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The Cyprus Climate Change Risk Assessment

Evidence Report



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Revision Table

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Abbreviations

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 Expenditures
CC	Climate Change
CCRA	Climate Change Risk Assessment
CDD	Cooling Degree Days
CTO	Cyprus Tourism Organization
CYSTAT	Statistical Service of Cyprus
DFMR	Department of Fisheries and Marine Research
DMP	Drought Management Plan
DoE	Department of Environment
DoF	Department of Forests
EC	European Commission
ESA	Environmentally Sensitive Areas
EU	European Union
FAO	Food & Agriculture Organisation
FTTH	Fibre-To-The Home
FWI	Fire Weather Index
GDP	Gross Domestic Product
GHG	Greenhouse Gasses
GMI	Guaranteed Minimum Income
HDD	Heating Degree Days
IAS	Invasive Alien Species
IBU	International Banking Units
ICT	Information and Communications Technology
IPCC	Intergovernmental Panel on Climate Change
ktoe	Kilotonne of oil equivalent
LNG	Liquefied Natural Gas
MCM	Million Cubic Meters

NBS	National Biodiversity Strategy
neZEH	Nearly Zero Energy Hotels
NPP	Net Primary Productivity
nZEB	Nearly Zero Energy Buildings
OA	Ocean Acidification
OPEX	Operating Expenses
PGA	Peak Ground Acceleration
PM	Particulate matter
RES	Renewable Energy Sources
RCM	Regional Climate Model
RCP	Representative Concentration Pathway (scenarios)
SLR	Sea Level Rise
SPEI	Standardized Precipitation Evapotranspiration Index
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
TCI	Tourism Climate Index
TER	Threatened Endangered and Rare (species)
THI	Temperature Humidity Index
UHI	Urban Heat Island
UK	United Kingdom
UNEP	United Nations Environment Programme
UNFCCC	Framework Convention on Climate Change
WDD	Water Development Department
WFD	Water Framework Directive 2000/60/EC
WTP	Willingness to Pay

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1. Executive Summary/Introduction

1.1 Executive Summary

The Climate Change Risk Assessment (CCRA) provides an overview of potential risks and opportunities of climate change for Cyprus to the end of the 21st century. Its findings, particularly related to those risks that require early action, will inform the development of adaptation plans by the Government and the Competent Authorities.

This report draws together and presents evidence from individual CCRA Sector Reports and recent research literature. The findings are presented for a range of possible future scenarios, including different levels of population growth, with an indication of the overall confidence in the results and areas where there are significant evidence gaps.

More specifically, this report provides evidence that can be used by the Ministry of Agriculture, Rural Development and the Environment and in particular by the Department of Environment, in order to implement successfully in the Republic of Cyprus, the Decision No 1313/2013/EU of the European Parliament and of the Council on a Union Civil Protection Mechanism and the obligation of publishing the **1st CCRA in 2016 for Cyprus**.

The Department of Environment has a statutory role to advise Ministers on the preparation of the national CCRA. The Government will then produce the **revised National Adaptation Program** that will set out the policies and proposals to address the risks identified by the CCRA.

In order to ensure that the CCRA is able to consider how different risks act together in time and space, and how responses may mitigate different risks, the **Evidence Report** is structured around chapters, based on particular economic, social and environmental systems where there are numerous interactions between the different risks considered, and/or similarities in the adaptation responses to the risks.

The CCRA gives an assessment of potential impacts (opportunities and threats) from climate change, focusing on how climate risks are likely to manifest themselves over the 21st century in the absence of action. For the 2016 **Evidence Report**, the Department of Environment produced a focused report that sought to address the following issues:

- Assess climate risks in the light of methods of assessment and knowledge of climate change impacts;
- A fuller assessment of how climate interacts with socio-economic factors and how these drivers of risk might change in the future, for example economic growth; population change; land-use change;
- How the effects of adaptation actions are likely to alter risk levels;
- Assess the magnitude of impact and the urgency of action needed for different threats and opportunities, as well as developing an understanding of the possible net effect of different risks acting together;
- Assess the uncertainties, limitations and confidence in the underlying evidence and analysis for different risks.

This **Evidence Report** covers Cyprus and will be used to inform both the Cyprus Government and Competent Administrations on future priorities for adaptation policy.

