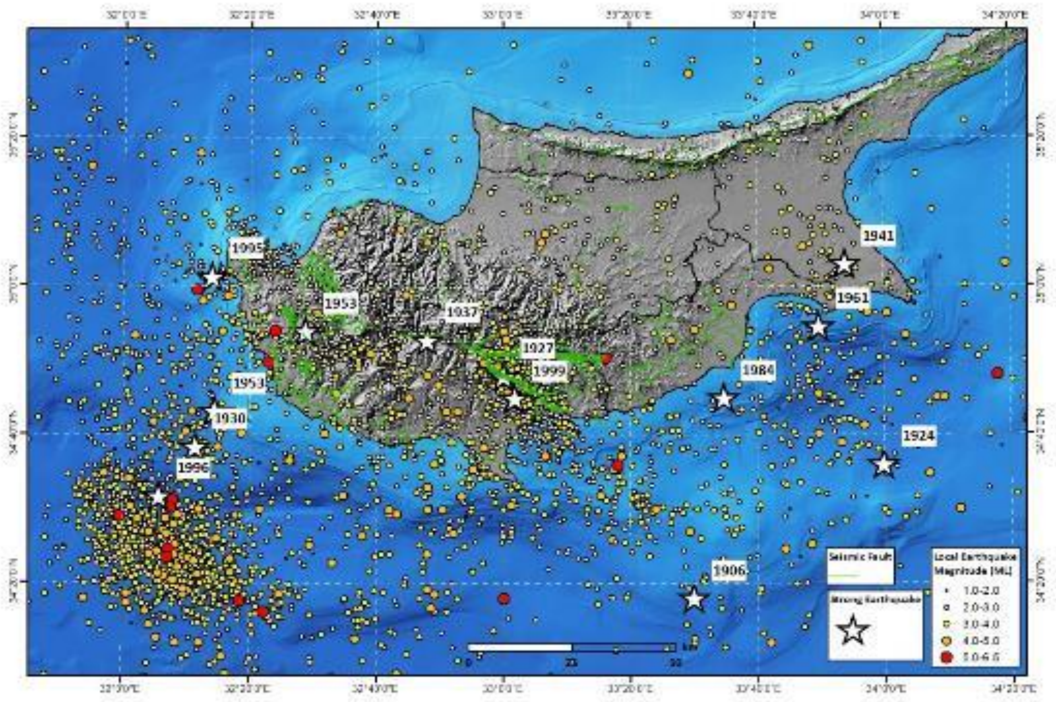


Figure 1.3: *Spatial distribution of earthquake epicenters recorded by regional seismological networks (1896-1997) and by the Seismological Network of Cyprus (1997-2013). The colour coding corresponds to earthquake magnitude in the local Richter scale. The green lines denote the possibly-active inland faults of Cyprus, and the stars denote the epicentres of the strongest earthquakes. The most important earthquakes of the last 60 years are shown in Table 2.*

The seismicity of Cyprus deduced from instrumental data over the period of 1896-2013, is shown in Figure 1.3 above. It is evident that the highest local seismic activity is observed in the south-west part of the Cyprus Arc and on land faults along the southern part of the island. In the north part of the island, the seismic activity of considerably lower, and there is a notable absence of shallow earthquakes.

The study of the historical and recent earthquakes shows that the distribution in time of the seismic activity is not regular, but there are periods of intense activity followed by periods of quiescence. In the period 1995-1999 an increase of seismic activity was observed with strong to very strong earthquakes with magnitudes of 5.6-6.8.

During the last 100 years, at least 500 earthquakes with epicenters in the vicinity of the broader Cyprus area were felt in parts of the island. Out of these, 15 caused damage and some of them unfortunately caused victims. The most important earthquakes of the last 60 years are summarized in Table 1.2.

Table 1.2: The most important earthquakes of the last 60 years.

Date	M	Comments
10 September 1953	**6.0, 6.1**	A destructive double earthquake in the district of Pafos. It killed 40 and injured about 100 people leaving 4000 people homeless. Damage was reported from all of the 158 villages of the Pafos district. 1600 houses were totally ruined and 10,000 buildings suffered serious damage. Causalities were limited because most people were out in the fields at the time the earthquake occurred. In Lemesos the shock caused extensive damage, where it triggered soil liquefaction of beach deposits on the seashore. The earthquakes were associated with a small tsunami along the coast of Pafos. The shocks were felt in Lebanon, Israel, Egypt, Kastellorizo, Rhodes and Turkey. About 26 felt aftershocks continued for over a year.
23 February 1995	**5.7**	Destructive earthquake in the district of Pafos causing the death of 2 people. Several houses collapsed in the villages of Pano Arodes and Miliou.
9 October 1996	**6.8**	Very strong earthquake in the southwest of Cyprus. It caused panic in the districts of Pafos, Lemesos, Lefkosia, Larnaca and Ammochostos and damage in mainly Pafos and Lemesos. Two people lost their lives and 20 were lightly injured.
11 August 1999	**5.6**	Strong earthquake with epicenter near Gerasa village in Lemesos, intensively felt across the entire island. It caused damage to buildings in Lemesos and the north part of the district. Forty people were lightly injured mainly because of panic. A large number of felt aftershocks continued for months.
15 April 2015	**5.5**	Strong earthquake with epicentre off-shore Kissonerga, Pafos. The earthquake, causing minor damage, was felt across the island: Very strongly in the Pafos district, especially in the epicentral area, strongly in the Lemesos district, moderately in the Lefkosia district and lightly in the Larnaka and Ammochostos districts.

1.3. SEISMIC HAZARD ASSESSMENT

Recent seismic hazard studies (Papazachos et. al, 2013) of the area of Cyprus show the seismicity statistical evaluation results summarized in Table 1.3.

Table 1.3. Statistical Evaluation of the time-independent seismicity of Cyprus (Papazachos et al, 2013)

Magnitude	Return Period (in years)	Number of earthquakes in 100 years
≥7.0	153	0.7
≥6.5	52	2
≥6.0	17	6
≥5.5	6	17
≥5.0	2	50

A more detailed approach, separating the island in 5 different hazard zones (Figure 1.4) leads to the results summarized in Table 1.4.

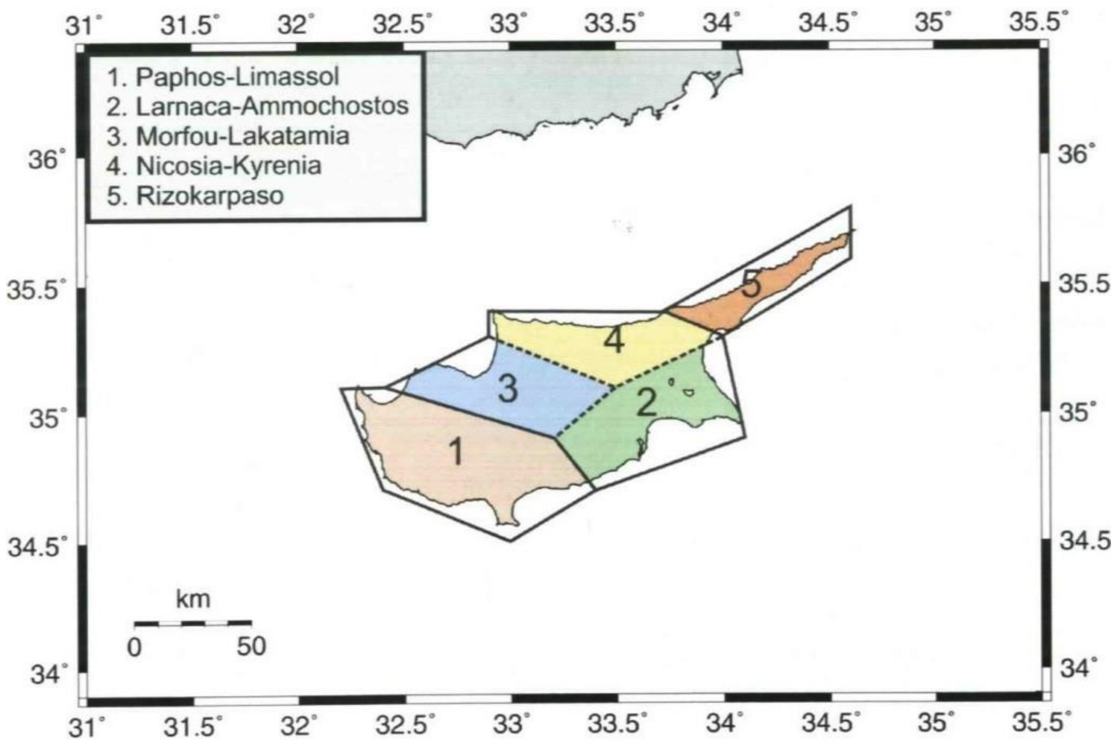


Figure 1.4: The five hazard zones of Cyprus with hazard level decreasing from 1 to 5 (See Table 3.4 for the hazard evaluation results)

Table 1.4: Mean return periods (in years) for intensity >VII (TVII) and the probability for macroseismic intensity to exceed the value of VII within a time period of 50 years (P50/VII) for the 5 hazard zones shown in Figure 1.5.

Zone	T_{VII} (years)	Probability ($P_{50/VII}$)
1. Pafos-Lemesos	59	0.57
2. Larnaca-Ammochostos	135	0.31
3. Morfou-Lakatamia	132	0.32
4. Lefkosia-Kerynia	145	0.29
5. Rizokarpaso	832	0.06

1.4. VULNERABILITY

A model for the estimation of losses under different scenarios of earthquakes (location, magnitude and intensity), ELER, has been created as part of a Research Programme for the prediction of seismic risk in the Middle East. From Cyprus, the Antiseismic Engineering Team of the Cyprus University of Technology (CUT) takes part. CUT (Chrysostomou 2013; Kyriakides, 2013) has also mapped the building stock of Cyprus (See Figures 1.8 and 1.9) and devised Vulnerability Curves for Cyprus, for different classes of buildings according to their year of construction, material of construction and height.

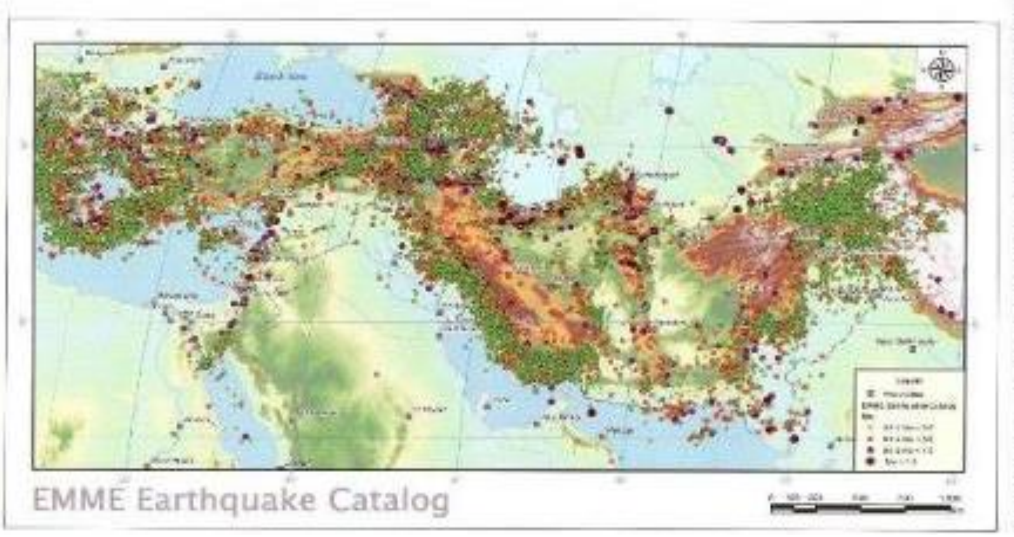


Figure 1.5: Earthquake model for the Middle East (Chrysostomou, 2015)

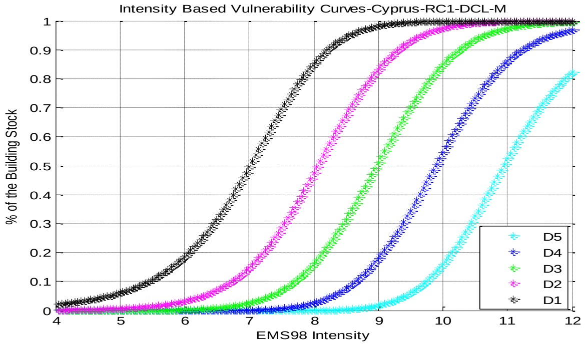


Figure 1.6: *Vulnerability curves for Cyprus, for different classes of buildings according to their year of construction, material of construction and height (Kyriakides, 2015)*

Table 1.5: Building stock of Cyprus (Cyprus Statistical Service CYSTAT, 2015$_a$)

URBAN	<1992 houses	<1992 apart.	>1992 houses	>1992 apart.	POPULATION
LEFKOSIA DISTRICT					
Lefkosia Municipality	13273	4398	4441	5431	53772
Agios Dometios Municipality	3053	983	741	1015	12553
Egkomi Municipality	2130	786	2362	2993	18219
Strovolos Municipality	11707	4104	6334	7394	67565
Aglantzia Municipality-Aglangia	3627	1296	2405	3283	21018
Lakatameia Municipality	3944	1485	3826	4825	38770
Latsia Municipality (Lakkia)	2089	734	1608	2262	16570
Geri	935	355	769	1056	8450
TOTAL	40758	14141	22486	28259	236917

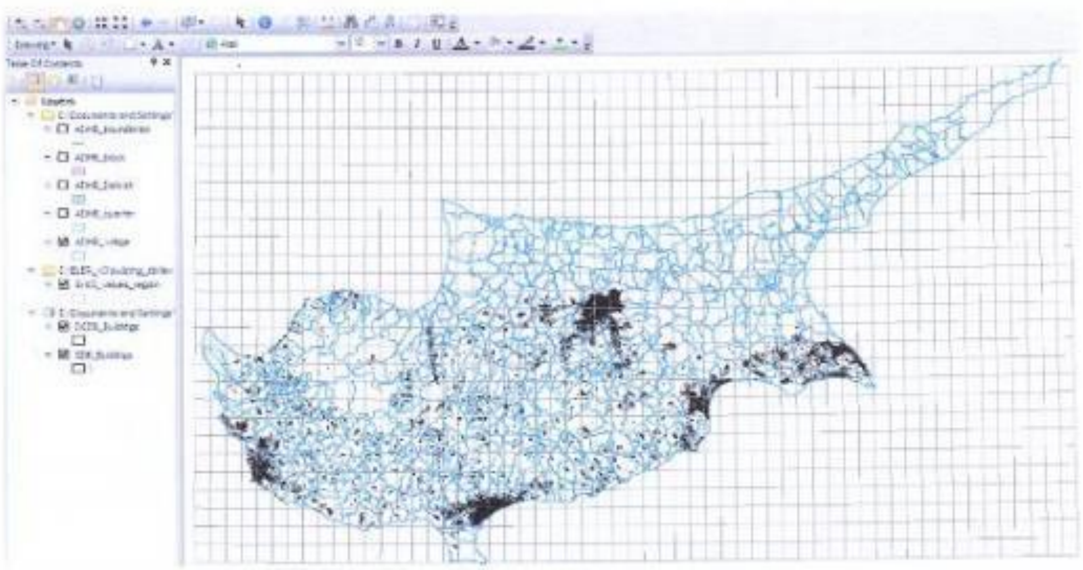


Figure 1.7: Spatial distribution of the building stock of Cyprus (Chrysostomou 2015; Kyriakides, 2015)

Reinforced Concrete ≤2 storeys: Approximately 70% of the existing building stock (their 65% is with a storey). The 60% have been designed and constructed before the application of the Cyprus Aniseismic Code of 1992.

Reinforced Concrete>2 storeys: Approximately 70% is with ≤ 5 storeys. Very few (~400) have 6-9 storeys.

There have been recorded approximately 45000 existing traditional buildings, mainly made of stone or adobe (sun dried earth blocks).

The first scenario corresponds to the design earthquake of new buildings in Cyprus (Probability of exceedance 10% in 50 years). Damages are mainly concentrated in Limassol and Pafos districts and concern approximately 16.500 buildings with serious damages, with a total replacement cost of approximately 9 billion Euros (values of 2015). It is also expected that around 11.000 people will be injured from lightly to fatally.

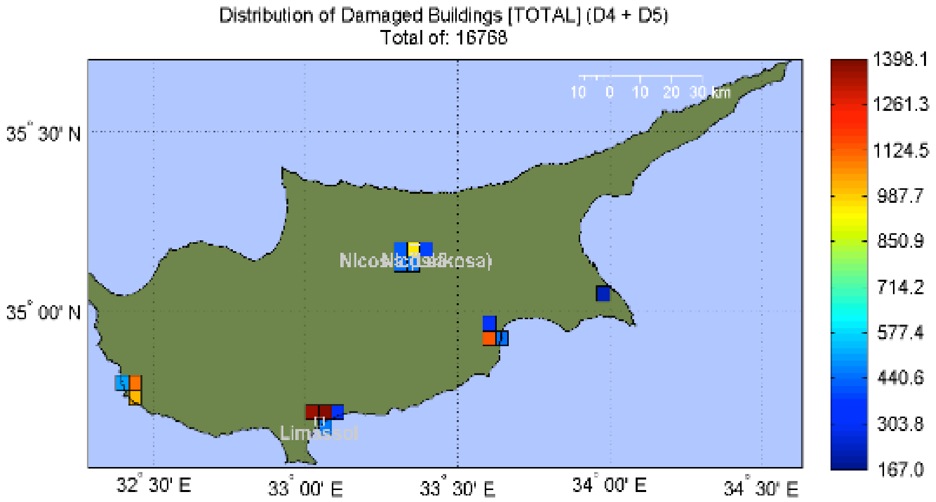


Figure 1.8: Distribution of Damaged buildings for scenario 1

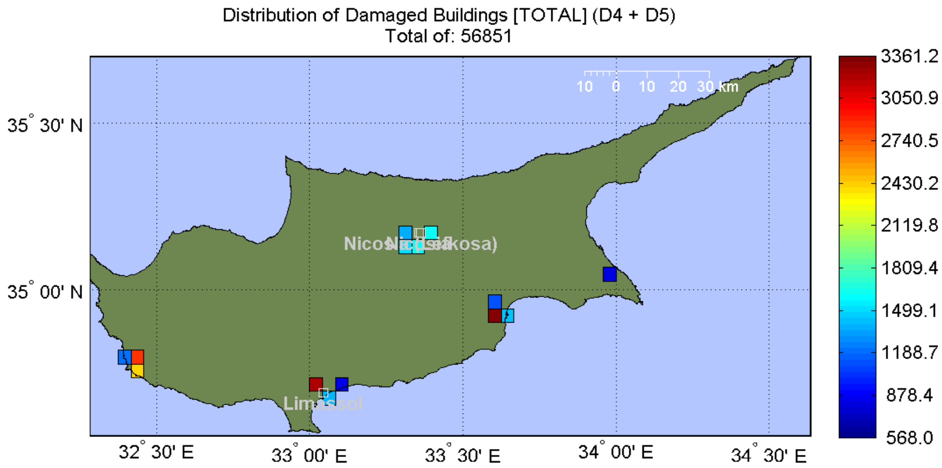


Figure 1.9: Distribution of Damaged buildings for scenario 2

The second scenario corresponds to the worst case scenario that can exist in or around Cyprus, according to the tectonic structure of the Cyprian Arc (Catastrophic earthquake-Probability exceeding 2% in 50 years). More than 56.000 buildings are expected to suffer serious damages, with a total replacement cost of the order 30 billion Euros (Values of 2015). It is also expected that approximately 60.000 people will be injured from lightly to fatally.

2. TSUNAMI

2.1. INTRODUCTION

Tsunami hazard in the Mediterranean Sea is low, compared to the Pacific Ocean, but it is still significant. Within the Mediterranean Sea (experiencing 10% of global tsunami activity), the tsunami hazard of Greece and Italy is the highest. The Cyprus-Levantine region is classified at the lowest level (Fokaefs and Papadopoulos, 2007). Within this area, the Levantine coast is at much higher risk than Cyprus.

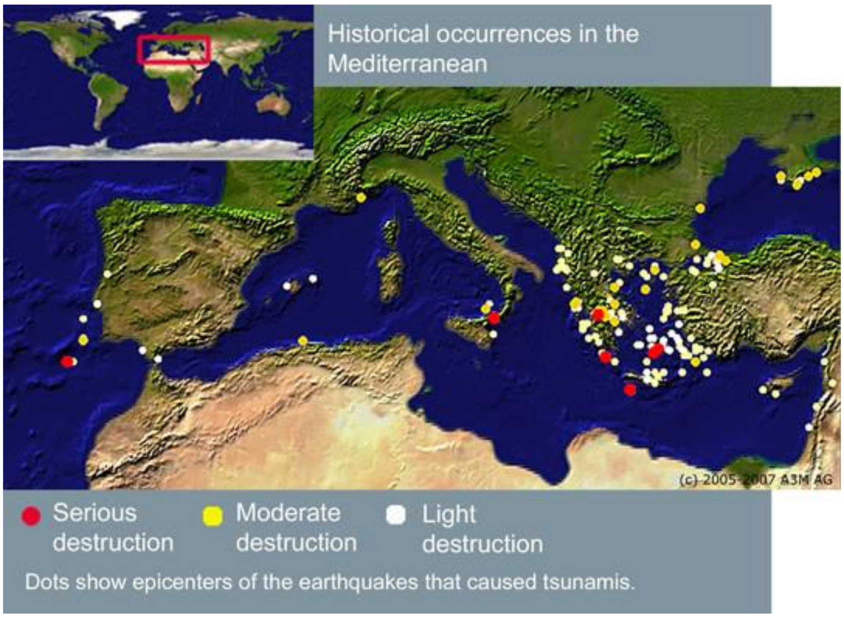


Figure 2.1: Historical tsunami occurrences in the Mediterranean region

However, for Cyprus an association between tsunami events and earthquakes has been documented through history by:

(a) Direct Observations,
(b) Archaeological Evidence, and
(c) Geomorphological Evidence.

The destructiveness of some historical events at local scale and the threat caused by regional events signify the need to evaluate tsunami risk by all available means.

The most catastrophic and well documented tsunamis in the Mediterranean were:
May 2003: After a quake near the coast of Algeria a tsunami was generated, which destroyed over 100 boats on Mallorca and flooded Palmas Paseo Maritimo.
August 1999: A large destructive earthquake struck north-west Turkey and generated a local tsunami within the enclosed Sea of Marmara. It occurred along the Northern Anatolian Fault zone. Its epicentre was in the Gulf of Izmit. Official estimates indicated that about 17 000 people lost their lives and thousands more were injured.

October 1963: Tsunamis can develop not only in oceans: In Italy, near the town of Longarone, the entire northern slope of Mount Toc slid into the Vaiont dam. The water spilled over the dam and destroyed a number of villages with a wave of 140 metres. 4 000 people lost their lives.

July 1956: The best documented and most recent tsunamigenic earthquake in the Aegean Sea between Greece and Turkey is the one that occurred near the south-west coast of the island of Amorgos, killing 53 people, injuring 100 and destroying hundreds of houses. The waves were particularly high on the south coast of Amorgos and on the north coast of the island of Astypalaea. At these two places, the reported heights of the tsunami were 25 and 20 m, respectively.

December 1908: Due to an earthquake and the ensuing tsunami, the city of Messina in Italy was almost completely destroyed. More than 75 000 people were killed.
November 1755: The Portuguese capital of Lisbon and its inhabitants were particularly badly hit by an earthquake that occurred in the eastern Atlantic Ocean. Two thirds of the city was destroyed from resulting fires. The people seeking refuge from the flames on the banks of the Tejo River were surprised by huge flood waves produced by the earthquake. Some 60 000 people lost their lives. The waves were even observed in Ireland and on the other side of the Atlantic on the Lesser Antilles. On the coastline of the Madeira Islands the waves still had a height of 15 metres.
1672: The Cyclades islands, especially Santorini, were shaken by an earthquake. The island Kos, in the east, was completely swallowed by the ensuing tsunami.
1650: A destructive earthquake was accompanied by a submarine explosion from the Colombo Volcano, which crater lies in the sea to the northeast of the island of Santorini. There was a devastating tsunami observed on the island of Ios, north of Santorini, and waves of up to 16 m were reported.
1303 AD: The quake with an estimated strength of 8 destroyed the island Rhodos and the eastern part of Crete. It caused a tsunami which reached the Egyptian coast.
365 AD: The quake of 8 to 8,5 in the year 365 caused heavy destruction on the whole of Crete. The tsunami that developed because of the quake destroyed complete coastal regions as far as Egypt and eastern Sicily. Records indicate that 50 000 people lost their lives in Alexandria.

1628 BC: The coasts of the entire eastern Mediterranean were submerged by flood waves of up to 60 metres high. The wave, caused by a volcanic eruption on Santorini, a Greek island in the Aegean Sea, and is believed to be responsible for the destruction of the Minoan culture.

Due to the small extend of the Mediterranean Sea, tsunami travel times are small, from seconds up to one hour in the eastern Mediterranean (See Figure 2.2 below)

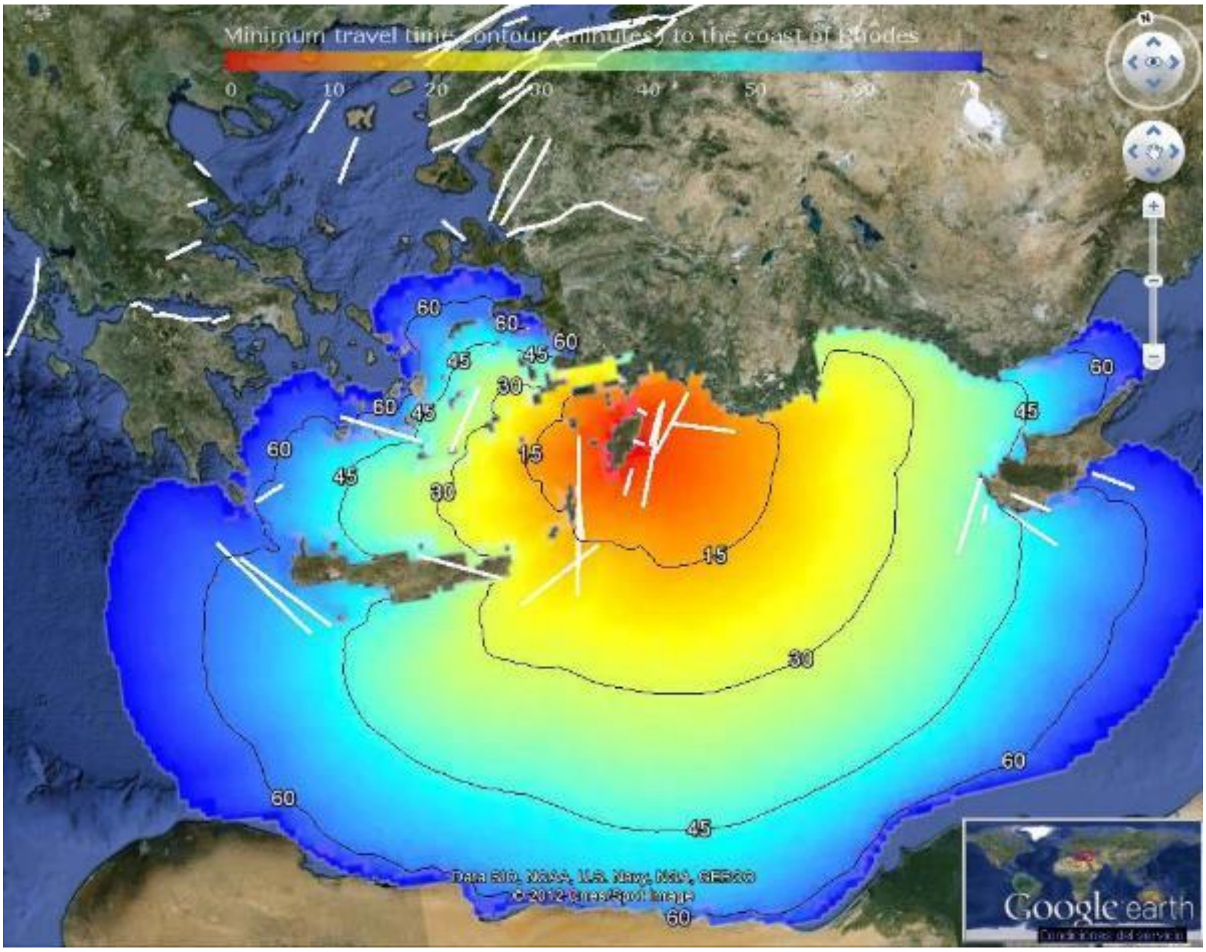
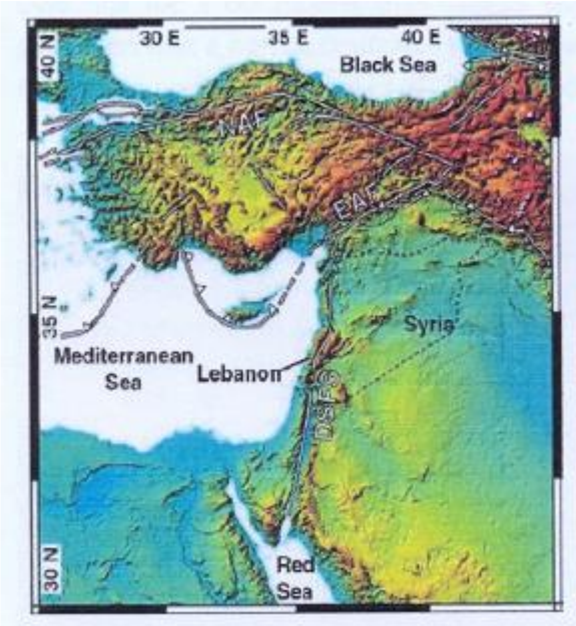


Figure 2.2 – *Tsunami travel times in the Mediterranean*

2.2. TSUNAMIGENIC AREAS THAT MAY AFFECT CYPRUS

The eastern part of the Mediterranean Sea is seismo-tectonically dominated by possible subduction along the Cyprian arc and the strike-slip Dead Sea Fault System.



There are two main mechanisms of tsunami generation, both of which are relevant to the east Mediterranean. These are:

(1) Shallow, high-magnitude, submarine earthquakes which cause significant vertical displacement of the ocean bottom.

(2) Earthquake-induced submarine land sliding.

Figure 2.3: Tectonic setting of the eastern Mediterranean (after Fokaefs & Papadopoulos, 2007)

The tsunamigenic areas that are expected to affect Cyprus are the Cyprian Arc, the eastern part of the Hellenic Arc and the Dead Sea Fault System. Tsunamis from these areas can originate by:

(a) Local, shallow and strong earthquakes originating along the Cyprus Arc, especially in the west and south-west of Pafos where the seismic activity is considerably higher than the other parts of the arc (e.g. the 1222 and 1953 earthquakes).

(b) Submarine land sliding near the coast of the Levantine Sea which is currently believed to be induced by earthquakes along the Dead Sea Fault System (e.g. the 1202 earthquake).

(c) Regional, shallow and strong earthquakes originating in the eastern segment of the Hellenic Arc, especially between Crete and Rhodes (e.g. the 1303 earthquake).

2.3. REPORTED TSUNAMIS ON THE COAST OF CYPRUS

Whereas the Levantine coast has been struck at least twenty times (Salamon et al., 2007) by tsunamis induced by earthquakes of the Dead Sea Fault System, the Cyprian and Hellenic Arcs, there is reliable evidence for two occasions that Cyprus was struck by a destructive tsunami (1202, 1222) and two occasions that a non-destructive tsunami was seen in the area (Ambraseys and Melville, 1988; Fokaefs and Papadopoulos, 2007; Yolsal et al., 2007). These are:

TABLE 2.1: Recorded tsunami events that hit Cyprus (Ambraseys and Melville, 1988; Fokaefs and Papadopoulos, 2007; Yolsal et al., 2007).

Date	Source of tsunami	Area affected	Description
1202	Possibly land slide near the Levantine coast due to a strong earthquake in the area of Israel, Syria and Cyprus.	Levantine coast and Cyprus	The sea between Cyprus and the Levantine coast parted and mountainous waves piled up throwing ships up onto the land. Eastern parts of the island were flooded
1222	Strong submarine earthquake south of Pafos.	Cyprus	One of the most destructive events reported in historical catalogues. Earthquake destruction and destructive tsunami flooding in Pafos and Lemesos. The castle of Pafos collapsed and the harbour was left without water.
1303	Strong earthquake in Hellenic Arc between Crete and Rhodes.	From Crete to Levantine coasts.	One of the largest and best documented seismic events in the history of the Mediterranean area. Destructive tsunami in Crete. Damaging sea-wave in Rhodes. Tsunami reported to be seen at SW Turkey, Egypt, Cyprus and Palestine.
1953	Strong double earthquake SW of Cyprus	Cyprus	Small tsunami along the coast of Pafos, which caused no damage.

It should be noted that Yolsal et al., 2007, have performed simulations of the 1222 and 1303 events calculating wave heights and their distribution functions in the Eastern Mediterranean.

There is additionally geomorphological evidence for strong tsunami action on the coast of Cyprus (Kelletat and Shellmann, 2001; Whelan and Kelletat, 2002; Noller et al., 2005, 2011), summarized in Figures 2.4 and 2.5 below.

Figure 2.4: Distribution of geomorphological features indicating or suggesting origin by tsunami process (After Noller et al., 2005, 2011).

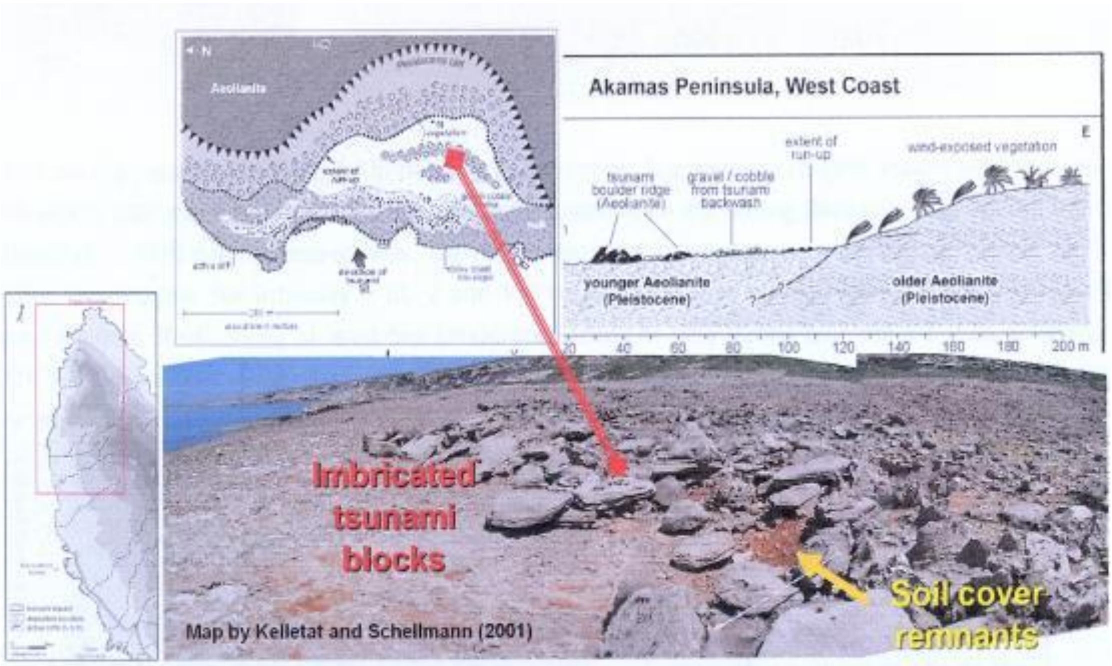


Figure 2.5: Tsunami deposits in Western Akamas area (After Kelletat & Shellmann, 2001).

2.4. STATISTICAL EVALUATION OF TSUNAMI HAZARD IN CYPRUS-LEVANTINE

The following Table 2.2 summarizes the results of Fokaefs and Papadopoulos (2007), for the tsunami hazard of the Eastern Mediterranean area of Cyprus – Levantine:

Tsunami Intensity scale	Wave Height (m)
I-V	<1.0
VI	2.0
VII-VIII	4.0
IX-X	8.0
XI	16.0
XII	32.0

Time Duration	Probability of Intensity >III	Probability of Intensity >V	Probability of Intensity >VIII
1	0.28	0.01	0.0001
50	0.81	0.34	0.13
100	0.96	0.56	0.24

***Table 2.2**: Tsunami hazard of the Eastern Mediterranean*

The average tsunami recurrence in the Cyprus – Levantine Sea region is roughly estimated to be around 30 years, 120 years and 375 years for moderate (intensity >III), strong (intensity >V) and very strong (intensity >VIII) events, respectively. The rate of tsunami occurrence equals 0.033, 8.3 . 10^{-3} and 2.7 . 10^{-3} events/year for intensity > III, V and VIII respectively. For a Poissonian (random) process the probabilities of observing at least one moderate, strong or very strong tsunami are 0.28, 0.01 and 3 . 10^{-3} within one year, 0.81, 0.34 and 0.13 within 50 years and 0.96, 0.56 and 0.24 within 100 years respectively.

3. FLOODS

The only type of floods relevant to Cyprus to-date, are relatively short-term flash floods in the zones surrounding watercourses (rivers or ephemeral streams) and in urban areas due to a localized storm water drainage surcharge. This type of flooding causes significant damage to movable flood prone items (such as automobiles, electrical goods etc.) since there is little, if any, warning of the event and the removal of exposure factor has limited application.

Storm water drainage network surcharge is a common cause of pluvial flood damage in urban areas. Drainage networks in city centres and commercial areas are designed for surcharge with a probability of 20% (1/5, return period of 5 years) in any one year. Even if the gullies and the pipes are clean the probability of pipe surcharge in a period of 20 years is almost 99%. Storm drains are designed based on rainfall statistics of the past. Climate change has an adverse effect on the probability and intensity of extreme events and hence drainage pipes will be surcharging more frequently than 20% in any one year.

River floods are associated with excess flow compared to the river channel capacity. The WDD has designated 19 Areas of Potentially Significant Flood Risk – (APSFRs). These areas are shown in Figure 3.1 and listed in Table 3.1.

The estimated number of people affected by flooding is presented in Figures 3.4 and 3.5, for the present building density and for the fully developed density respectively, for events having a probability of exceedance of 1 in 20, 50 and 100 years.

Figure 3.1: The identified 19 areas of potential flooding in Cyprus (in red)

SN	Name of stream	Description of Area	Area of basin (Km^2)	Length (m)
1	Pediaios	Politico-Nicosia Municipality	118.5	25 310
2	Kleimos	Engomi-Ayios Dometios	15.0	5 740
3	Merika	Kokkinotrimithia	11.7	3 250
4	Kalogeros	Strovolos and Latsia	30.2	5 630
5	Merikas-Koutis-Katouris	Paliometocho-Ay. Trimithias	54.9	5 690
6	Almiros-Alikos	Dali	76.9	7 750
7	Stream of Paralimni Lake	Paralimni	13.3	3 290
8	Gialias	Nisou, Pera Chorio, Dali	101.8	5 810
9	Ormidhias	Ormidhia	24.8	4 960
10	Archangelos-Kammitsis	Aradhippou-Leivadia	97.4	11 300
11	Kamaron	Kamares-Larnaca	44.7	6 640
12	Koshinas	Mesogi-Paphos-Chloraka	13.6	8 770
13	Limnarka	Paphos	15.7	3 380
14	Germasogeias	Germasogeia	172.3	6 070
15	Vathias	Mesa Geitonia-Ayios Athanas.	21.3	7 700
16	Garillis (new and old basin)	Polemidhia-Lemesos	103.5	13 730
17	Markettou-Ypsonas	Ypsonas	14.2	3 760
18	Komitis-Astromeritis	Astromeritis	5.1	3 600
19	Vasilikou-Paphos	Paphos	5.5	7 790

***Table 3.1**: The 19 identified areas of potential flooding in Cyprus*

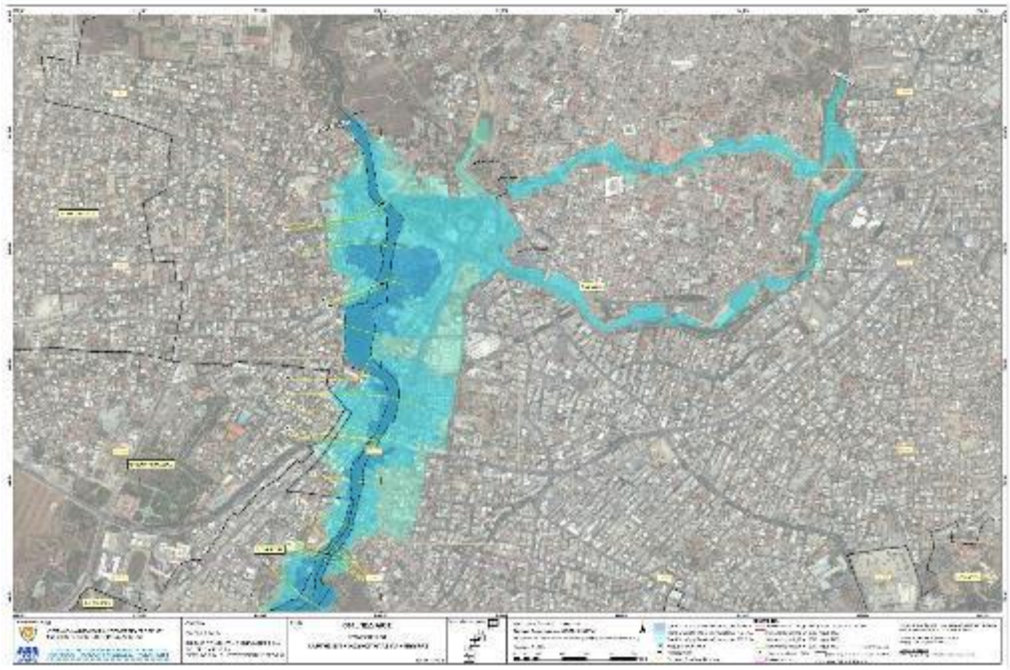


Figure 3.3: A typical plan of a suburb of the capital Nicosia showing the risk of flooding for three return periods: 20, 100 and 500 years, as well as the depth of possible flooding.

According to data from the final report of the preliminary flood risk assessment during the 29/10/1859 – 31/1/2011, there were 93 total deaths due to floods in Cyprus.