This report provides an overview of the risk assessment, including a synthesis of the key findings. It presents the best information available on the vulnerability of Cyprus to climate change, identifies notable risks and opportunities and gaps in our current understanding of climate risks. The assessment was undertaken across 12 “sectors” (or research areas) and drew evidence from literature reviews, expert elicitation and more detailed quantitative analysis, where the data allowed. It incorporated feedback from stakeholders in these sectors, to identify potential impacts and to select risks for more detailed analysis. For each Sector a Sector Report was produced.

The analysis was based on the **United Kingdom CCRA methodology** [1, 2] and included identification of risk metrics, development of response functions, an adaptive capacity assessment, competent authorities mapping and assessment of the magnitude of the risks (see Annex I). It required consultation with government departments to collect data and support the analysis. The UK Sector Risk Assessment reports [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13] as well as the findings of the CYPADAPT programme [14, 15, 16] were valuable sources of information. The findings of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) were also taken into account [17, 18]. Analytical references supporting the findings of this report are found in the 12 Sector Reports.

The main **policy instruments and institutions** that govern climate change adaptation to the main risks are analytically described in each Sector Report. Some of the policies that have been taken into account include the following:

- The River Basin Management Plan and Water Policy, drafted in the framework of the Water Framework Directive
- The Flood Risk Management Plan, drafted in the of the Floods Directive
- The National energy efficiency action plan of Cyprus, drafted in the framework of the Energy Efficiency Directive
- The National Renewable Energy Action Plan drafted in the framework of the 2009/28/EC Directive
- The Nearly Zero Energy Buildings Action Plan drafted in the framework of the Energy Performance of Building Directive
- The European Common Agriculture Policy
- The National Biodiversity Strategy. Cyprus has formulated the National Biodiversity Strategy (NBS) during 2013, as a reference document in order to fulfil the commitments accepted with the ratification of the Convention on Biological Diversity.
- The Strategy for the Management of waste
- The low-carbon development strategy of Cyprus to 2050
- The Multiannual national plan for the development of sustainable aquaculture

It should be highlighted that Climate change adaptation measures (Existence of national risk assessments for disaster management taking into account climate change adaptation;) is an

ex-ante conditionality which has to be fulfilled before the start of the programming period 2014-2020.

1.2 Background

Climate Change (CC) is currently considered as one of the greatest challenges to mankind in the 21st century. Climate change is a global issue, and measures designed to reduce it cannot be successful unless the nations of the world act together in a coordinated and harmonious manner. The countries of the world have joined forces under the auspices of the UN Framework Convention on Climate Change (UNFCCC), which was agreed in 1992 and entered into force in 1994, and the Kyoto Protocol to that Convention which was agreed in 1997 and took effect in 2005. These nations (196 parties to the UNFCCC and 192 parties to the Kyoto Protocol) work within the boundaries of the Framework Convention in order to coordinate measures for mitigation and adaptation to climate change. Cyprus is a party to the UNFCCC and the Kyoto Protocol.

The most important milestones on CC action at a European and Cypriot level are the following:

- 1992 Adoption of the United Nations Convention on Climate Change (UNFCCC)
- 1994 UNFCCC entered into force
- 1997 Cyprus ratified the UNFCCC as a non-Annex I Party
- 1998 Adoption of the Kyoto Protocol
- 2003 Cyprus ratified the Kyoto Protocol
- 2008 Start of the Kyoto Protocol's First Commitment period
- 2009 EU's climate and energy package for 2020 agreed
- 2011 Cyprus change its UNFCCC status to Annex I party
- 2011 EU's 2050 roadmap agreed
- 2012 End of the Kyoto Protocol's First Commitment period
- 2012 Doha amendment to the Kyoto Protocol

According to the definitions given by the IPCC, **Climate change** refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes [18].

IPCC defines **Risk** as the potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. Thus, **Risk assessment** is the qualitative and/or quantitative scientific estimation of risks [18].

1.3 The CCRA Framework

The CCRA gives an assessment of potential impacts (opportunities and threats) from climate change, focusing on how climate risks are likely to manifest themselves over the 21st century in the absence of action. Following the methodology applied in the 1st UK CCRA, the data gathering and analysis work for the CCRA was divided into sectors (see Annex I). The Cyprus CCRA focused on the following 12 sectors:

- Agriculture (Agronomy Subsector and Livestock Subsector)
- Biodiversity & Ecosystem Services
- Built Environment
- Business, Industry & Services
- Energy
- Forestry
- Floods & Coastal Erosion
- Health
- Marine & Fisheries
- Transport
- Soil
- Water

The Evidence report draws together and interprets the evidence gathered by the CCRA conducted for each sector regarding current and future threats (and opportunities) posed by the impacts of climate change.

The components of the CCRA sought to:

Identify and characterise the impacts of climate change. This was achieved by developing the Tier 1 list of impacts (>400), which included impacts across the sectors as well as impacts not covered by the sectors and arising from cross-sector links.

Identify the main risks for closer analysis. This involved the selection of Tier 2 impacts (>70) for further analysis from the long list of impacts in Tier 1. Higher priority impacts were selected based on the social, environmental and economic magnitude of impacts and the urgency of taking action.

Assess current and future risk, using climate projections and considering socio-economic factors. The risk assessment was undertaken by developing 'response functions' that provide a relationship between changes in climate with specific consequences based on analysis of historic data, the use of models or expert elicitation. In some cases this was not possible, and a narrative approach was taken instead. The climate projections were then applied to assess future risks. The potential impact of changes in future society and the economy was also considered, to understand the combined effects for future scenarios.

Assess vulnerability. This involved:

- a review of Government policy on climate change in each sector

- an assessment of the social vulnerability to the climate change impacts
- an assessment of the adaptive capacity of each sector

Report on risks to inform action. The results for the 12 sectors are presented in separate reports. This Evidence Report draws together the main findings from these reports, including consideration of cross-linkages between sectors, and outlines the risks to the Cyprus as a whole.

The main findings from the twelve sector reports were drawn together under **five themes**:

- Rural Economy
- Natural Environment
- Built environment & Infrastructure
- Human health and wellbeing
- Business & Industry

2 Characterising the future

2.1 Climate change scenarios

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 study, 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, we used averages for a 20-year period centred around 2000, i.e. 1991-2010. 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 are also examined. We avoided examining the very near future (e.g. 2020), 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 $4,5 \text{ W m}^{-2}$, while in RCP8.5 it is $8,5 \text{ W m}^{-2}$. The more optimistic RCP2.6, scenario was not used since this scenario is much less likely to occur and there are much fewer simulations in EURO-CORDEX/MED-CORDEX available with RCP2.6.

The main purpose of the 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/>). We used two MED-CORDEX models that have performed 12 km (0,11 degree) horizontal resolution simulations, and three EURO-CORDEX models with the same resolution.

Initially, the ESGF website (<http://esgf.llnl.gov/>) on which the EURO-CORDEX data is stored was unexpectedly deactivated for maintenance since July 2015, the time when the CCRA climate modelling analysis was about to commence. This has been a major disruption to the analysis plan and caused some delays. However, to mitigate this, the climate science team of the CCRA has managed to acquire data from EURO-CORDEX RCMs that performed 12 km simulations (three versions of SMHI – see below) via personal communication. These models' results, along with the results from two MED-CORDEX models that simulated on 12 km resolution were analysed. Eventually, we managed to analyse five models in total, which is higher than the target that was initially set (three models).

The five regional climate models used are:

- 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 presenting changes in the future, the present-day climate of Cyprus as simulated by the models was presented. 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 in the winter, and lowest in the summer in most of the areas, except for the continental lowland areas that experience more rain in the autumn and spring. The wettest part of the island is 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 region with the smallest increases is the western coastal areas, while the region 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 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 CCRA. It is noted that the coastline is already subject to erosion, as a result of human activities such as sand mining, dam and illegal breakwater construction and urbanisation. Climate change impacts could deteriorate this erosion. No studies have been accomplished yet to clarify whether coastal erosion in Cyprus is also attributable to climate change.