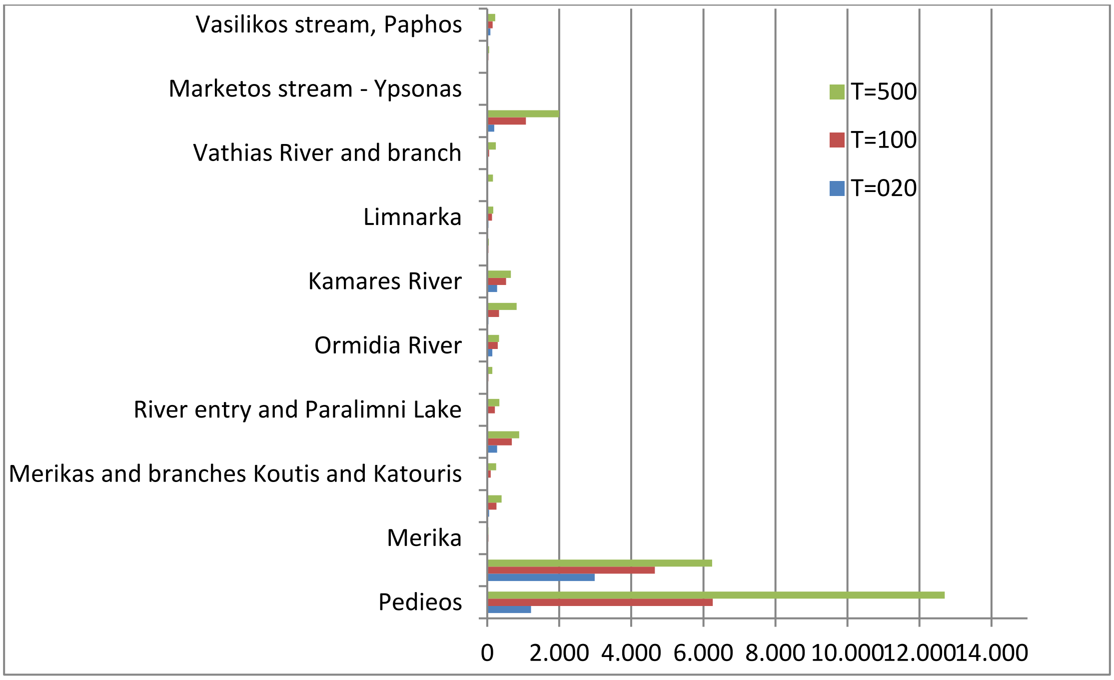


***Figure 3.4**: Estimated number of people affected by flooding at present building density (T= return period)*

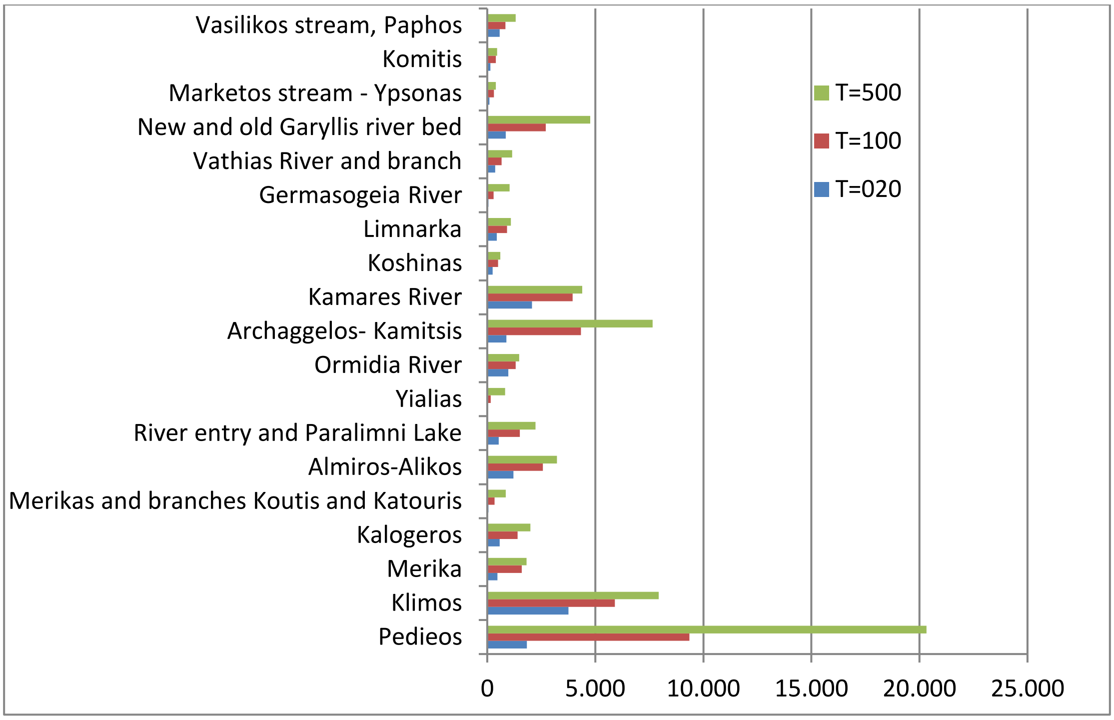


Figure 3.5: *Estimated number of people affected by flooding for fully developed areas (T= return period)*

Based on the APSFR report the number of people, presently at a significant risk of flooding (5% in any one year) is 5.370. This number will rise to 15.170 due to urbanisation. The metric derived from the above data is presented in Figure 3.6.

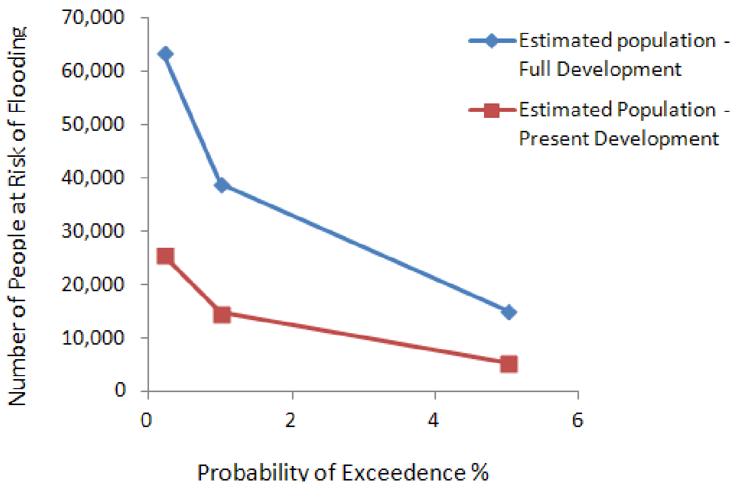


Figure 3.6: *Metric for the number of people at risk of flooding (in the 19 areas of the potential risk of flooding)*

It is noted that, the number of people exposed to significant risk of flooding will increase both due to urbanisation and to a lesser extent due to climate change.

The metric derived from the number of properties at risk of flooding in the designated 19 Areas of Potentially Significant Flood Risk – (APSFRs) is presented in Figure 3.7.

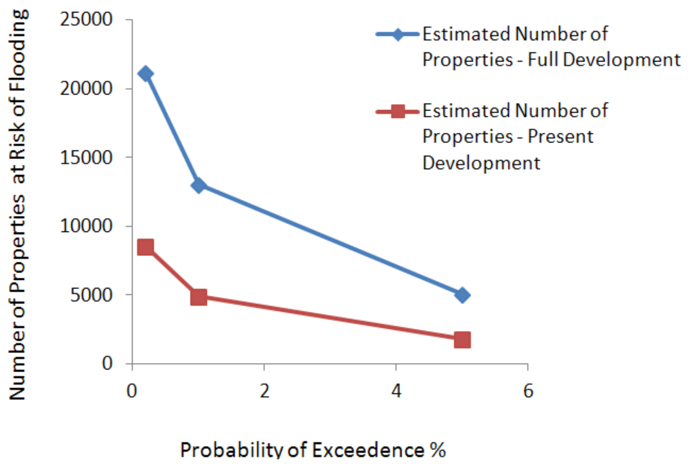
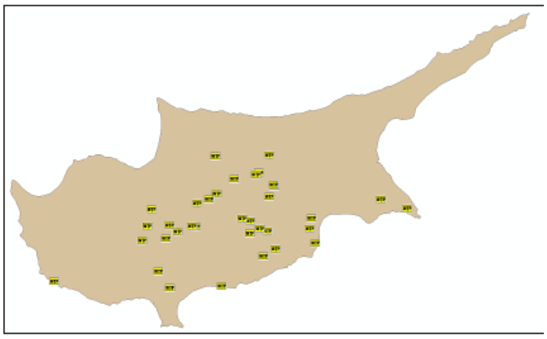


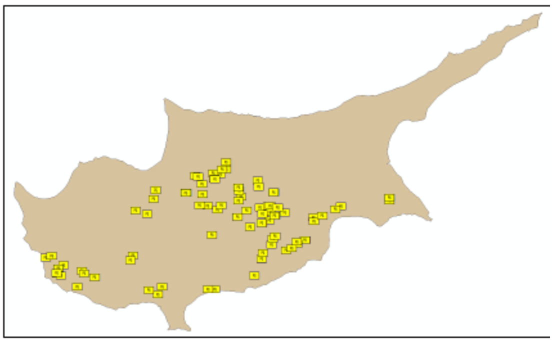
Figure 3.7*: Metric for the number of properties at risk of flooding (in the 19 areas of the potential risk of flooding)*

The consequences of flooding of transport infrastructure are qualitatively assessed, as little has been published. The Larnaka Airport had experienced flood damage and the operation was affected after one extreme event. The airport then adopted measures to address the problem and hence no metric may be derived.

Bridges are normally designed for 50-year return period storm events. As the change in rainfall intensity may not be quantified, this metric is also a qualitative one.



ΕΙΚΟΝΑ 2 ΕΓΚΑΤΑΣΤΑΣΕΙΣ ΕΠΕΞΕΡΓΑΣΙΑΣ ΛΥΜΑΤΩΝ



ΕΙΚΟΝΑ 3 ΑΝΤΛΙΟΣΤΑΣΙΑ ΠΟΣΙΜΟΥ ΝΕΡΟΥ

Figure 3.8*: Sewage Treatment Plants and Potable Water Pumping Stations (APSFR)*

Based on the APSFR, there are a number of critical utilities around the island. There is little information about the risk of flooding of such utilities. Each project has its own unique characteristics and no metric may be derived.

Impacts of flooding may have positive or negative impacts depending on individual circumstances. Certain things might be vulnerable to drainage and drying or to wetting and flooding.

ΕΙΚΟΝΑ 4 ΑΡΧΑΙΟΛΟΓΙΚΟΙ ΧΩΡΟΙ (ΜΑΥΡΟ ΧΡΩΜΑ) ΚΑΙ ΠΕΡΙΟΧΕΣ ΠΡΟΣΤΑΣΙΑΣ ΟΠΥ (ΜΠΛΕ ΧΡΩΜΑ)

Figure 3.9: *Archaeological sites (black colour)*

4. COASTAL EROSION AND SEA LEVEL RISE

4.1. BACKGROUND

Coastal erosion is caused by the movement of sediments from one area to another. The area in which the total volume of sediments decreases experiences erosion and the area in which it increases experiences accretion.

Erosion is considered as both a “blessing” and a “curse”. Without erosion there would have been no sandy beaches and no sediments around. The loss of sediments from a natural beach is a curse, as there is loss of precious land and risk to people’s safety.

Coastal erosion may be caused by various mechanisms such as:

- Sediment mining from the coastal zone.
- Obstruction in the movement of sediments along the coastline, causing erosion downdrift and accretion updrift (e.g. the Larnaka Marina causes beach creation in the Finikoudes area and erosion north of the Marina; towards Dhekelia).
- Obstruction in the supply of sediments from the rivers – interruption of the “cycle of sediments”. Dams arrest the sediments that used to be deposited at the river mouth, thus starving the coastal environment from the supply of sediments.

A coastal area is prone to erosion if two conditions are satisfied:

1. There are sediments which may be transported
2. There is a driver that can initiate movement and can transport sediments away from the area

Regarding the first factor (presence of sediments), sandy, shingle and pebble beaches are prone to erosion. Rocky beaches and manmade beaches are typically not prone to erosion.

Regarding the second factor (driver), wave action is the main natural driver (Beach mining is a practice that is nowadays prohibited by law.) The wave action may be reduced so that the driver that initiates sediment movement and transport is below the required threshold for the particular beach characteristics (sediment size, density, beach slope etc.).

This report analyses the approach in assessing the climate change impact on beaches in Cyprus and in particular on coastal erosion.

4.2. SEA DEFENCE WORKS

The Coastal Section of the Department of Public Works is the competent Government's authority, which has initiated and is implementing an island-wide master plan for the protection and improvement of the coasts of Cyprus.

Coastal erosion was primarily caused by beach mining and damming of sediment supply from the rivers. The approach adopted by Cyprus is the reduction of the driver that causes erosion, namely the reduction of the wave action on the eroded beaches. A series of offshore detached breakwaters have been built in numerous areas (Figure 4.1 below) and more such measures are under implementation. These breakwaters are typically erected at a water depth of the order of 4m and the crest of the breakwater is slightly above mean sea level, of the order of 0,5m.

Figure 4.1: *Limassol Coastline showing a series of offshore detached breakwater (Groynes are to be demolished)*

The wave height is depth limited that is the waves are breaking before reaching the structures and hence the wave height is not affected by the increased height. However, a sea-level increase will lead to higher water depth at the structure and hence the maximum wave height is higher. This parameter is normally taken into account for the design of the works for extreme events.

4.3. SEDIMENTS TRAPPED IN DAMS

The sediments eroded on land and that would have normally reached the coastal zone through the rivers are now piling up in the dams. The dams are silting up and the storage capacity of the dams is gradually reduced. The dams were designed for a dead storage for 50 years sediment accumulation.

4.4. COASTAL ZONES

Regarding the Coastal Zones, the first priority with respect to its vulnerability to climate change is related to the coastal erosion. Erosion constitutes a serious issue for the coasts of Cyprus, especially for the sandy and gravel beaches of the island such as the coastlines of Larnaka and Limassol which have been suffering from severe erosion during the last 30 years. However, the phenomenon of coastal erosion in Cyprus is mainly attributed to human interventions which in some cases are triggered by natural causes associated with climate change. The second priority of the coastal zones of Cyprus concerning climate change vulnerability is related to coastal flooding, inundation and squeezing. Scientists project an increase in the frequency of large storms in the coming centuries which can cause storm surges that flood low-lying coastal areas and allow destructive wave action to penetrate inland. At the same time, a potential sea-level rise would increase the area likely to be inundated by these coastal storms. ‘Coastal squeezing’ is another major problem presented by sea flooding when physical or anthropogenic barriers obstruct the process of landwards retreating. Given the significant proportion of the Cyprus coastline occupied by urban and tourist infrastructure, coastal squeezing may constitute a serious issue for certain areas in the future.

4.5. LAND AFFECTED BY COASTAL EROSION AND WAVE OVERTOPPING

Coastal erosion and wave overtopping are affected by climate change due to two factors:

a) Increase of water depth and hence increase of breaking wave height at the same location. For example, a rock at a water depth of 3m will be impinged by a larger wave when the water depth increases to say 3.5m.

b) Change of wave height and direction due to climate change. If the wave direction changes or the wave height changes due to climate change then the coastal hydraulics change and the sediment movement changes.

Sea level may not be predicted from climate change models. Projections show that in the Eastern Mediterranean sea level is expected to rise by 0.5-1.0m by 2100. In Cyprus there is no organisation responsible for collecting information on sea level variations, analysing and disseminating the information. Data collected and analysed by the Oceanography Centre of the University of Cyprus cover a limited duration and one location (Zygi). No conclusions were derived on past trends of sea level change.

The metric used for sea level rise (Figure 4.2) is therefore based on published predictions.

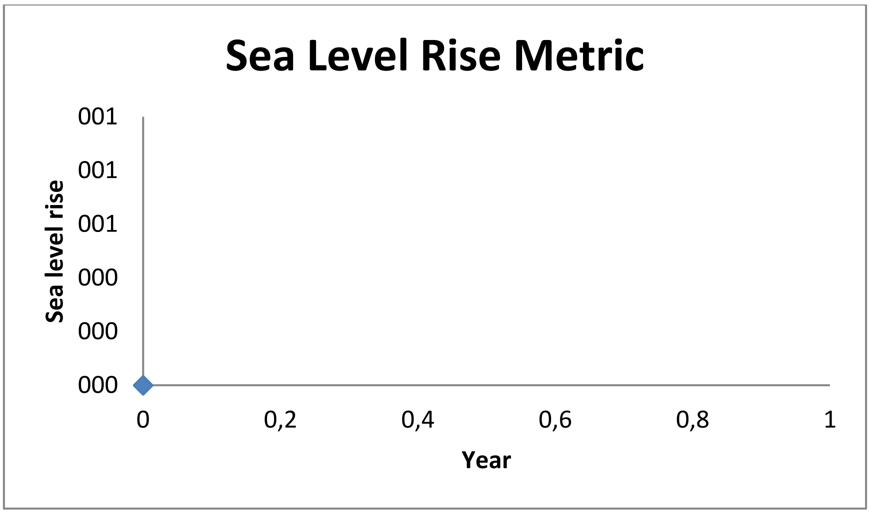


Figure 4.2*: Metric for sea level rise*

Figure 4.3 presents the matrix for the change of the required mass of natural rock to remain stable in a wave storm for various water depths.

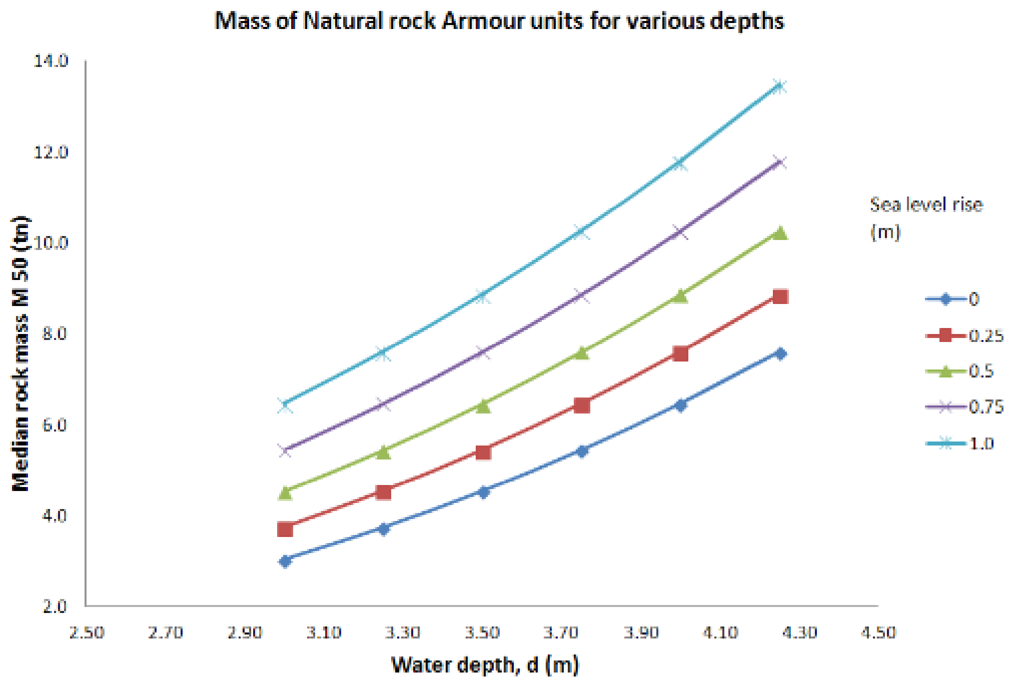


Figure 4.3*: Metric for natural rocks to remain stable during wave attack for various water depths (depth limited wave conditions)*

5. FOREST AND WILD FIRES

Cyprus may be characterized by its forests and the great diversity of natural vegetation. According to the FAO, 18,7% or about 173000 ha on Cyprus are covered by forests. Between 1990 and 2010, Cyprus lost an average of 600 ha or 0.37% per year. In total, between 1990 and 2010, Cyprus gained 7,5% of its forest cover, or around 12000 ha (Cyprus Forest Information and Data). Forests in Cyprus are classified in two groups a) forests and b) other wooded land (including maquis and garique). These two major forest types account for about 42% of the total land area (DoF, 2006). About 40% of this land is of state ownership. High forests account for 45% of the total forest area and lower vegetation for the rest 55% (Fig. 5.1). Plantations account only for 2,3% and were mainly planted in the past for fuelwood production, sand dune stabilisation and swamp drainage.

Forest ecosystems are mainly established across the Troodos and Pentadaktylos ranges as well as along the coastal belt. It worth noting that there is no forest in the central Mesaoria plain, which is in general characterized as a climatic semi-arid zone with a prolonged drought period. Over the last decades there has been observed a small increase in forest cover due to afforestation of state land and abandonment of private land. Forest ownership status plays an important role in the quality of forest management. State forests are managed by the Department of Forests (DoF) and are under a systematic management and protection status, with almost 80% of this land use type registered in the Natura 2000 network (DoF, 2006). Private forests are usually fragmented small parts of land, with an average size of 2-4 ha, growing at the borders of state forests.

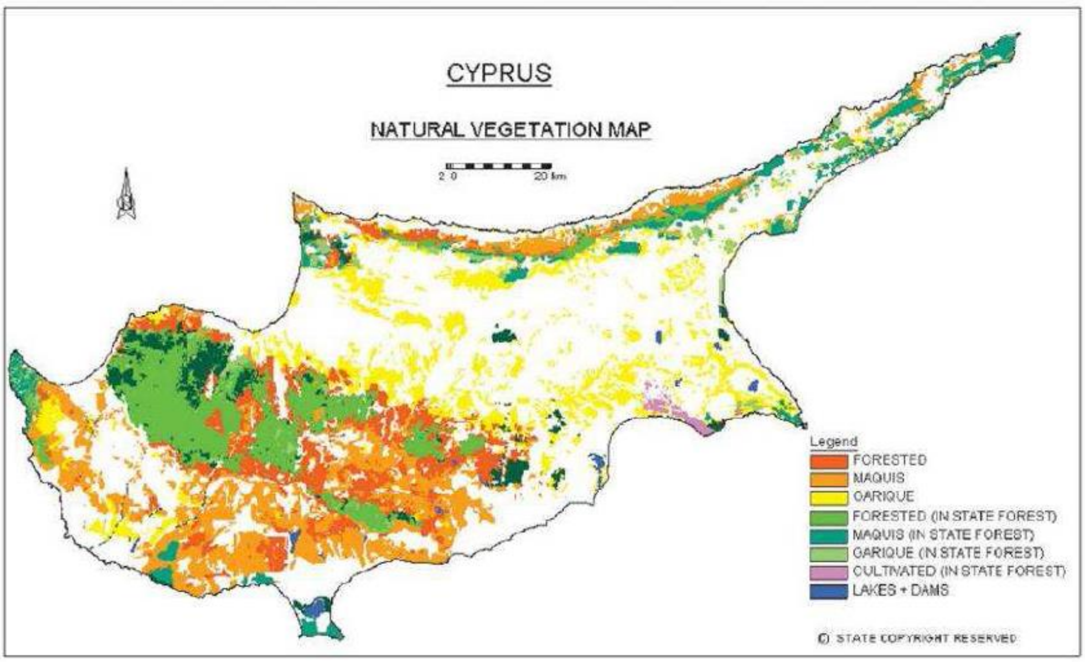


Figure 5.1: *Natural Vegetation Map of Cyprus (Source: ECHOES Cost Action 2009)*

Forest fires are a significant component of Mediterranean forests (Pausas et al., 2009). Many species have evolved traits to deal with frequent fires (Pausas et al. 2009), such as fire seeding

(Pinus brutia) and resprouting (Quercus coccifera). Although many Mediterranean ecosystems are resilient to fire (e.g shrublands or oak forests) others are fire-sensitive (pine woodlands) (Pausas et al. 2009). At the ecosystem level (considering post-fire vegetation changes and soil losses) some common Mediterranean forests (like pine plantations) can be sensitive to changes in fire frequency. Fire regimes (including fire frequency and severity) are associated with the prevailing climatic conditions. Climate also affects the provision of 'fuel', in the form of leaf and needle litter to the forest floor. Warmer future conditions are expected to increase fire risk across the Mediterranean region (Moriondo et al., 2006), although changes in fuel availability should be also taken into account (Pausas and Fernández-Muñoz 2012). Additionally, the impacts of forest fires could be further enhanced by climatic changes through increased drought periods (Gedalof & Berg 2010) and variability in precipitation, as well as subsequent feedbacks on post-fire regeneration and soil erosion. In general, the impacts of forest fires are lasting on the social, environmental and financial constituents of the local affected communities (Katzis et al., 2013). The number of forest fires has been reported to increase during the 2000- 2006 period, although the total burnt area did not follow a similar positive trend (Boustras et al. 2008). Using a meteorologically based fire weather index, Lemesios et al. (2014) simulated an increased fire risk under future warmer conditions and a higher vulnerability at the mountainous areas of the Troodos mountain range. Using in-situ aerial technology, Katzis et al. (2013) provided relevant proactive and reactive surveillance.

In the Mediterranean region, rising temperatures and decreasing rainfall will lead to increased occurrence of drought periods. This is likely to increase the most important abiotic risk in the region, the risk of fire (Lindner et al., 2008). Fire in Cyprus is by far the most destructive single agent, threatening forests and other wild land. According to Boustras et al. (2008), during the period 2000-2006 an increase in the number of fire events was observed although the total burnt area was reduced. The later can be explained by to the integrated programmes of the DoF ranging from the reduction of the fire risk to the prevention of a fire break. According to more recent data from the DoF (2015), the mean number of fires for the period between 2002 and 2014 was 198, with the mean area burnt around 2100 ha per year. The highest number of fire events was recorded in 2013, and was associated with an increased burnt area. The decadal patterns of fire events and area burnt are presented in Figure 5.2.

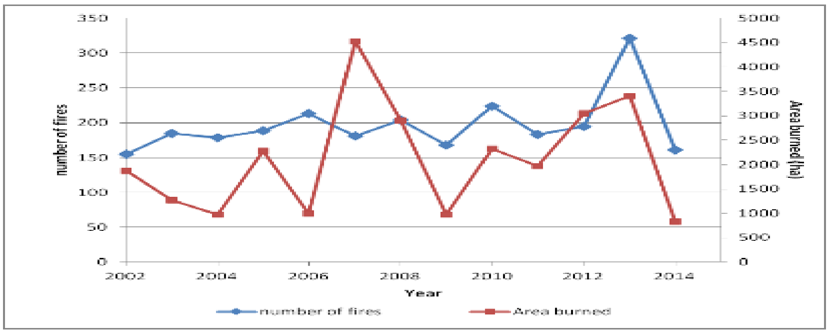


Figure 5.2: Number of fires and Area burnt during the 2002-2014 period (Source: DoF, 2016)

The analysis of climate data during the 2002 to 2014 period from the Pafos airport (European Climate Assessment and Data), suggest an increase in mean annual temperature and no clear trend for annual precipitation. The relationship between total annual precipitation and fire events seems to be negative, suggesting that more fires could start during dry years. No clear trend was identified between the area burn and annual precipitation or temperature (Figure 5.3).

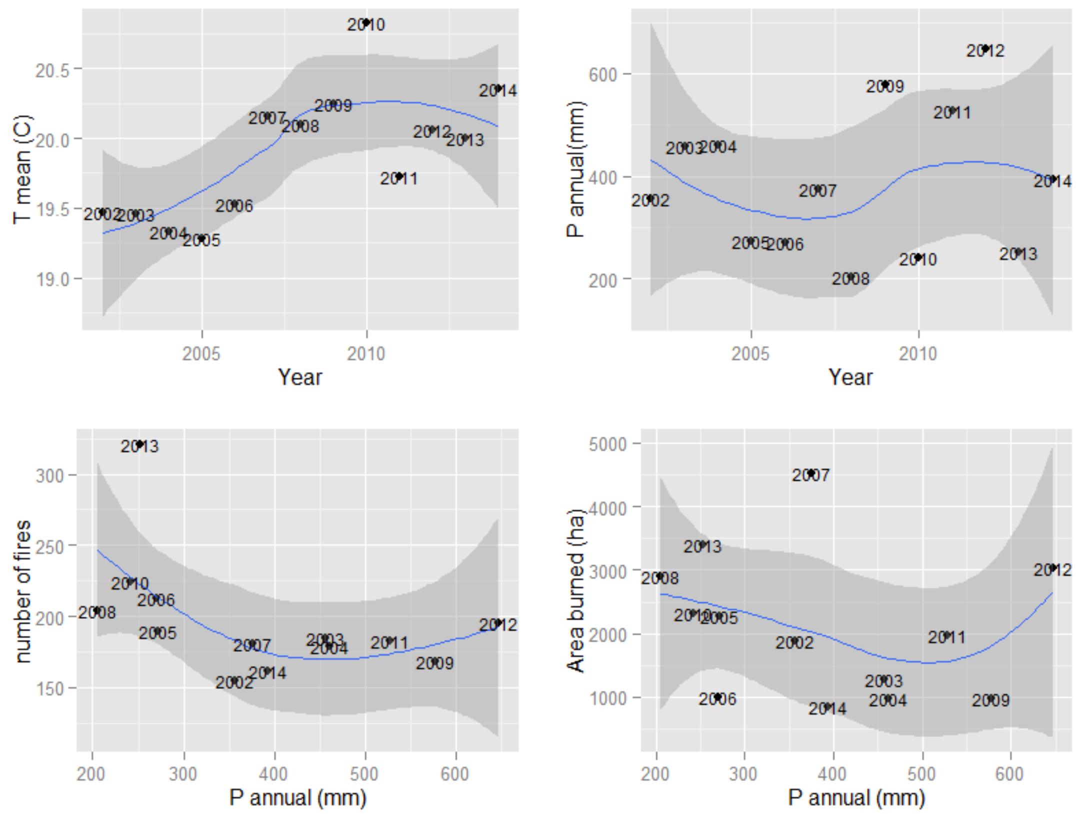


Figure 5.3: *Annual temperature and precipitation data for the 2002 - 2014 period at Pafos, and relationship between number of fire event and total area burnt with total annual precipitation.*

The fire hazard in Cyprus is high during the summer period, as can be seen in Figure 5.4 for the 2000-2006 period. This is because of:

- the community composition of forests on Cyprus (thousands of hectares of resinous pine trees),
- the prevailing climatic conditions (long, hot and dry summers, as well as strong winds)
- the topographic conditions (steep slopes).

The biggest percentage of forest fires ignitions is of human origin (Ioannou & Papageorgiou, 2007). During the period 2000-2014 only 131 fires (or 12%) were caused from natural causes, mainly lightnings. Fires caused by negligence or accidentally are the most frequent causes of forest fires, representing 88% (or 990 out of 1302) of the total number of fires for the period 2000-2014. Agricultural activities constitute the main reason for the occurrence of a forest fire (42%), while 21% of the fires are maliciously caused.

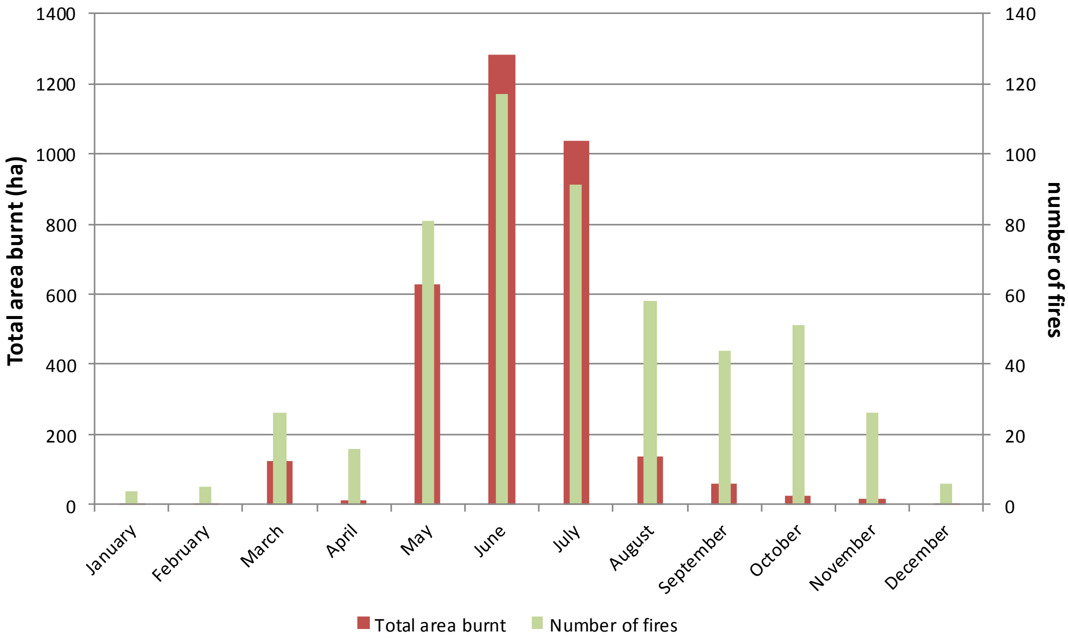


Figure 5.4: *Number of forest fires and total area burnt per month in Cyprus in 2000 – 2006 (info source: Boustras et al. 2008)*

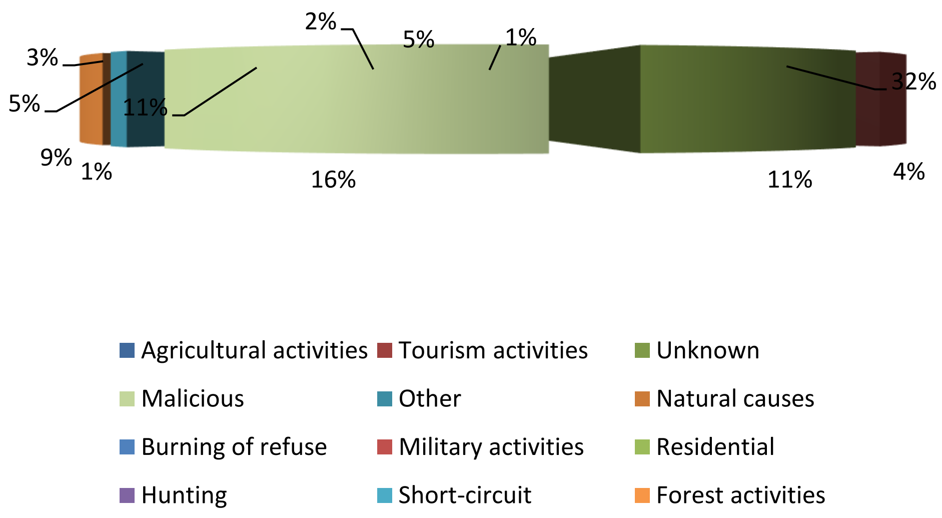


Figure 5.5: *Sources of ignition for the period 2000-2014 (info source: DoF, 2015).*

According to Moriondo et al. (2006) climate change is expected to lead to an increase in the number of years with fire risk, especially in the northern parts of the Mediterranean region, where the number of years at risk increases by up to 50%. Projected changes in fire regime will also affect forest ecosystems that are adapted to fire. For instance, Black pine (Pinus nigra) is a fire-resistant tree species provided that it is exposed to low intensity surface fires (Fulé et al. 2008, Christopoulou et al., 2013). Mature trees of Pinus nigra can withstand surface fires due to their thick bark and the fact that they grow tall with few branches in the lower bole

(Tapias et al., 2001, 2004; Pausas et al., 2009). Recent studies highlights the importance of maintaining fire-resistant stands with large trees that are more likely to survive after a surface fire and which can also serve as seed sources for the recolonization of the burnt area after severe crown fires (Christopoulou et al. 2014), an on-going phenomenon which is expected to further increase under scenarios of global warming.

In order to develop a response function for the "Risk of Wildfires" risk metric, the Canadian Forest Fire Weather Index (FWI) was estimated across Cyprus, using the daily baseline climate conditions provided by the RCM at 12.5 Km^2 resolution. The Canadian FWI uses the daily climatic conditions of a particular location including temperature, relative humidity, wind speed and precipitation to account for the effects of fuel moisture and wind on fire behaviour and to ultimately estimate the FWI index, which is a metric of fire intensity. Although it was originally developed for Canada, the FWI is systematically used in areas around the world (Carvalho et al., 2008; Dimitrakopoulos et al., 2011). The following figure (Figure 5.6) illustrates the mean FWI under baseline conditions, using the daily climate data provided from the RCM. Calculations of FWI were made at a set of RCM simulation points surrounding the study areas, and then a smooth cubic spline was used to interpolate across the geographic extent of the island (Flannigan and Wotton, 1989).

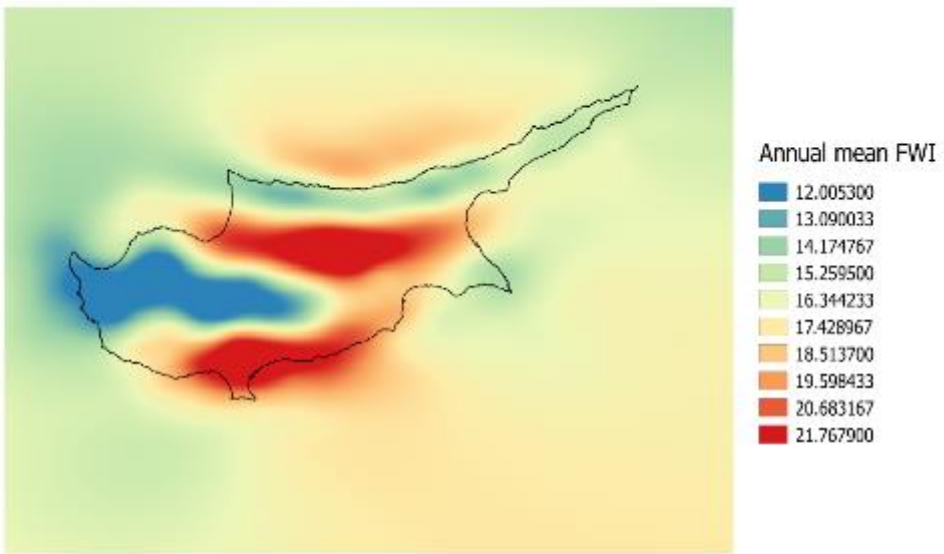


Figure 5.6: Annual mean FWI for the Baseline period.

The estimated FWI was subsequently regressed against two key variables from the forest fire dataset (number of fires and total area burnt). We used the modeled climate data for the baseline period rather than data from weather stations because the fire description database was not spatially explicit, and by averaging across the whole geographic extend of the island we could describe the overall fire risk. As most forest fires occur during the summer season we estimated the mean FWI and the mean number of days with extreme FWI (>30) across the whole geographic extend of the island for June, July and August. The results of this analysis are presented in the following Figure 5.7. A positive relationship between total burnt area and July FWI and the number of days with extreme FWI was identified. This relationship, along with an estimation of area (and projected changes of the area) with extreme fire risk, were used to develop a response function and estimate the metric of the wildfires risk.

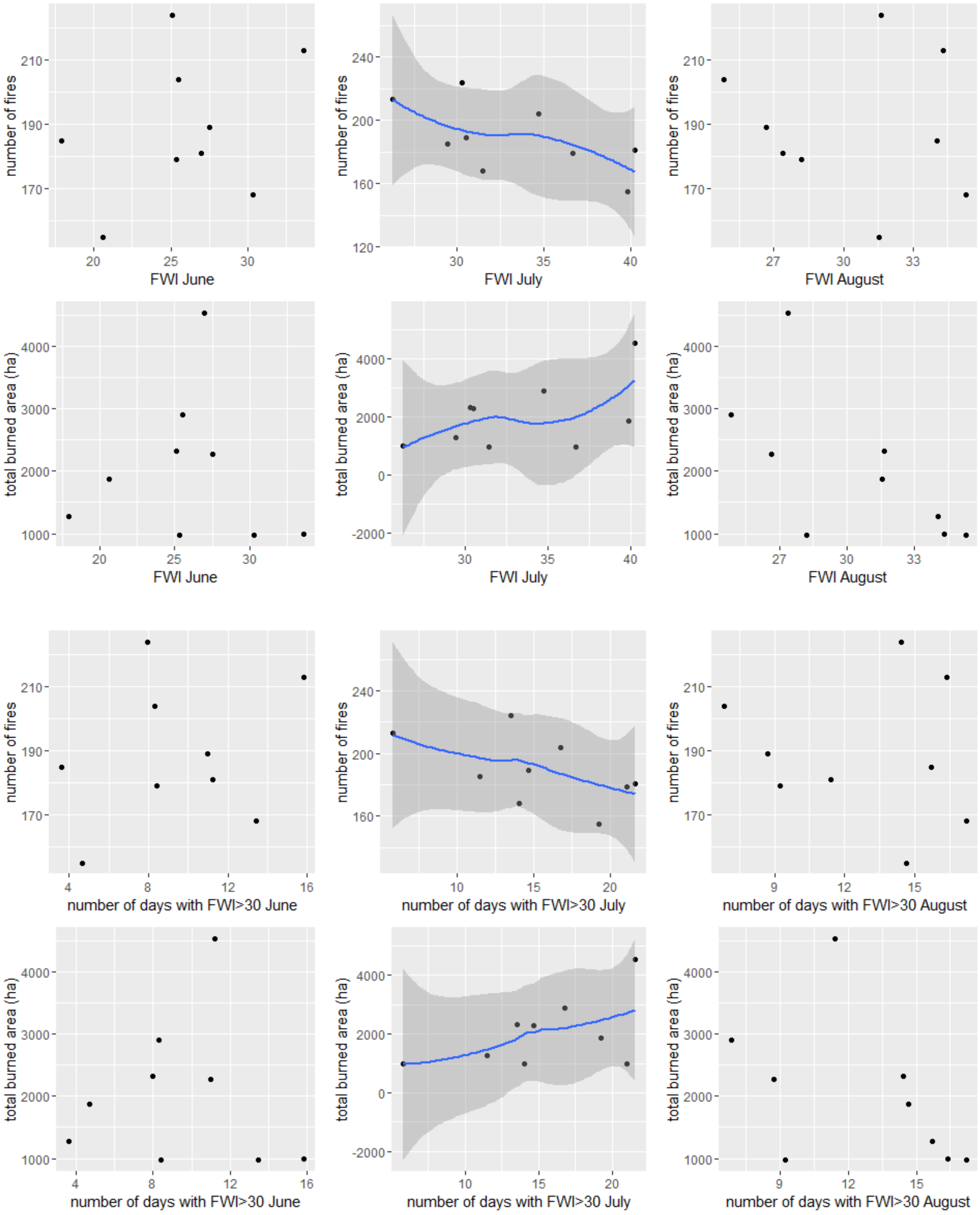


Figure 5.7: *Number of fires and total burnt area relationships with FWI and FWI extreme*

6. RISKS FOR HUMAN HEALTH

6.1. OVERVIEW OF THE HEALTHCARE SYSTEM OF CYPRUS

The healthcare system of Cyprus consists of two parallel delivery systems: a public one and a private one.

The public system is exclusively financed by the state budget, with services provided through a network of hospitals and health centres directly controlled by the Ministry of Health. Public providers have the status of civil servants and are salaried employees. The private system is financed mostly by out-of-pocket payments and to some degree by Voluntary Health Insurance. Other minor health care delivery sub-systems include the Workers' Union schemes, which mostly provide primary care services, and the schemes offered by semi-state organizations such as the Cyprus Telecommunication Authority and the Electricity Authority of Cyprus. The first mostly have their own network of providers, while the second use private providers (Theodorou et al., 2012).

Health services in the public system are provided by six general hospitals (Lefkosia General, Archbishop Makarios III Lefkosia, Larnaka General Makarios III, Ammochostos General, Lemesos General and Pafos General), four specialist centres (Thalassemia Centre, Cyprus Institute of Neurology and Genetics, Bank of Cyprus Oncology Centre and the Arodafnousa Palliative Care Centre), one Mental Health Hospital (Athalassa Mental Health Hospital), two small rural hospitals (Kyperounda and Polis), 38 health centres, as well as many sub-centres for primary services (Theodorou et al., 2012; CYSTAT, 2016).

The private sector is comprised of for-profit hospitals, polyclinics, clinics, diagnostic centres and independent practices. According to CYSTAT (2014 data) there are 73 private hospitals/clinics with 1.385 beds (CYSTAT, 2016).

In 2014, hospital beds totalled 2.912. Of these 1.527 were operating in the public sector (of which 132 in Athalassa Mental Health Hospital) and 1.385 in the private sector (CYSTAT, 2016).