2.2 Socio-economic scenarios

The nature of risks, vulnerability and adaptive capacity all change over time in response to both climate and socio-economic drivers. From an historical perspective it is clear that social and economic trends can have a far greater influence than natural climate variability on many risks. Improvements in services (health, water, energy, etc.), advances in technology and good regulation may reduce risks. Increased population size, uncontrolled development and social changes may mean greater exposure to hazards, increases in vulnerability and greater pressure on the natural environment. Increasing wealth will always inflate damage and disruption costs and it is essential to disaggregate these effects to understand the relative influence of climate and socio-economic change.

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 persons 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 persons 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.

The evolution of the at risk of poverty and social exclusion (AROPE) indicator, which had risen significantly from 23,3% in 2008 to 27,1% in 2012, recorded a further increase 27,8% in 2013. As regards the evolution of the AROPE sub-indicators, the at-risk of poverty rate showed a small increase from 14,7% in 2012 to 15,3% in 2013, while it showed a small decrease in relation to 2008 data (15,9%). A more significant deterioration in the 2013 figures was recorded as regards the severe material deprivation rate which increased to 16,1% compared to 15% in 2012 and 9,1% in 2008. The quasi-jobless households (people living in very low work intensity households) rate also exhibited a significant increase in the same period (to 7,9% in 2013 from 6,5% in 2012 and 4,5% in 2008).

The profiles of AROPE and its sub-indicators indicate that there is an overall trend in reduced rates in people over 65 years and an increasing trend in the unemployed, but also among the working groups. This reflects the high unemployment rate in Cyprus but also the reduced earnings related especially to new acquired jobs by young people.

In combating conditions of poverty and social exclusion, Cyprus has undertaken a major reform of its welfare system. As welfare benefits were considered to be fragmented and in order to improve efficiency, a comprehensive social governance was decided through the

creation of a single welfare benefit administration service with appropriate national registry and other control and check mechanisms. The Guaranteed Minimum Income (GMI) Scheme, which will ultimately replace the public assistance benefit, was implemented in July 2014 with the aim to provide assistance to individuals and families that cannot, despite their efforts, gain enough income to support themselves. Cyprus is in a transitional stage where public assistance continues to be provided to beneficiaries, until the processing of their GMI applications is completed, while the GMI is also provided to families, which were not receiving any income support benefits in the past.

With the full implementation of the GMI and based on an impact assessment conducted, it is expected that the AROPE rate will decrease by 3,2%. Its impact will mainly be seen in the depth of poverty as the GMI, upon full implementation is expected to decrease the poverty gap by 16,8%.

The GMI provides for basic needs based on a minimum consumption basket and covers also other needs, such as housing (rent or mortgage interest), municipality taxes and extraordinary needs, as well as care needs and long-term care. The GMI incorporates a new group, the working poor as an eligible group and consolidates low-income pensioners.

Furthermore, the GMI provides the framework for two mechanisms, namely social care and social intervention to GMI recipients. Social care provides for the subsidisation of the cost of home, institutional, respite and day care including child care of GMI recipients. Social Intervention refers to the activation and social inclusion of GMI recipients. This action includes a wide spectrum of services provided to a person or family unit receiving the GMI that will empower and support them in their social integration. The ultimate purpose of this action is the employment rehabilitation through co-operation with the PES. Cyprus is in the process of developing these tools.

Also the Council of Ministers adopted in November 2014, the National Strategy on Social Policy for the period 2014-2020 aiming to reduce the number of people-at-risk-of-poverty and social exclusion by 27.000 people or decrease the percentage from 23,3% in 2008 to 19,3% by 2020.

The Strategy sets the main policy guidance for the period 2014-2020 providing a comprehensive approach to the challenges faced. The Strategy addresses the promotion of children's welfare, the reform of the welfare system, active inclusion, long-term care and effective governance.

The Cyprus economy achieved enviable progress in the 50 years since the country's independence. The traditional agricultural economy of the early 1960s was gradually transformed into an economy characterised by a high standard of living and a robust financial sector. Recovering at a relatively fast pace from the catastrophic consequences of the Turkish invasion, it gained full membership of the European Union (EU) in 2004 and of the euro area in January 2008.

In recent years, the Cyprus economy has been dominated by the services sector: trade, financial and business services, and shipping are key drivers of economic growth. The construction sector and the real estate development sector also play an important role in the economy. Sectoral contributions to growth have varied significantly over time. The primary sector has seen its contribution to Gross Domestic Product (GDP) decline further, reflecting not only the loss of the largest part of agricultural land, but also a structural shift of the economy towards the tertiary sector. Wholesale and retail trade, and hotels and restaurants were the largest contributors to the total value added in the 1990s, which is consistent with the growing importance of internal and foreign trade and of tourism in the economy. Progressively, other sectors also grew in importance, such as financial and business services and real estate, which became major contributors to economic growth. It is worth noting that the role of government services (public administration, defence, health and education) gained significance too.

Cyprus's major imports are raw materials, consumer and capital goods, transport equipment and fuel, while major exports are pharmaceutical products, cement, cigarettes, paper products, plastic products, potatoes, citrus fruit, wines, and furniture.

The tertiary sector of services is considered as the backbone of the Cyprus economy, accounting for more than 80% of GDP in 2011. This reflects the gradual evolution of the economy from an exporter of minerals (mainly copper and asbestos) and agricultural products during 1960-73, an exporter of manufacturing products (mainly clothing) at the end of the 1970s, to an international business and service centre in the 1980s – today.

In March 2013, the Eurogroup decided to provide financial assistance up to 10 billion euro to the Republic of Cyprus, after intensive negotiations. At the same time, it was decided to dissolve and absorb Laiki Bank by the Bank of Cyprus, while a haircut was imposed on uninsured deposits of the two banks.

The violent restructuring of the Cypriot banking sector, the continued negative external environment and the fiscal consolidation measures adopted by the Government of Cyprus, negatively affected the growth of the economy in 2013. The capital restrictions imposed by the Government also had a negative impact on the economy. From the demand side, the decline in private consumption and investment was lower than predicted, especially towards the end of the year. From the supply side, the relatively satisfactory performance of the tourism sector and professional services, helped to limit the recession.

In the labour market, the unemployment rate in 2013 increased significantly to 16%, as a result of the economic downturn. The unemployment rate was contained to some extent by the measures adopted by the Government, the reduction of the foreign labour and the reduction in earnings.

Furthermore, Cyprus was dealt a severe blow by the Evangelos Florakis Naval Base explosion in July 2011, with the cost to the economy estimated at €1–3 billion, or up to 17% of GDP.

For 2013, inflation stood at 0,4%, which largely reflects the adjustment of the labour market and price developments, which are deemed necessary so that to improve the productivity and competitiveness of the economy. The current account deficit exhibited a significant decrease in 2013, reaching -1,9% of GDP. This positive development is mainly due to the major decrease of imports, which was higher than the reduction in exports. In terms of public finances, fiscal targets in 2013 were outperformed (budget deficit of -5,4%) due to prudent budget execution, as well as less than predicted recession. However, the public debt rose significantly (112% of GDP), reflecting the sharp decline in GDP.