The main actors in the health care system are the Ministry of Health, the Ministry of Finance, the Ministry of Labour, Welfare and Social Insurance and to a lesser degree the Ministries of Education and Culture, Defence, Energy, Commerce, Industry and Tourism, Agriculture, Rural Development and Environment. Professional associations also play an important role. These include the Cyprus Medical Association, the Cyprus Nurses and Midwives Association, the Union of Public Doctors and the Union of Public Nurses, the Pancyprian Association of Private Hospitals, the workers' union of Pancyprian Federation of Labour, Cyprus Workers' Confederation, and Democratic Labour Federation of Cyprus, and some voluntary organizations and NGOs. Some of these organizations are politically influential in the health care planning process (Theodorou et al., 2012).

During 2014, 78.573 patients were treated and discharged from the general hospitals, compared with 78.670 in 2013, recording a decrease of 0,1%. In addition 1.405 patients were treated and discharged from Kyperounta and Polis rural hospitals in 2014 compared to 1.499 in 2013, recording an decrease of 6,3% (CYSTAT 2016).

The number of patients that were treated and discharged from general hospitals increased from 2011 to 2012 (6,5% increase) and then decreased from 2012 to 2014 (2,1% decrease), whereas the corresponding number in rural hospitals increased every year from 2011 to 2014 (Table 6.1).

Table 6.1: *Patients discharged by public hospitals, 2011-2013 (CYSTAT, 2016)*

Hospital	2011		2012		2013		2014	
	No.	%	No.	%	No.	%	No.	%
General Hospitals	75.441	98,3	80.369	98,4	78.670	98,1	78.573	98,2
Rural Hospitals	1.315	1,7	1.341	1,6	1.449	1.9	1.405	1,8
Total	76.756		81.710		80.169		79.978	

In 2013, 58.250 patients were discharged by private clinics and hospitals (21.428 day cases), whilst in 2014 the number rose to 68.243 (21.085 day cases).

Table 6.2 shows the number of people per doctor and hospital bed. The percentage of beds occupancy in general hospitals decreases over the years and they are higher than the bed occupancy in rural hospitals. Patients tend to stay longer in rural than in general hospitals; though, the length of stay decreases over the years. The total expenditures on health services lies between 6,4% and 6,8% of GDP over the years 2011 to 2014, which is lower than the corresponding percentage in all other EU countries.

Table 6.2: *General health indicators of Cyprus (CYSTAT, 2016)*

	2011	2012	2013	2014
People per doctor	335	332	313	295
People per hospital bed	284	288	293	293
Bed occupancy in General Hospitals (%)	92,4	77,0	75,5	77,4
Average length of stay in General Hospitals (days)	5,3	4,7	4,7	4,8
Bed occupancy in Rural Hospitals (%)	66,6	47,5	50,8	47,1
Average length of stay in Rural Hospitals (days)	9,4	7,2	6,3	6,3
Total expenditures on health services (€mn) as % of GDP	6,8	6,6	6,7	6,4

The percentage of patients discharged from general or rural hospitals by disease category are presented in Figures 1.1 and 1.2. Number of cases with neoplasm in general hospital had a significant increase in 2014 (14% of all cases) compared to 2011 (5,4%) and 2012 (5,8%). Diseases with the greatest increases in rural hospitals are those of the circulatory (2011: 6,7%, 2012: 13,1%, 2013: 13,5%, 2014: 17,4%), respiratory (2011: 3,4%, 2012: 8,7%, 2013: 10,2%, 2014: 13%) and digestive system (2011: 4,9%, 2012: 8,3% , 2013: 9,3%, 2014: 10,7%).

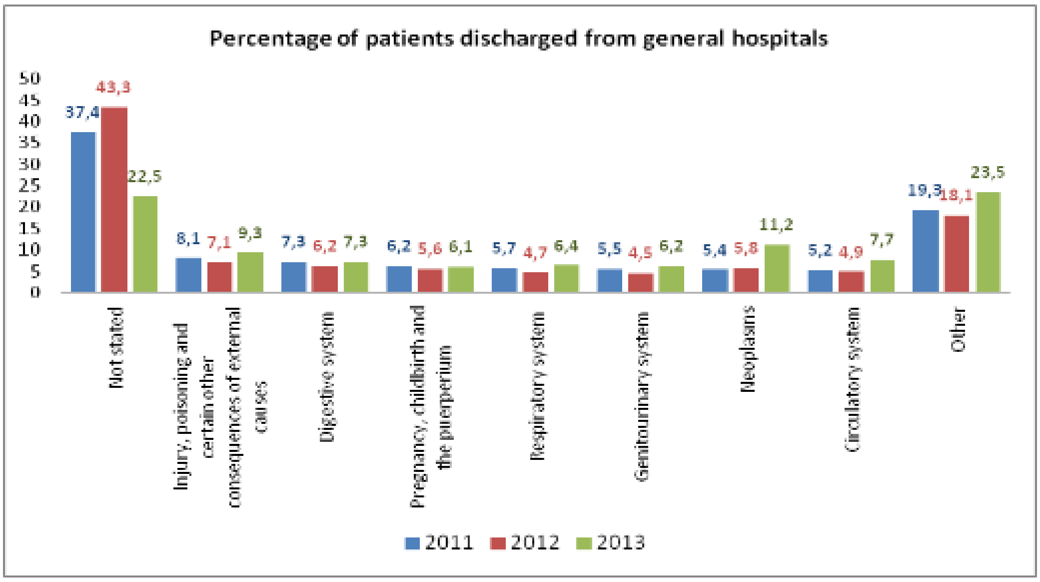


Figure 6.1 *Percentage of cases discharged from general hospitals by disease category (CYSTAT, 2016)*

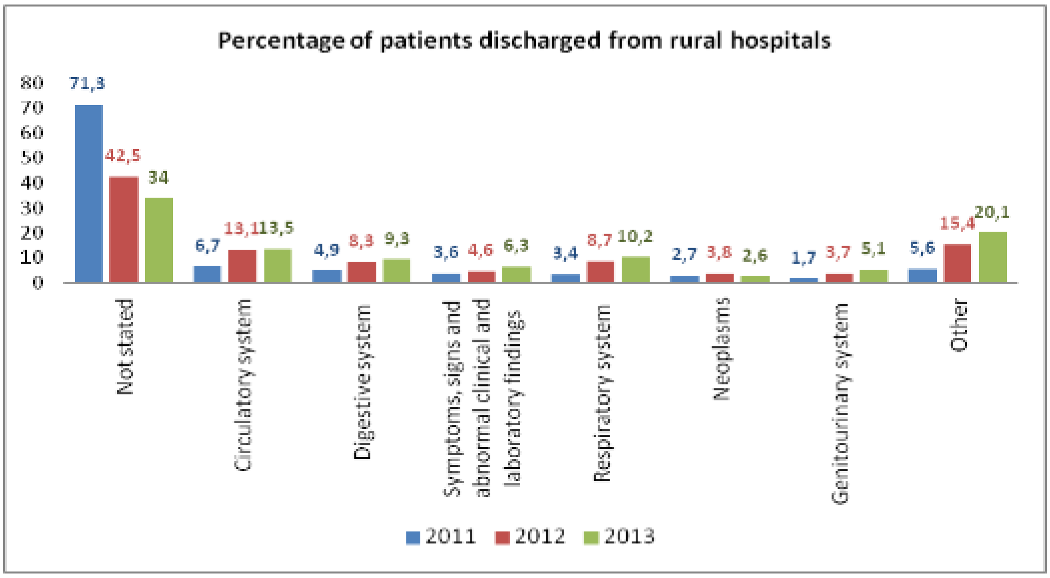
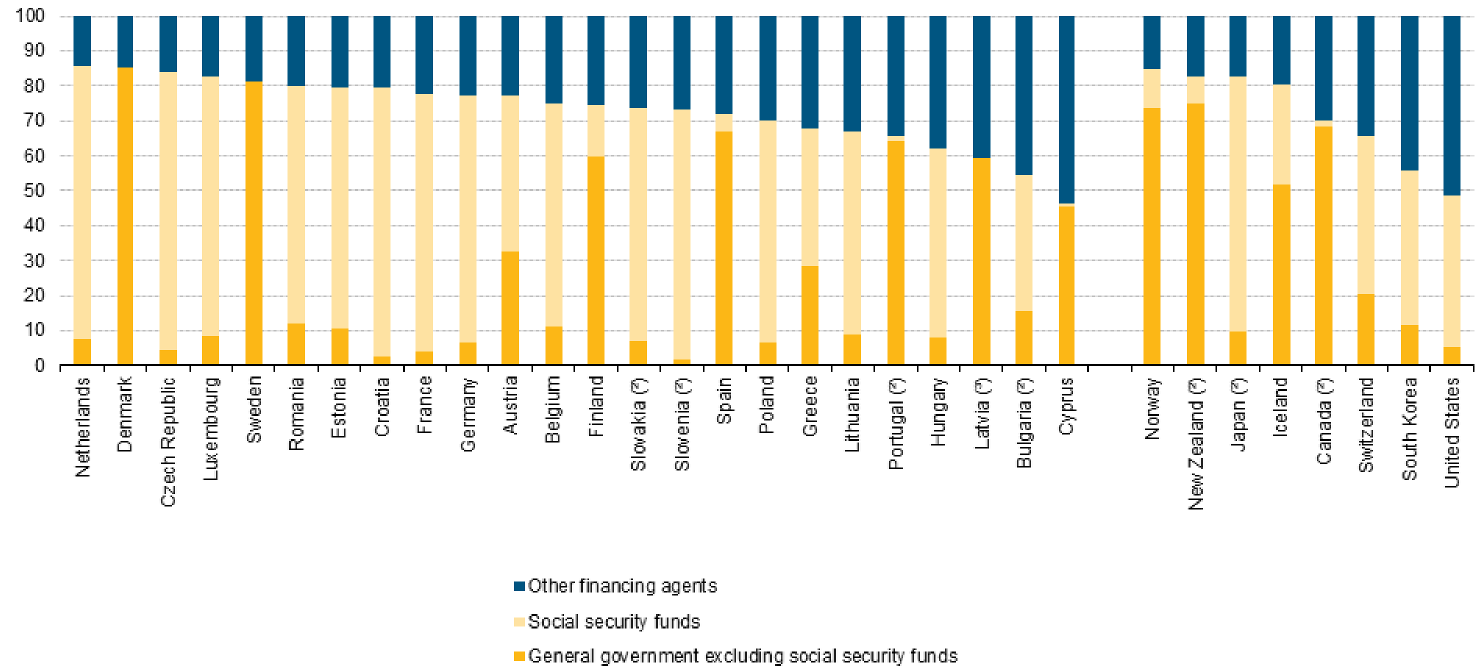


Figure 6.2: *Percentage of cases discharged from rural hospitals by disease category (CYSTAT, 2016)*

Since 2003, total health expenditure in Cyprus as a percentage to GDP has increased by approximately 1%, despite the fact that it was one of the countries most severely hit by the recent economic crisis in the Eurozone. Nevertheless, the total health expenditure in Cyprus compared with the total health expenditure in EU 28 is about half (Figure 6.3).

In 2014, total expenditure on health services in Cyprus for the private sector was 658,9 million (664,3 million in 2013) and for the public sector was 448,1 (540,1 million in 2013) (CYSTAT, 2016) According to Eurostat, Cyprus is an exception among the EU members with respect to the fact that expenditures in the private health sector significantly exceed those of the public sector (EUROSTAT, 2016). Cyprus has one of the lowest amounts of money spent in the EU countries for health (Figure 6.4).



(¹) Denmark, Cyprus, Portugal, Iceland, Norway and Switzerland: provisional. Ireland, Italy, Malta and the United Kingdom: not available.
(²) 2011.
(³) 2010.

***Figure 6.3:** Healthcare expenditure by financing agent, 2012 (% of current healthcare expenditure) (EUROSTAT, 2016a)*

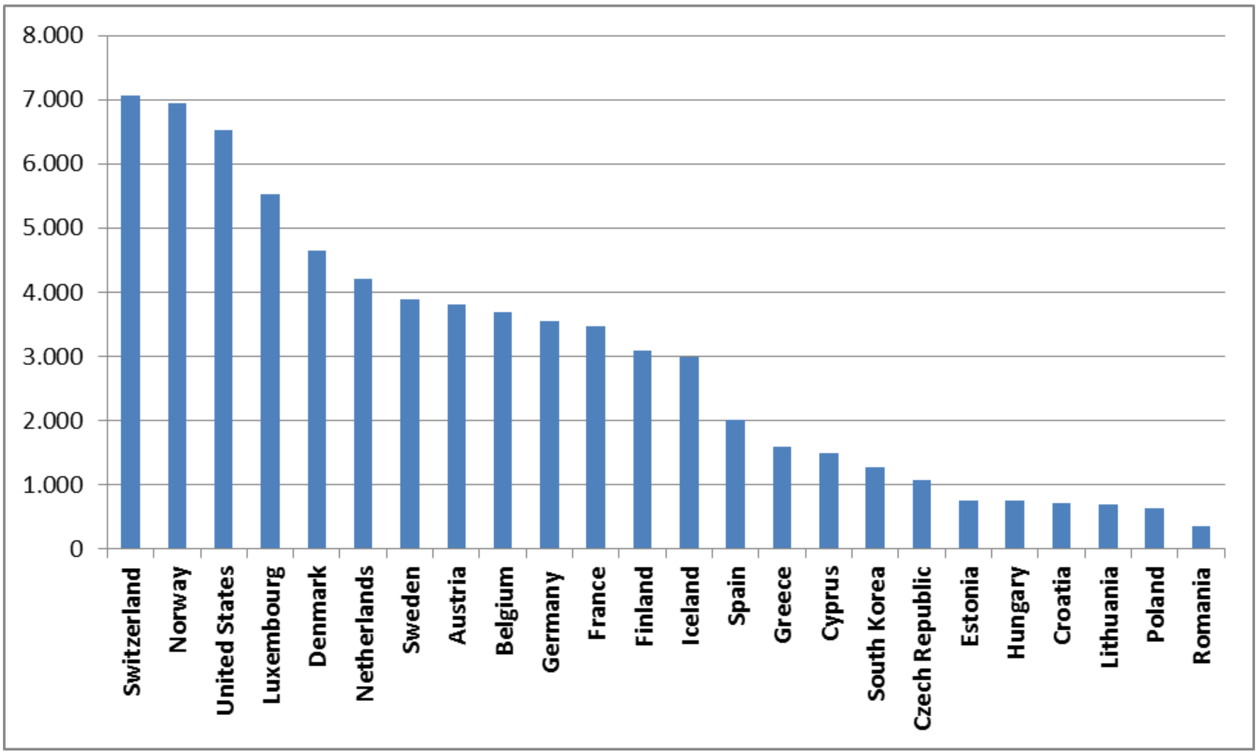


Figure 6.4: *Health care expenditure by all financing agents in selected countries (euros per inhabitant, 2012) (EUROSTAT, 2015)*

6.2. CAUSES OF DEATH IN CYPRUS

There were 5.272 deaths recorded in Cyprus in 2013 compared to 5.225 in 2004, a rise of 0,9% (Table 6.3). Between 2012 and 2013 the number of deaths decreased by 6,8% (5.659 deaths in 2012 vs 5.272 in 2013) recording the largest percentage decline in the past 10 years. The five leading causes of death for the period 2004-2013 were: Diseases of the circulatory system (38,2%), Neoplasms (21,5%), Endocrine, nutritional and metabolic diseases (7,5%), Diseases of the respiratory system (7,1%), External causes of injury and poisoning (5,9%) (Ministry of Health, 2015).

In 2013, among the deaths due to diseases of the circulatory system (34,6% of all causes of death), 22,2% was due to ischaemic heart diseases, 6,9% due to cerebrovascular diseases and the remaining 5,4% was due to other diseases of the circulatory system. Among neoplasms (24,6% of all causes of death), 23,7% was due to malignant neoplasms and the remaining 0,9% due to non-malignant neoplasms. Among the deaths due to endocrine, nutritional and metabolic diseases (8,4% of all causes of death), 7,1% was due to diabetes mellitus and the remaining 1,3% was due to other endocrine, nutritional and metabolic diseases. Among the deaths due to diseases of the respiratory system (8,0% of all causes of death), 2,9% was due to chronic lower respiratory diseases, 1,2% due to Pneumonia, 0,2% due to Influenza and the remaining 4% was due to other diseases of the respiratory system. Among the deaths due to external causes of morbidity and mortality (5,5 of all of all causes of death), 4,25% was due to accidents, 0,85% due to intentional self-harm, 0,2% due to assaults and the remaining 0,1% was due to other external causes (Ministry of Health, 2015).

As shown in Table 6.4, in 2012 higher standardized death rates were observed for the highly prevalent diseases of the circulatory system (402,17 deaths per 100.000 persons in Cyprus vs 394,18 deaths per 100.000 persons in EU 28), endocrine nutritional and metabolic diseases (84,72 deaths per 100.000 persons vs 29,98 deaths per 100.000 persons) and diseases of the genitourinary system (41,89 deaths per 100.000 persons vs 19,57 deaths per 100.000 persons).

Moreover, in 2012 Cyprus had a higher death rate compared with the EU 28 countries from infectious and parasitic diseases (16,89 deaths per 100.000 people vs 15,97 deaths per 100.000 people) and diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (8,36 deaths per 100.000 people vs 2,98 deaths per 100.000 people).

Higher death rates for several less usual causes were observed in 2012 like diseases of the skin and subcutaneous tissue (6,99 deaths per 100.000 people vs 1,81 deaths per 100.000 people), diseases of the musculoskeletal system and connective tissue (5,2 deaths per 100.000 people vs 5,15 deaths per 100.000 people), certain conditions originating in the perinatal period (2,85 deaths per 100.000 people vs 2 deaths per 100.00 people) and congenital malformations, deformations and chromosomal abnormalities (2,39 deaths per 100.000 people vs 2,32 deaths per 100.000 people).

Finally, higher standardised death rates in 2012 were found for symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (52,94 deaths per 100.000 people vs 37,52 deaths per 100.000 people).

In 2013, Cyprus had a higher standardised death rate than the EU-28 for the following causes of death:

- Endocrine, nutritional and metabolic diseases (82,08 deaths per 100.000 people vs 29,73 deaths per 100.000 people).
- Diseases of the genitourinary system (36,23 deaths per 100.000 people vs 19,33 deaths per 100.000 people).
- Diseases of the skin and subcutaneous tissue (5,3 deaths per 100.000 people vs 1,8 deaths per 100.000 people).
- Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (6 deaths per 100.000 people vs 2,98 deaths per 100.000 people).
- Diseases of the respiratory system (84,32 deaths per 100.000 people vs 82,5 deaths per 100.000 people).
- Pregnancy, childbirth and the puerperium (0,09 deaths per 100.000 people vs 0,05 deaths per 100.000 people).

Table 6.3: *Main causes of death (Ministry of Health, 2015).*

Causes of death	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2004-2013
All causes of death	**5.224**	**5.425**	**5.125**	**5.380**	**5.194**	**5.182**	**5.093**	**5.393**	**5.659**	**5.272**	**52.947**
Diseases of the circulatory system	2.013	2.125	2.040	2.092	2.015	1.951	1.929	2.113	2.113	1.823	20.214
Neoplasms	1.005	1.012	1.017	1.109	1.139	1.177	1.154	1.193	1.278	1.297	11.381
Endocrine, nutritional and metabolic diseases	389	387	390	387	393	359	365	426	434	444	3.974
Diseases of the respiratory system	350	364	343	389	356	395	360	366	434	424	3.781
External causes of morbidity and mortality	319	410	294	330	314	313	293	277	293	289	3.132
Other	1.148	1.127	1.041	1.073	977	987	992	1.018	1.107	995	10.465

Table 6.4: *Standardized death rate per 100.000 people by cause in EU 28 and Cyprus (EUROSTA, 2016b)*

Causes of death - Standardised death rate by residence	EU-28			Cyprus		
	2011	2012	2013	2011	2012	2013
All causes of death (A00-Y89) excluding S00-T98	**1.026,73**	**1.035,12**	**1.020,93**	**1.031,27**	**1.053,74**	**951,52**
Certain infectious and parasitic diseases (A00-B99)	15,43	15,97	15,95	16,28	16,89	15,71
Neoplasms	277,11	275,82	273,92	203,6	212,77	210,46
Malignant neoplasms (C00-C97)	*268,63*	*267,21*	*265,1*	*195,76*	*205,55*	*202,34*
Non-malignant neoplasms (benign and uncertain)	*8,48*	*8,61*	*8,82*	*7,83*	*7,22*	*8,12*
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	3	2,98	2,98	8,94	8,36	6
Endocrine, nutritional and metabolic diseases (E00-E90)	29,62	29,98	29,73	84,21	84,72	82,08
Mental and behavioural disorders (F00-F99)	31,1	34,17	36,4	18,5	19,79	18,78
Diseases of the nervous system and the sense organs (G00-H95)	35,33	38	38,14	29,39	36,3	30,85
Diseases of the circulatory system (I00-I99)	395,33	394,18	383,35	417,77	402,17	341,57
Ischaemic heart diseases	*139,26*	*136,87*	*131,87*	*127,68*	*115,85*	*104,18*
Other heart diseases	*90,27*	*91,49*	*89,47*	*142,29*	*133,36*	*107,67*
Cerebrovascular diseases	*94,11*	*92,48*	*88,68*	*85,66*	*82,42*	*71,86*
Other diseases of the circulatory system (remainder of I00-I99)	*71,7*	*73,34*	*73,33*	*62,14*	*70,55*	*57,86*
Diseases of the respiratory system (J00-J99)	80,53	83,71	82,5	79,83	89,55	84,32
Diseases of the digestive system (K00-K93)	45,83	45,25	44,1	38,59	29,92	35,3
Diseases of the skin and subcutaneous tissue (L00-L99)	1,74	1,81	1,8	7,74	6,99	5,3
Diseases of the musculoskeletal system and connective tissue (M00-M99)	4,97	5,15	5,03	4,17	5,2	5
Diseases of the genitourinary system (N00-N99)	19,17	19,57	19,33	35,45	41,89	36,23
Pregnancy, childbirth and the puerperium (O00-O99)	0,05	0,04	0,05		0,09	0,09
Certain conditions originating in the perinatal period (P00-P96)	2,01	2	1,94	1,73	2,85	0,62
Congenital malformations, deformations and chromosomal abnormalities (Q00-Q99)	2,34	2,32	2,32	2,96	2,39	1,16
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (R00-R99)	36,02	37,52	37,42	43,47	52,94	34,66
External causes of morbidity and mortality (V01-Y89)	47,14	46,66	45,99	38,65	40,94	43,4

6.3. ENVIRONMENTAL HEALTH

Air quality in Cyprus is an issue of concern especially for Particulate Matter (PM). According to reports published by the European Environment Agency (EEA), 100% of the urban population in Cyprus was exposed to unhealthy levels of particulate matter (PM_{10}), above the EU reference value in 2009, 2010, 2011 and 2012 (European Environment Agency, 2013, 2014). The percentage of the total population exposed to ozone concentrations above the target value in the 2006 – 2010 period ranged from 0% in 2010 to 50,9% in 2009. The percentage of the total population exposed to PM_{10} concentrations above the day limit values in the 2006 – 2010 period exceeded 80%, reaching 99% in (European Environment Agency, 2013).

In 2012, according to an analysis of the EEA, the energy use and supply is responsible for 64% of NOx emissions, 17% of non-methane VOCs, 99% of sulphur dioxide (SO2) emissions and 29% of fine particulate matter ($PM_{2,5}$) (European Environment Agency, 2014). According to the data from the Department of Labour Inspection, in the 2000 - 2014 period, there is a continuous decrease in the concentration of air pollutants (NO, NO_2, CO and SO_2) except ozone and particulate matter (PM). This reduction is mainly due to improved fuel quality, the introduction of new technology vehicles equipped with a catalytic converter, the periodic inspection of vehicles, etc. (Ministry of Labour, 2016).

Ozone exceedances are mainly attributed to the climatic conditions prevailing in Cyprus, such as high temperatures and high solar radiation, as well as to transboundary pollution of Ozone and its precursors from the eastern Mediterranean and the neighbouring countries (Ministry of Labour, 2016).

The main causes of Particulate Matter exceedances are (Ministry of Labour, 2016):

- emissions from vehicles, central heating and various industrial sources,
- airborne dust from agricultural areas, the Sahara and Asia
- resuspension from roads and uncovered urban areas during periods of drought and
- sea salts (marine aerosols).

The annual concentration at background stations, which are less influenced by anthropogenic pollution sources, is usually very close to the annual limit value (Ministry of Labour, 2016).

In 2015, dust transport episodes were observed. The dust originated from the Sahara desert and regions of Northern Africa and Western Asia. Between the 7^{th} and the 12^{th} of September a significant dust transport episode from Syria was observed. During this period, the PM_{10} concentrations were extremely high and the mean daily concentration reached the 2600 mg/m^3 (Ministry of Labour, 2016).

PM can cause or aggravate cardiovascular and lung diseases, heart attacks and arrhythmias. It can also affect the central nervous system and the reproductive system, and can cause cancer. One outcome of exposure to PM can be premature death. 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 (European Environment Agency, 2014).

The European Environment Agency estimated that in Cyprus in 2012, 790 premature deaths were attributable to $PM_{2,5}$ (or 8.000 Years of life lost - YLL) and 40 (or 500 Years of life lost - YLL) to Ozone (European Environment Agency, 2015).

6.3.1. IDENTIFICATION OF MAIN RISKS

Table 6.5: *Guidance on the classification of the "urgency of decisions"*

Class	Urgency	Response
High	• Major policy, investment or other decisions required **before 2020** that will either undermine or strengthen the future resilience of infrastructure, investments, communities, biodiversity etc. • The objectives of these decisions may be undermined by the speed of climate consequences relative to the decision's payback period, whether measured in financial, environmental or social value. • Decisions have limited flexibility, e.g. development of 'long life' assets with 'lock in' to a specific adaptation pathway. • There is low understanding of the risks and / or of the options to adapt to them. • There is a significant shortfall in adaptive capacity with a likelihood of locked-in maladaptation unless action is taken to raise adaptive capacity very soon.	Act Now
Medium	• Major policy, investment or other decisions will be **taken before 2050** that will either undermine or strengthen the future resilience of infrastructure, investments, communities, biodiversity etc. • The objectives of these decisions may be undermined by the speed of climate consequences relative to the decision's payback period, whether measured in financial, environmental or social value. • There is medium understanding of the risks and / or of the options to adapt to them. • Decisions have some flexibility and there is some potential for incremental adaptation over the long term.	Watch Carefully

Class	Urgency	Response
	• There is some shortfall in adaptive capacity with a limited risk of locked-in maladaptation unless action is taken to raise adaptive capacity	
Low	• Major policy, investment or other decisions are **not required before 2050.** • There is high understanding of the risks and / or of the options to adapt to them. • Decisions have high flexibility with potential for incremental adaptation over time. • There is little or no shortfall in adaptive capacity with limited or no need to raise adaptive capacity to avoid maladaptation.	Wait and see

6.3.2. THE TIER 1 LIST

A total of 46 impacts and consequences for the Health sector were identified. These can be clustered as following:

- Temperature Morbidity (Summer)
- Temperature Mortality (Summer)
- Air Pollution (Ozone)
- Air pollution (Particulate Matter)
- Pollen and allergens
- Infrastructure Failure
- Food Supply
- Vector-Borne Diseases
- Water Quality and Water-Borne Diseases
- Demand for Emergency Medicine
- Food-Borne Diseases
- Outdoor Activities
- Sunlight/ UV Exposure
- Agricultural Contaminants

- Healthcare System Staff Performance
- Algal/Fungal Growth in Buildings
- Increased use of pesticides and herbicides in buildings
- Air Pollution (Winter)
- Extreme Weather Event (flooding, storms, landslides) Mortality & Injuries
- Mental Health
- Social Disruption
- Temperature Morbidity (Winter)
- Medicine Efficacy
- Mobile Care and Support Services
- Patient Recovery Rates
- Traffic Accidents
- Healthcare System Property damage

6.4. OTHER IMPACTS

6.4.1. INFRASTRUCTURE FAILURE AND HEALTHCARE SYSTEM PROPERTY DAMAGE

Transport, communications and power generation infrastructure may be compromised during extreme weather events, such as floods, storms and heat waves. Health care infrastructure could also be directly affected by floods, storms and heat waves. For example, IT server overheating and disruption to communication may occur in health centres, hospitals, polyclinics, clinics, diagnostic centres and independent practitioners during heat waves. Such incidents could seriously compromise access to healthcare services.

Heat waves may also cause disruption to the health care sector if indoor temperatures in hospitals are not appropriately controlled.

Healthcare delivery will rely in part on the adaptive capacity of hospital infrastructure that is required to respond to the predicted physical and health-related impacts of climate change.

Regarding the vulnerability to floods, it is noted that no public hospitals or private clinics are within the floodplains defined by the Flood Risk Management Plant that was drafted within the framework of the Floods Directive

6.4.2. WATER AND FOOD BORNE DISEASES

Increased temperatures and changes in seasonal precipitation patterns is also likely to lead to more favourable conditions for the spread of certain water-borne, food-borne and vector-borne diseases in the future.

The European Centre for Disease Prevention and Control recently assessed the potential impacts of climate change on food and waterborne (FWB) diseases in Europe associated water temperature, seasonality, air temperature, heavy rainfall events, precipitation, and temperature changes with FWB pathogens.

Campylobacteriosis and salmonellosis were cited with the highest frequency in association with air temperature; campylobacteriosis and non-cholera vibrio infections were reported in association with water temperature; cryptosporidiosis followed by campylobacteriosis were related with highest frequency with precipitation; and cryptosporidiosis followed by non-cholera vibrio were found in association with precipitation events (European Centre for Disease Prevention and Control, 2012).

The most prevalent FWB disease in Europe is campylobacteriosis which exhibits strong seasonality and has been associated with a number of meteorological variables and specific weather events, which indicates that campylobacteriosis peaks may shift as a result of climate change in the future. Temperature has also a pronounced influence on salmonellosis and food poisoning notifications, which can be attributed to improper food storage and handling at the time of eating. Nonetheless, salmonellosis incidence has declined throughout Europe over the last ten years, in part due to public health measures. Therefore, carefully implemented health promotion and food safety policies should be able to counterbalance the probable negative impacts on public health. Erratic precipitation events are predicted to increase cryptosporidiosis outbreaks, even though the strength of the association might vary by climatic region (European Centre for Disease Prevention and Control, 2012).

Listeria sp. was not associated with temperature thresholds, extreme precipitation events, or temperature limits. Despite the lack of scientific data, it is not likely that climate change will directly influence listeriosis incidence, though it could result in more cases through indirect pathways. The association between climatic determinants and *Norovirus* is tenuous, in part due to the relative lack of published information. As such, no data are available on temperature extremes or thresholds, or on the after- effects of storms, droughts, or rain events. In contrast, there is documented evidence of a strong association between rising summer (water) temperatures, extended summer seasons and non-cholera *Vibrio* spp. infections. Nevertheless, any increase of the disease burden is projected to be modest due to low current incidence rates (European Centre for Disease Prevention and Control, 2012).

The European Centre for Disease Prevention and Control concluded that whether the potentially increased transmission of Cryptosporidium spp., non-cholera Vibrio spp., Salmonella spp. and Campylobacter spp. will manifest as a greater public health risk in the future depends not only on the accuracy of climate predictions but also on:

- the current and future state of disease prevention and control infrastructures,
- the baseline resilience and health status of exposed populations, and
- the extent to which climate change adaptation strategies specifically designed to address FWB diseases have been devised and implemented.

According to the analysis in the Water Sector Report, it seems unlikely that global warming will have a major impact on the risk of disease associated with mains water supplies in Cyprus. With the current available evidence and scenarios for climate change in Cyprus it would appear that the public health effects of climate change, at least as far as waterborne disease is concerned, are likely to be relatively negligible when compared to other public health concerns.

Although a potential risk, the public and environmental health infrastructure is likely to prevent substantial changes in the prevalence of the FWB diseases.

6.4.3. FOOD SUPPLY AND NUTRITION

Under climate change, the frequency and intensity of extreme weather events such as droughts, floods and storms could increase, with an adverse impact on livelihoods and food security. Climate-related disasters have the potential to destroy crops, critical infrastructure, and key community assets therefore deteriorating livelihoods and exacerbating poverty (The World Food Programme, 2013).

Changes in climatic conditions have already affected the production of some staple crops, and future climate change threatens to exacerbate this. Higher temperatures will have an impact on yields while changes in rainfall could affect both crop quality and quantity. Climate change could increase the prices of major crops in some regions. For the most vulnerable people, lower agricultural output would also mean lower income. Under these conditions, the poorest people — who already use most of their income on food — would have to sacrifice additional income to meet their nutritional requirements (The World Food Programme, 2013).

Climate-related risks affect calorie intake, particularly in areas where chronic food insecurity is already a significant problem. Changing climatic conditions could also create a vicious cycle of disease and hunger. Nutrition is also likely to be affected by climate change through related impacts on food security, care practices and health (The World Food Programme, 2013). The risks of climate change are not just to the production capacity of food security – but also to the potential growth in incomes and ability to purchase food of poor people, the risk of market disruptions, effects on supply and storage systems, and effects on stability of agricultural and rural incomes as well as nutritional content. Studies point to changes in the nutritional quality of foods (reduced concentration in proteins and in some minerals like zinc and iron), due to elevated CO_2, particularly for flour from grain cereals (Food and Agriculture Organization of the United Nations, 2016).

6.4.4. VECTOR-BORNE DISEASES

Vector-borne diseases are infections transmitted by the bite of infected arthropod species, such as mosquitoes, ticks, triatomine bugs, sandflies, and blackflies. Arthropod vectors are cold-blooded (ectothermic) and thus especially sensitive to climatic factors. Weather influences survival and reproduction rates of vectors, subsequently influencing habitat suitability, distribution and abundance, intensity and temporal pattern of vector activity (particularly biting rates) throughout the year, as well as rates of development, survival and reproduction of pathogens within vectors. However, climate is only one of many factors influencing vector distribution, such as habitat destruction, land use, pesticide application, and host density (Semenza and Menne, 2009).

West Nile fever is caused by the West Nile virus, a virus of the family Flaviviridae, which is part of the Japanese encephalitis antigenic group. West Nile fever mainly infects birds and infrequently human beings through the bite of an infected Culex mosquito (Semenza and Menne, 2009).

During the last years, West Nile Fever cases in humans have increased in several Mediterranean countries. For example, in Israel, a severe upsurge occurred during the hot summer of 2000 and again in the extremely warm summer of 2010. A change in the seasonality of the disease was observed, as the outbreaks began earlier in the year. An outbreak first occurred in Central Macedonia in northern Greece in the summer of 2010. During the same period, cases in humans were also reported in other Mediterranean countries: Turkey, Italy and Spain (together with other locations, mainly in Eurasia). Additionally, it was detected in horses in Greece, Italy, Gibraltar and Morocco. A study by found that uncharacteristically elevated temperatures during the summer of 2010 correlated with the West Nile fever upsurge in humans. Since 2010, all subsequent years (2011–2014) have been characterized by the re-emergence of West Nile fever within the same countries. A recent research analysed the status of infection by West Nile fever in Europe and its neighbouring countries in relation to environmental and climatic risk parameters. The anomalous temperatures in July were identified as one of the main risk factors (Negev et al, 2015).

Dengue is the most important arboviral human disease, however, mainly due to nearly universal use of piped water the disease has disappeared from Europe. Dengue is frequently introduced into Europe by travellers returning from dengue-endemic countries but no local transmission has been reported since it would also depend on the reintroduction of its principal vector, the mosquito *Aede aegypti* (also the yellow fever mosquito) which is adapted to urban environments. However, over the last 15 years another competent vector *Ades albopictus* (Asian tiger mosquito) has been introduced into Europe and expanded into several countries, raising the possibility of dengue transmission (Semenza and Menne, 2009).

Transmission of the dengue virus is sensitive to climate. Temperature, rainfall and humidity affect the breeding cycle, survival and biting rate of the mosquito vectors, while temperature in particular favours the rapid development of the vector (which is highly sensitive to climate conditions), increases the frequency of blood meals, and reduces the extrinsic incubation period. During the years 2008–2012, dengue fever cases were reported in several Mediterranean (and Adriatic) countries: Greece, Croatia, Italy, Malta, France, Spain and Portugal. Although most cases were probably imported, in 2010 local transmission of dengue was reported in both Croatia and France. Today, there is an apparent threat of dengue outbreaks in the Mediterranean European countries. According to the ECDC evaluations, future expansion of the vector could be further facilitated by climate change, as altered warming and precipitation patterns might increase the number of suitable niches (Negev et al., 2015).

Chikungunya fever is caused by a virus of the genus Alphavirus, in the family Togaviridae, which is transmitted to human beings by the bite of infected mosquitoes such as *A. aegypti*, and *A. albopictus* (Semenza and Menne, 2009).

In 2007, first transmission in Mediterranean Europe was reported from north-eastern Italy. During the period between 2008 and 2012 imported cases were reported in several countries in the Mediterranean basin including Greece, Italy, France and Spain. If global climate change continues, *A. albopictus and A. aegypti* will disperse beyond their current geographic boundaries, since temperature plays a very significant role in the development (and mortality rates) of *A. albopictus*. As *A. albopictus* is currently present in the region, Chikungunya outbreaks may be caused in the north western Mediterranean under favourable climatic conditions (Negev et al., 2015).

Malaria is caused by one of four species of the *Plasmodium* parasite transmitted by female *Anopheles* spp. mosquitoes. Historically malaria was endemic in Europe, including Scandinavia, but it was eventually eliminated in 1975 through a number of factors related to socioeconomic development. The potential for malaria transmission is intricately connected to meteorological conditions such as temperature and precipitation (Semenza and Menne, 2009).

The potential for malaria and other "tropical" diseases to invade southern Europe is commonly cited as an example of the territorial expansion of risk due to climate change (socioeconomic, building codes, land use, treatment, capacity of health-care system, etc.). While climatic factors may favour autochthonous transmission, increased vector density, and accelerated parasite development, other factors (socioeconomic, building codes, land use, treatment, etc.) limit the likelihood of climate-related re-emergence of malaria in Europe (Semenza and Menne, 2009).

During the years 2008–2012, malaria cases were reported in several Mediterranean countries: Cyprus, Greece, Malta, Spain and Portugal. While most malaria cases were reported as imported, in 2012 twenty-two cases from Greece and one from France were reported as not imported. In 2012 in the eastern Mediterranean and North Africa, malaria cases were reported in Lebanon, Egypt, Libya, Tunisia and Morocco. According to the WHO, all cases were imported with no local transmission. Since dominant or potentially important malaria vectors exist in the area, global climate change creates the potential, albeit relatively small, for the reappearance of malaria in countries where it was previously eradicated (Negev et al, 2015).

Leishmaniasis is a protozoan parasitic infection caused by *Leishmania infantum* that is transmitted to human beings through the bite of an infected female sandfly. Temperature influences the biting activity rates of the vector, diapause, and maturation of the protozoan parasite in the vector. Sandfly distribution in Europe is south of latitude 45°N and less than 800 m above sea level, although it has recently expanded as high as 49°N (Semenza and Menne, 2009).

During the period of 2003–2008, Leishmaniasis cases were reported from 16 Mediterranean countries, particularly in the eastern and southern sides of the basin. On average, 85.555 cases per year were reported for the Mediterranean basin, most of them in Algeria, Syria, Libya and Morocco. During the same period, Leishmaniasis cases were reported from 22 Mediterranean countries around the whole basin (on average, 875 reported cases per year for the entire region) (Negev et al, 2015).

Vector reproduction, parasite development and bite frequency generally rise with temperature. Therefore, malaria, tick-borne encephalitis, and dengue fever are very likely to become increasingly widespread in certain parts of the world (mainly in tropical and sub-tropical climates) due to projected rises in temperatures (Hames and Vardoulakis, 2012). Climate is an important geographic determinant of vectors, but the data do not conclusively demonstrate that recent climatic changes have resulted in increased disease vector-borne disease incidence on a pan-European level. The risk of reintroduction of malaria into certain European countries is very low and determined by other variables rather than climate change. Introduction of dengue, West Nile fever, and chikungunya into new regions in Europe is a more immediate consequence of virus importation into competent vector habitats; climate change is one of many factors that influence vector habitat (Semenza and Menne, 2009).

However, future outbreaks of certain vector borne diseases such as malaria, would still be expected to be rare and limited in number in Europe. It is important to note that the relevance of environmental change to patterns of disease depends on the susceptibility of local populations to the disease, the robustness of local food and water safety measures, vector control measures and communicable disease surveillance and control arrangements (e.g. vaccination programmes, legislation). It is likely that the public health infrastructure would prevent the indigenous spread of Vector borne diseases (Hames and Vardoulakis, 2012).

6.4.5. DEMAND FOR EMERGENCY MEDICINE

Emergency medicine is very likely to experience a significant change in demand for its services over and above current annual levels as a result of climate change. This is likely to result in an increase in levels and variety of demand during extreme weather events, such as heat waves.

6.4.6. OUTDOOR ACTIVITIES

Working, exercising or playing outdoors during extreme weather events such as heat waves, floods and windstorms will increase the health risks for those exposed. The main health impacts of this are likely to include respiratory and cardiovascular effects due to heat exhaustion, sunstroke and sunburn. However, there will also be a number of health benefits such as increased exposure affecting vitamin D levels. People most at risk of adverse health effects would be those exercising or working outdoors during high temperatures.

6.4.7. SUNLIGHT/ UV EXPOSURE

The most common diseases linked to ultraviolet radiation exposure are skin cancers and cataracts as well as other less common detrimental health effects including sunburn, photodermatoses, photoaggravation of inflammatory skin disorders and immunosuppressive effects on the skin. The most serious of these effects are skin cancers, which are either melanoma or non-melanoma skin cancers.

Health benefits of ultraviolet radiation exposure include the synthesis of vitamin D, and although ultraviolet exposure may exacerbate inflammatory skin conditions it also has some therapeutic effects. It has long been known that vitamin D is required to maintain a healthy skeleton through a process of calcium metabolism and the main source of vitamin D is through exposure to short wave ultraviolet radiation, with diet playing a minor role.

The amount of UV radiation which reaches the surface of the earth is dependent on a number of factors, the main one of which is the amount absorbed by the stratospheric ozone layer. The effect of climate change on UV radiation exposure is difficult to assess due to probable increased outdoor activity due to extended summer season and lower levels of clothing.

Cyprus has year-round sunshine and therefore ultraviolet radiation levels are on the high end. The population-weighted average daily ambient ultraviolet radiation R level for 1997–2003 was 3439 J m^{-2}, which was higher than other countries in the Mediterranean region. Despite the high ultraviolet radiation levels in Cyprus, skin cancer rates are relatively low; in 2008 the WASR of melanoma was 5,8 for men and 5,7 for women. Melanoma of the skin was the eighth most common cancer in both men and women in 2008. Whether the rate reflects better protection from ultraviolet radiation through human factors (use of sunscreen and protective clothing during exposure to the sun) or genetic factors (relating to skin colour etc.) is not known. Considering the geographic location of Cyprus and conquests it experienced by many different populations, such as Phoenicians, Egyptians, Romans, Venetians, Ottomans, British, and so on, the genetic make-up of the Cypriot population is most likely complex and reflected in the enormous skin colour variation of the people (going from very light complexions to very dark complexions). Even though the rate of skin cancer is relatively low, it has been rising over the years suggesting ultraviolet radiation is having a bigger impact on the population (Farazi, 2014)

Both negative and positive effects of increased sunlight/ ultraviolet radiation exposure are difficult to quantify. It should be noted that the risk of malignant skin tumours as a result of UV exposure is currently considered to be of a greater consequence.