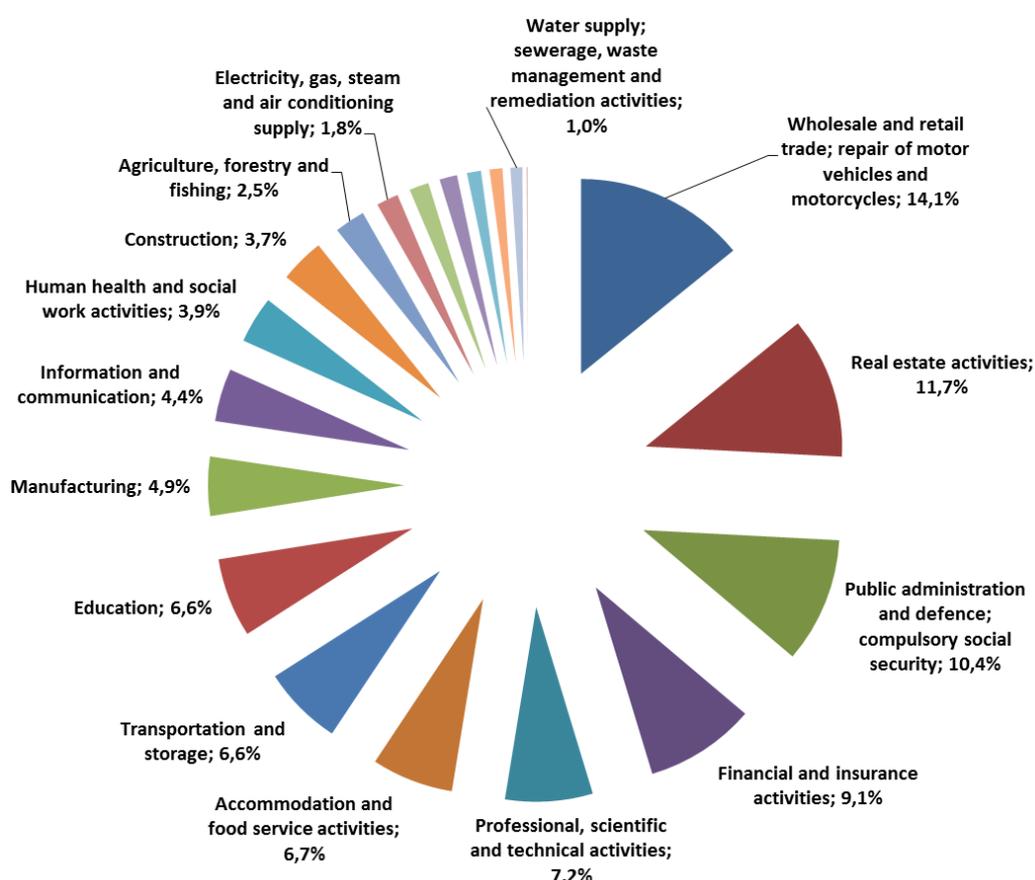


Figure 2.1 Distribution of GDP by economic activity, 2013

The CCRA used a standard set of population projections across all sectors and these were particularly important health, built environment and energy assessments where the number of people and properties has a significant influence on future risks. In order to capture the wide range of uncertainty in future population, two projection variants were used (Main Scenario and No migration variant) which were derived from the Eurostat. Two time horizons (2050 and 2080) were selected to correspond with the central year of key 20 year time periods (2041-2060) and (2071-2090).

Europop2013, the latest population projections released by Eurostat, provide a **main scenario** and **four variants** for population developments from 2013 to 2080 across 31 European countries. These projections were produced using data for 1 January 2013 as a starting point and therefore include any modifications made to demographic statistics resulting from the 2011 population census exercise.

Data on population, live births and deaths used as input data in EUROPOP2013 round are official statistics provided by the national statistical authorities to Eurostat in the frame of annual demographic data collection. Migration flows have been measured in terms of net migration (including statistical adjustment) and computed as residual from the annual demographic balance. The 'main input dataset' includes the 2013 base-population and the assumptions for fertility, mortality and international net migration (including statistical adjustment), and defines the frame of main scenario for producing the population projections. Four variants were obtained by modifying one of the assumptions' component while the other components of the 'main input dataset' were maintained constant.

Europop2013 projections result from the application of a set of assumptions on future developments for **fertility, mortality and net migration**. The projections should not be considered as forecasts, as they show what would happen to the resulting population structure if the set of assumptions are held constant over the entire time horizon under consideration; in other words, the projections are 'what-if' scenarios that track population developments under a set of assumptions. As these projections are made over a relatively long time horizon, statements about the likely future developments for the EU's population should be taken with caution, and interpreted as only one of a range of possible demographic developments.

The time horizon covered in Europop2013 is 2013 until **2080** for the **main scenario and zero migration variant**, and 2013 until **2060** for the **higher life expectancy, reduced migration and lower fertility variants**.