6.4.8. AGRICULTURAL CONTAMINANTS

Humans are potentially exposed to a number of agriculturally derived chemicals and pathogens in the environment (air, soil, water and sediment) by a number of different routes. This not only includes consumption of food (both crops and livestock) exposed to contaminants through the food chain, as well as via groundwater and surface waters used for drinking, but also from direct contact with water bodies or agricultural soils through for example, recreational use. A likely increase in the use of pesticides as crop diseases become more prevalent will increase levels of pesticide applied to food items. Changes in climate (e.g. warmer conditions and drier summers), could result in the emergence of new pathogens, or the increased incidence of existing diseases. Although existing drinking water treatment and monitoring will likely prevent high human exposure levels, human exposure to pathogens in food items may increase, although the magnitude of this increase will be highly dependent on the contaminant type.

Although attributing health effects due to agricultural contaminants to the general population is often inconclusive, several studies have associated different health outcomes with exposure to chemicals from agriculture. These include Parkinson's disease, linked to exposure to pesticides and a number of medical disorders linked to chlorphenoxy herbicide exposure (Hames and Vardoulakis, 2012).

6.4.9. HEALTHCARE SYSTEM STAFF PERFORMANCE

Healthcare staff performance may be compromised during heat waves, if indoor temperatures are not appropriately controlled. Floods may also affect negatively the ability to get to work. IT equipment and power failures due to extreme weather will also compromise staff performance.

6.4.10. MEDICINE EFFICACY

Manufactured drugs are in general licensed for storage at temperatures up to 25°C. Exposure of medicines (or other medical and laboratory materials) to high temperatures during storage and transit could have consequences on their efficacy (Hames and Vardoulakis, 2012).

6.4.11. PATIENT RECOVERY RATES

Patient recovery may be compromised during extreme weather events, particularly during heat waves, if indoor temperatures in hospitals are not appropriately controlled.

6.4.12. ALGAL/FUNGAL GROWTH IN BUILDINGS

Mould can have significant consequences for human health, most commonly allergic reactions to the spores, especially asthma. The main climate driver for condensation, damp and mould is increased winter precipitation and consequent higher humidity levels. More research is needed to determine the link between damp homes and respiratory conditions.

6.4.13. INCREASED USE OF PESTICIDES AND HERBICIDES IN BUILDINGS

With a progression to warmer summers, there is an increased likelihood of infestations occurring in properties. Increase in vector reproduction and parasite development could lead to increased use of pesticides and herbicides in homes. Exposure to pesticides has been associated with neurodevelopmental outcomes and leukaemia, as well as acute pesticide poisoning in extreme exposures.

6.4.14. AIR POLLUTION (WINTER)

Winter air pollution episodes are likely to decline in frequency and intensity partly as a result of warmer temperatures. The likely decrease in winter air pollution episodes will be associated with a proportional decrease in mortality and morbidity. Apart from climatic effects, winter air pollution episodes are also likely to further decline due to projected reductions in atmospheric emissions (e.g. traffic-related) of particulate matter (PM_{10}), nitrogen oxides (NO_X) and Volatile Organic Compounds due to future tightening of both fuel and vehicle emission legislation. The effect of the projected changes in atmospheric emission on winter air pollution is likely to be much larger than any effects associated with changing climatic conditions (Hames and Vardoulakis, 2012).

6.4.15. EXTREME WEATHER MORTALITY AND INJURIES

Extreme weather events such as floods, storms can cause deaths and injuries, however there are no sufficient data to quantify the future risk.

6.4.16. MENTAL HEALTH

Mental health impacts of storms and floods can arise as a result of the stress of evacuation, property damage, economic loss, and household disruption. However, there remains limited evidence regarding the long-term mental health impacts of these events (IPCC, 2014).

6.4.17. SOCIAL DISRUPTION

Extreme weather events can increase in social disruption, exacerbating inequalities in communities and raising tensions between different social groups e.g. between those who live in areas more likely to flood and those who do not or can afford to protect their properties. Mental stress, violent behaviour and suicides increase during hot weather. Ambient temperature and heat waves are strongly correlated with increases in violent crime and associated injuries. Increased night-time temperatures can also lead to heat stress and sleep deprivation, with a potential increase in social unrest. Although some research has been carried out into how social behaviour changes under different climate effects, further research is required in this area (Hames and Vardoulakis, 2012).

6.4.18. TEMPERATURE MORBIDITY (WINTER)

Within winter months, as temperatures increase this will almost certainly result in a reduction in the number of hospital admissions due to cold related illnesses.

6.4.19. MOBILE CARE AND SUPPORT SERVICES

Mobile care and support services include ambulances, transportation of patients and organs, etc. Potential problems in the future will be mainly due to transport network and infrastructure problems and traffic accidents. Adverse weather conditions could also increase disruption to mobile support services and could endanger lives and limit the supply of medicines and the delivery of urgent health care to patients. Ambulance response times can be adversely affected by severe weather.

6.4.20. TRAFFIC ACCIDENTS

A future changing climate is likely to have an effect on the number of traffic accidents as a result of a number of factors, the main ones of which are outlined below.

Warmer weather is likely to lead to more vehicle breakdowns due to overheating of engines with resultant disruption to travel and also to increased wear and tear of road surfaces

Wetter winters will increase the risk of landslide, with a subsequent increase in risk to transport links, as well as directly, traffic accidents. More intense rainfall levels in winter will lead to an increased risk of traffic accidents due to reduced visibility leading to more difficult driving conditions, as well as localised flood areas as a result of low areas and/or an overwhelmed drainage system.

7. LAND DESERTIFICATION

7.1. LAND DESERTIFICATION OVERVIEW

Land desertification is one of the most serious environmental issues at global, national, regional and local scales. Desertification has been defined as "the land degradation in arid, semi-arid and dry sub-humid areas, resulting from various factors, including climatic variations and human activities" (UNEP, 2016). The process of desertification is characterized by the reduction of available soil water to the growing plants resulting to critical low plant productivity. Land desertification is the consequence of a series of important degradation processes in semi-arid and arid regions, where water is the main limiting factor of land use performance on ecosystems. Desertification of an area will proceed if certain land components are degraded beyond specific thresholds, above which further change is irreversible. The following three major processes of land degradation can be distinguished: (a) the loss of nutrient-rich topsoil due to wind and water erosion, (b) the decrease in soil water content induced by various causes including unsustainable agricultural practices or overgrazing, and (c) the accumulation of salts or other toxic substances in the soil.

Soil erosion is a significant process of land degradation and, consequently, desertification in the island of Cyprus. The prevailing climatic conditions are characterized by high rainfall erosivity and long rainfall seasonality and aridity favoring soil erosion of sloping areas. Soil salinization is another main degradation and desertification process affecting mainly plain areas with poor drainage conditions and especially the coastal areas. Extensive forest fires occurring during the dry period and induced by man is a significant cause promoting desertification. In addition, overgrazing is regarded as a serious pressure on natural environment and a well-known desertification driver in areas where morphology, climate, vegetation cover and soil are unsuitable for intensive use.

Among the physical environment characteristics climate, soil, and vegetation are important factors of desertification in Cyprus. Rainfall, amount and distribution, is a major factor affecting biomass production, and soil erosion rates on hilly lands. The prevailing semi-arid climatic conditions, which are expected to worsen in the near future, are characterized by seasonal distribution of rainfall which makes the existing ecosystems vulnerable to land degradation and desertification. The uneven annual and inter-annual distribution of rainfall, and the occurrence of extreme events are the main climatic factors contributing to land degradation desertification. However, desertification will proceed, in a certain landscape, when the soil is not able to provide the plants with rooting space, water and nutrients. In the semi-arid zones, the land becomes irreversibly desertified when the rootable soil depth is not capable to sustain a certain minimum vegetation cover. There are cases that desertification proceeds even on deep soils, when their water balance is not capable of meeting the needs of plants. Extensive studies in the last decades supported by a plethora of applied EU commissioned research and projects have shown that the soil parameters greatly affecting desertification are parent material, soil depth, slope gradient, slope aspect, soil texture and amount of rock fragments on the soil surface. These parameters are related to water availability to the plants and to soil erosion resistance.

7.2. METHODOLOGY

The following two threats due to climate change have been assessed (a) soil erosion, and (b) land desertification. Even though soil salinization risk is an important threat especially for the coastal areas, the assessment was not possible due to the lack of detailed soil maps of Cyprus.

7.2.1. SOIL EROSION ASSESSMENT

Soil erosion risk has been assessed using the recently derived from the most recent state of the art methodology of the EU research project DESIRE (2010). The proposed methodology has been based on a series of indicators related to climate, soil, vegetation, fires, agriculture, cultivation, husbandry, land management, land use, water use, tourism, social, and institutional (Table 7.1). The following parameters-indicators are used for the estimation of soil erosion risk affecting desertification risk: annual rainfall, aridity index, rainfall seasonality, slope aspect, slope gradient, soil depth, soil textural class, organic matter of surface horizon, agricultural cover type, natural vegetation cover type, percentage of plant cover, parallel employment, tillage operations, tillage depth, tillage direction, grazing control, grazing intensity, fire protection, sustainable farming, soil water conservation measures, land abandonment, land use intensity, period of existing land use, run-off water storage, tourism intensity, population density, subsidies, and policy implementation.

Table 7.1*: Indicators with the corresponding weighing indices for the assessment of soil erosion risk in agricultural areas, pastures, and forests*

Indicators	Water erosion		
	Agricultural areas	Pastures and shrubs	Forests
CLIMATE			
Rainfall	0.348		
Rainfall seasonality	0.245	0.654	0.41
Aridity index			0.225
SOIL			
Slope aspect	0.191		
Slope gradient	0.359		
Soil depth	0.082	0.167	0.225
Soil texture		0.115	
Organic matter	0.17		
VEGETATION			
Vegetation cover type	0.089		0.369
Plant cover	0.089	0.305	0.169
FIRES			
Fire risk			-0.417
Burnt area		-0.182	0.309

Indicators	Water erosion		
	Agricultural areas	Pastures and shrubs	Forests
AGRICULTURE			
Parallel employment	-0.159		
CULTIVATION			
Tillage operations	0.158		
Tillage depth		-0.24	
Tillage direction		0.124	
HUSBANDRY			
Grazing control		0.186	
Grazing intensity			-0.392
LAND MANAGEMENT			
Fire protection			0.247
Sustainable farming	0.196		
Soil water conservation		0.134	
Terracing (presence)	0.176		
LAND USE			
Land abandonment	-0.364		0.133
Land use intensity	0.205	0.175	
Period of existing land use		0.112	
WATER USE			
Runoff water storage	-0.155	0.314	
TOURISM			
Tourism intensity		0.127	
SOCIAL			
Population density			0.356
INSTITUTIONAL			
Farm subsidies	0.105	0.405	
Policy implementation	0.38	0.282	

The classes for each indicator used with the corresponding indices are given in Table 7.2 (Kairis et al., 2013; Kosmas et al., 2013). The climatic data used are those for rainfall and air temperature provided for the project for climate projections RCP4.5 and RCP8.5. Aridity index was calculated. The aridity index has been estimated by the Bagnouls-Gaussen index (BGI) using the following equation:

$$BGI = \sum_{i=1}^{n} (2ti - Pi)*k$$

Where: ti is the mean air temperature for month i in °C, Pi is the total precipitation for month i in mm; and k represents the proportion of month during which 2ti - Pi >0. Rainfall seasonality (SI) calculated according to Walsh and Lawler (1981):

$$SIi = \frac{1}{Ri}\sum_{n=1}^{n=12}\left|Xin - \frac{Ri}{12}\right|$$

Where Ri is the total annual precipitation for the particular year under study and Xin is the actual monthly precipitation for month n. The general soil map of Cyprus was used for assessing the indicators soil depth, soil texture, and organic matter. Slope gradient and slope aspect was defined using the existing topographic map of Cyprus. Vegetation cover was defined using CORINE 2000. Based on this map the indicators related to fire, agriculture, cultivation, husbandry, land use ware assessed. Data on climate, water use were identified from the existing provided reports. Data for the indicators related to tourism and social were found from the Cyprus Statistical Service. Farm subsidies have been allocated according to existing EU regulation. Policy implementation was assessed based on the land use type. The area has been divided according to land cover type in: (a) agricultural areas, (b) pastures, and (c) forested areas. The algorithms with the corresponding beta values of the linear regression model used for each cover type are given in Table 7.1.

Table7.2: *Indicators with the distinct classes for each indicator and the related sensitivity (vulnerability) score*

CLIMATE

Annual air Temperature (°C)	<12	12-15	15-18	18-21	>21
	1.0	1.8	1.5	1.8	2.0

Annual rainfall (mm)	<280	280-650	650 -1000	>1000
	2	1.6	1.3	1.0

BG aridity index	<50	50-75	75-100	100-125	125-150	>150
	1.0	1.2	1.4	1.6	1.8	2.0

Rain seasonality	<0.19	0.20-0.39	0.40-0.59	0.60-0.79	0.80-0.99	1.00-1.19	>1.20
	1.0	1.2	1.4	1.6	1.8	1.9	2.0

Rain erosivity (mm/h)	<60	60 -90	91-120	121-160	>160
	1.0	1.2	1.5	1.8	2.0

SOILS

Slope aspect	N, NW, NE	S, SW, SE	Plain
	1.0	2.0	1.0

Slope gradient (%)	<2	2 - 6	6-12	12-18	18-25	25-35	35-60	>60
	1.0	1.2	1.4	1.6	1.7	1.8	1.9	2.0

Soil depth (cm)	<15	15-30	30-60	60-100	100-1500	>150
	2.0	1.8	1.6	1.4	1.2	1.0

Soil textural class	Very coarse	Coarse	Medium	Moderate fine	Fine	Very fine
	2.0	1.8	1.6	1.2	1.3	1.4

Organic matter of surface horiz. (%)	High >6.0	Medium 2.1-6.0	Low 2.0-1.1	Very low <1.0
	1.0	1.3	1.6	2.0

VEGETATION

Agricultural cover type	Cereals	Olives	vines	almonds	oranges	vegetables	cotton	bare
	2.0	1.0	1.4	1.3	1.6	1.8	1.5	2.0

Natural vegetation cover type	Mixed Med. machia/ evergreen forest	Med. machia	Permanent grassland	Annual grassland	Deciduous Forest	Pine forest	Evergreen Forest	bare
	1.2	1.4	1.5	1.8	1.6	1.4	1.0	2.0

Plant cover (%)	<10	10-25	25-50	50-75	>75
	2.0	1.8	1.5	1.3	1.0

FIRES

Fire risk	Low	Moderate	High	Very high
	1.0	1.4	1.7	2.0

Burnt area (ha burnt/10 years/10 km^2 of territorial)	Low (<10 ha)	Moderate (10 -25 ha)	High (26 - 50 ha)	Very high (>50 ha)
	1.0	1.3	1.7	2.0

AGRICULTURE

Parallel employment	NO	industry	tourism	State	Municipality
	1.0	2.0	1.4	1.7	1.5

CULTIVATION

Tillage operations	NO	Plowing	Disking, harrowing	Cultivator
	1.0	2.0	1.7	1.4

Tillage depth (cm)	NO	<20	20-30	30-40	>40
	1.0	1.1	1.3	1.7	2.0

Tillage direction	Down-slope	Up-slope	Parallel to Contour up- slope furrow	Parallel to Contour down-slope furrow	Down-slope Oblique	Up-slope Oblique	Other (No tillage)
	2.0	1.4	1.2	1.5	1.8	1.3	1.0

HUSBANDRY

Grazing control	NO	Sustainable Number of animal	Fencing	Avoidance of soil compaction (very wet soil)	Fire Protection
	2.0	1.0	1.2	1.4	1.3

Grazing intensity	Low (SR<GC)	Moderate SR=GC to 1.5GC)	High (SR>1.5GC)
	1.0	1.5	2.0

LAND MANAGEMENT

Fire protection (Protected/total area %)	NO	Low <25%	Moderate 25-50%	High 50-75%	Very high >75%
	2.0	1.8	1.6	1.3	1.0

Sustainable farming	No Sustainable Farming	No tillage	Minimum Tillage	Inducing Plant cover	Up-slope tillage	Minimum plowing depth
	2.0	1.0	1.3	1.1	1.4	1.5

Soil water conservation measures	Weed control	Mulching	temporary storage of water runoff	inducing vapor adsorption	No
	1.0	1.0	1.0	1.2	2.0

Terracing (presence of) (area protected/total area, %)	NO	Low, <25%	Moderate, 25-50%	High, 50-75%	Very high, >75%
	2.0	1.7	1.5	1.2	1.0

LAND USE

Land abandonment (ha/10 years/10 km^2	Low (<10 ha)	Moderate (10 -25 ha)	High (26 - 50 ha)	Very high (>50 ha)
	1.0	1.3	1.6	2.0

Land use intensity	Low	medium	High
	1.0	1.5	2.0

(Period) of existing land use	<1 year	1-5 years	5-10 years	10-20 years	30-50 years	>50 years
	2.0	1.8	1.6	1.4	1.2	1.0

WATER USE

Runoff water storage	No	Low	moderate	adequate
	2.0	1.8	1.4	1.0

TOURISM

Tourism intensity	Low R<0.01	Moderate R=0.01-0.04	High R=0.04-0.08	Very high R>0.08

(number of overnight stays /10 km^2 =R)	1.0	1.3	1.7	2.0

SOCIAL

Population density (people / km^2)	Low <50	Moderate 50-100	High 100-300	Very high >300
	1.0	1.3	1.7	2.0

INSTITUTIONAL

Subsidies	NO	Sub/environ. Protection	sub/area	sub/animal	sub/kg
	1.2	1.0	2.0	2.0	2.0

Policy implementation	Adequate >75% of the area	Moderate (25-75% of the area)	Low (<25% of the area)	No
	1.0	1.4	1.7	2.0

7.2.2. LAND DESERTIFICATION ASSESSMENT

The sensitivity (vulnerability) to desertification has been assessed based on the MEDALUS project definition of Environmentally Sensitive Areas (ESAs). Four types of ESAs have been distinguished based on the stage of land degradation (Kosmas et al., 1999):

Critical ESAs: Areas already highly degraded through past misuse, presenting a threat to the environment of the surrounding areas, i.e. badly eroded areas subject to high run-off and sediment loss. This may cause appreciable flooding downstream and reservoir sedimentation.

Fragile ESAs: Areas in which any change in the delicate balance between natural and human activity is likely to bring about desertification. For example, a land use change (a shift towards cereals cultivation) on sensitive soils might produce immediate increase in run-off and erosion, and perhaps pesticide and fertilizer pollution downstream.

Potential ESAs**:** Areas threatened by or prone to desertification under significant climate change, if a particular combination of land use is implemented or where offsite impacts will produce severe problems elsewhere, for example pesticide transfer to downslope or downstream areas under variable land use or socio-economic conditions.

Non Threatened ESAs**:** Areas with deep to very deep soils, nearly flat, well drained, coarse-textured or finer textured soils, under semi-arid or wetter climatic conditions, independently of vegetation, are considered as being non-threatened by desertification.

The various types of ESAs to desertification have been defined by using certain key indicators or parameters for assessing the land capability to withstand further degradation, or the land suitability for supporting specific types of land use. For the evaluation of the environmentally sensitive areas to desertification four physical environment qualities are considered: soil quality, climate quality, vegetation quality and management quality (Kosmas et al., 1999) and (Figure 7.1). The indicators used for the above compilation are: soil texture, parent material, rock fragments, slope gradient, soil depth, soil drainage, annual rainfall, aridity index, slope aspect, fire risk, erosion protection, drought resistance, percentage of plant cover, land use intensity, and land policy enforcement. The physical environment qualities (soil quality, climate quality, vegetation quality) and the management quality have been combined in the following equation for calculation of the environmentally sensitivity index (ESAI) for the definition of the various types of ESAs to desertification.

$$ESAI = (SQI * CQI * VQI * MQI)^{1/4}$$

The ranges of ESAI for each of type of the ESAs including three subclasses in each type appear in Table 7.3. Each type of ESAs is defined on a three-point scale, ranging from 3 (high sensitivity) to 1 (lower sensitivity), in order that the boundaries of the successive classes of ESAs may be better integrated.

Table 7.3: *Types of ESAs and corresponding ranges of indices*

Type	Subtype	Range of ESAI
Critical	C3	>1.53
«	C2	1.42-1.53
«	C1	1.38-1.41
Fragile	F3	1.33-1.37
«	F2	1.27-1.32
«	F1	1.23-1.26
Potential	P	1.17-1.22
Non affected	N	<1.17

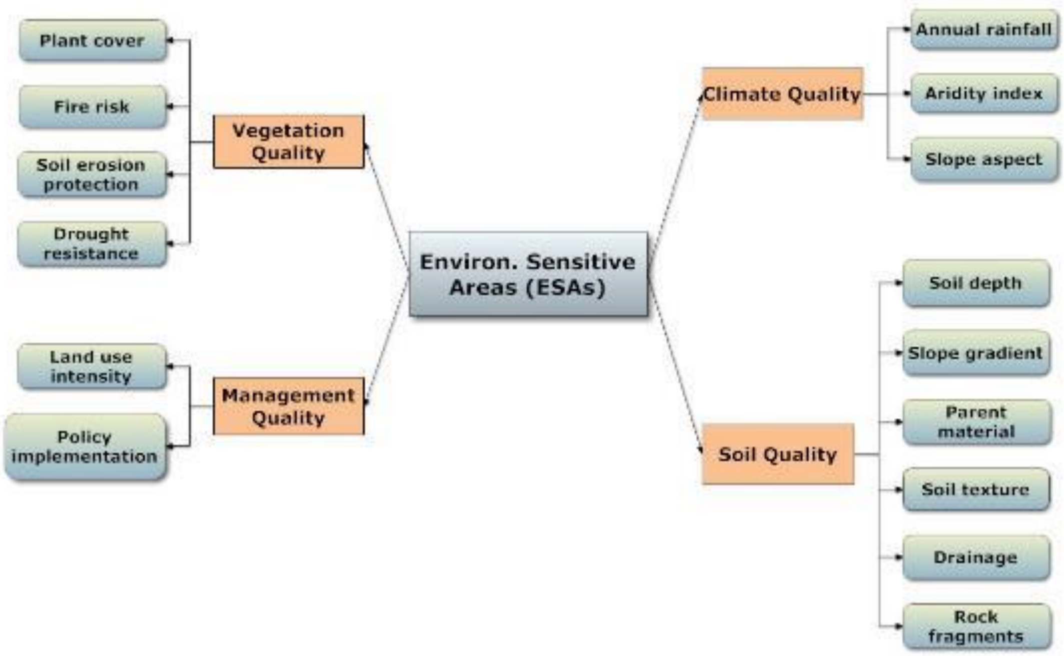


Figure 7.1: The indicators and qualities used for identification environmentally sensitive areas (ESAs) to desertification

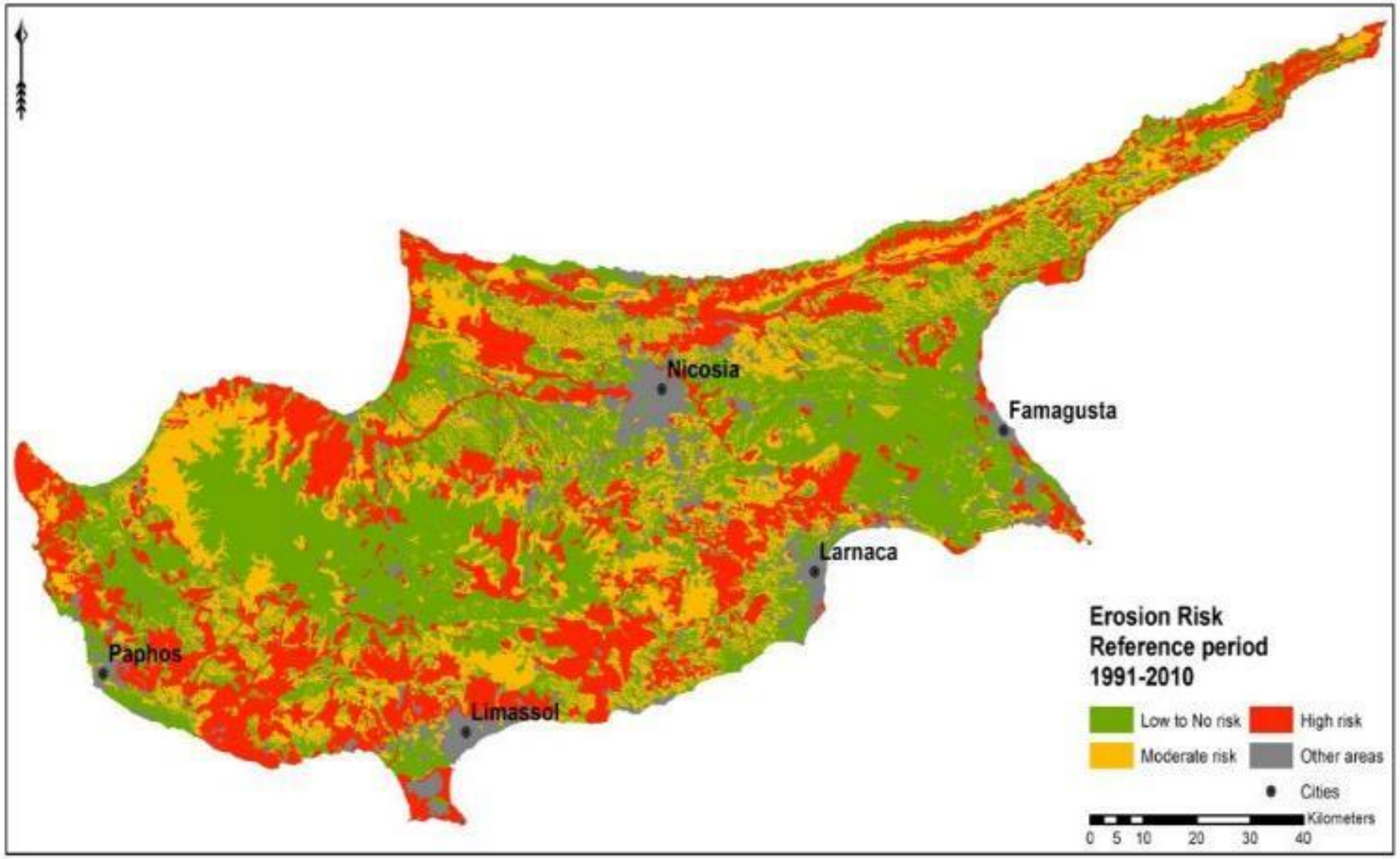
7.3. ANALYSIS OF LAND DEGRADATION AND DESERTIFICATION

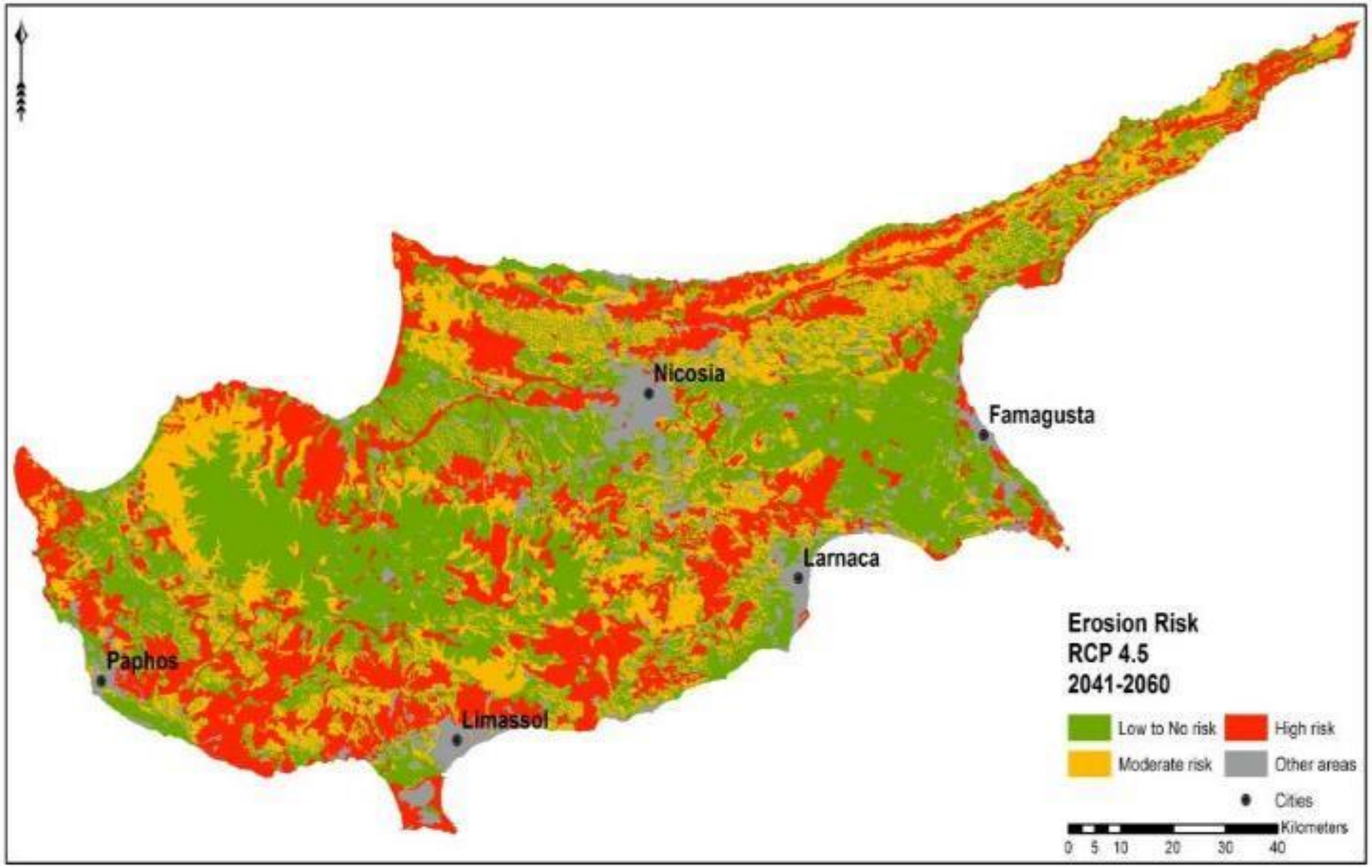
7.3.1. SOIL EROSION RISK ASSESSMENT

Climate projection RCP4.5

As Figure 7.2 shows the area of Cyprus is highly affected by soil erosion basically due to the sloping terrain. Based on the reference period climatic data, areas with high and moderate risk of soil erosion cover 26.6% and 23.5%, respectively (Table 7.4). However, a significant part of the island (43.3% of the total area) is characterized by low or no erosion risk. Soil erosion risk is expected to increase under the climate projection RCP4.5 for both periods (2041-2060, and 2071-2090). Areas with moderate erosion risk will increase from 23.5% to 24.2% in the period 2041-2060 to 26.4% in the period 2071-2090. Areas with low erosion risk are expected to decrease from 43.3% in the reference period to 41.5% in the period 2041-2060 and to 39.0% in the period 2071-2090. Areas characterized with high erosion risk are expected to remain unchanged.

The increase in erosion risk is expected due to the decrease in annual rainfall and the increase in air temperature adversely affecting rainfall seasonality and aridity index. The increase in aridity is expected to affect negatively plant cover and therefore surface rain water runoff and soil erosion will increase. The average aridity index, measured by Bagnouls-Gaussen index, is expected to change from 209.5 (reference period) to 248.7 in the period 2041-2060 to 269.2 in the period 2071-2090. The average rain seasonality index, derived by the Walsh and Lawler (1981) equation, is estimated to slightly increase from 0.78 (reference period) to 0.79 in 2041-2060 to 0.81 in 2071-2090.


Nicosia
Famagusta
Larnaca
Paphos
Limassol
Erosion Risk
Reference period
1991-2010
Low to No risk
High risk
Moderate risk
Other areas
Cities
Kilometers
0 5 10 20 30 40


Nicosia
Famagusta
Larnaca
Paphos
Limassol
Erosion Risk
RCP 4.5
2041-2060
Low to No risk
High risk
Moderate risk
Other areas
Cities
Kilometers
0 5 10 20 30 40

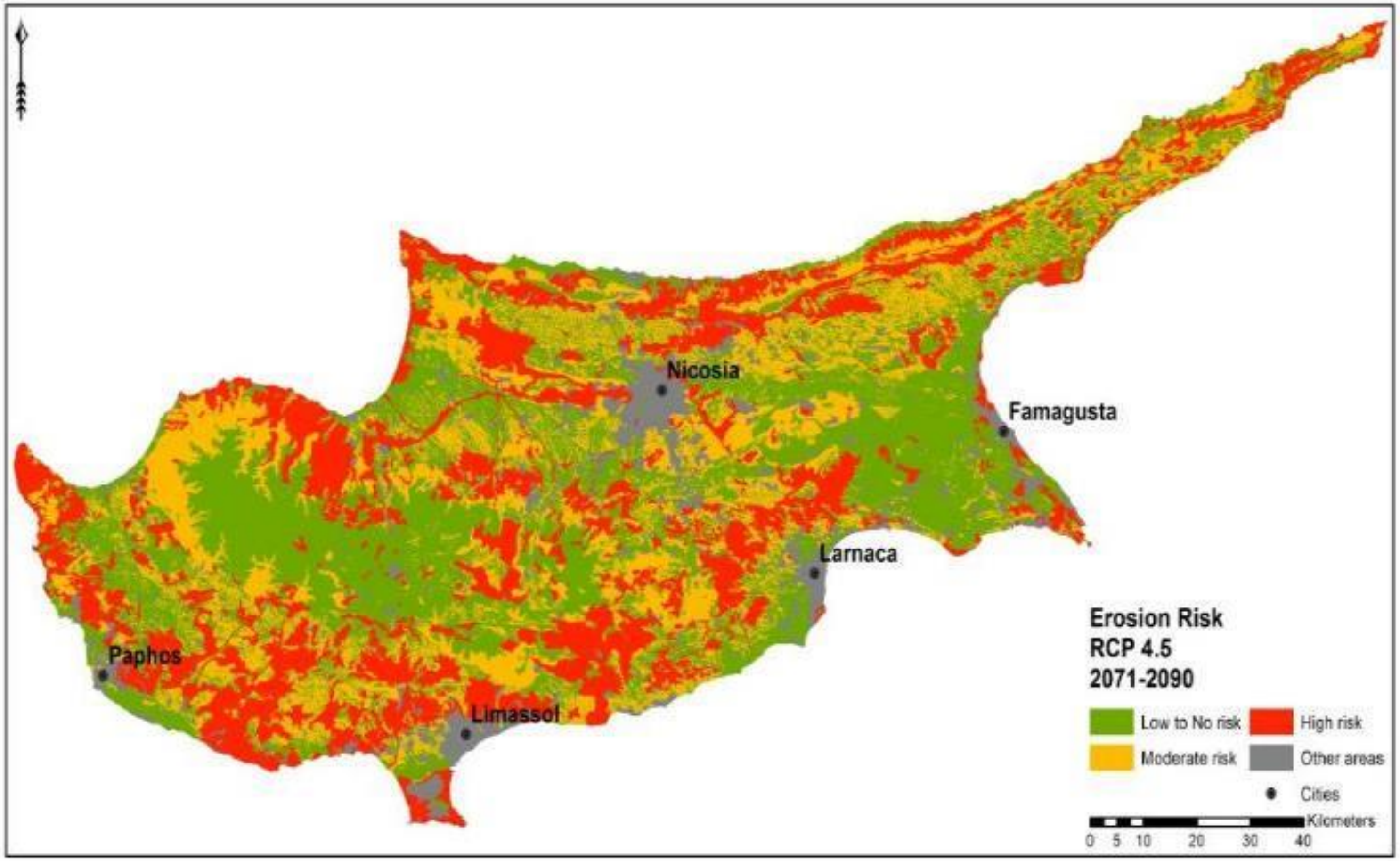


Figure 7.2: *Assessment of soil erosion risk for (a) reference period (upper), (b) period 2041-2060 (middle), and (c) period 2071-2090 (lower) for the climate projection RCP4.5.*

Table 7.4: *Distribution of erosion risk for the reference period, period 2041-2060 and period 2071-2090 for the climate projection RCP4.5*

Erosion risk	Reference period		Climate projection RCP4.5 (period 2041-2060)		Climate projection RCP4.5 (period 2071-2090)	
	area (ha)	area (%)	area (ha)	area (%)	area (ha)	area (%)
High	244877,1	26,6	244318,4	26,5	246187,5	26,7
Moderate	216772,9	23,5	223136,4	24,2	243223,6	26,4
Low-no risk	399494,7	43,3	382450,7	41,5	359099,5	39,0
Other areas	72144,9	7,8	72144,9	7,8	72144,9	7,8
TOTAL	922050,5	100,0	922050,5	100,0	922050,5	100,0

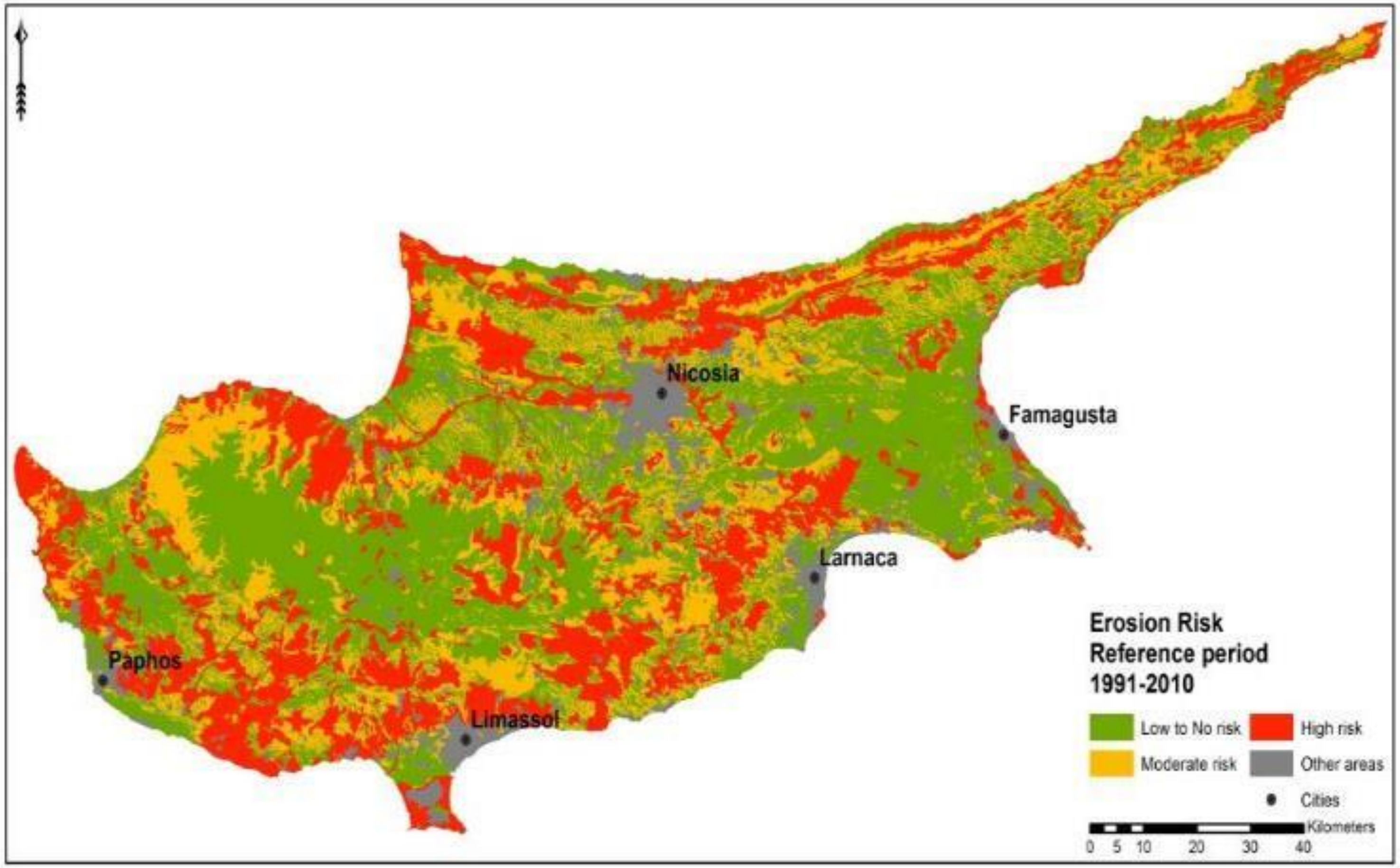
Climate projection RCP8.5

Similar trends with climate projection RCP4.5 have been assessed on soil erosion risk for the climate projection RCP8.5. The soil erosion risk is expected to be both higher compared to the reference period conditions and to climate projection RCP4.5 (Figure 7.3). As Table 7.5 shows, areas with low to no erosion risk will decrease from 43.3% in the reference period to 42.9% in the period 2041-2060 and to 37.4% in the period 2071-2090. Areas with high erosion risk will increase from 26.6% in the reference period to 27.0% in the period 2041-2090 and then a slight decrease to 26,3% is expected in the period 2071-2090. Areas characterized with moderate erosion risk will decrease from 23.5% in the reference period to 22.2% in the period 2041-2070 and then a significant increase to 28.5% is expected for the period 2071-2090.

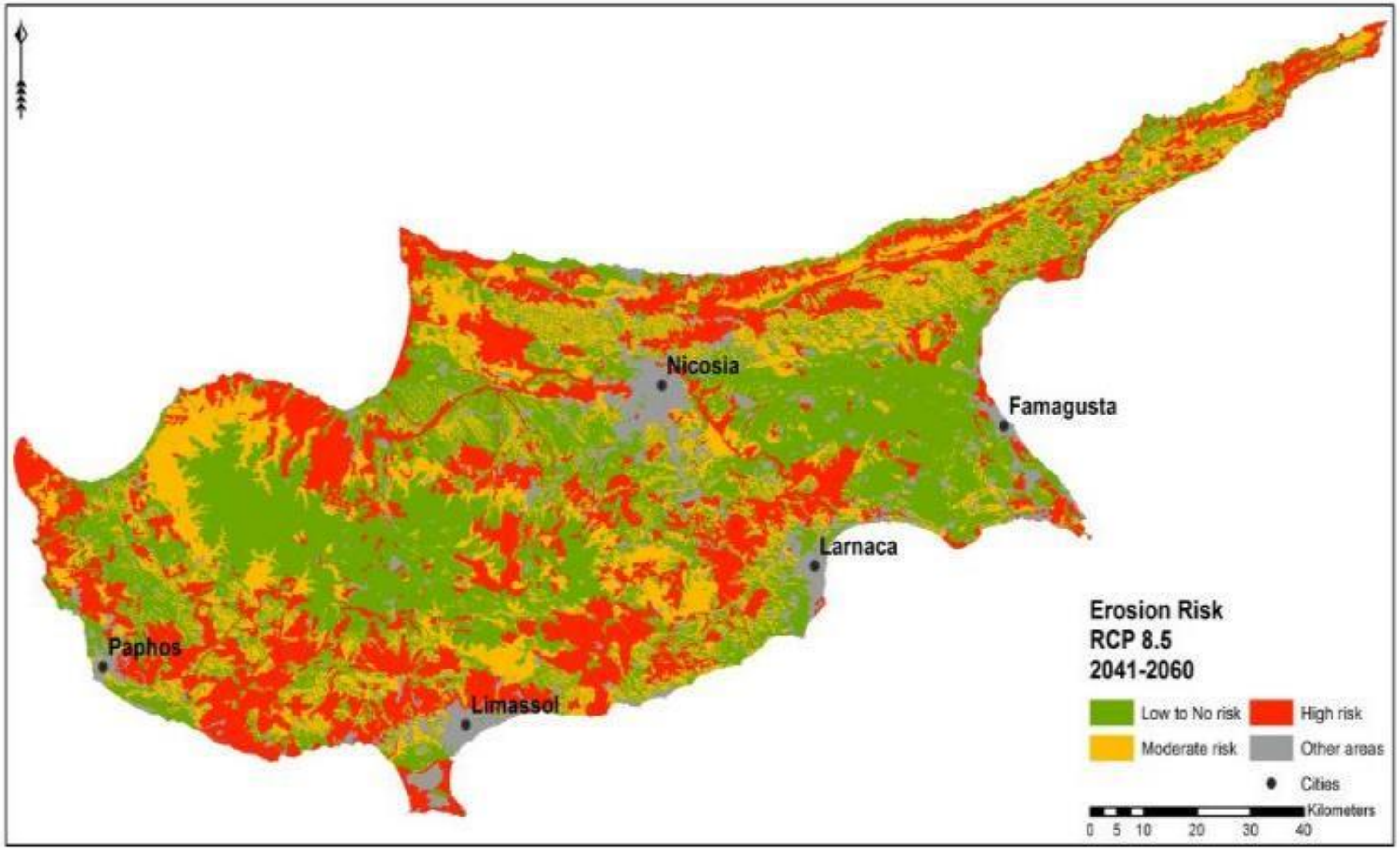
Regarding climate projection RCP4.5, the increase in erosion risk is expected due to the decrease in the annual rainfall and the increase in air temperature adversely affecting rainfall seasonality and aridity index. The average aridity index, measured by Bagnouls-Gaussen index, is expected to change from 209.5 (reference period) to 264.4 in the period 2041-2060 to 290.6 in the period 2071-2090. The rain seasonality index, derived by the Walsh and Lawler (1981) equation, is estimated to increase from 0.78 (reference period) to 0.84 in 2041-2060 and then to decrease to 0.75 in 2071-2090.

Table 7.5: *Distribution of erosion risk for the reference period, period 2041-2060 and period 2071-2090 for the climate projection RCP8.5*

Erosion risk	Reference period		Climate projection RCP8.5 (period 2041-2060)		Climate projection RCP8.5 (period 2071-2090)	
	area (ha)	area (%)	area (ha)	area (%)	area (ha)	area (%)
High	244877,1	26,6	248753,5	27,0	242699,2	26,3
Moderate	216772,9	23,5	204597,6	22,2	262659,7	28,5
Low-no risk	399494,7	43,3	395059,5	42,9	344546,7	37,4
Other areas	72144,9	7,8	72144,9	7,8	72144,9	7,8
TOTAL	922050,5	100,0	922050,5	100,0	922050,5	100,0



Nicosia
Famagusta
Larnaca
Paphos
Limassol
Erosion Risk
Reference period
1991-2010
Low to No risk
High risk
Moderate risk
Other areas
Cities
Kilometers
0 5 10 20 30 40



Nicosia
Famagusta
Larnaca
Paphos
Limassol
Erosion Risk
RCP 8.5
2041-2060
Low to No risk
High risk
Moderate risk
Other areas
Cities
Kilometers
0 5 10 20 30 40

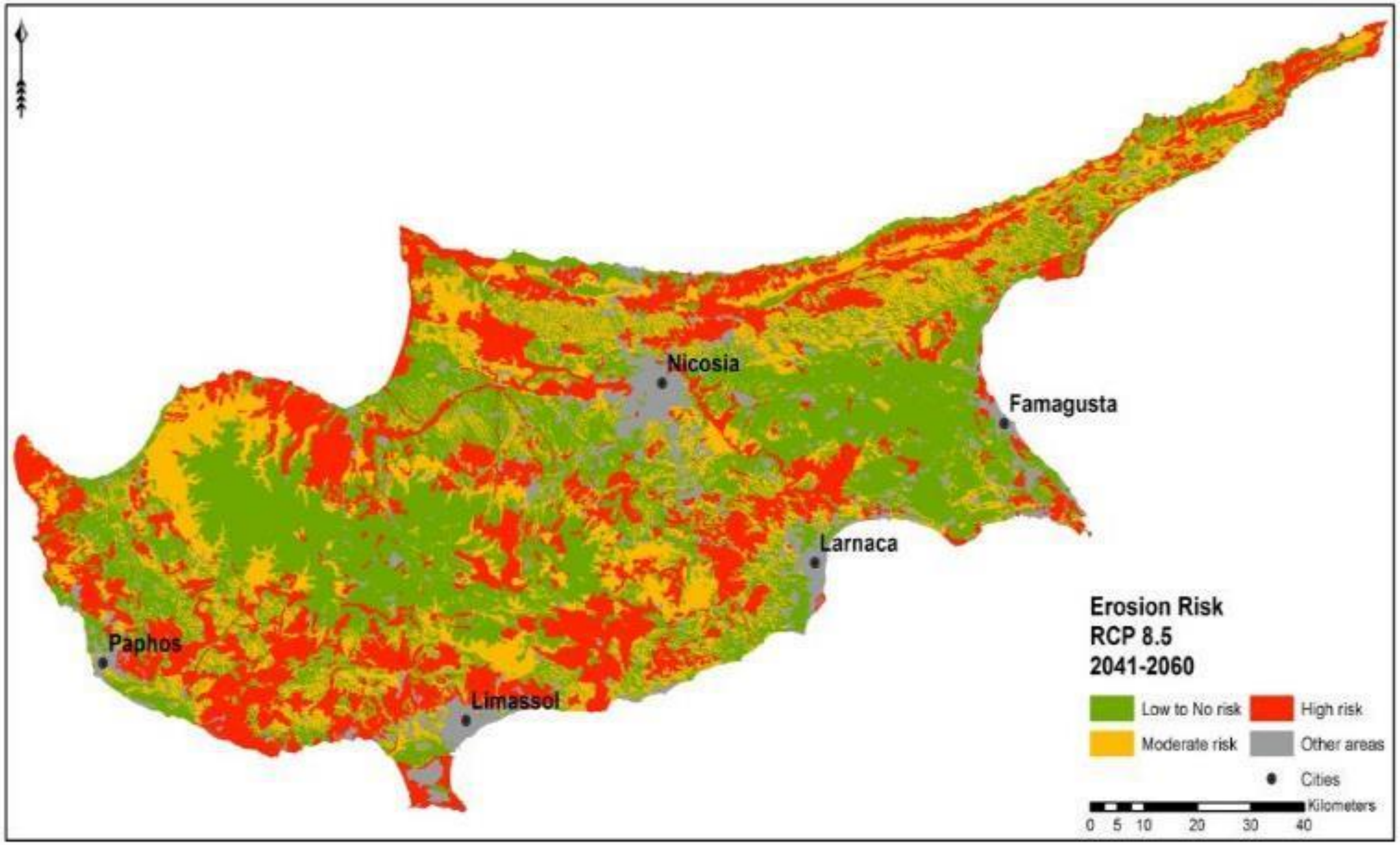


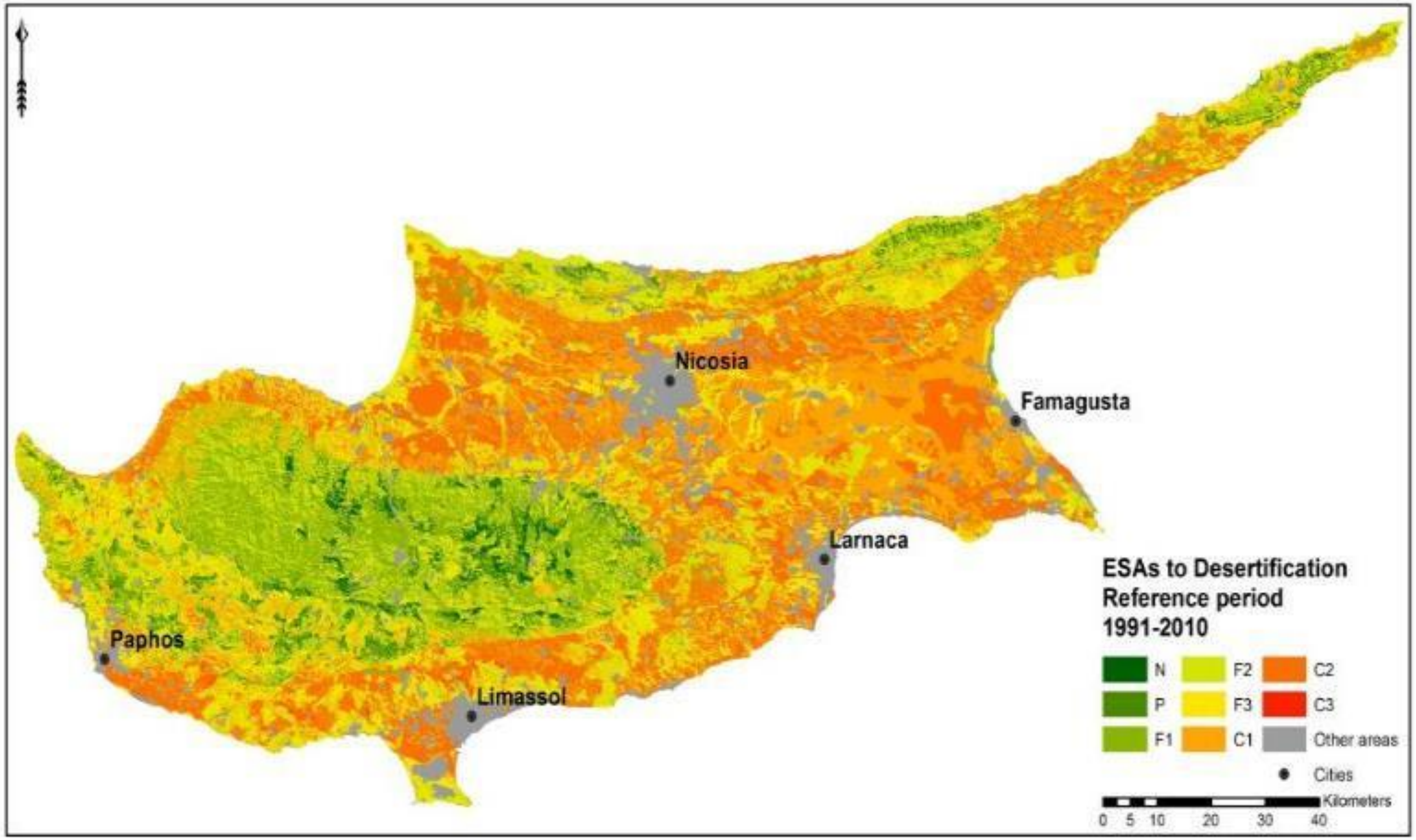
Figure 7.3: *Assessment of soil erosion risk for (a) the reference period (upper), (b) period 2041-2060 (middle), and (c) period 2071-2090 (lower) for the climate projection RCP8.5*

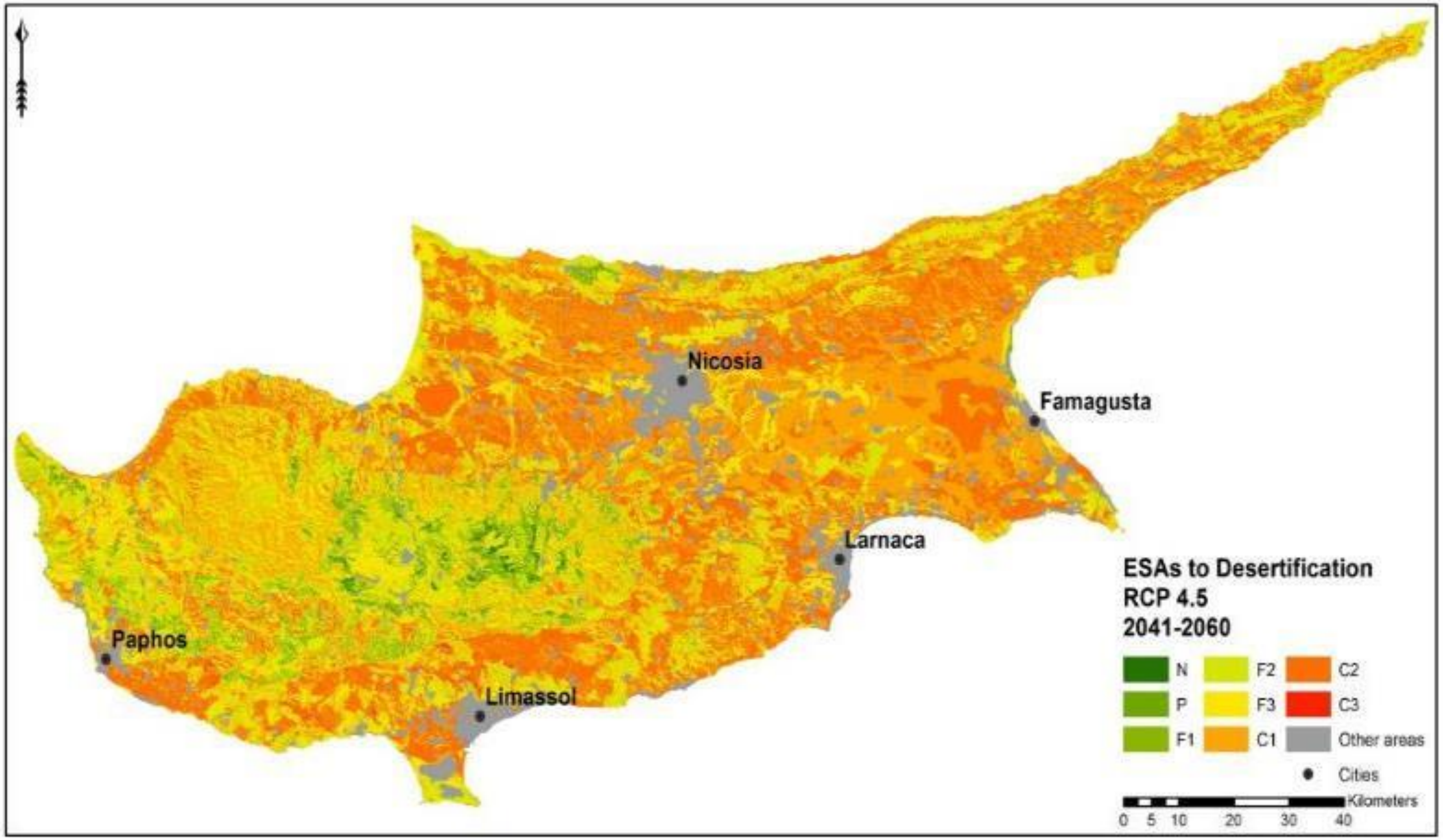
7.3.2. LAND DESERTIFICATION RISK ASSESSMENT

Climate projection RCP4.5

The island of Cyprus is mainly characterized by critical and fragile type areas to desertification (Figure 7.4), covering 42.9% and 44.6% of the total land, respectively. Potentially non-threatened areas to desertification cover only 3.9% and 0.8% of the land, respectively (Table 7.6). The expected decrease in the rainfall and the increase in air temperature accompanied by an increase in aridity index will result in the increase of the vulnerability to desertification in the whole island of Cyprus.

Some areas which are characterized as prone to desertification under the reference period climatic conditions will change to fragile, while areas characterized as fragile are expected to change in critical to desertification. Areas critical to desertification are expected to increase from 42.9% (reference period) to 52.0% in the period 2041-2060 to 54.9% in the period 2071-2090. In addition, areas characterized as critical sub-type C2 is expected to increase from 19.6% (reference period) to 24.4% in the period 2041-2060 to 27.7% in the period 2071-2090. This change is mainly expected from the conversion of critical sub-type C1 to critical sub-type C2 due to the increasing aridity. However, critical areas to desertification sub-type C1 are expected to increase due to the increased vulnerability to desertification of the fragile sub-type F3 areas. Areas prone to desertification are expected to decrease from 3.9% (reference period) to 1.4% and 1.1%, and fragile sub-type F1 from 11.3% (reference period) to 3.3% and 2.8% in the periods 2041-2060 and 2071-2090, respectively, and to be converted mainly to fragile sub-types F2 and F3 (Table 7.6).


Nicosia
Famagusta
Larnaca
Paphos
Limassol
ESAs to Desertification
Reference period
1991-2010
N
P
F1
F2
F3
C1
C2
C3
Other areas
Cities
Kilometers
0 5 10 20 30 40


Nicosia
Famagusta
Larnaca
Paphos
Limassol
ESAs to Desertification
RCP 4.5
2041-2060
N
F2
C2
P
F3
C3
F1
C1
Other areas
Cities
Kilometers
0 5 10 20 30 40

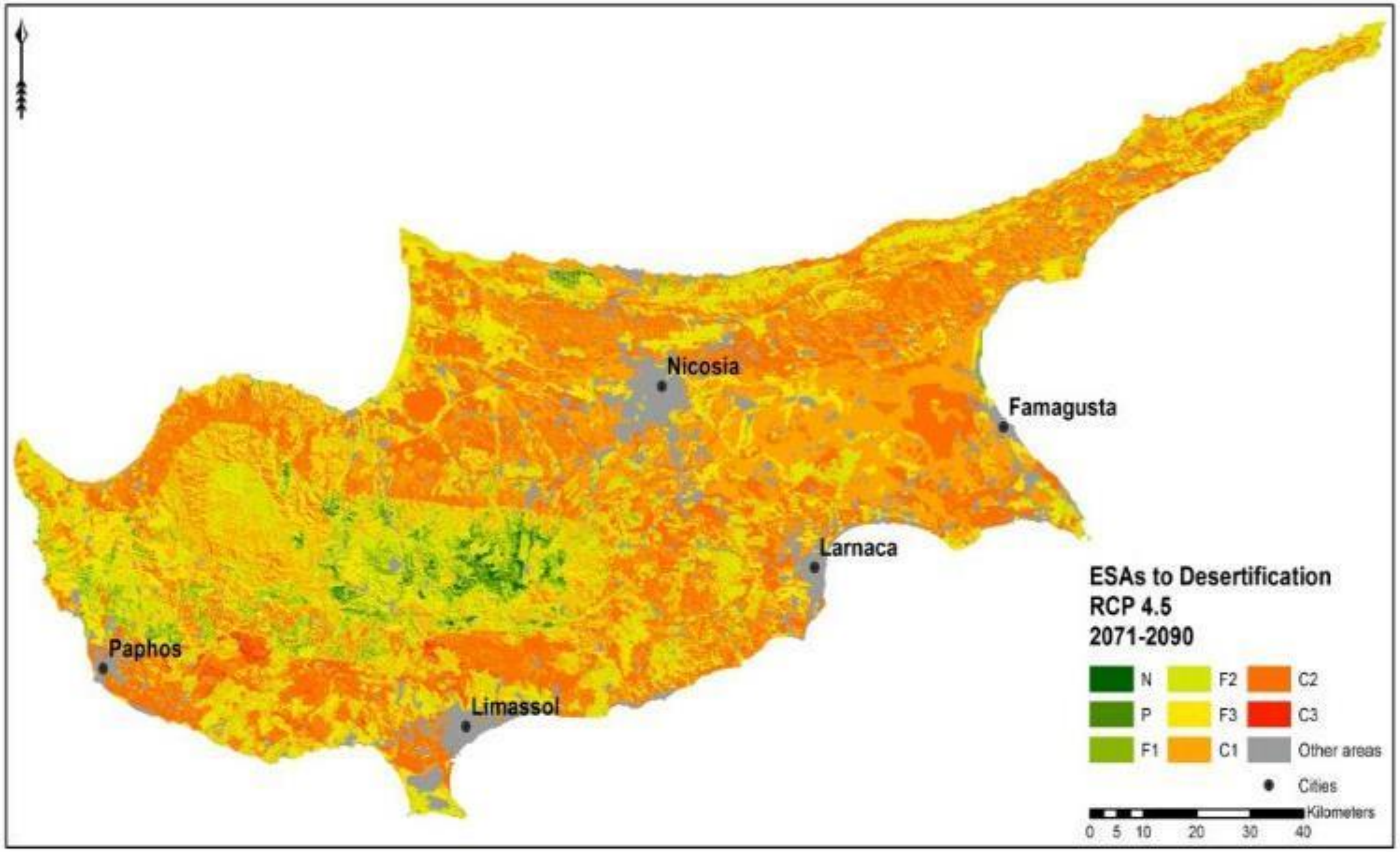


Figure 7.4: *Assessment of land desertification (a) the reference period (upper), (b) the period 2041-2060 (middle), and (c) the period 2070-2095 (lower) for the climate projection RCP4.5*

***Table 7.6**: Distribution of environmentally sensitive areas to desertification for the reference period, period 2041-2060 and period 2071-2090 for the climate projection RCP4.5*

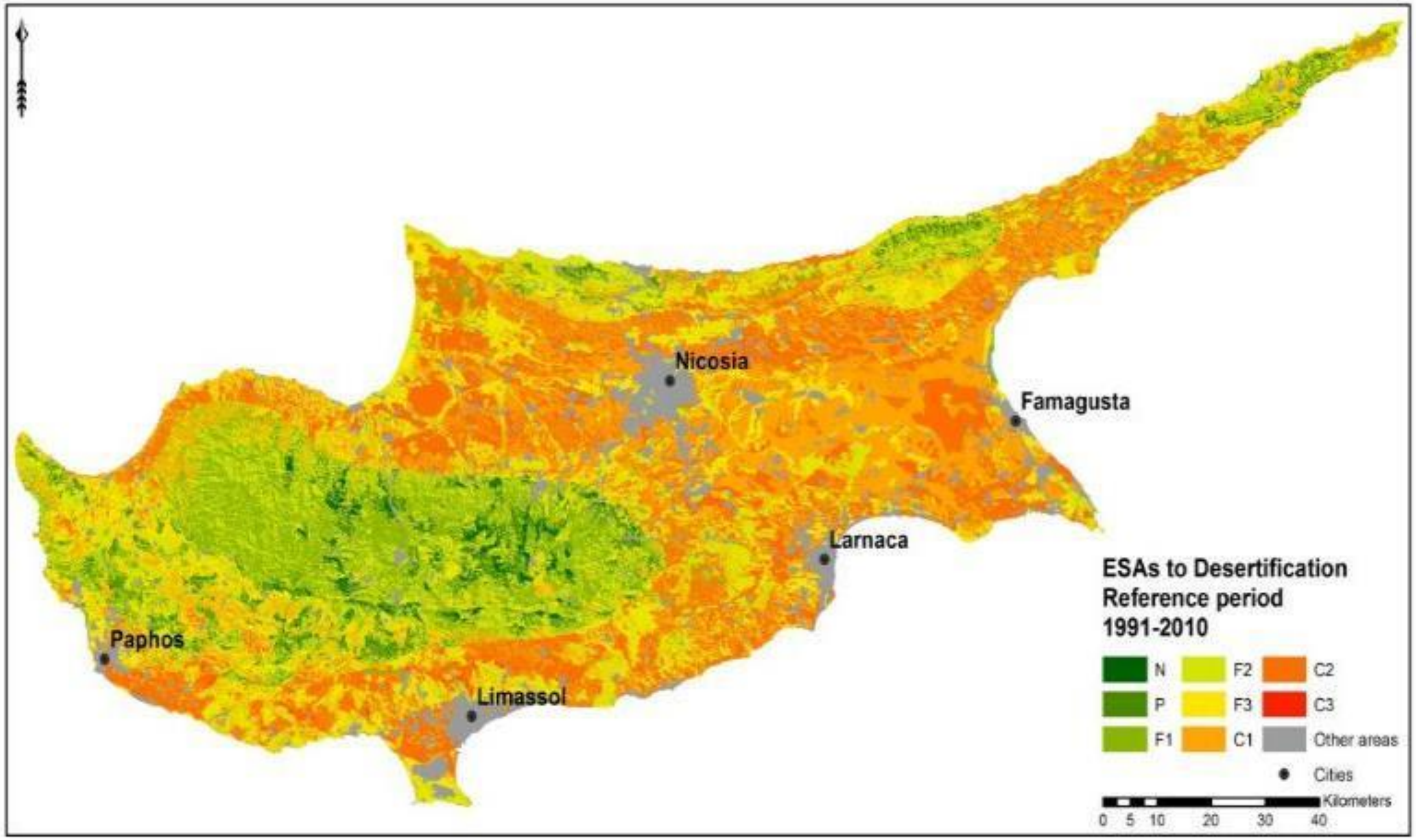
Environmentally sensitive areas to desertification (ESAs)	Reference period		Climate projection RCP4.5 (period 2041-2060)		Climate projection RCP4.5 (period 2071-2090)	
	area (ha)	area (%)	area (ha)	area (%)	area (ha)	area (%)
Critical-C3	452,1	0,1	646,7	0,1	1809,6	0,2
Critical-C2	181000,0	19,6	225305,0	24,4	249360,3	27,0
Critical-C1	214132,9	23,2	253736,2	27,5	255099,7	27,7
Fragile-F3	121303,9	13,2	168676,2	18,3	161389,3	17,5
Fragile-F2	185660,5	20,1	157161,3	17,0	144823,3	15,7
Fragile-F1	104167,7	11,3	30134,1	3,3	25615,9	2,8
Potential-P	36207,2	3,9	12694,3	1,4	9994,7	1,1
No threatened-N	6981,3	0,8	1551,8	0,2	1813,0	0,2
Other areas	72144,9	7,8	72144,9	7,8	72144,9	7,8
TOTAL	922050,5	100,0	922050,5	100,0	922050,5	100,0

Climate projection RCP8.5

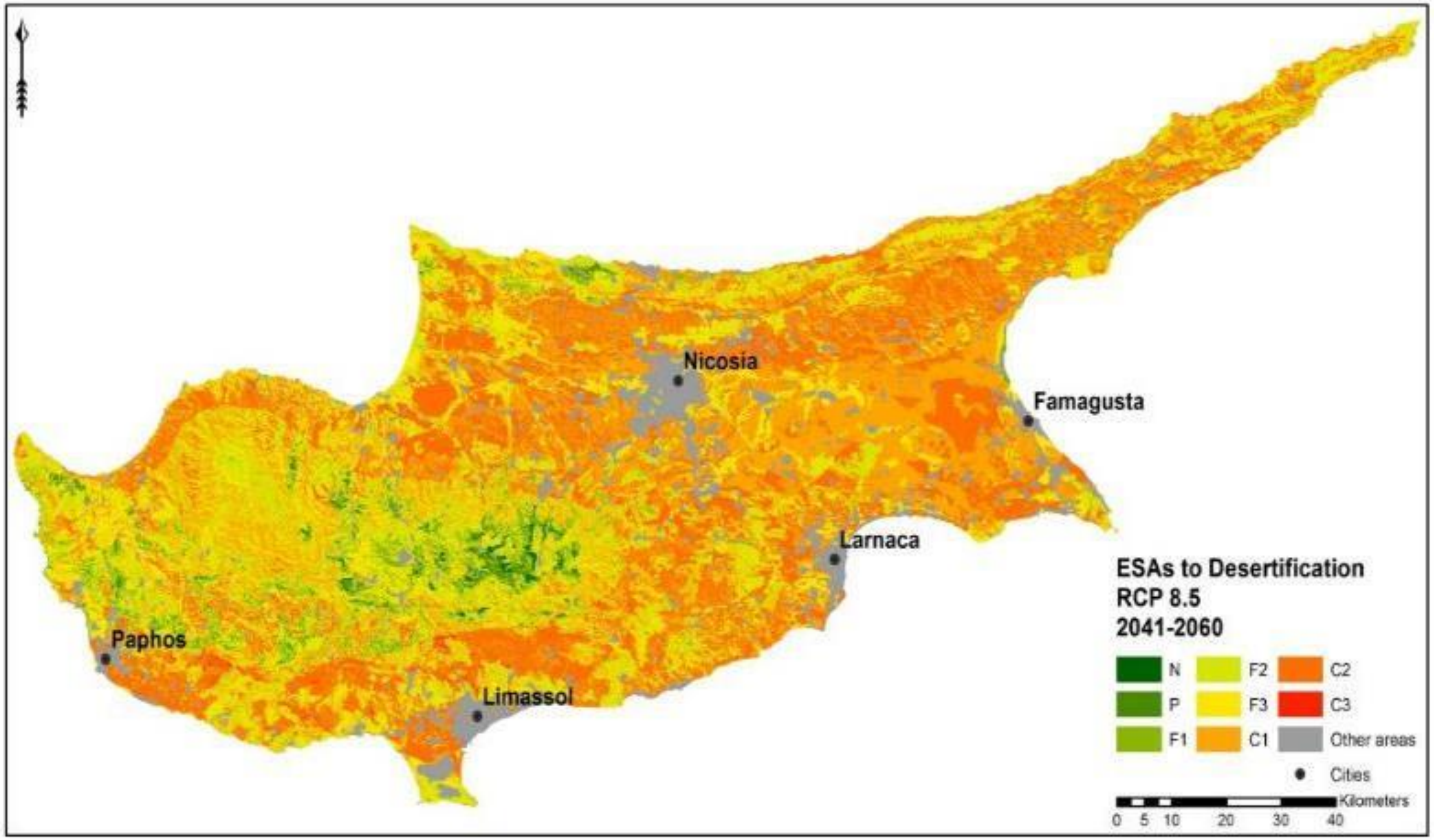
The analysis of the climatic data of climate projection RCP8.5 has shown that the hazard of land desertification risk is expected to increase as in the climate projection RCP4.5 (Figure 7.5). Critical areas to desertification are expected to increase from 42.9% of the total land (reference period) to 52.3% in the period 2041-2060 and to 55.5% in the period 2071-2090. In addition, fragile areas are expected to decrease from 44.6% (reference period) to 38.3% in the period

2041-2090 and 35,9% in the period 2071-2090. Generally, the expected decrease in rainfall and increase in air temperature will increase aridity index and therefore vulnerability to desertification if it is considering that the other parameters remain approximately constant.

Areas characterized as critical sub-type C2 are expected to increase from 19.6% (reference period) to 24.9% in the period 2041-2060 to 27.5% in the period 2071-2090. This change is mainly expected from the conversion of the critical sub-type C1 to critical sub-type C2. However, critical areas to desertification sub-type C1 are expected to increase due to mainly the expected vulnerability increase to desertification of the fragile sub-type F3 areas. The sub-type F3 is expected to change from 13.2% (reference period) to 18.0% in the period 2041-2070 and then to 17.3% in the period 2071-2010. As in climate projection RCP4.5, areas prone to desertification are expected to decrease from 3,9% (reference period) to 1,3% and 1,0%, and fragile sub-type F1 from 11.3% (reference period) to 3.3% and 2,6% in the periods 2041-2060 and 2071-2090, respectively, and converted mainly to fragile sub-types F2 and F3 (Table 7.6).



Nicosia
Famagusta
Larnaca
Paphos
Limassol
ESAs to Desertification
Reference period
1991-2010
N
F2
C2
P
F3
C3
F1
C1
Other areas
Cities
Kilometers
0 5 10 20 30 40



Nicosia
Famagusta
Larnaca
Paphos
Limassol
ESAs to Desertification
RCP 8.5
2041-2060
N
P
F1
F2
F3
C1
C2
C3
Other areas
Cities
Kilometers
0 5 10 20 30 40

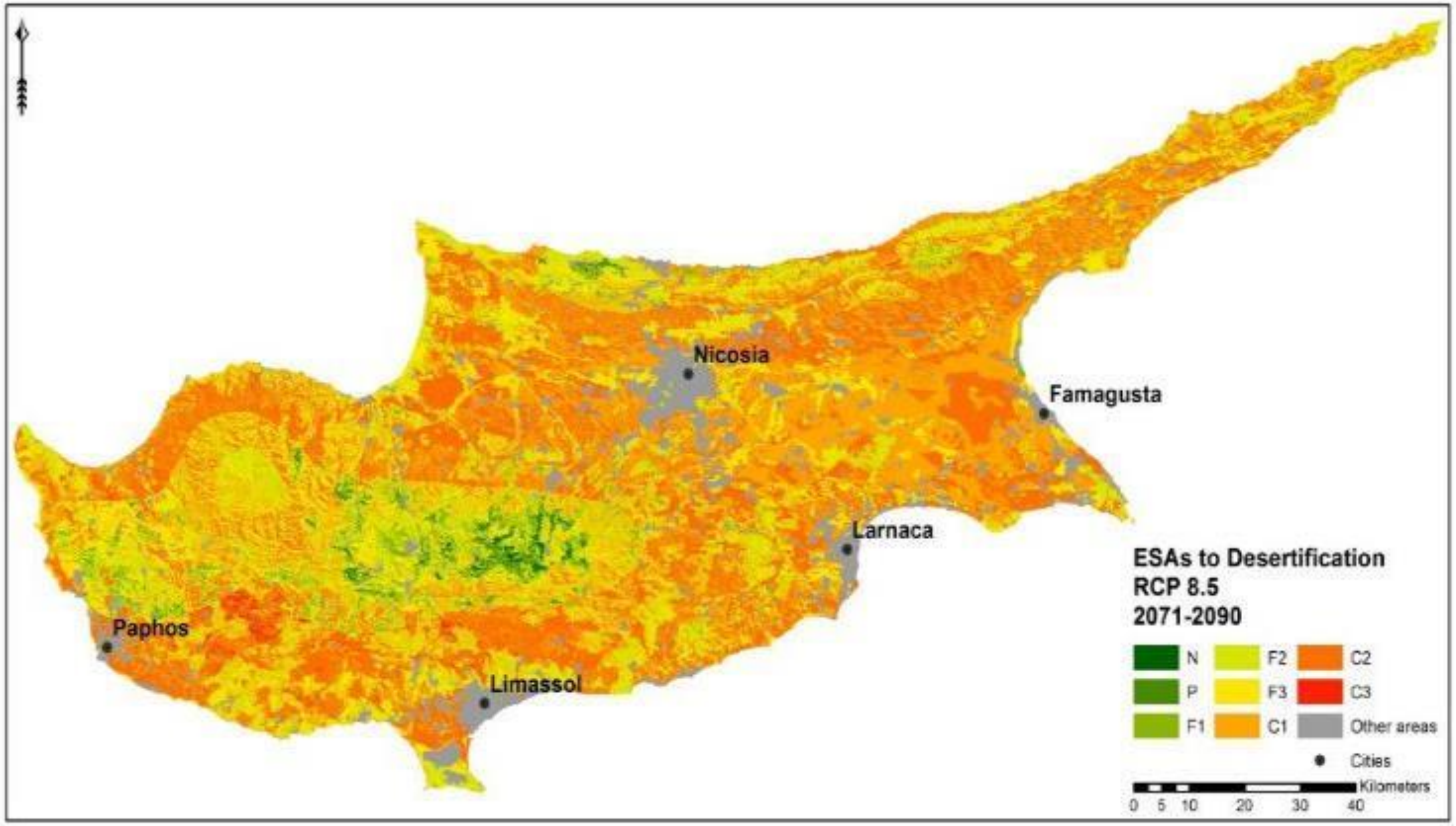


Figure 7.5: *Assessment of land desertification (a) the reference period (upper), (b) the period 2041-2060 (middle), and (c) the period 2070-2095 (lower) for the climate projection RCP8.5*

Table 7.7: *Distribution of environmentally sensitive areas to desertification for the reference period, period 2041-2060 and period 2071-2092 for the climate projection RCP8.5*

Environmentally sensitive areas to desertification (ESAs)	Reference period		Climate projection RCP8.5 (period 2041-2060)		Climate projection RCP8.5 (period 2071-2090)	
	area (ha)	area (%)	area (ha)	area (%)	area (ha)	area (%)
Critical-C3	452,1	0,1	1014,5	0,1	2626,6	0,3
Critical-C2	181000,0	19,6	229834,5	24,9	253679,9	27,5
Critical-C1	214132,9	23,2	251991,4	27,3	253122,3	27,5
Fragile-F3	121303,9	13,2	166326,8	18,0	159089,6	17,3
Fragile-F2	185660,5	20,1	156405,7	17,0	146100,0	15,8
Fragile-F1	104167,7	11,3	30355,6	3,3	24241,6	2,6
Potential-P	36207,2	3,9	12129,6	1,3	9376,9	1,0
No threatened	6981,3	0,8	1847,5	0,2	1668,5	0,2
Other areas	72144,9	7,8	72144,9	7,8	72144,9	7,8
TOTAL	922050,5	100,0	922050,5	100,0	922050,5	100,0

8. RISKS FOR WATER RESOURCES

8.1. OVERVIEW OF THE SECTOR

The morphology of Cyprus is dominated by the following morphological units:

- The Troodos Mountain Complex.
- The northern mountain range (Pentadaktylos).
- The central plain (Mesaoria).
- The hilly area around the Troodos mountain complex.
- The coastal plains.

Cyprus has an intense Mediterranean climate with typical seasonal variation according to temperature, rainfall and weather generally. Fast changes in weather characterize autumn and spring, which are short and separate the hot, dry summers lasting from mid-May to mid-September and the rainy, rather changeable winters, which last from November to mid-March. Due to its island nature, Cyprus depends solely on rainfall, as far as natural water resources are concerned. In recent years, the artificial production of desalinated water has been added to the water resources potential.

The rainfall varies with latitude and altitude. Thus, in the eastern part of the island, the Famagusta district, the average annual rainfall is 320 mm and is increasing westward, reaching in Pafos 540 to 550 mm. Within the same catchment area, however, rainfall is increasing significantly with altitude. For example, in the Pafos area, the average annual rainfall varies from about 400mm in the coastal areas to more than 700mm in the mountains. Besides the spatial variability, the annual precipitation has extremely high temporal variability.

On average, 80% to 85% of the rainfall returns to the atmosphere as evapotranspiration. This percentage is possible to reach up to 95% in the driest years. This means that, in terms of annual contributions to water resources, the variability of rainfall is enhanced by the increase of the evapotranspiration as rainfall diminishes. The result is that during the dry years, the volumes of water added to the resources is sub multiple of the mean annual average.

In terms of runoff, the decisive factor is the Troodos Mountain from which numerous large and small rivers originate. The total of 25 significant, in terms of runoff, rivers and streams originate from the mountains of Troodos. The total average runoff in Cyprus is around 250 to 300 x10^6 m^3 annually. Part of this runoff contributes to the groundwater supply. Hydrographically, the island of Cyprus is subdivided into 9 hydrological regions made up of 70 river basins and 387 sub-basins. The area under the control of the government includes 47 river basins. It should be stressed that most watercourses termed “rivers” in Cyprus exhibit non-permanent flow and, given their size, would be called “streams” in countries with larger surface area and bigger basins. Thus, a sense of proportionality should be always borne in mind when considering the Cyprus river basins in the context of systems used by countries such as the UK.

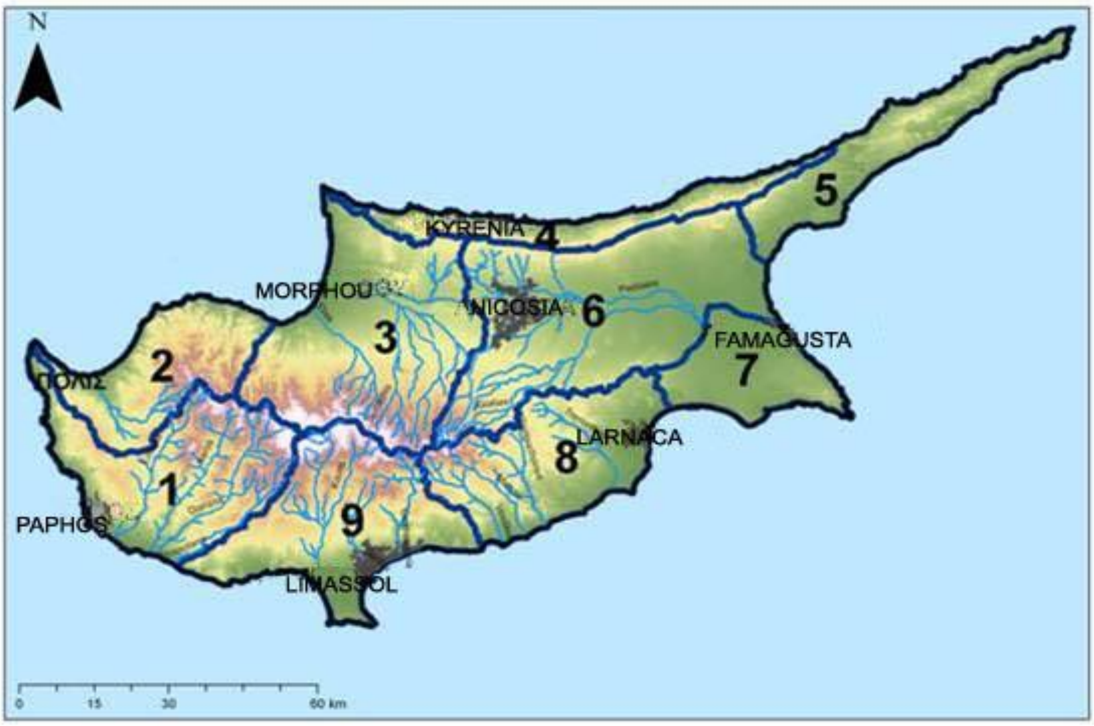


Figure 8.1: *Cyprus River Basins* (source: WDD 2015)

In terms of aquifers, 20 of the 21 groundwater bodies of Cyprus, within the areas under effective government control, are either contained within the Troodos Mountain, or directly supplied by runoff coming from this mountain range. An exception is the groundwater body of Kokkinochoria in the Famagusta district. However, this also, but to a lesser extent, is fed by the river Gialias which originates from the Troodos mountain.

According to 2008-2013 data, it is estimated that the natural recharge of ground water bodies in the area where effective control is exercised by the Government of the Republic, is $220x10^6$ m^3 annually. In the natural recharge, the volumes of artificial recharge with fresh (Yermasoyia) and recycled water (Paphos - Ezousa) is included.

8.2. WATER RESOURCES AND CONSUMPTION

8.2.1. RESOURCES

The main water supply sources in Cyprus are the dams and their reservoirs, groundwater sources, via boreholes, the desalination plants and recycled water.

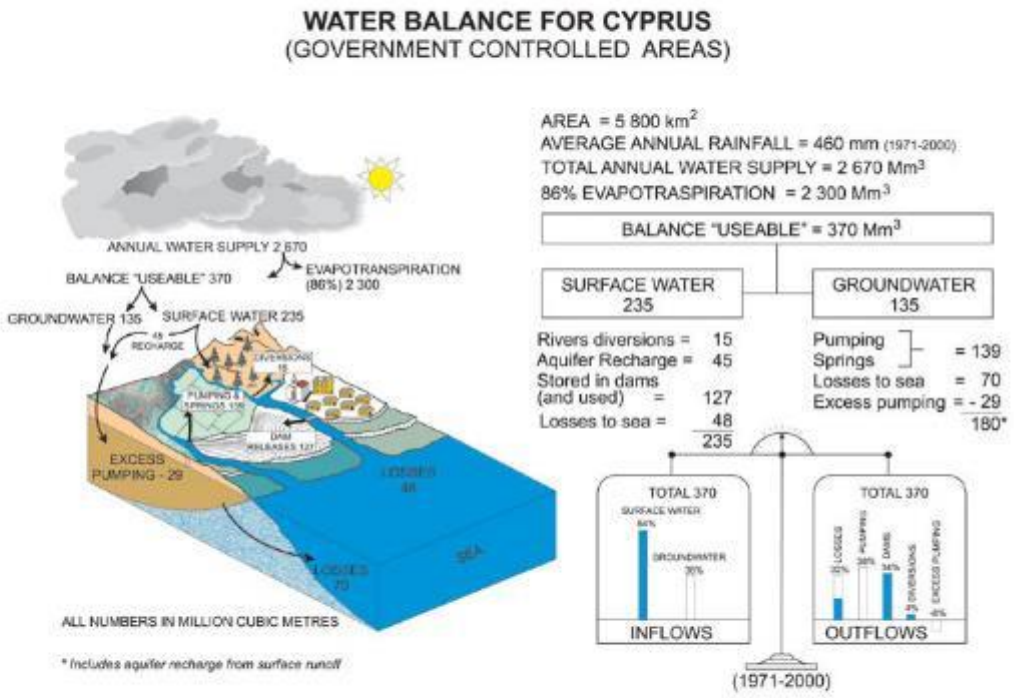


Figure 8.2: *Water Balance for Cyprus (in the Government controlled areas* (source: WDD 2015, website)

The water supply to different users - consumers is, primarily, through Government owned and run Water-Works (GWW) which include, dams, water treatment plants, desalination plants, groundwater recharge facilities and production boreholes, trunk pipelines for water supply and irrigation and primary distribution systems, including those for recycled water.

The main responsible government agency is the Water Development Department (WDD) as the primary service provider (supplier of water) for the essential water uses (supply of drinking water to wholesale or retail consumers) and Irrigation (fresh-not filtered water for various uses and recycled water for restricted uses).

GWWs operate almost as autonomous systems - complexes regarding drinking water supply and irrigation. They are grouped as follows:

Large GWWs (operated by the WDD):

A. The GWW included in the Integrated Project of the Southern Conveyor Project (South Conveyor, Irrigation Project (IP) of Vasilikos-Pentashinos, IP of Germasogeia-Polemidia, IP of Akrotiri, IP of Kiti - Mazotos - Alaminos, IP of Athienou, IP of Kokkinochoria, Governmental Water System (GWS) of Limassol, GWS of Yermasoyia acquifer, GWS of Nicosia, GWS of Larnaka - Famagusta) .

B. The GWW of Pafos**,** which includes the IP of Pafos and the GWS of Pafos.

C. The GWW of Chrysochous on the northwest side of the island, which includes the IP of Chrysochous, Ayia Marina, Argaka and Pomos. In the same area is the dam of Pyrgos, which irrigates areas of Pyrgos and it is part of the Significant Non G.W.W.

Other small GWW:

D. Smaller G.W.W.s like the Irrigation Projects in the area of Nicosia (Xyliatos, Vyzakia, Lymbia, Kalopanagiotis) groundwater recharge projects such as those based on Tamasos and Akaki-Malounta dams, and the Irrigation Project of Karkoti which includes the Dam of Solea and the irrigation project of Avdimou – Paramali in Limassol area.

The groundwater systems used for water supply are: Treminthos (CY-03A), Mari-Kalo Chorio (CY-06), Akrotiri (CY-09), Paramali-Avdimou (CY-10), Pafos (CY-11A), Letimvou-Giolou (CY-12), Androlikou (CY-14), Chrysochou-Gyalia (CY-15A), Pyrgos (CY-16), Central and Western Mesaoria (CY-17), Lefkara-Pahna (CY-18), Troodos (CY-19) και MYTS1.

A number of desalination plants are operational namely, those of Larnaka, Dekelia, Episkopi (Limassol) and Vassilikos. They have a combined maximum treatment capacity of 222.000 m^3/day or ~73 hm^3/year.

Tertiary treatment of wastewater has been installed in the following WwTPs: Limassol, Pafos, Agia Napa, Larnaka, Anthoupolis (Nicosia), Vathia Gonia (WDD), with a total capacity of 135.700 m^3/day. The main areas that are irrigated by reused water are: Fassouri, Pareklissia, Pentakomo, Agios Georgios Alamanou, Larnaka (Dromolaxia), Greater Area of Nicosia (the latter from the WwTP of Vathia Gonia).

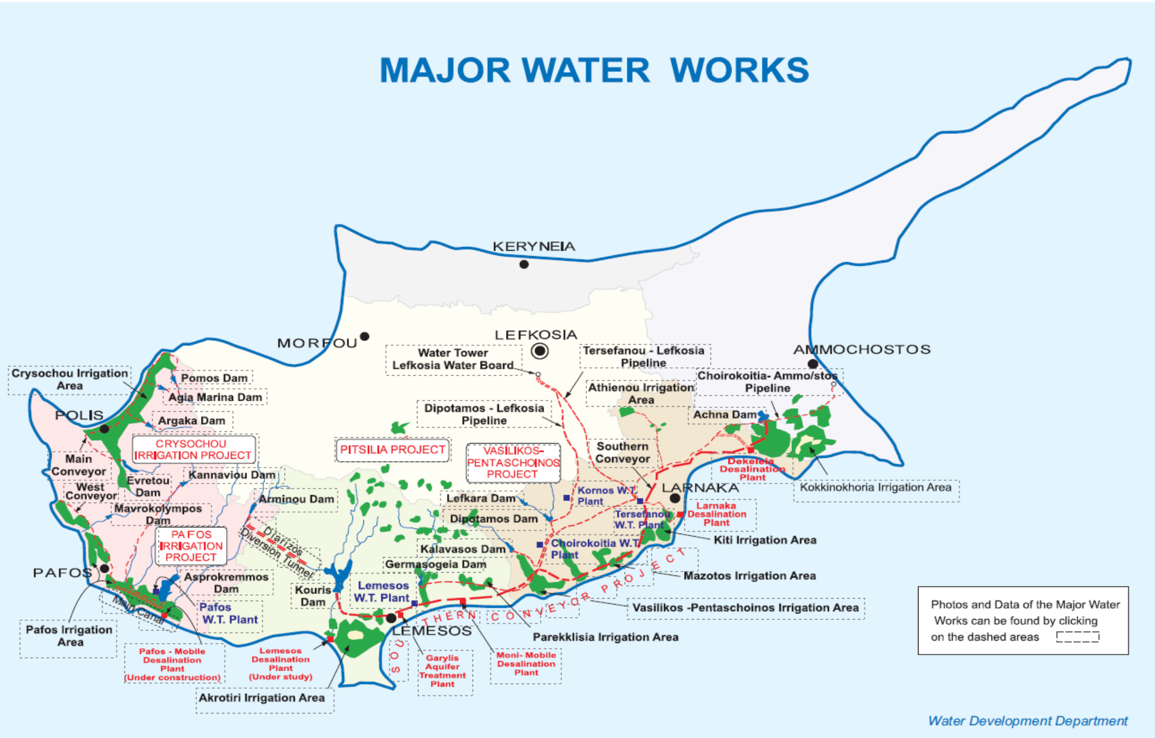


Figure 8.3: *Major Water Works in Cyprus (source: WDD, 2015)*

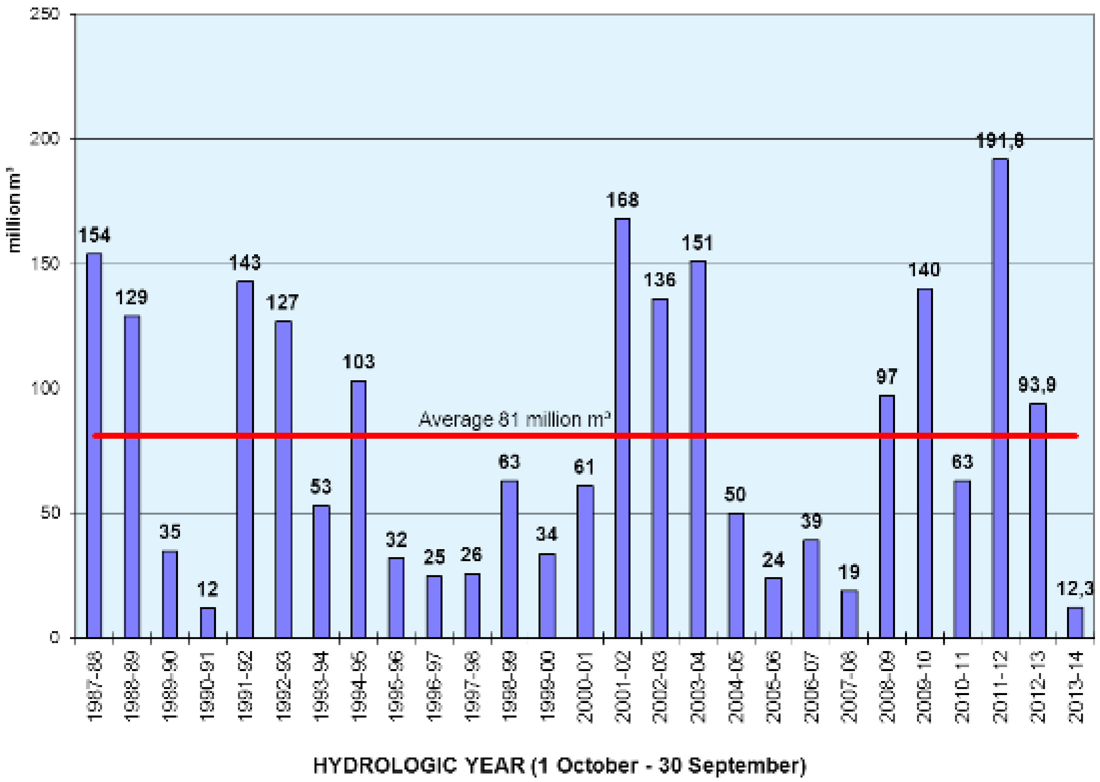


Figure 8.4: *Recorded Inflows (1987/88-2013/14) to Dams in Cyprus* (source: WDD, 2015)

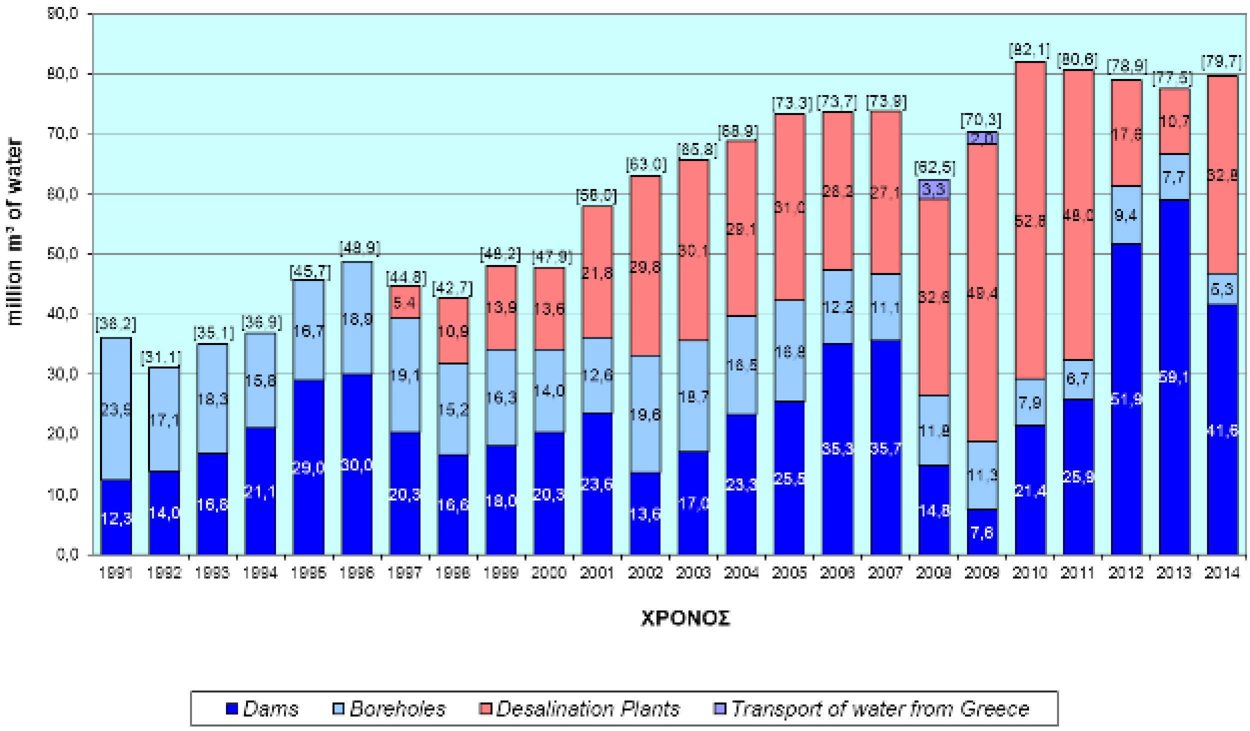


Figure 8.5 *Government Water Supply Projects –Sources (1991-2014)* (Source: WDD 2015)

8.2.2. CONSUMPTION

By far the greatest proportion of water demand is met through government schemes (GWWs). The rest is met mainly by private boreholes, as well as small, often communal, schemes.

With regard to GWWs, the demand and supply figures are as follows:

Taking into account the available data for the period 2008-2014 the average annual water supply from the main government projects was approximately 80 million m³ of which:

- ~ 40,2 million m³ or 68% was supplied by dams
- ~ 7,3 million m³ or 12% was supplied by government boreholes and
- ~ 32,5 million m³ or 55% was supplied by desalination plants.

The average annual irrigation water provided from GWWs was ~ 58 million m³ of which:

- 41,1 million m³ or 71% was met from the dams
- 5,1 million m³ or 9% from government boreholes and
- 11,6 million m³ or 20% from reuse.

The above, however, do not correspond to total irrigation demand from GWWs as there have been years, in the past, when up to 69 million cubic meters were supplied and consumed. The average figure represents actual volumes provided. Any demand not thus met was covered either through reduction of production or, quite commonly, additional water from private boreholes.

Based on analysis carried out for the Cyprus Water Policy Review (WDD 2012), adding water supply demand met outside the GWWs raises total demand to 90 – 95 million m³/year. This leaves only 10 to 15 million cubic meters per year as water supply demand not relying on GWWs. This figure is progressively reducing with the expansion of Government water supply schemes.

The corresponding figure for total irrigation water demand was 150 million m³/year. This shows quite a different situation when compared to water supply. When irrigation met by small schemes and private boreholes is added to Government supplied irrigation, the total demand roughly doubles. This is an important point in terms of Climate Change impacts as private supplies can’t be expected to benefit from the adaptability of well-managed government schemes which may diversify in terms of resources.

The average annual consumption of water from GWWs is presented in the following figure.

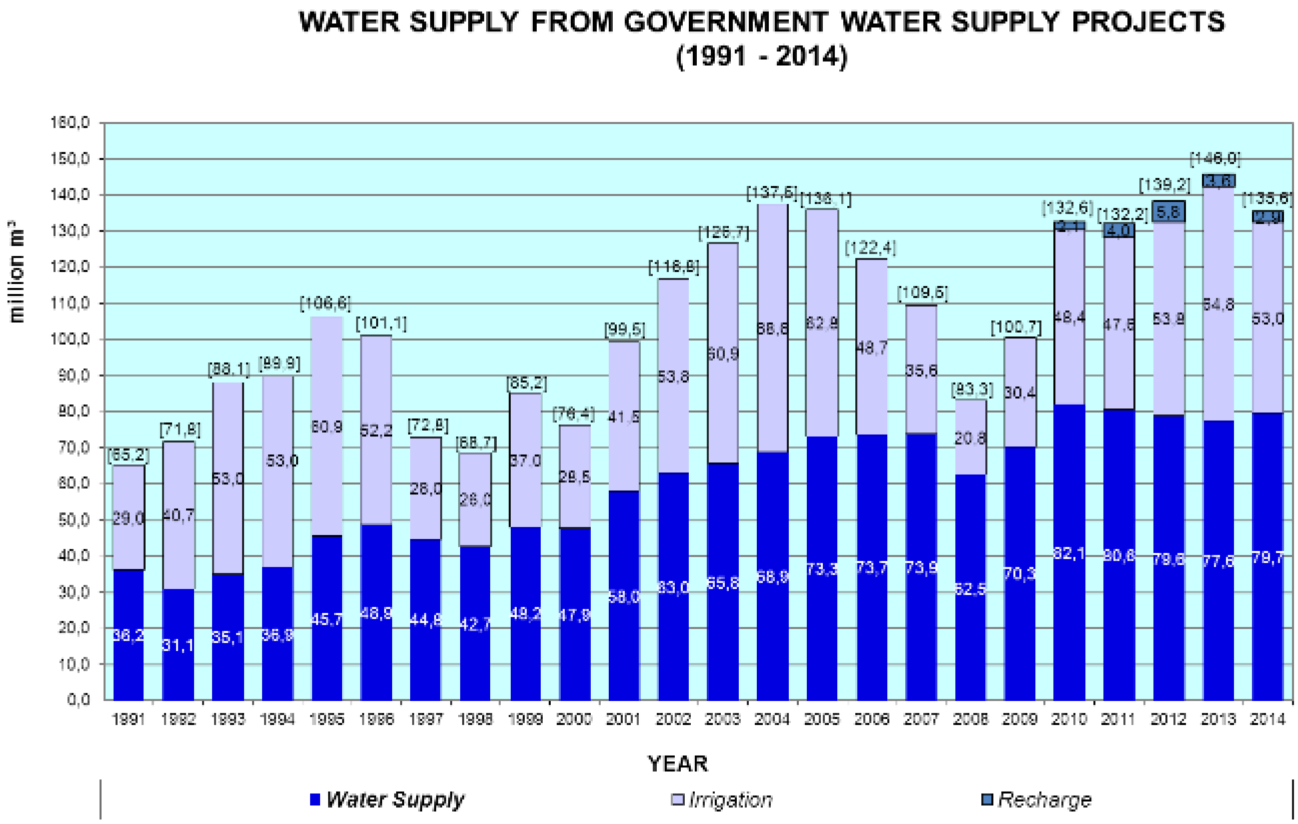


Figure 8.6: *Water Supply from Government Water Supply Projects* (Source: WDD, 2015)

8.2.3. ENVIRONMENTAL FLOWS

Changing flow patterns can affect the natural world in a number of ways. Firstly, they determine how much water is available for different ecosystems and could therefore affect a number of species to varying extents. For example, summer low flows may provide an inadequate physical habitat for certain fish species. Secondly, low flows can also have implications for water quality. The direct link between water, the natural environment and the structure and function of habitats means that there are also likely to be increasing pressures on the water industry to manage the resource in a way that protects and, where possible, maximizes the opportunity to maintain and restore biodiversity (Lawton et al., 2010) The particular issues for the water industry include managing low flows and the ecological status of rivers, are now considerations under the Water Framework Directive (WFD), introduced in 2000.

8.3. CHARACTERISING THE FUTURE

8.3.1. WATER QUALITY

Studies investigating the impacts of climate change on water quality are at fairly early stages, with a considerable amount of uncertainty involved due to the complex interactions between land use change, climate change and aquatic ecosystems.

Climate change is considered as a direct and indirect threat to public health. Harmful health impacts of climate change are related to increasing heat stress, extreme weather events, poor air quality, water and vector borne diseases. The direct effects are caused by extreme weather events, and the indirect ones are a result of poor air and drinking water quality, diseases, food insecurity and ecological changes. Climate-change-related alterations in rainfall, surface water availability and water quality could affect the burden of water related diseases. Water-related diseases can be classified by route of transmission, thus distinguishing between water-borne (ingested) and water-washed diseases (caused by lack of hygiene). There are four main considerations to take into account when evaluating the relationship between health outcomes and exposure to changes in rainfall, water availability and quality: (a) linkages between water availability, household access to improved water, and the health burden due to diarrheal diseases, (b) the role of extreme rainfall (intense rainfall or drought) in facilitating water-borne outbreaks of diseases through piped water supplies or surface water, (c) effects of temperature and runoff on microbiological and chemical contamination of coastal, recreational and surface waters and (d) direct effects of temperature on the incidence of diarrheal disease.

8.3.2. ASSETS AND INFRASTRUCTURE

Water and wastewater assets and infrastructure in Cyprus could be affected by climate change in a number of ways. For example, increased drought conditions could mean that abstraction points that are no longer viable are relocated or replaced, leading to stranded assets, with solutions to replace these assets potentially high-cost and energy intensive. There is also the potential for odor nuisance from treatment works and sewers during these conditions. Soil movement may also increase due to changing precipitation patterns, potentially affecting underground assets such as pipes, requiring innovative pipe flexing solutions or an increase in maintenance.

Conversely, changing precipitation patterns may present opportunities in terms of the use of certain assets such as reservoirs and sustainable drainage systems. However, such options could be costly to construct and maintain, and in the case of reservoirs, difficult to locate.

Flooding could have a number of potentially serious implications for water and wastewater assets. One consequence to be considered is the flooding of critical assets such as pumping stations and treatment works.

Flooding could also affect other assets such as dams and impounding reservoirs, which may need to be strengthened to improve their resilience to increased rainfall. Changes in sedimentation due to soil erosion could also affect these assets.

8.3.3. MITIGATION ASPECTS

One of the major challenges the water industry is facing is mitigating the impacts of climate change through reducing energy consumption while still maintaining environmental and water quality standards. Carbon management plans being produced or implemented by water companies will take this into consideration.

Actions which can be taken to mitigate the impacts of climate change are:

- implementation of energy efficient projects, where applicable,
- reuse of treated effluent and recycling of biosolids (sewage sludge) to land and
- use of renewable sources of energy such as wind power, biofuels and combined heat and power.

8.4. SOCIO-ECONOMIC INFLUENCE OF THE PROJECTED CONSEQUENCES

The pressures posed by the socio-economic development of the country to the water sector are directly or indirectly related to climate change. Urbanised areas-human habitation, human induced changes in hydraulic conditions, high water demands, diffuse pollution to surface waters agricultural intensification, droughts and less precipitation are just some of them.

To evaluate the relative future influence of socio-economic factors (extending from now until 2080s), four key drivers were considered for Water Sector. The four drivers are:

i) Population needs/demands

During the last century there is a population increase in Cyprus, which is expected to increase further. In addition to that, there is a substantial growth in the number of tourist arrival, especially during the last decade. This trend leads to higher demands and needs for natural resources and it is expected to be even stronger in the future.

ii) Global stability

This driver of change is related to various socioeconomic events (e.g. natural disasters, economic instability) that could affect global stability with direct impact on the island’s stability. The extremes are higher global stability (with little pressure on Governments and people) compared to today, and lower global stability (with a high degree of pressure on Governments, or people that outweigh other priorities) compared to today.

iii) Distribution of wealth

This aspect considers the distribution of wealth amongst the Cypriot population; the extremes being whether it is more even compared to today or more uneven (with a strong gradient between the rich and poor) compared to today. A potential solution to the Cyprus issue will be also relevant here as currently the GDP of the southern part of the island is much higher to the GDP of the northern part.

iv) Land use change/management

These dimensions relate to aspects of sub-urbanisation and coastalisation as further detailed in the Built Environment Sector report. In particular, suburbanisation takes the form of rapid population growth and development sprawl in the suburbs located at the edges of the main urban areas[1]. If this trend is maintained in the future, rural areas "abandonment" would lead to an increase in the abandoned agricultural lands with direct impacts to the rates of agricultural development and irrigation water demands. Agricultural land abandonment could be an opportunity for the water balance of the island. However, it should be noted that ceasing of traditional agricultural practices leads to increase in environmental pollution.

On the other hand, intensification to agriculture means increased needs of irrigation water which is a threat for the water balance of the island and a quantified impact of climate change to the water sector as described in chapter 5 herewith.

Coastal tourism development is dominant in Cyprus, with most of the coastal tourism accommodation located in rapidly growing coastal village communities, notable in the settlements of Ayia Napa and Paralimni in the southern Ammochostos District, with increased needs for water supply for potable and other uses.

8.5. ADAPTIVE CAPACITY

The following five interrelated characteristics are conducive to adaptive capacity (see the following Figure 8.7): the asset base, the institutions and entitlements, knowledge and information, innovation and flexible forward – looking decision – making.

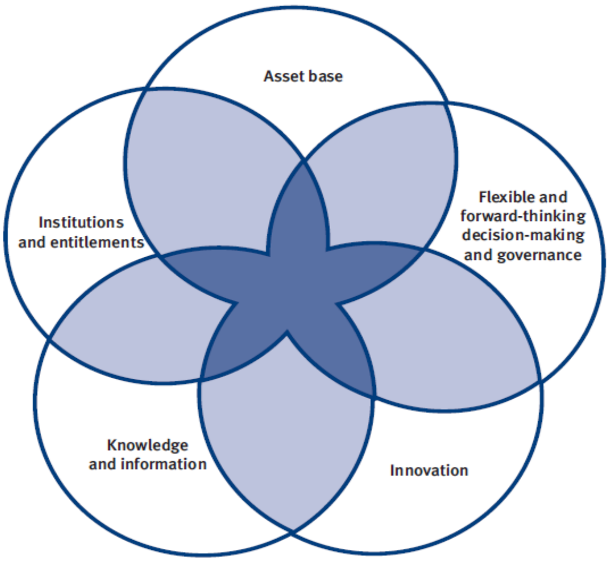


Figure 8.7: *The relationships between characteristics of adaptive capacity at the local level*

The five characteristics described are a starting point to conceptualize adaptive capacity at the local level, and an entry point for discussion of national level policies to increase community or household-level adaptive capacity. Further research will be needed to explore

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[1] *As defined by* ***Population Censuses***

their relationships and roles, as well as to better understand the interrelations across each of the five characteristics.

In Cyprus, the water industry and its regulators have a high level of understanding of potential climate change impacts on water availability and a good understanding of the implications of climate change for the sector's resilience:

- The potential risks of climate change have been considered by the WDD. A planning horizon on 'security of supply' has been already set and this plays a key role in increasing the sector's ability to adapt to climate change.

- As part of the planning process, the WDD provides advice and guidance on appropriate ways of including climate change within the plans of the water boards, which also consider other factors impacting the provision of water services, such as changes in demand, population growth and environmental legislation.

If the sector is to further increase its ability to adapt to climate change, the following are particular priorities:

- Developing a better understanding of water quality and asset deterioration issues;

- Developing a better understanding of biodiversity issues.

- Ensuring that more decisions about water take account of water security beyond the regulated period of 25 years.

A key challenge with respect to adaptation is the lack of clear evidence regarding water quality changes resulting from complex interactions between land-use change, aquatic ecosystems and climate change. Areas where further investigation could take place include: the environmental impacts of drought; mechanisms to encourage increased efficiency in water use and the impacts of increased desalination.

9. RISKS FOR BIODIVERSITY

9.1. SPECIES DIVERSITY

1.1.1. FLORA

One of the most important features of Cyprus biodiversity is its rich and unique floristic diversity, with 2,005 plant taxa and a high number of endemic taxa, estimated at about 144 taxa (Cyprus National Biodiversity Strategy, 2013). However, it should be mentioned that these data are dynamic as new species are recorded; new confirmations of presence take place or systematic reclassifications are made. A continuously updated checklist of flora of Cyprus is available on line (Hand et al., 2015) where the most recently changes or updates can be found.

Most of the endemic plant taxa of Cyprus are located in the two mountain ranges of the island: 100 endemic plants are found on the Troodos mountain range, out of which 45 are local endemics of Troodos mountain range and 56 in Pentadaktylos range, out of which 14 are local endemics (UNEP-MAP, 2007). Despite their small distribution and high number of pressures that are facing, sand dunes ecosystems of the island are particularly important areas in terms of endemic and endangered plant species (Hadjichambis et al., 2004).

Apart from the endemic species, particularly important is the high proportion of rare and endangered species. Among the 328 plant taxa of the Cyprus flora evaluated in the Red Data Book, based on the IUCN Red List criteria, 46 taxa were classified as Critically Endangered (CR), 64 as Endangered (EN) and 128 as Vulnerable (VU). It should be noted that since the release of the Red Data Book new endemic species have been described, such as Cynara makrisii and Papaver paphium. Seven of the endemic plant taxa of Cyprus have been included in the Top 50 Mediterranean Island Plants, a special book of IUCN concerning wild plants in the islands of the Mediterranean at the brink of extinction (Montmollin and Strahm, 2005)

1.1.1. FAUNA

Cyprus is characterized by a rich and diverse fauna, which includes endemic, rare and protected species. Cyprus hosts 39 mammal species, 19 of which are bats. The Mediterranean Monk Seal Monachus monachus is a priority species of the Annex II of the Habitats Directive and, based on The IUCN Red List of Threatened Species, is classified as Critically Endangered (CR) (Aguilar and Lowry, 2013)

Particularly important is the presence of endemic mammal species and subspecies, such as:

- The Cyprus mouflon Ovis orientalis ophion (Ovis gmelini ophion) which is often described as the "national animal of Cyprus" and which is the largest wild mammal in Cyprus and has been widely studied (Hadjisterkotis, 2007).

- The relatively recent described (Cucchi et al., 2006) endemic mouse species Mus cypriacus recently described as a new endemic species of Cyprus.

Cyprus is particularly important for its avifauna since it hosts a great diversity of bird species, including endemic species and subspecies. So far 397 bird taxa have been recorded, a number which is not stable, as new visitors are recorded from time to time (BirdLife Cyprus, 2015). Sylvia melanothorax and Oenanthe cypriaca are endemic bird species, while four endemic subspecies are also present: Otus scops cyprius, Parus ater cypriotes, Certhia brachydactyla dorotheae and Garrulus glandarius glaszneri.

Many of the bird taxa of Cyprus are protected based on national, European and/ or International legislation. Thirty (30) important areas for bird species listed under Annex I of the Birds Directive (2009/147/EC) and for other regularly occurring migratory species have been included in the Natura 2000 Network as Special Protection Areas (SPAs), while 34 areas have been recognised as Important Bird Areas (IBAs) by BirdLife International according to internationally agreed scientific criteria (BirdLife Cyprus, 2015). Several of the bird species are classified as threatened based on the IUCN Red List of Threatened Species (Thanos, 2005) such as Gyps fulvus, Aegypius monachus, Aquila heliaca, Hieraaetus fasciatus, Larus auduinii, Pterocles orientalis etc.

Cyprus hosts 22 reptiles, of which the snake (Hierophis cypriensis) and the lizard (Phoenicolacerta troodica) are endemic to the island. There are also 8 endemic subspecies, such as Natrix natrix cypriaca, which together with the endemic Hierophis cypriensis are priority taxa of the Annex II of the Habitats Directive. Based on the IUCN Red List Zypern-schlanknatter (Hierophis cypriensis) is classified as EN, while Natrix natrix cypriaca although is not included in the IUCN Red List is characterised as critically endangered (Blosat, 2008) Of great interest is the presence of the two sea turtles; the green turtle Chelonia mydas and the common turtle Caretta caretta, which are also priority species of the Directive 92/43/EEC. Three frogs constitute the amphibian fauna of the island.

According to Fauna Europaea 5317 taxa form the invertebrate fauna of the island. Nevertheless, only few orders have been adequately studied. The actual number of insect species of Cyprus is estimated at about 6000-7000 species, with a high endemism percentage, reaching 10% (Cyprus National Biodiversity Strategy, 2013).

9.2. POTENTIAL IMPACTS OF CLIMATE CHANGE

In order to explore the potential impacts of climate change on the habitat types and/or species of interest, the SDMs developed under Baseline conditions were subsequently used to project the future distribution under two climate change scenarios (RCP45 and RCP85) at two time periods 2050 and 2070. For that purpose, the downscaled ($1km^2$) climate data from the WORLDCLIM database were used as predictors of the potential species/habitat distributions. It should be noted that these projections are indications of the area that would have a future climate similar to the one that the habitat types and/or species are found today and cannot be used as definite predictions. In order to categorize the potential differences in suitable climate zones the ratio of future to current suitable area was estimated and the scoring system used for the assessment of the vulnerability of Natura 2000 species and habitats for climate change in Europe (Vos et al. 2010) was subsequently applied (Table 9.1).

Table 9.1: *The scoring system used to quantify the risk of habitat suitability under different climate change scenarios.*

Ratio between current and future potential suitable climate zone	Impact	Score
Ratio >1	No risk	0
Ratio 0.7-1	Low risk	1
Ratio 0.5-0.7	Moderate risk	2
Ratio 0.3-0.5	High risk	3
Ratio <0.3	Very high risk	4

This indicator/metric represents the ratio of future to current area where suitable climate conditions for a species are found. For some species even if they would be able to colonize their future range (BD2) the actual suitable area could be smaller. Thus values of this metric close to zero suggest a large decline in the suitable area and a large risk and values close (or higher than) one suggests a small decline (or even increase) in the overall suitable climate space and thus a lower risk.

An example of the applied methodology is given for the (Sub-) Mediterranean pine forests with endemic black pines (9530) habitat type. Figure 9.1 indicates the current range of distribution of this habitat type across Cyprus, restricted between 1200m and 1900m asl. Black grid cells indicate areas where a confirmed presence of this habitat type exists while coloured cells indicate the probability of finding this habitat type based on the SDM. The second row of Figure 9.1 gives the expected area where this particular habitat type could be found under the RCP45 and RCP85 climate change scenario in 2050. The ratio of total area between each scenario and the baseline conditions was estimated at 0.21 and 0.20 respectively yielding a risk score of 4 for both scenarios for this particular habitat type. In a similar way, the third row of Figure 4.1 gives potential changes in the distribution of the P. nigra habitat type for the 2070 reference period. In this case the ratios were estimated to be 0.18 and 0.05 for RCP45 and RCP85 respectively yielding in both cases a high risk score (4).

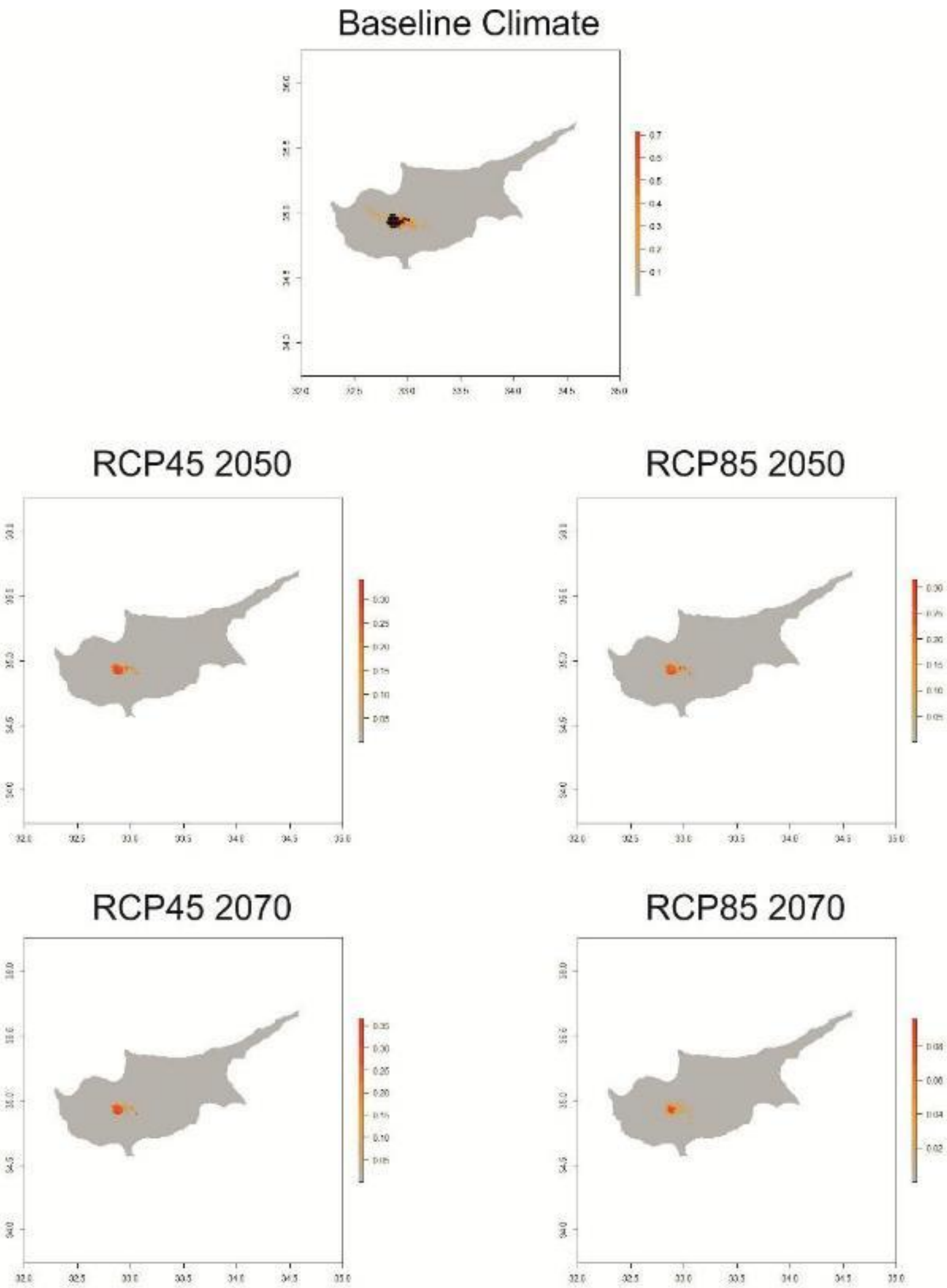

Figure 9.1: *An example of estimating risk scores for the two scenarios for 2050 and 2070 for the* Pinus nigra *9530 habitat type.*

Figure 9.2 summarizes the risk score between different climate scenarios for all habitat types that were analyzed for the purpose of this report. The overall analysis presented in Tables 9.2 to 9.9, suggests that for the low emissions RCP45 scenario at 2050, 55% of the habitat types will be facing no to low risk. However, for the same emissions scenario in the longer (2070) term 50% of the habitat types will be facing a high to very high risk in terms of climatic suitability. Following the warmer RCP 85 scenario, 69% of the habitat types will be at no to low risk by 2050, but around 55% of the habitat types will be classified at the high to very high risk category by 2070.

A similar methodology was implemented for each one of the 52 species modeled for the purpose of this report. This analysis indicated that following the RCP45 scenario, approximately 50 % of the studied species will be facing a low to no risk by 2050 and 2070. Under the RCP85 scenario a similar amount of the studied species will be placed at the low to no risk group by 2050, but almost 50% will be facing a high to very high risk by 2070.

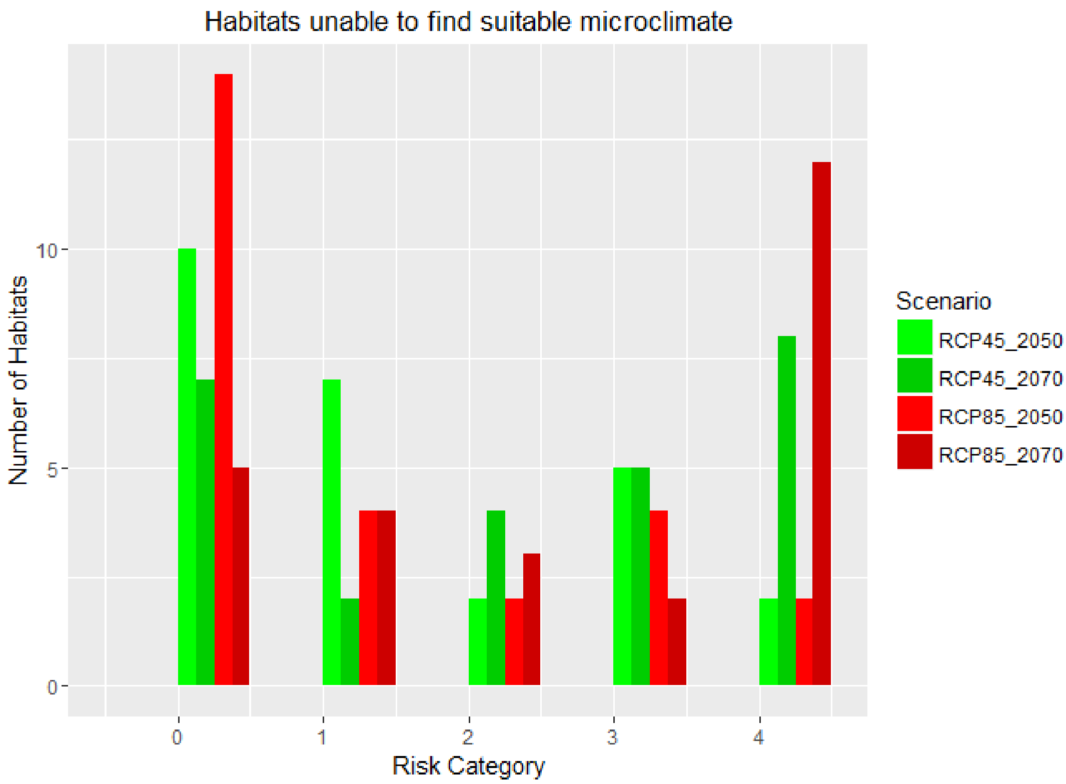

Figure 9.2: *Number of habitat types per risk category and Climate Change Scenario.*

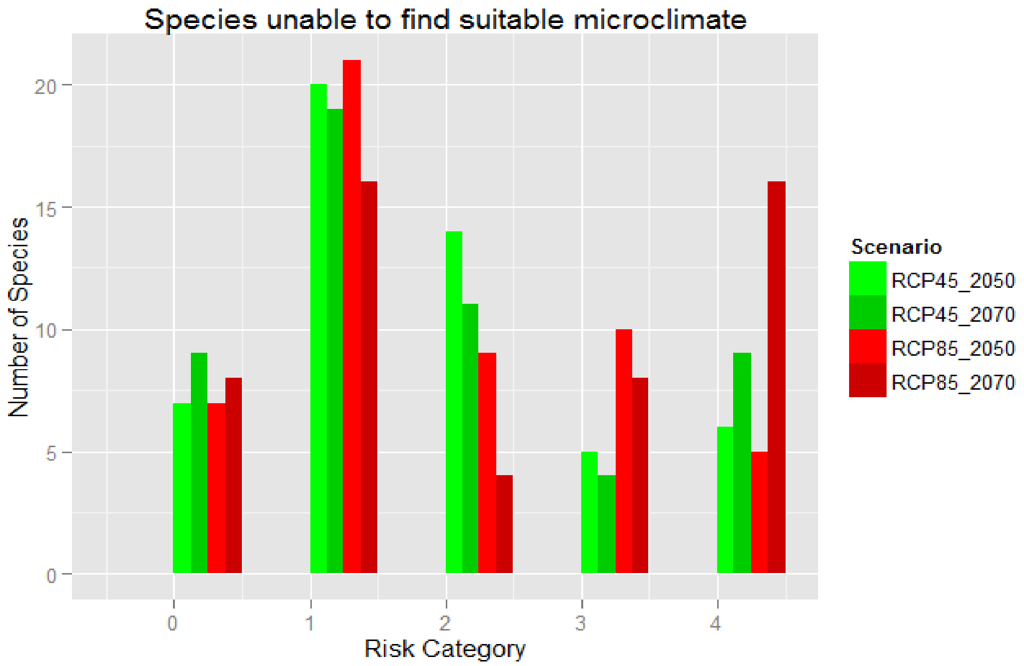

Figure 9.3: Number of species per risk category and Climate Change Scenario

Table 9.2: Summary of the risk scores for the 2050 RCP 45 scenario for different habitat groups

Habitat Group	No risk	Low risk	Moderate risk	High risk	Very high risk
Forests	2	3	2	3	1
Freshwater	3			1	
Grasslands	1	1		1	1
Rocky Caves	2	2			
Schlerophyllous	2	1			
	10(38%)	7(27%)	2(8%)	5(19%)	2(8%)

***Table 9.3:** Summary of the risk scores for the 2050 RCP 85 scenario for different habitat groups*

Habitat Group	No risk	Low risk	Moderate risk	High risk	Very high risk
Forests	4	2	2	2	1
Freshwater	3			1	
Grasslands	1	1		1	1
Rocky Caves	3	1			
Schlerophyllous	3				
	14(54%)	4(15%)	2(8%)	4(15%)	2(8%)

Table 9.4: *Summary of the risk scores for the 2080 RCP 45 scenario for different habitat groups*

Habitat Group	No risk	Low risk	Moderate risk	High risk	Very high risk
Forests	2		2	3	4
Freshwater	1		1	2	
Grasslands	1	1			2
Rocky Caves	2		1		1
Schlerophyllous	1	1			1
	7(27%)	2(8%)	4(15%)	5(19%)	8(31%)

Table 9.5: *Summary of the risk scores for the 2080 RCP 85 scenario for different habitat groups*

Habitat Group	No risk	Low risk	Moderate risk	High risk	Very high risk
Forests	1	1	1	1	7
Freshwater	1	1		1	1
Grasslands	1		1		2
Rocky Caves	2		1		1
Schlerophyllous		2			1
	5(19%)	4(15%)	3(12%)	2(8%)	12(46%)

Table 9.6: *Summary of the risk scores for the 2050 RCP 45 scenario for different species groups*

Species Group	No risk	Low risk	Moderate risk	High risk	Very high risk
Amphibians		3			
Invertebrates		1			1
Mammals		6	9	1	3
Plants	4	2	3	4	2
Reptiles	3	8	2		
	7(13%)	20(38%)	14(27%)	5(10%)	6(12%)

***Table 9.7:** Summary of the risk scores for the 2050 RCP 85 scenario for different species groups*

Species Group	No risk	Low risk	Moderate risk	High risk	Very high risk
Amphibians		3			
Invertebrates	1				1
Mammals		6	7	3	3
Plants	4	2	2	6	1
Reptiles	2	10	1		
	7(13%)	21(40%)	9(17%)	10(19%)	5(10%)

***Table 9.8:** Summary of the risk scores for the 2070 RCP 45 scenario for different species groups*

Species Group	No risk	Low risk	Moderate risk	High risk	Very high risk
Amphibians		3			
Invertebrates		1		1	
Mammals	1	6	9	1	2
Plants	7		2	2	4
Reptiles	1	9			3
	9(17%)	19(37%)	11(21%)	4(8%)	9(17%)

***Table 9.9:** Summary of the risk scores for the 2070 RCP 85 scenario for different species groups*

Species Group	No risk	Low risk	Moderate risk	High risk	Very high risk
Amphibians		3			
Invertebrates			1		1
Mammals	1	5	1	7	5
Plants	6		1	1	7
Reptiles	1	8	1		3
	8(15%)	16(31%)	4(8%)	8(15%)	16(31%)

Based on these estimations, the risk score for BD1 was set to 2 for the 2050 projection for both climate change scenarios and to 3 for the 2080 reference period. The confidence level is rather high, as observations of loss of species and habitats climatically suitable areas across the world has started to accumulate. However, there is a limited number of published studies in Cyprus that can support this modelling analysis with empirical evidence. In addition, other factors (apart from climate) can affect species distribution shifts that were not specifically considered in this analysis.

9.3. DISCUSSION: IMPLICATIONS FOR ADAPTATION

In this sub-chapter a discussion of the various impacts identified in previous ones including direct climate risks and socio-economic influences is made in addition to how these risk could be moderated by the adaptive capacity.

9.3.1. RISKS

Species movements, migration patterns and interactions (including BD1, BD2 and BD3)

Many species could naturally adapt to climate change by shifting their distribution to more climatically favourable areas. The ecological characteristics of species, including their ability to utilise resources as well as disperse along the landscape would be particularly important. As species are characterised by a range of niches and strategies individualistic responses are expected. These natural responses will be substantially regulated by habitat availability and fragmentation. Habitat loss and fragmentation could severely restrict the ability of species to migrate to more suitable areas. In general, such restrictions would favour more generalist species.

The Natura 2000 network in Cyprus comprises 61 sites and represents about 28% of the area of the Republic of Cyprus (Zomeni and Vogiatzakis, 2014), which is a relatively high proportion, compared to other European countries (Gaston et al., 2008). The efficiency of protected areas networks, particularly in terms of enabling species movement and migration is related to its connectivity (Hannah, 2008). Although a specific analysis of the Natura 2000 network on the island is required, both the structural and functional connectivity of the forested areas of the Natura 2000 network in Cyprus is rather high (Estreguil and Caudullo, 2014). On top of that, 80% of the roadless areas in Cyprus is found within the Natura 2000 network indicating an additional value. In general, it seems that the Natura 2000 network is well designed but explicit analysis of its efficiency under climate change scenarios is required. This should also take into account both the ecological characteristics of the protected species (natural adaptive capacity) as well as various socio-economic factors.

Pest diseases and invasive non-native species (including BD4 and BD5)

These risks are mainly controlled by socio-economic factors. However, climate change may act synergistically and enforce the persistence and spread of pest, diseases and non-native invasive species. In addition, loss of biodiversity could lead to ecosystems that are more prone to invasion (Fargione and Tilman, 2005). Overall, the economic and environmental costs of IAS, pests and pathogens can be significant especially for those invasive species, the can disrupt the balance of ecosystems by outcompeting and displacing native species. The net result is the loss of habitat, rare and endangered species, and native biodiversity. As ecological communities change, essential ecological functions can be altered and ecosystem services can be degraded (Clark et al., 2014).

In order to better quantify these risks inventories of their spread and effects on biodiversity and ecosystem services should be developed and maintained. Analyses relating the spread and affect metrics with key climatic variables are also required. Such knowledge will enable the inclusion of climate change in local and regional risk assessment evaluations of these threats.

Coastal zones

The coastal zone of Cyprus is densely populated and environmentally vulnerable. It is subjected to increasing pressures from a number of sources, with the most important being tourism, industrial development, urban expansion, exploitation of marine resources and population growth (Camp, 2008 and Tsiourtis, 2002). In the coastal zone of Cyprus 16 habitats types that are included in the Habitats Directive (92/43/EEC) Annex I have been identified, out of which 3 are classified as priority ones. Several endemic and TER plant species occur within the coastal zone of the island. Coastal zone vulnerability to climate change in Cyprus is mainly related to erosion and flooding, inundation and squeezing. Habitat changes due to sea level rise and alteration of storm frequency and intensity could negatively affect numerous important flora and fauna species (Casale and Tucker, 2015)

Cyprus has implemented an Integrated Coastal Area Management Programme (CAMP). Particularly for the Biodiversity Sector, mitigation measures proposed by the UNEP-MAP could be further implemented to increase the adaptive capacity of the system. Because the coastal zone biodiversity of the island is strongly linked with one of the key economic activities, i.e. tourism, these practices should particularly take into account potential feedbacks and interactions. Such measures include among others 1) the establishment of a protection coastal zone to avoid urban development close to the present coastline, mainly in the tourist areas and 2) Conservation of the dead leave stratum of *Posidonia* on the shore in order to prevent beach erosion. Cross-sectoral approaches to an integrated management are also obvious here.

Increased soil erosion and desertification due to climate change

As also discussed in the Agriculture Sector Report, the most vulnerable areas include olive cultivation zones, pine forests and shrublands under grazing. Soil erosion could have substantial direct effects on society and indirect ones though impacts on ecosystem services. Important feedbacks between vegetation establishment and growth and soil erosion have been identified, that could also lead to more complex system behaviour. Further research and integrated models are necessary to assess such changes. Maintenance of terraced walls could be an important protective measure against soil erosion with additional positive impacts on biodiversity (Cohen et al., 2015).

Increased soil moisture deficits and changes in primary productivity

Soil water availability is expected to decrease across the island following a warmer and drier future, at least at the longer term. This would lead to changes both in the frequency and the intensity of drought and would have a direct impact on many species and habitats as well as the on overall productivity of the ecosystems. A number of important ecosystem services are related to the primary productivity of ecosystems and the cycling of nutrients and water. Important interactions exist with carbon storage and CO_2 emissions and are directly linked to climate mitigation measures.

Water availability and major drought events

Cyprus already faces intense problems of water shortage and drought, which are expected to intensify as a result of climate change. Various ecosystems in Cyprus depend on water availability, including wetlands, fresh water ecosystems, riparian habitats and peat grasslands of Troodos. Interactions between human driven water management practices and the natural water cycle could lead to complex system behaviour with both direct and indirect impacts on ecosystems. A cross-sectoral approach is needed to optimise adaptation and mitigation strategies.

Wildfires

Risk of wildfires is expected to increase in Cyprus following various climate change scenarios. Human factors are the most important elements of ignitions and there are important socio-economic influences that could be of higher significance in controlling the regime of wildfires. Wildfires have important consequences for ecosystems and the services they provide. Discussion on controlling fire risk as well as the organisational adaptive capacity is provided in the Forestry Sector Report.

9.3.2. COSTS AND BENEFITS

Valuation techniques can provide costs and benefits for both the use and non-use (existence) values of biodiversity and for a range of ecosystem services. A detailed analysis is required to evaluate the range of services provided by ecosystems in Cyprus. This should particularly take into account cross-sectoral links and interactions.

9.3.3 LIMITATIONS OF ANALYSIS AND KNOWLEDGE GAPS

The analysis presented in this report illustrates a first attempt to systematically estimate the risk of climate change in a range of ecosystems and related services in Cyprus. This analysis was constrained by limited data availability and particularly: a) The lack of quantitative data that can be used to quantify the effects of change in specific climatic parameters on the establishment, growth and survivorship of key species and habitats on the island, b) The lack of quantitative data to estimate the relationship of pests and diseases with key environmental variables, c) Data on the economic valuation of ecosystem services for different habitats and species and d) Mechanistic simulations of ecosystems response to changing environmental conditions for various ecosystems. Integrated models (including land use changes and other socio-economic factors) need to be parameterised for ecosystems found in Cyprus with the use of empirical field data.

10. RISKS FOR ENERGY SUPPLY

10.1. OVERVIEW OF THE SECTOR

10.1.1. GROSS NATIONAL INLAND ENERGY CONSUMPTION

The gross inland energy consumption represents the quantity of energy necessary to satisfy inland consumption and it covers: (a) consumption by the energy sector itself; (b) distribution and transformation losses; (c) final energy inland consumption by end users; and (d) “statistical differences” (between primary energy consumption and final energy consumption).

Gross inland consumption can be calculated by the following formula: primary production + recovered products + total imports + variations of stocks - total exports - bunkers. Sometimes, gross inland consumption is referred to as “primary consumption”.

The total gross inland energy consumption in Cyprus totaled 2.189 ktoe in 2013 which represents a 13% reduction compared to 2012, and a 14% increase compared to 1993 (20-year time period (EUROSTAT, 2016)The annual Gross Inland Energy Consumption for years 1993 – 2013 is presented in the following graph.

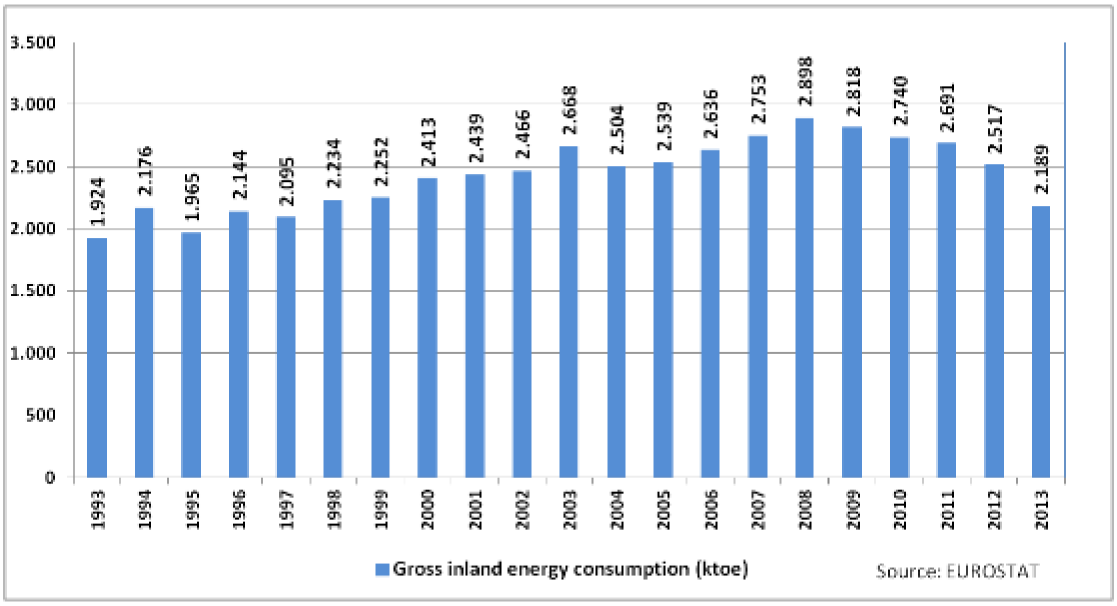

Figure 10.1: *Gross Inland Energy Consumption in Cyprus (1993 – 2013)*

10.1.2. FINAL ENERGY CONSUMPTION

Final Energy Consumption expresses the sum of the energy supplied to the final consumer's door for all energy uses. It is the sum of final energy consumption in industry, transport, households, services, agriculture, etc. and it excludes energy used by the energy sector, because the fuel quantities transformed in the electrical power stations of industrial auto-producers and the quantities of coke transformed into blast-furnace gas are considered to be part of the transformation sector.

In transport, Final Energy Consumption covers the consumption in all types of transportation, i.e., rail, road, air transport and inland navigation, and in households, services, etc. covers quantities consumed by private households, commerce, public administration, services, agriculture and fisheries.

The Final Energy Consumption in Cyprus totaled 1.615 ktoe in 2013 which represent a 24% increase compared to 1993 (20-year time period) and 1.764 ktoe in 2012. The annual Final Energy Consumption and the Final Energy Consumption by sector for years 1998 – 2013 are presented in the following figures (EUROSTAT, 2016; EU COMMISSION-DG ENER, 2015).

In the period 2011-2013, final energy consumption dropped by 15,8% due to the financial and energy crisis that hit Cyprus.

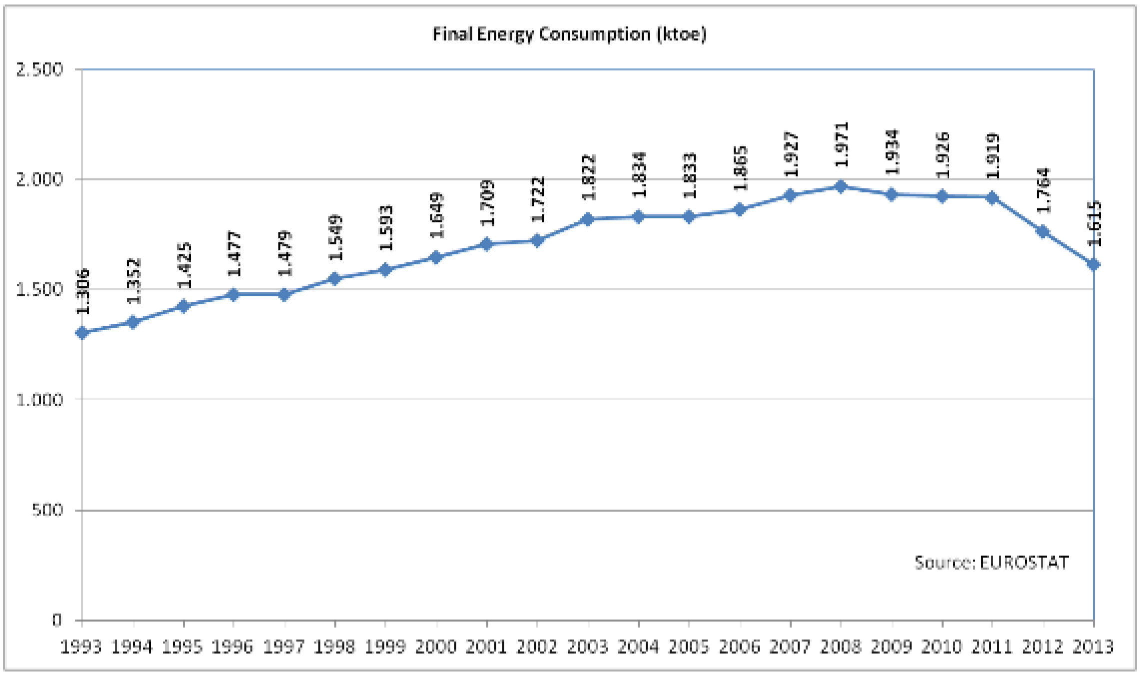

Figure 10.2: *Final Energy Consumption in Cyprus (1993 – 2013)*

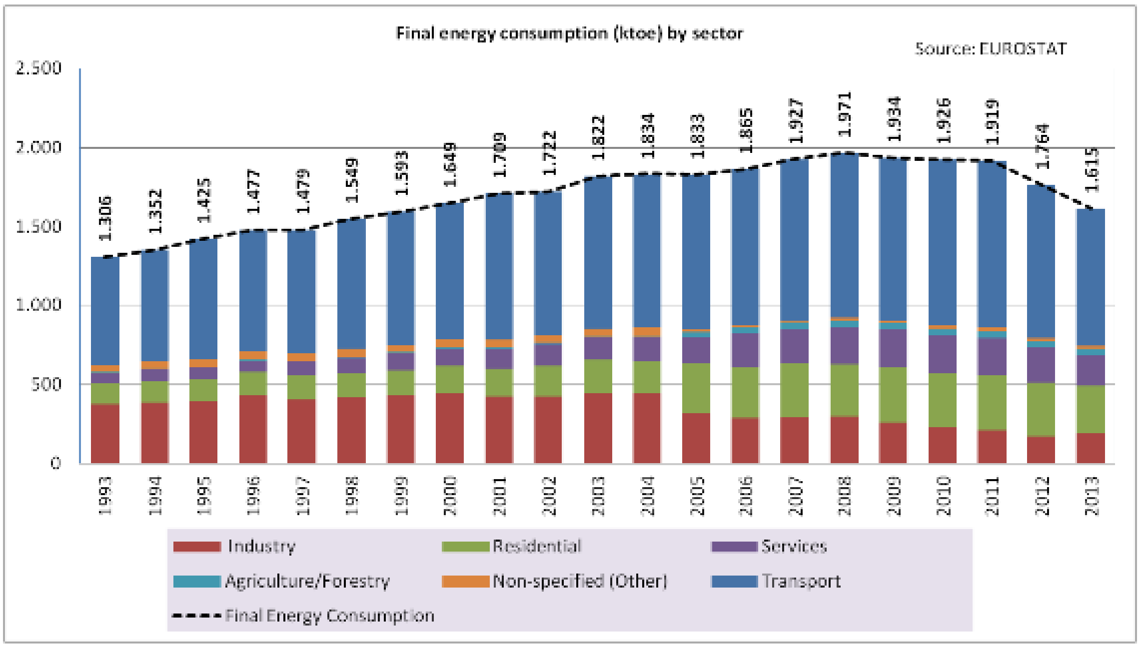

Figure 10.3: *Final Energy Consumption by sector in Cyprus (1993 – 2013)*

The Final Energy Consumption by sector for years 2011 – 2013 is given in the next table, where it appears that in 2013 the amount of energy consumption of all sectors has been reduced from 2011 to 2013, except to industry, where in 2013 there was a 10% increase compared to 2012 and to Agriculture / Forestry where there was no change compared to 2012 (EUROSTAT, 2016).

Table 10.1: *Final Energy Consumption by sector in Cyprus (2011 – 2013), ktoe*

Sector	**2011**	**2012**	**2013**
Transport	1.054	967	869
Industry	208	170	187
Residential	352	346	303
Services	237	222	199
Agriculture/Forestry	43	42	42
Non-specified (Other)	25	17	15
Final Energy Consumption	**1.919**	**1.764**	**1.615**

The follwowing Figure 10.4 presents the percentage of Final Energy Consumption by sector in 2013 (EUROSTAT, 2016).

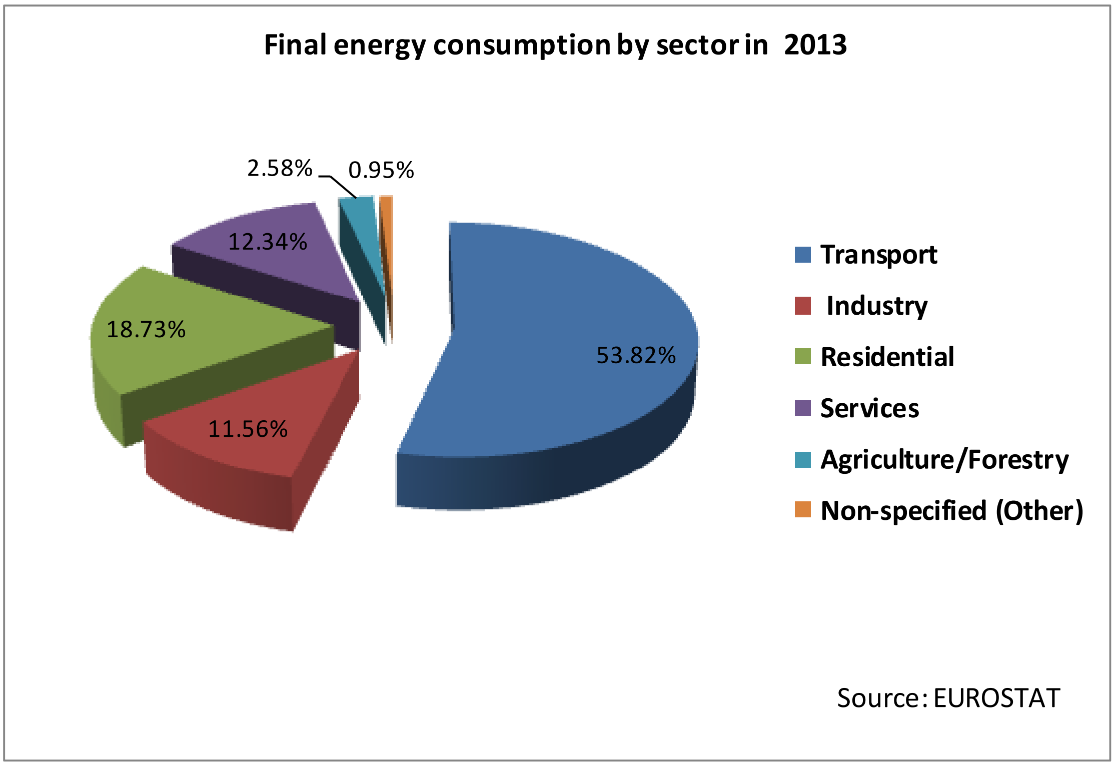

Figure 10.4: *Final Energy Consumption by sector in Cyprus (2013), ktoe*

Under the EU Directive 2009/28/EC Cyprus has adopted a National Renewable Action Plan outlining the pathway which will meet its 2020 renewable energy and Greenhouse Gas Emission targets. Cyprus 2020 renewable energy targets are:

- 13% contribution from renewable energy sources in the final use of energy;
- 10% contribution from renewable energy sources in the road transport consumption;
- 5% reduction of greenhouse gas emissions from 2005, for categories outside the scope of the Greenhouse Gas Emission Allowance Trading Scheme.

According to the National Renewable Action, the expected contribution of RES in heating and cooling is 23,5% and in electricity is 16%.

Actions aiming to achieving these targets are:

- Diversification of energy sources through implementation of the strategic goal for introduction of natural gas into the country's energy mix.
- Increasing the country's energy self-sufficiency and strengthening of its geostrategic role in the greater area through the development of research actions related to the island's fossil fuel energy potential.
- Maximization of efficient utilization of renewable energy sources aiming to replace energy from imported sources.

- Energy saving both in the primary form and its final use.
- Ensuring sufficient electric power supply potential.
- Development of the country's self-sufficiency in relation to the import of primary fuels by maintaining sufficient security stocks.

In 2014, Cyprus submitted to the European Commission, in compliance the Energy Efficiency Directive 2012/27/EU its third National Energy Efficiency Action Plan that sets primary energy savings target of 14,3% in 2020.

10.2. ELECTRICITY SUPPLY

10.2.1. ELECTRICITY GENERATION

The electrical requirements of the island are provided by:

- Three (3) main power stations operated by the Electricity Authority of Cyprus, namely: (a) Moni power station, (b) Dhekelia power station, (c) Vassilikos power station,
- Self-producer installations (internal combustion units), and
- Renewable energy sources (RES) that include Biomass/Biogas units, Wind Turbines & wind Farms and Photovoltaic systems.

10.2.2. INSTALLED CAPACITY

Conventional electrical power supply

The total installed capacity of conventional units in 2013 reached 1.508,4 MW, of which 1.477,5 refer to EAC power stations. The installed capacity in conventional power stations since 1964 is presented in the following chart (CYSTAT, 2014).

A. Electricity Authority of Cyprus (EAC)

The maximum output capacity of power stations operated by EAC at the end of 2013 reached 1478 MW and remained the same in 2014. During the year 2013, the Electricity Authority of Cyprus completed the restoration of the Vassilikos Power Station. All remaining conventional generator units of the Moni Power Station (Units 3, 4 , 5 & 6) of 30 MW nominal capacity each, were decommissioned since 14 October, 2013 (EAC, 2013; EAC, 2014).

1. Moni Power Station

At the end of 2013 four (4) Gas Turbines of 37,5MW nominal capacity each, having a total capacity of **150MW** were installed and became available. It is noted that since 14/10/2013 Units 3, 4, 5 and 6 were withdrawn from the installed capacity of the Station and therefore the installed capacity of the steam units has been reduced to 0 MW. The installed capacity of the station in year 2014 remained the same.

2. Dhekelia Power Station

The installed capacity of Dhekelia Power Station in 2013 was **460 MW** (6 x 60 MW Steam Units and 6 Internal Combustion Engines of total capacity of 100 MW). The installed capacity of the station in year 2014 remained the same.

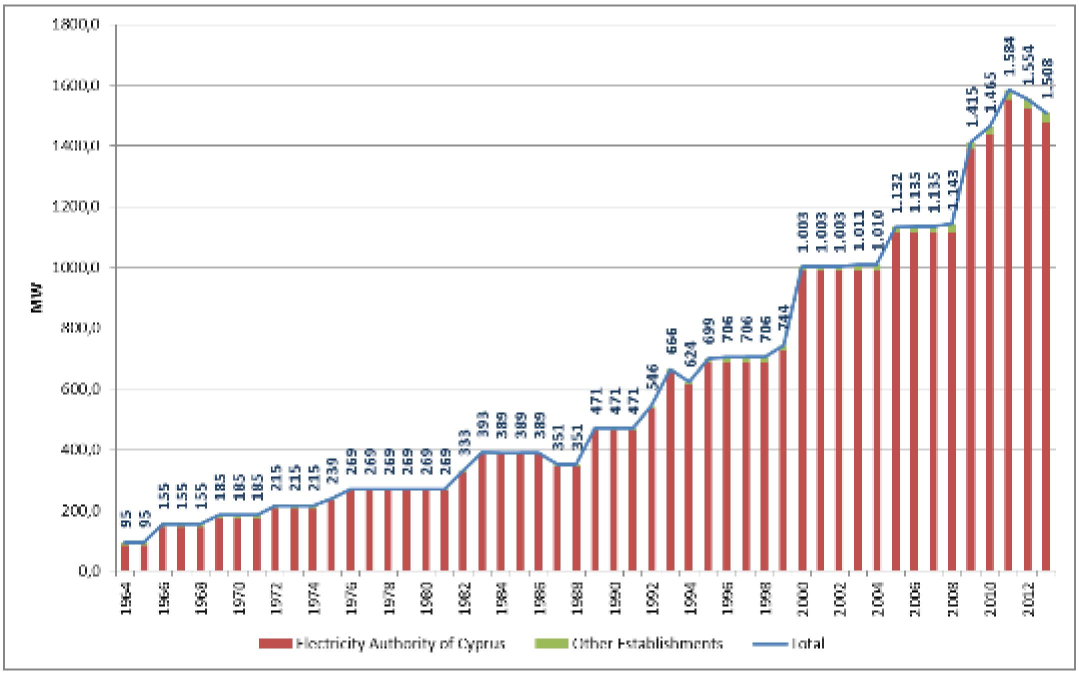

Figure 10.5: *Installed capacity of electric generators (MW), 1964-2013*[2]

3. Vassilikos Power Station

The installed capacity of Vassilikos Power Station at the end of 2013 was 868 MW (3 x 130 MW Steam Units, 2 x 220 MW Combined Cycle Gas Turbines Units and 38 MW Black Start Gas Turbine Unit). By the end of 2013 the damages done by the explosion at the Naval Base (11/7/2011) were restored. The installed capacity of the station in year 2014 remained the same.

B. Self-Producer Installations

According to CYSTAT, by the end of 2013 the installed capacity of electrical generators operated by other establishments reached 30,9MW (CYSTAT, 2014). The installed capacity of Self-Producer Installations exceeding 1MW by the end of 2013 was 27,07 MW (CERA, 2013):

- Vassilikos Cement Works SP1-2004 , 6MW
- Vassilikos Cement Works SP-3-2006, 5MW

[2] *The figures for 2011 include the conventional units at Vassiliko Power Station with a total capacity of 755MW which became non operational due to the events of the 11th July 2011, but exclude the temporary units of EAC with a total capacity of 167MW. The figures for 2012 include conventional units with a total capacity of 500MW which became non operational due to the events of the 11th July 2011, but exclude the temporary units of EAC with a total capacity of 285MW.*

• Elmeni Quarry, SP4-2006,	1,6MW
• Farmakas Quarry SP-5-2007,	2,0MW
• Hellenic Copper Mines Ltd SP6-2008,	3,8MW
• Vasa Gravel, SP-9-2008,	3,19MW
• Medcon Quarries, SP12-2011,	2,24MW
• Gennadios Quarry SP13-2011,	2,04MW
• Pyrga Quarry Sp 15-2013,	1,2 MW

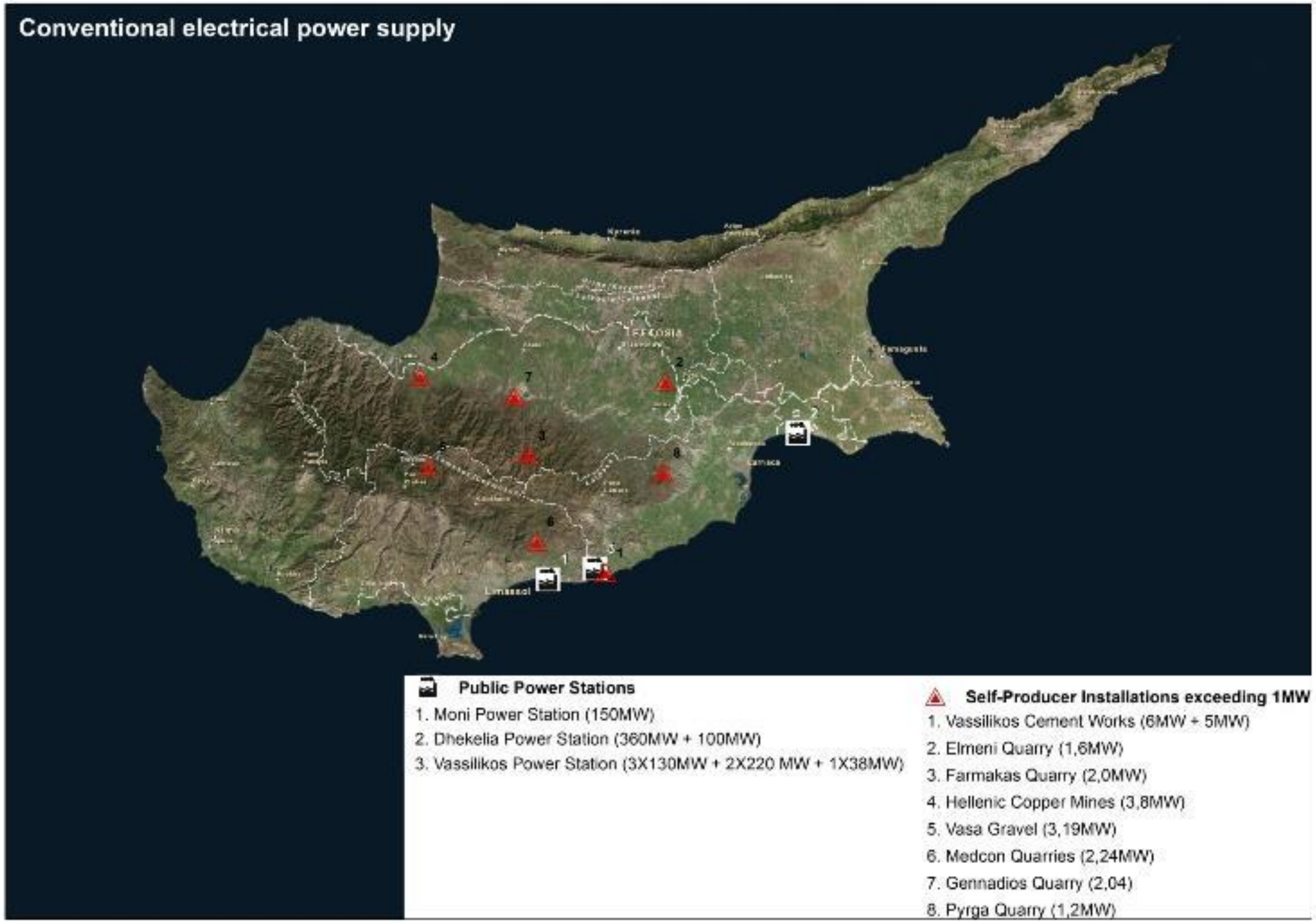

Figure 10.6: *Conventional Electrical Power supply System*

RES electrical power supply

The share of renewable energy sources in the energy mix has increased quite recently in Cyprus under the Grant Scheme for the Promotion of Renewable Energy Sources and Energy Conservation. This policy measure received significant interest from the public, leading to an increased penetration of RES to the final energy consumption between 2005 and 2014, as illustrated in the following table and Figures.

Total electricity capacity from Renewable Energy Sources (RES) in Cyprus reached 202,1 MW in 2014. The objective, as per the National Renewable Action Plan is to reach a minimum capacity of 584MW by 2020.

Table 10.2: *RES installations connected to the transmission & distribution networks*

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	No of Units									
Biomass/Biogas	0	0	1	8	8	10	11	12	13	13*
Wind Turbines and wind Farms	0	0	0	0	0	1	3	5	5	5
Photovoltaic systems	38	133	196	321	469	647	797	1.039	1.767	1.873
	Installed Capacity (Kw)									
Biomass/Biogas Units	0	0	250	3.310	3.555	7.214	7.964	8.764**	9.714*	9.714*
Wind Turbines and wind Farms	0	0	0	0	0	82.000	133.500	146.700	146.700	146.700
Photovoltaic systems	155	578	843	1.586	2.695	5.564	9.329	16.364**	31.260	45.727

** According to AEC 2013 and 2014 Annual Reports. Data differ from RAEC 2013 Annual Report and CERA RES Report for September 2015*

*** According to AEC 2012 Annual Report. Data differ from RAEC 2013 Annual Report*

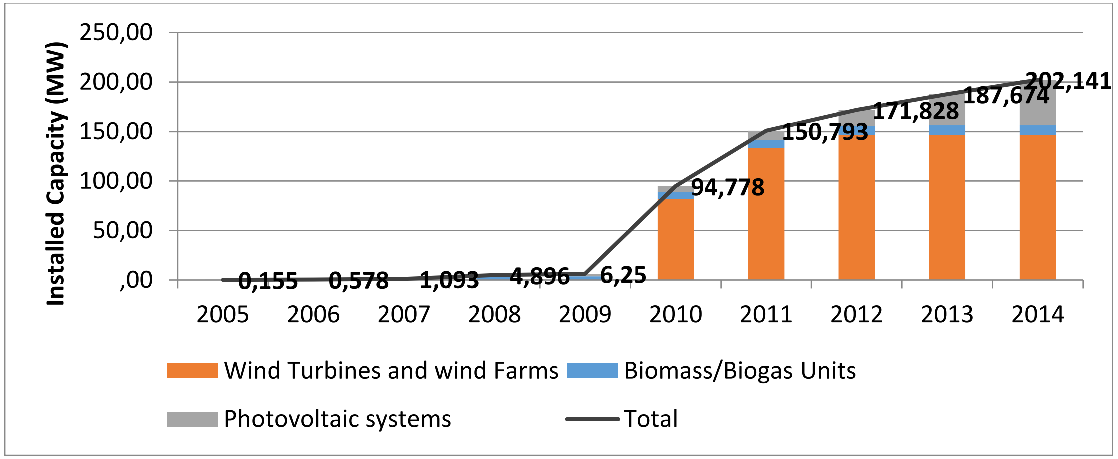

Figure 10.7: *RES installed capacity (MW), 2005-2014*

A. Wind Farms connected to the transmission & distribution network

In 2013 five (5) Wind Farms, of a total installed capacity of 146,7 MW were in commercial operation (CERA, 2013):

- DK Winsupply Ltd, 82 MW
- Rokas Aeoliki (Cyprus) Ltd, 20 MW
- Moglia Trading Ltd, 10,8MW
- Aerotricity Ltd, 2,4 MW
- Ketonis Developments Ltd, 31,5MW

The number and installed capacity of wind farms in 2014 remained the same (EAC, 2014).

B. Biomass/ Biogas Units

The total Installed Capacity of stations using Biomass/ Biogas in 2013, which are connected to the Distribution Network amounted to 9,7 MW from the 13 Generating Stations of Cogeneration of Heat and Power (EAC, 2013). To this number a producer having a capacity of 0,6 MW who is not connected to the electricity grid should be added. So, the total installed capacity of biomass units (autonomous or interconnected to the electricity system) for 2013 amounted to approximately 10,4 MW (CERA, 2013).

In 2014, the number of stations using Biomass/ Biogas which are connected to the Distribution Network rose remained the same EAC (2014).

C. Photovoltaic Systems connected to the transmission & distribution network

The total Installed Capacity of Production Plants with the use of Photovoltaic Systems in 2013, which are connected to the Distribution Network, amounted to 31,3MW from 1.767 Photovoltaic Systems for electricity generation (CERA, 2013). These figures rose to 45,7 MW and 1.873 systems in 2014 (EAC, 2014).

Figure 10.8: *Wind Farms*

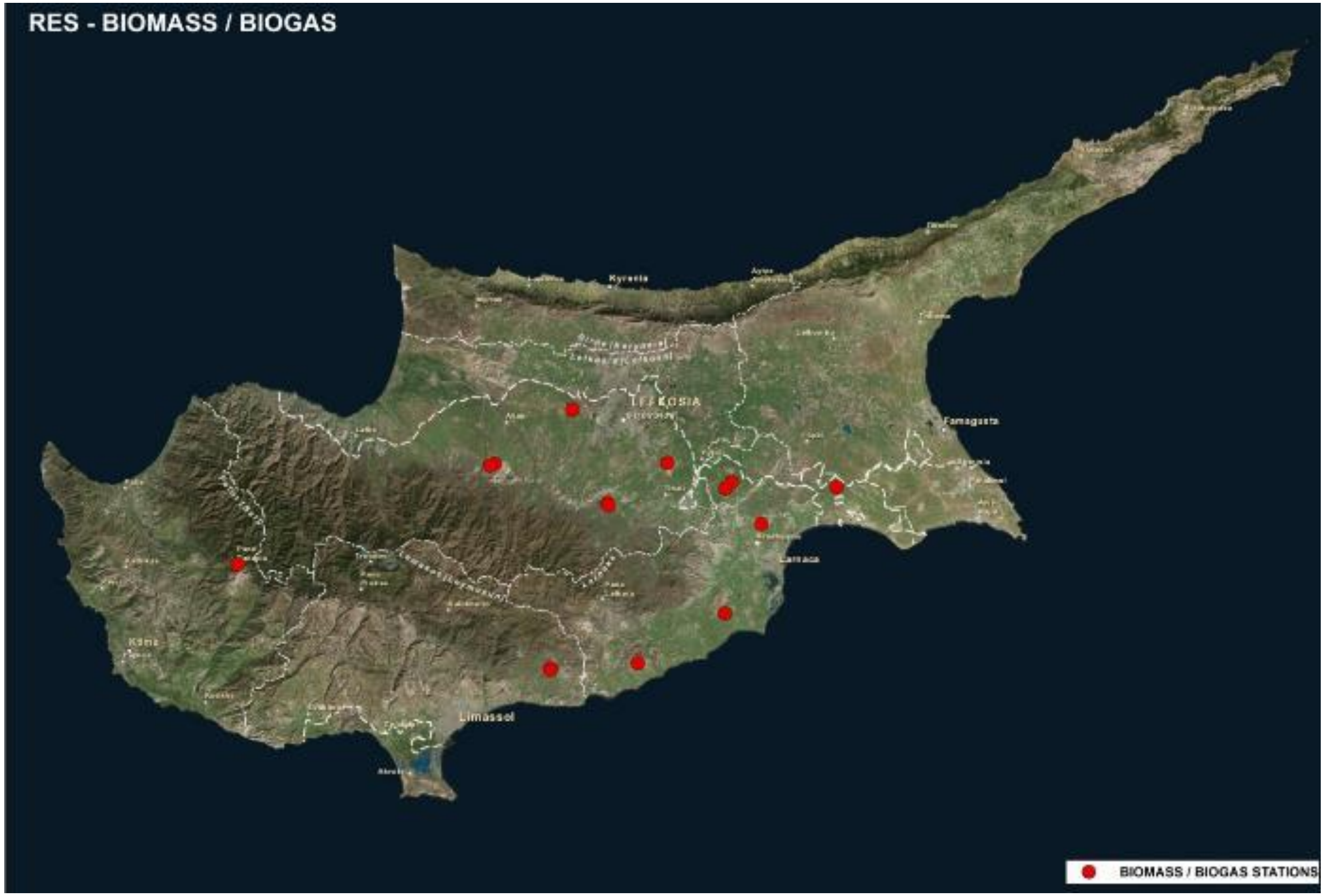

Figure 10.9: *Biomass/Biogas power stations*

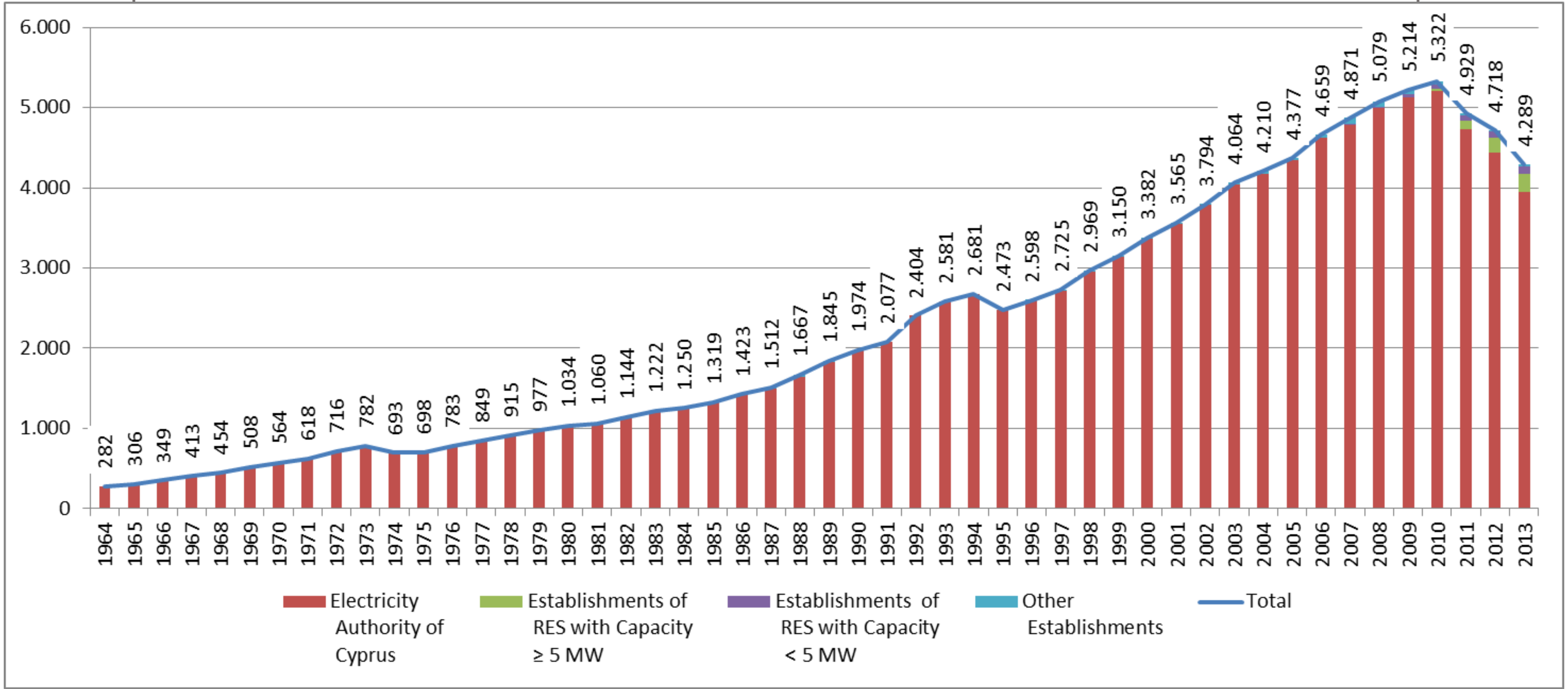

Figure 10.10: *Gross production of electricity, 1964-2013[3] (CYSTAT, 2014)*

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[3] *Gross Production refers to the amount of electric energy produced, as metered at output terminals in the power stations. "Other Establishments" category refers to electricity production from autoproducers using combustible fuels´ generators. RES production includes production from systems which are not connected to EAC's grid.*

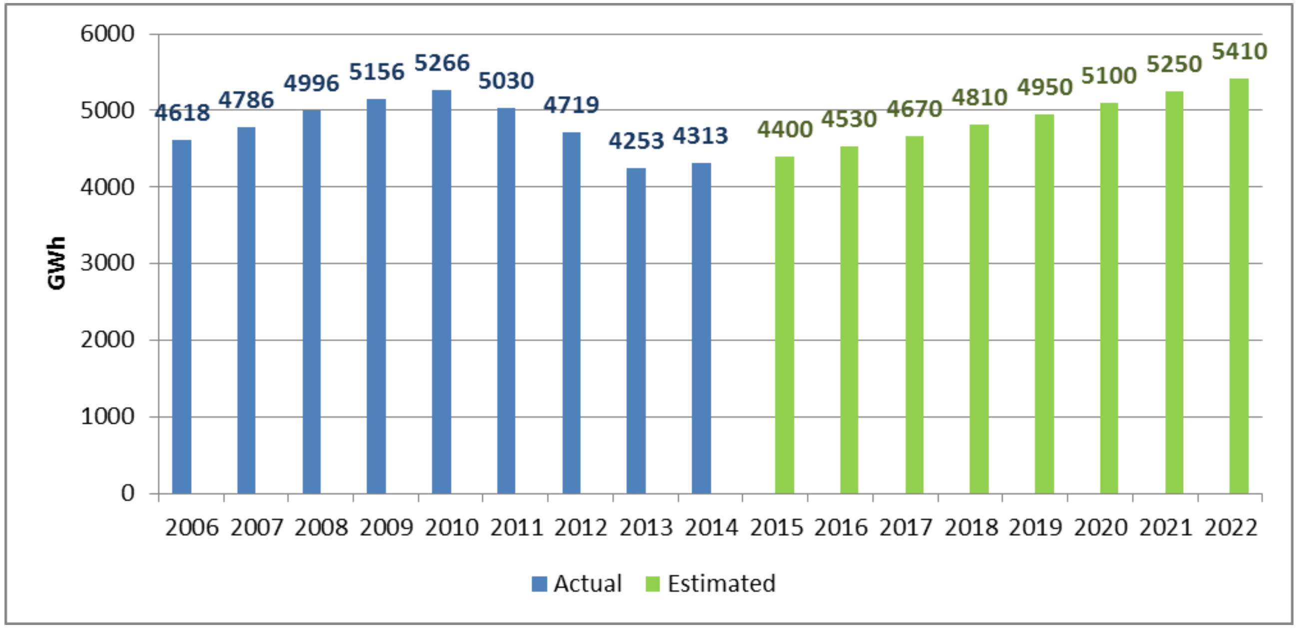

Figure 10.11: *Actual electrical energy generated and forecast (EAC, 2013; EAC, 2014)* [4]

10.2.3. TRANSMISSION NETWORK

The transmission network is the backbone of the EAC's system, connecting the Power Stations to the load centres. EAC has 64 substations. The network is presented in the following figure (EAC, 2014).

[4] *According to EAC Annual Reports. Since 2009 data include RES generation.*

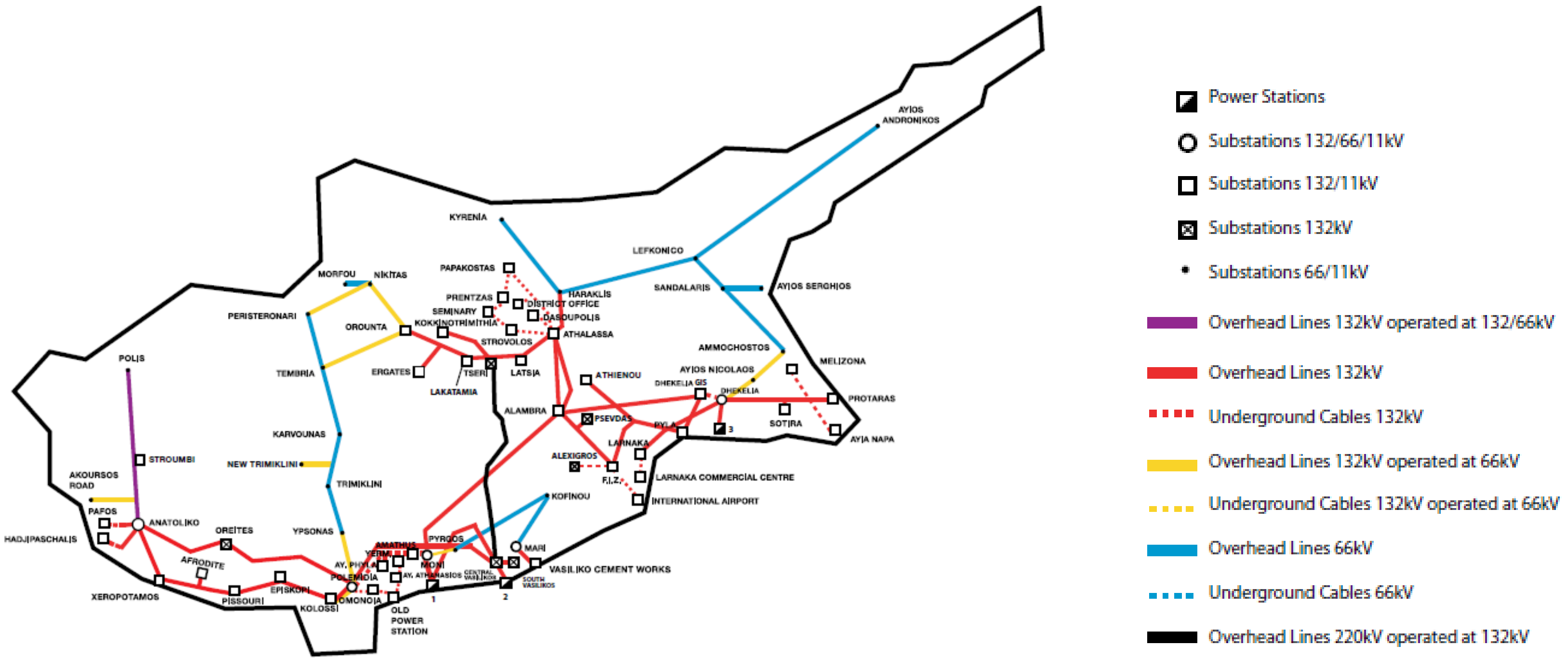

Figure 10.12: *EAC transmission network (EAC, 2014)*

10.2.4. Electricity consumption

Since 1995, electricity consumption was steadily increasing until 2010. Following 2010, the electricity consumption was decreasing, reaching 3.896.280 MWh in 2013, due to the financial and energy crisis. In 2013, billed sales of electricity in the government-controlled areas amounted to 3.893.400 MWh, compared to 4.355.600 MWh in 2012, representing a decrease of 10,6%. In 2014, billed sales of electricity in the government-controlled areas amounted to 3.915.479 MWh, compared to 3.889.788 MWh the previous year, representing an increase of 0,7% (CYSTAT, 2014; EAC, 2014)

Between 2000 – 2014, on average the distribution of billed consumption was as following:

- Domestic 36,3%
- Commercial 41,2%
- Industrial 17,6%
- Agriculture 3,1%
- Public Lighting 1,8%

The distribution of billed consumption for 2013 and 2014 is presented in the following figures.

At the end of 2014, the total number of consumers in the government-controlled areas of Cyprus, stood at 554.574, a net increase of 5.126 or 0,9% from 2013. The highest percentage of consumers (78%) belong to the domestic consumers' category, while the percentages for the categories commercial, industrial, agriculture and street lighting is 15%, 2%, 3% and 2% respectively (EAC, 2014).

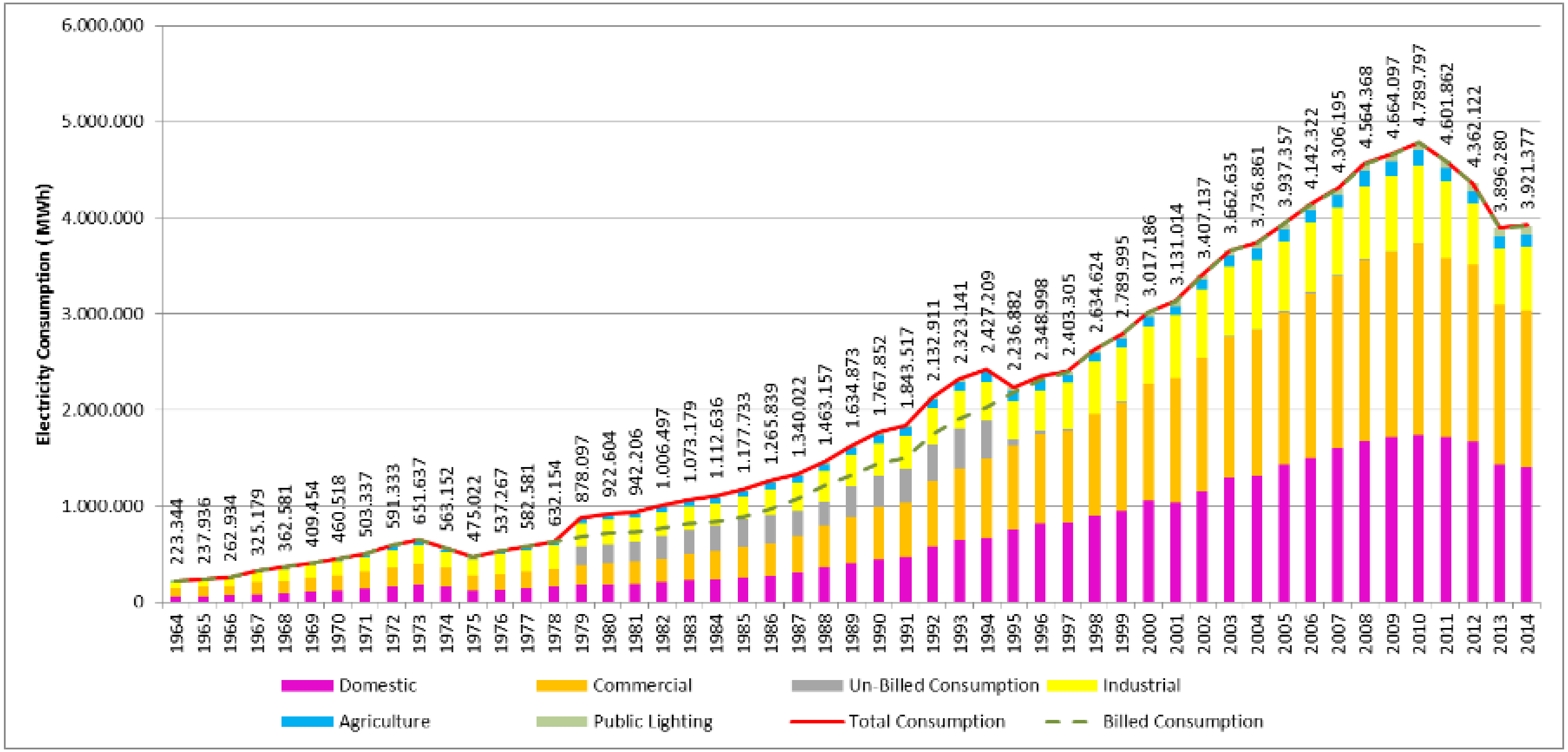

***Figure10.13**: Electricity consumption by category*

10.3. FUTURE TRENDS AND RISKS

10.3.1. INTRODUCTION

In order to estimate the consequences of CC, the climate projections were applied on the response functions. No malicious acts are considered under the present study.

For each metric a scorecard is given to indicate the confidence in the estimates given and the level of risk or opportunity.

Confidence is assessed as high (H), medium (M) or low (L).

Risks (Threats and opportunities) are scored either high (3) medium (2) or low (1) (shown to the right). These will be given for the lower (L) and upper (U) estimates for the 2050s and 2080s.

Metric Code	Metric Name	Confidence	2050s		2080s	
			L RCP4.5	U RCP8.5	L RCP4.5	U RCP8.5
			Risk/opportunity			
X	XXXX					

Classification of Confidence

Confidence Class	Definition
High (H)	Reliable analysis and methods, with a strong theoretical basis, subject to peer review and accepted within a sector as “fit for purpose”.
Medium (M)	Estimation of potential impacts or consequences, grounded in theory, using accepted methods and with some agreement across the sector
Low (L)	Expert view based on limited information, e.g. anecdotal evidence, or very simplistic estimation methods

Risks and opportunities are scored as the magnitude classes used for scoring impacts in the Tier 2 selection. For scoring purposes 3 = High, 2 = Medium and 1 = Low. For the scorecard, the risk/opportunity level relates to the most relevant of the economic/environmental/social criteria.

Level of risk or opportunity	
3	Positive - High consequences
2	Positive - Medium consequences
1	Positive - Low consequences
1	Negative -Low consequences
2	Negative - Medium consequences
3	Negative - High consequences
-	No data

10.3.2. DATA USED

Estimates of future risk are given under the two (2) most plausible Representative Concentration Pathway (RCPs) scenarios in compliance with the latest Assessment Report of the IPCC (AR5). The RCP8.5 is the most severe scenario, featuring the highest emissions and 8,5 Wm^{-2} of global mean radiative forcing by 2100 relative to the pre-industrial times. The RCP4.5 is a medium scenario, featuring 4,5 Wm^{-2} radiative forcing in 2100).

The results from these scenarios are analysed for two future time periods that are sufficiently distant from the present-day and therefore offer a higher possibility for statistically significant results. These periods are 2050s (2041-2060) and 2080s (2071-2090), to assess climate change in mid and late 21st century. We avoided the 2020 period as it is too close to the reference, present-day period, and therefore the noise is expected to dominate the results. To ensure a high signal-to-noise ratio, we averaged the output of 20 years centred around those two periods. Future changes were estimated as the difference from the 1991-2010 reference, present-day period.

The climate variables applied on the response functions, were generated from daily data of the SMHI-MPI (EURO-CORDEX) model, as this model had a complete availability of data for all the scenarios, periods, and variables of interest.

Table 10.3*: BE1-Energy demand for cooling*

Metric Code	Metric Name	Confidence	2050s		2080s	
			L RCP4.5	U RCP8.5	L RCP4.5	U RCP8.5
			Risk			
BE1	Energy demand for cooling	M	2	2	2	3

The gross energy consumption (Ec) for cooling can be calculated from CDD using the following formula:

$$Ec = \frac{PbxCDDx24}{1000}$$

Where

- Pb is the average U-value of the building multiplied by the area of the thermal envelope of the building in Watts per Kelvin (W/K).
- CDD is the Cooling Degree Days

Pb = AxU where

- A = surface area (m^2)
- U = thermal transmittance (W/m^2K)

Note that as the energy consumption is in kWh and cooling degree days are [no. days×degrees] we must convert W/K into kWh per degree per day by dividing by 1000 (to convert W to kW), and multiplying by 24 hours in a day (1 kW = 1kWh per hour). Since one degree temperature difference in Celsius and Kelvin scale are the same, they get cancelled and no conversion is required.

In order to calculate the energy demand for cooling, CDDs were calculated at Municipality/Community Level.

The total area of the residential buildings was calculated from the number of households of each Municipality/Community (2011 census) assuming an average area of **168** sq. metres (typical household).

The total area of rooms in Star Hotels, Hotel Apartments, Tourist Apartments and Tourist Villages was calculated assuming the following values of room surface:

Table 10.4: *Mean room surface (m^2)* [5]

Star Hotels					Tourist Apartments	Tourist Villages	Hotel Apartments
1	**2**	**3**	**4**	**5**			
22	**24**	**26**	**30**	**34**	**40**	**30**	**30**

The average thermal transmittance of both residential building and rooms in hotels etc. was assumed as 1 W/m^2K.

In hotels, the calculations did not take into account the cooling of communal areas and the room occupancy.

[5] *Data for Star Hotels are from www.irena.org/publications. Renewable Energy Roadmap for the Republic of Cyprus, 2015.*

Table 10.5: *Electricity consumption for space cooling, GWh/year*

	Reference period	2050s		2080s	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
Residential buildings	**263**	**450 (+187)**	**540 (+277)**	**478 (+215)**	**783 (+520)**
Star Hotels, Tourist Apartments Tourist Villages, Hotel Apartments	**4,2**	**8,2**	**9,5**	**8,6**	**14,9**

Under the RCP8.5 scenario, in 2050s, energy demand for household cooling can rose up to the 14% of the current total electricity consumption and in the 2080s up to 20%.

Table 10.6*: EN1-Energy demand by water suppliers*

Metric Code	Metric Name	Confidence	2050s		2080s	
			L RCP4.5	U RCP8.5	L RCP4.5	U RCP8.5
			Risk			
EN1	Energy Demand by Water Suppliers	**L**			1	3

Using data from the Water Sector and taking into account the average annual electricity consumption in the desalination plants of Dhekelia and Larnaca for the 2001-2011 period (4,85 Kwh/m^3), the following projections in additional electricity consumption for water supply due to climate change were made.

Table 10.7: *Increase in annual electricity consumption due to the desalinations plants*

	2050s		2080s	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Increase in annual desalination production (m^3) (data from Water Sector)	0	0	7.000.000	50.000.000
Increase in annual electricity consumption (GWh)	0	0	33,95	242,50

Additionally to these impacts, the increase in GHG emissions from changes in energy use must be considered.

Table 10.8: BE3-Energy demand for heating

Metric Code	Metric Name	Confidence	2050s		2080s	
			L RCP4.5	U RCP8.5	L RCP4.5	U RCP8.5
			Opportunity			
BE3	Energy demand for Heating	M	2	2	2	3

The projected change in actual heating degree-days weighted by households has been calculated for both the reference period and the different CC scenarios using projections of changes in minimum and maximum temperature. The response function developed in paragraph 4.4 has then been used to calculate the change in domestic space heating demand[6].

Table 10.9: Actual HDDs weighted by households

Reference period	2050s		2080s	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5
862	670	620	693	407

Table 10.10: Energy demand for space heating, ktoe/year

Reference period	2050s		2080s	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5
223	173 (-22%)	160 (-28%)	179 (-20%)	105 (-53%)

***Table 10.11:** Electricity consumption for space heating, GWh/year*

Reference period	2050s		2080s	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5
280	217	201	225	132

There is a clear reduction in the projected levels of energy demand to heat households in future decades. These savings are significant at household level. Future climate conditions will improve the thermal comfort during winter taking into account that only a small percentage

[6] Taking into account the 303.242 households of the 2011 Census.

of the average area of the buildings is heated during winter and the majority of the dwellings are lacking of thermal comfort.

***Table 10.12**: EN2-Electricity turbine efficiency*

Metric Code	Metric Name	Confidence	2050s		2080s	
			L RCP4.5	U RCP8.5	L RCP4.5	U RCP8.5
			Risk			
EN2	Electricity Turbine Efficiency	L				

Increased ambient temperature reduces the efficiency of thermal power plants in turning fuel into electricity; however, there are no sufficient data to quantify the risk.

***Table 10.13**: EN3-Flooding of power stations*

Metric Code	Metric Name	Confidence	2050s		2080s	
			L RCP4.5	U RCP8.5	L RCP4.5	U RCP8.5
			Risk			
EN3	Flooding of Power Stations	L				1

Cyprus, in the framework of the Floods Directive has published Flood Risk and Hazard maps that focus on fluvial floods and define floodplains under different return periods (T=20, 100, 500). Power stations of Cyprus are not associated with these flood plains. The only infrastructure that was found vulnerable to fluvial floods is the substations. From the 64 substations of EAC, one (1) is located near the watercourse of Yermasogeia river and within the floodplains (T=100 and T=500). Yermasogeia substation is 132/11kV.

Regarding sea flooding, in the current project, the following scenarios of Sea Level Rise (SLR) were examined (see also the Business, Industry and Services Sector Report):

- 0,5 for the 2050s and
- 1m for the 2080s

All the existing power stations are located near the shore line. For the two abovementioned scenarios of SLR there are no impacts on the main stations, however infrastructure for the discharge of cooling water might be affected in the distant future.

Regarding the Vassilikos Master Plan and the foreseen facilities (5 LNG liquefaction plants each of 5 million tons per year capacity, a 230MW Combined Cycle Power plant of PEC Power energy Cyprus Ltd, a 300 MW combined cycle of Vouros Power etc.), the Strategic Environmental Assessment of the plan states that Climate Change adaptation has been considered by the Master Plan and inland installations are well away from the coast and are protected from sea level rise. The study has taken into account a maximum SLR of 30,5cm in the 2050s and 58,4 cm in the 2080s (MECIT, 2015_a).

Taking into account the above-mentioned assumptions and considerations there is a low risk in the distant future for the power stations due to SLR. The risk is limited to the infrastructure related with cooling water disposal facilities.

***Table 10.14**: EN4-Power station cooling processes*

Metric Code	Metric Name	Confidence	2050s		2080s	
			L RCP4.5	U RCP8.5	L RCP4.5	U RCP8.5
			Risk			
EN4	Power Station Cooling Processes	L				

Future increase in seawater temperature will have an impact on the efficiency of the thermal power stations. However, there are no sufficient data to quantify the risk.

***Table 10.15**: Transmission capacity-overhead and EN6 transmission capacity-underground*

Metric Code	Metric Name	Confidence	2050s		2080s	
			L RCP4.5	U RCP8.5	L RCP4.5	U RCP8.5
			Risk			
EN5, 6	Transmission Capacity	L				

The capacity of the transmission network will be affected by projected changes in air temperature. However, there are no sufficient data to quantify the risk.

Table 10.16: *EN7-heat related damage/disruption*

Metric Code	Metric Name	Confidence	2050s		2080s	
			L RCP4.5	U RCP8.5	L RCP4.5	U RCP8.5
			Risk			
EN7	*Heat Related Damage/Disruption*	*L*				

There are no sufficient data to quantify the future risk.

10.3.3. SOCIAL INFLUENCE OF THE PROJECTED CONSEQUENCES

The way the Energy Sector may change in the future is likely to be dependent upon government policy and strategy. Cyprus is at a major crossroad for the development of its energy system. The key driving elements for the evolution of Cyprus' energy system are (IRENA, 2014):

- the potential availability of natural gas, either imported or indigenous, within this decade;
- the plan to open up the monopolistic electricity market to competition, with a view to reduce cost and give choice to consumers;
- the imminent end of derogations given to the electricity sector of Cyprus with respect to the application of EU emission limits, particularly according to the Large Combustion Plants Directive (Directive 2001/80/EC setting emission limits for SO2, NOx and dust) and the free allocation of CO2 certificates;
- new techno-economic developments, particularly with respect to renewable energy technologies, power electronics, smart and energy efficient technologies; and
- the current economic situation of Cyprus, which is seeing increasing need for reduced energy costs in businesses and households.

Regarding natural gas, **i**n 2003 and 2008, the Government of Cyprus expropriated land at Vassilikos for the construction of the Vassilikos Energy Centre (VEC), which was to comprise an onshore LNG import terminal by the coast east of the Vassilikos power station and storage for white and black oil products in the north of the VEC site closer to the Larnaca-Limassol motorway. The gas import policy would benefit EAC by eliminating the need to retrofit flue gas desulphurization at two heavy fuel oil-fired units at Vassilikos power station and also by reducing CO_2 emissions because the availability of natural gas would permit the construction and operation of more efficient gas-fired combined cycle gas turbine (CCGT) power plants (MECIT, 2015_b).

The original plans of the Cyprus Government for the design of the VEC have changed since the discovery of natural gas. Noble Energy discovered gas in significant quantities in late 2011 in deepwater Block 12. Recent results of the appraisal of the Aphrodite gas field indicate gross mean reserves of 5 trillion cubic feet (Tcf), with a range of 3,6 to 6,0 Tcf. The Cyprus domestic market will consume some of this gas, particularly for power generation where it will replace expensive fuel oil and gasoil, but the bulk will need to be sold in international markets to justify the large investment in developing the field and building a gas pipeline to shore. Noble Energy and its partner in Block 12, Israel's Delek Group, signed a Memorandum of Understanding with the Cyprus government in June 2012 to develop a LNG liquefaction plant within the VEC site. The government awarded Production Sharing Contracts for additional Blocks in early 2013 to the company Total (Blocks 10, 11) and the consortium Eni-Kogas (Blocks 2, 3, 9), and further gas discoveries are expected (MECIT, 2015_b).

According to Vassilikos Master Plan the following LNG facilities are planned:

- Phase 1 LNG –three 5 Mtpa LNG trains
- Phase 2 LNG – space for up to two 5 Mtpa LNG trains
- LNG jetty, designed for multiple uses: LNG import, LNG export and possibly HFO import or oil product import/export

Regarding oil storage and gas-based industries the following are foreseen:

- Phase 1 oil storage – with the potential to accommodate 4 million m^3 of oil products including VTTV and Petrolina storage
- Phase 2 oil storage – with the potential to accommodate 3 million m^3 of oil products
- LPG storage in pressurised mounded storage
- Gas-based industries, e.g. methanol and gas compressor station

Cooling and heating demand is likely to change in the future due to an increase in population. This demand depends also on the quality of the building stock, the mitigation policies as well as on the efficiency of the cooling/heating systems.

Due to the high degree of the uncertainties involved, socioeconomic changes haven't been applied.

10.3.4. ECONOMIC IMPACTS

A monetisation exercise allows an initial comparison of the relative importance of different risks within and between sectors. Since money is a metric with which people are familiar, it may also serve as an effective way of communicating the possible extent of climate change risks and help raise awareness.

A variety of methods are available to determine the costs. These methods can be categorized according to whether they are based on:

- Market prices (MP)
- Non-market values (NMV) or
- Informed judgement (IJ)

Informed judgement has been used where there is no quantitative evidence and was based on extrapolation and/or interpretation of existing data.

Notes:

1 - signifies a negative impact or loss; + signifies benefits or cost reduction

2 Impact Cost Ranking:

- Low (L) = €10.000 – 99.000 per annum;
- Medium (M) = €100.000 – 999.000 per annum;
- High (H) ≥ €1m per annum
- ? = not possible to assess

3 Confidence:

- High: Significant confidence in the data, models and assumptions used in monetisation and their applicability to the current assessment.
- Medium: There are some limitations regarding consistency and completeness of the data, models and assumptions used in monetisation.
- Low: The knowledge base used for monetisation is extremely limited.

Table 10.17: *Summary of monetization scoring*

Risk Metric	2050	2080	Estimation Method	Confidence	Notes
BE1 - Energy demand for cooling					
L, RCP4.5	-H	-H	Informed judgement/MP	M	
U, RCP8.5	-H	-H			
EN1 - Energy Demand by Water Suppliers					
L, RCP4.5		-H	Informed judgement/MP	M	
U, RCP8.5		-H			
BE3 - Energy demand for Heating					
L, RCP4.5	+H	+H		M	

U, RCP8.5	+H	+H	Informed judgement/MP		
EN2 - Electricity Turbine Efficiency					
L, RCP4.5	?	?	-	-	
U, RCP8.5	?	?			
EN4 - Power Station Cooling Processes					
L, RCP4.5	?	?	-	-	
U, RCP8.5	?	?			
EN5, 6 - Transmission Capacity					
L, RCP4.5	?	?	-	-	
U, RCP8.5	?	?			
EN7 - Heat Related Damage/Disruption.					
L, RCP4.5	?	?	-	-	
U, RCP8.5	?	?			

For the estimation of the economic magnitude a price of 0,19 €/KWh was used (, 2014 average household electricity price excluding taxes and levies).

***Table 10.9:** Estimated additional annual cost/benefit compared to baseline (million Euros)*

Estimated additional annual cost/benefit compared to baseline (million euros)	**2050s**		**2080s**	
	RCP4.5	**RCP8.5**	**RCP4.5**	**RCP8.5**
Electricity for domestic space cooling	**35,53**	**52,63**	**40,85**	**98,8**
Electricity for domestic space heating	**-11,97**	**-15,01**	**-10,45**	**-28,12**
Electricity for desalination plants			**6,46**	**46,17**

10.3.5. ADAPTIVE CAPACITY

The adaptive capacity of the sector to changing demand in power and heat is dependent on the following four aspects:

1. Installation of new power plants for following future energy demand
2. Energy efficiency measures undertaken or underway;
3. Use of solar energy for heating and cooling. In Cyprus, solar thermal systems are widely used for the needs for hot water, while photovoltaic systems are increasingly used at household level reducing therefore the pressure on the energy supply sector; and
4. Introduction of natural gas in the energy supply portfolio.

New power stations

According to CYPADAPT project, the following targets have been set[7] (CYADAPT, 2015):

1. Maximum output capacity (2016): ~1.700 MW

2. Peak demand (2016): ~1.400 MW

3. Energy capacity (2020): 7.360 GWh

According to more recent data (EAC 2014 Annual Report), the installed capacity of the power stations reached 1478 MW and there are no current plans for its augmentation in the near future (until 2017).

In order to assess the sensitivity of the sector regarding the changing demand for electricity and heat a series of additional indicators should be taken into consideration, as for instance energy dependence of the island on imports.

First of all, the main sensitivity 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 electrical requirements are expected to grow over time, requiring the installation of new power plants.

The current electricity production regime is dependent on imported oil, fact that implies concern over the energy dependence of the island, which in turn implies questions about how secure is the energy system and capable of delivering electrical energy whatever the external political and economic circumstances.

[7] *CYPADAPT references data from the Development Plan of EAC that were retrieved from the 2011 Annual Report*

Energy efficiency measures

Cyprus has established a National Energy Efficiency Action Plan, 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 toe[8], while the contribution by sector is as follows:

1. Residential sector: 161.877 toe (87,5%);
2. Tertiary sector (public sector, general government and enterprises): 23.681 (12,8%);
3. Industrial sector: 1.284 toe (0,69%) and
4. Transport sector: 3.909 toe (2,11%).

Natural gas introduction

In order to diversify the energy supply mix, a policy measure which shall be soon undertaken is the introduction of natural gas. The use of natural gas in power generation is estimated to lead savings of up to 271.000toe.

Based on the measures taken so far and those under way, the adaptive capacity of the cooling/heating energy demand was ranked as High.

[8] *Reflecting 10% energy savings comparing to the energy consumption of the reference year.*

11. MARINE POLLUTION

11.1. INTRODUCTION

The island nature of the country imposes that, for planning the allocation of pollution prevention and combating means, emphasis must be placed on: marine areas, where there is an objectively higher possibility that a serious pollution incident may occur due to the frequent passage of transit tankers and due to the operation of on-shore oil-handling facilities; on offshore installations; on environmentally sensitive protected areas (sea parks, lagoons, river deltas, areas where protected species lay their eggs, areas of particular natural beauty, etc.) which might be threatened.

The following risk factors are considered as posing the greatest threats for oil pollution:

- Ship accidents, including collisions, groundings, explosion, structural failure and disintegration.
- Ship traffic.
- Transfer of oil during ship bunkering operations and STS.
- Transfer of oil from oil tankers to oil handling facilities and power plants.
- Transboundary oils movements in neighboring countries.

The risk assessment takes also into account other geographical, economical and sensitivity parameters as follows:

- Areas of high ecological value and in need of special environmental protection.
- Areas with economic activity (tourism, public beaches, hotels, desalination, water intakes, fishing, fish farms, port and marinas) to be severely affected from an oil spill.
- Locations with dense ship traffic.
- Locations with dense oil transfer operations.
- Amount and properties of oils likely to be spilled.
- Areas with limited or difficult access.
- Fish farms and shell-fish farms.

- Aquatic habitats.
- Industrial sea water intakes.
- Sites of archaeological interest.
- Areas of a particular natural beauty, Mediterranean Specially Protected Areas and areas protected under National Fisheries Law.
- Shallow-water areas or sea areas with little hydrodynamic circulation, where the use of chemical oil dispersants must be avoided.

The level of success to a catastrophic oil spill scenario depends mainly on the proper identification of the imminent risks. This is best done through regular risk assessment. The Mediterranean Decision Support Tool for Maritime Safety (MEDESS-4MS) can be used as it offers a comprehensive and integrated multi-model approach regarding our response to oil spills at sea and takes into account all three important aspects related to marine pollution, that is, Prevention, Detection and Control.

11.2. WORST CASE SCENARIO

Table 11.1 summarizes the number of tanker visits to each oil-receiving coastal facility, and the products and average volumes transported and transferred. This information can be used to identify the most probable worst case oil pollution scenario in Cypriot waters.

***TABLE 11.1**: The average number of tankers visiting oil-receiving coastal facilities each year, and the average volumes of heavy grades of oil discharged in each visit.*

Facility	Number	HFO (MT)	Gasoil (MT)
Moni power station	6–12	8–15,000	
Dhekelia power station	24–36	20–30,000	
Vasilikos power station	24	20-30,000	

An operational discharge during HFO transfer at a power station could feasibly result in the release of several hundred tons of oil into the environment, close inshore. By experience and past accident analysis, an empirical correlation between the tanker size and spill amount is given in the following table:

TABLE 11.2- Correlation between the tanker size and the estimated spill amount

Deadweight (DWT) tons	30,000	50,000	70,000	100,000	200,000	240,000
Estimated spill amount	700	1100	3,000	5,500	10,500	15,000

11.3. WILDLIFE RESPONSE

The impact on wildlife and biodiversity can have severe consequences and will depend upon the environmental sensitivity, the type and quantity of the pollutant and the location of the oil spill. Public opinion and media react very sensitive on scenes and pictures of oil birds and wildlife and the measure of success to an oil spill is often measured by the ability to protect and rehabilitate oiled wildlife.

The government Veterinary and Health Services of the Republic of Cyprus have the primary responsibility to maintain an appropriate and well-designed oiled wildlife response plan and to provide proper guidance and arrange for the necessary personnel for the immediate and effective protection, cleaning and rehabilitation of affected birds, animals and other wildlife.

11.4. PLACE OF REFUGE – SHIPS IN DISTRESS

In certain circumstances directing a stricken vessel to a place of refuge may be considered a priority action to prevent or reduce the harmful effects of a spill. The Department of Merchant Shipping (DMS), as the competent national maritime authority of the Republic of Cyprus may designate any appropriate area as a place of refuge, in accordance with IMO Resolution A.949 (23) concerning 'Guidelines on Places of Refuge for Ships in Need of Assistance', depending on a range of environmental and climatic factors as well as the nature of the incident.

Granting refuge to a vessel in distress is done in accordance with the provisions of the "Plan for the Accommodation of ships in Distress", which has been drafted in accordance with the relevant IMO guidelines and Article 22 of the Merchant Shipping Laws of 2004 and 2010 "Community Vessel Traffic Monitoring and Information System.

12. CYBER RISKS

12.1. NATIONAL LEVEL CYBER RISK ASSESSMENT – HIGH LEVEL DESCRIPTION

This project involved a risk assessment, on a national level, regarding cybersecurity, along with a number of preparatory tasks in order to perform the assessment in the best way possible. The scope of the project included:

1. A **risk assessment with a high level view**, focusing on risks that could manifest, and which could affect the Republic of Cyprus on a national level, taking into account threats, vulnerabilities and impact. Individual in-depth risk assessments were not developed for every stakeholder (e.g. government sector and **critical information infrastructure (CII)** operators), but their relationships and dependencies are being examined with regards to the risks that are found.
2. The final result of this project is a justified **Risk Register**, which the government will use to support risk management decisions in the area of cybersecurity and the protection of CIIs.
3. This Risk Register also includes **recommendations for managing each risk** that were identified, including recommended changes for changes to existing CII legislation.

THE PARTICULARS OF THE NATIONAL LEVEL CYBER RISK ASSESSMENT ARE DETAILED BELOW.

12.2. NATIONAL LEVEL CYBER RISK ASSESSMENT – PROJECT WORK

It is noted that the project follows the recommendations of the General Reports of the European Union Agency for Network and Information Security (ENISA), which include high-level information on the methods used for national level cyber risk assessments in other countries. The steps that were included are the following:

Chart the dependency levels of the Republic of Cyprus on cyberspace, and collect information on relevant national level factors that may affect risks to CIIs, taking into account the levels of Internet penetration in Cyprus, the complexity of online public services, the use of e-commerce, geopolitical conditions, services that citizens use and any other factors that affect the dependence of Cyprus as a country on cyberspace.

Understand how the structure and process of the public sector may affect the way that the national level risk assessment is conducted, through analysis of whether the Cyprus government operates in a centralised or decentralised manner, and whether a hierarchical model or a collaborative horizontal approach is used in decision making processes, in order to guide the implementation of the risk assessment.

Understand the process and way that risk decisions are made on a national level, through charting the processes through which risk decisions are made (across all sectors) on a senior governmental level.

SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis regarding the current levels of preparation of the Republic of Cyprus to perform the risk assessment, through analysis, via consultations, stakeholder focus groups and questionnaires, of the current preparedness level of the Republic of Cyprus regarding the conduct of the risk assessment and how it can be improved for future iterations of the risk assessment process.

Identify and select standard definitions and taxonomy, through definition of the main terms (vocabulary) which are relevant to the conduct of the risk assessment, along with the creation of taxonomy. A list of definitions of the main terms was created (e.g. risk, threat, vulnerability, impact, etc.) from reliable sources (e.g. ISO standards), and this list was the subject of consultation with the relevant project stakeholders.

Identify qualitative sources of risk data, through identification and reporting on qualitative sources of risk data, as far as threats, vulnerabilities and related impacts are concerned. These sources were categorised into national and external sources (e.g. security companies, academic institutions, international organisations such as ENISA, ISO, etc.).

Identify dependencies between cybersecurity risks and other domains/sectors, including the collection of relevant information and opinions of CII operators within the Republic of Cyprus (e.g. sectors such as energy, transport, finance, health, water, government) regarding the ways in which they use cyberspace, the effects on their infrastructure in case identified risks are manifest, and the dependencies between these sectors (e.g. dependence of the ICT sector on the energy sector, dependence of the finance sector on the electronic communications sector, etc.).

As part of this activity, and to complete the modelling of dependencies, a criticality analysis was conducted on all of the infrastructures (i.e. potential CIIs) that were identified earlier during the project. The identified CIIs include infrastructures in the energy, transport, electronic communications, banking, financial, water, sewage, food, health and state sectors.

SWOT analysis on the differences between an integrated versus a harmonised approach to managing interdependencies, and select one approach, with a SWOT analysis on the differences between an integrated versus a harmonised approach to the management of interdependencies that were identified and described in the previous step. In the integrated approach, stakeholders use the same tools and methods for managing these interdependencies, whereas in the harmonised/collaborative approach, stakeholders are free to select their relevant tools and methods. The harmonised approach imposes more due diligence regarding the validation of the approaches used by stakeholders and on the validity of their results.

SWOT analysis on methodologies and select one to apply, the particular methodology to follow for the risk assessment itself was carefully selected, taking into account current cybersecurity risk assessment methodologies. Selection criteria included the following:

- **Scope -** Does it focus on a particular sector or can it be used in multiple areas?
- **Objectives -** Can it be used for a general risk assessment, or only to protect a specific technical system?
- **Applied Techniques -** Does it demand qualitative or quantitative analysis?
- **Provenance -** Does it come from the public or the private sector? Is it recent?

- **Success Stories -** Has it been used successfully in the past? Can examples be provided?

The final result of this activity was the decision to use a modified version of the NIST SP800-30 methodology to conduct the risk assessment itself.

Identify, contact and engage stakeholders, through a comprehensive stakeholder analysis to determine who needed to be involved in the risk assessment, using the results of previous activities as a guide. Their desired involvement was recorded via a RACI analysis (Responsible, Accountable, Communicated, Informed).

Conduct Risk Assessment, based on the selected methodology from the relevant earlier step, resulting in a comprehensive Risk Register, with full analysis of the cybersecurity risks that affect CIIs and the government sector. Emphasis was given on the sector interdependencies and on the current status of the Republic of Cyprus, in terms of the manifestation probabilities of the identified risks. The government will be able to use this Risk Register for decision making purposes and for risk management in the area of cybersecurity and the protection of CIIs. The Risk Register also includes recommendations for managing each risk. These recommendations include, among others, proposed changes to existing CII legislation.

12.3. NATIONAL LEVEL CYBER RISK ASSESSMENT – THREATS

Potential threats in cyberspace manifest in a range of sources, targets, volume and complexity, and in addition to these they are constantly changing. For the effective protection of CIIs, it is vitally important for CII operators to conduct regular and formalised risk assessments for their own organisations, as well as to manage the risks that are identified as part of this process. Appropriate risk assessments will result in informed estimates for the threats involved, and also the potential impact and likelihood of such threats materialising.

In this project, the following high-level threats were analysed across all the CIIs that were identified:

- Inability to Identify, Manage and Mitigate Risks / Threats.
- Disruption of Business Operations - Physical Damage or Theft (Unauthorised Access to Premises).
- Disruption of Business Operations - Damage and Destruction (Natural Disasters).
- Disruption of Business Operations - Loss of Essential Services.
- Disruption of Business Operations – Equipment (Hardware / Software) Failure.
- Disruption of Business Operations - Ability to recover from a disastrous event.
- Information Disclosure / Compromise of Information Integrity / Availability - Unauthorized Logical Access to Assets.
- Disclosure of Information - Data Interception In Transit.
- Disclosure of Information - Data in Storage (At Rest).

- Disclosure of Information - Ineffective Deletion of Data.
- Disclosure of Information - Unintentional Disclosure.
- Disruption of Business Operations - Software Malfunction.
- Information Disclosure / Remote Spying - Application / Network Attacks.
- Information Disclosure / Remote Spying - Intrusion of Malware.
- Disruption of Business Operations - Denial of Service Attacks.
- Information Disclosure / Compromise of Information Integrity / Availability - Abuse and/or Forging of Rights.
- Information Disclosure / Remote Spying – Lack of Network Controls.

12.4. NATIONAL LEVEL CYBER RISK ASSESSMENT – STATUS AND NEXT STEPS

This project has now been completed (as of October 2016), however it is not possible to provide information on the actual results (risk levels, CII status, etc.), as a decision is pending regarding the classification of the project deliverables. A number of actions at the national and organisational level, in order to address the risks that have been identified, are planned for implementation in 2017, and the national level risk assessment (including the CII criticality analysis) is due to be repeated in 2018 for its second iteration.

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