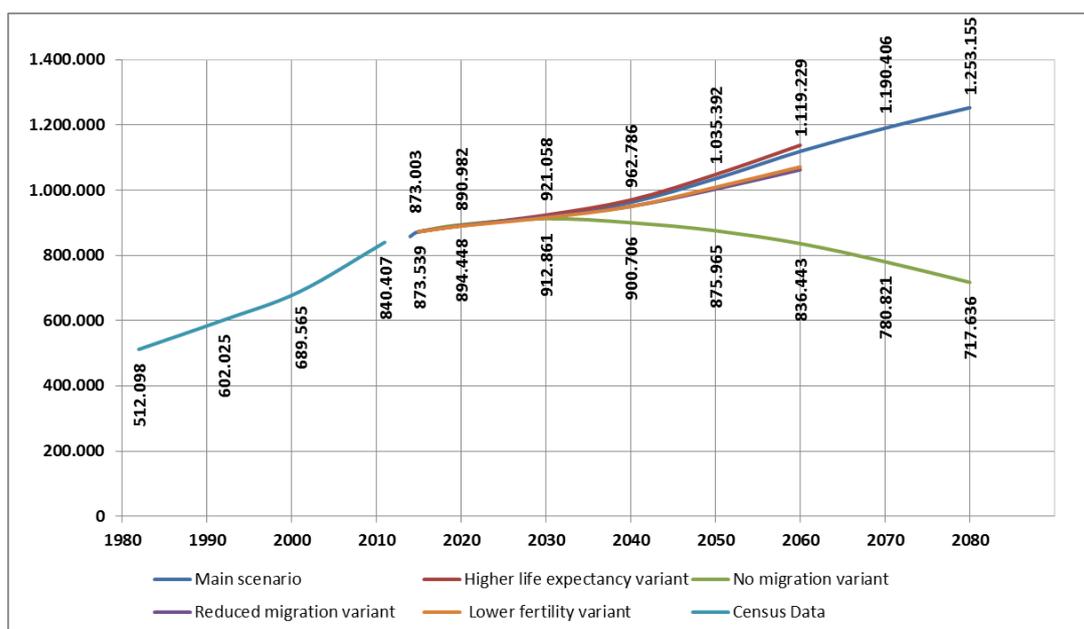


Figure 2.2 Europop2013 Cyprus population projections and Census Data

Figure 2.2 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.

As an alternative approach for some sector assessments considered a number of other dimensions, providing some qualitative discussion on how these may affect future risks:

Population needs/demands. This dimension is intended to encapsulate drivers of population size and distribution (geographically and demographically) and the pressure the population forces onto the country in terms of housing, education etc. One extreme is that there is a high degree of demand on natural, economic and social resources (demand exceeds supply and more people are exposed to risk); the other is that demand is very low (supply exceeds demand and people are less exposed to risk).

Global stability. This dimension describes drivers based on world events that would increase or decrease global stability (e.g. war, natural disasters, economic instability). 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 and people that outweigh other priorities) compared to today.

Distribution of wealth. This dimension considers the distribution of wealth amongst the 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.

Land use change/management. These dimensions relate to aspects of urbanisation versus rural development.

2.3 Approach to analysis and understanding risk

There were essentially three key components to the risk assessment, namely:

- The development of functions to describe the climate sensitivity of individual consequences (referred to as response functions);
- The use of these functions in conjunction with climate projections to estimate the change in risk relative to the present day baseline; and
- The scaling of these 'response' projections to take account of how they may be influenced by future changes in socio-economic conditions and any autonomous or planned adaptation.

These components of the assessment were considered individually and collectively, so that the relative contribution of each of the following could be clearly identified:

- The underlying sensitivity of the risk,
- The projected change in the relevant climate variable; and
- The socio-economic influence.

The CCRA method has focused on understanding the sensitivity of selected risks to current and future climate and which, collectively, make up the 'risk landscape'. In both the process of identifying the risks and developing response functions, consideration was given to identifying aspects of the risk landscape that were particularly vulnerable and so likely to be susceptible to, or unable to cope with, adverse effects of climate change. In many instances, this depends not only on the sensitivity of the particular risk (i.e. how quickly the consequence changes in response to a change in some climate variable) but also whether the consequence is likely to be pushed beyond some critical threshold, or whether the relevant system has some inherent capacity to adapt.

The advantages of the CCRA method are that:

- It is relatively simple to understand;

- The analysis can be done with the data and knowledge currently available; and
- It allows a clear presentation of relative risk that may arise as a result of climate change.

However, the 'reductionist' nature of the method also carries some disadvantages:

- There is limited analysis of the interaction with other non-climate drivers of change; and
- The approach has a limited ability to capture complexity, non-linearity and systemic risks.

Where relevant these issues are highlighted in the text. Overall, this approach means that the influence of climate is explored in detail but the influence of social, political and economic changes is less well developed. Future CCRA cycles are expected to improve this aspect of the risk assessment.

3. Rural Economy

3.1 Introduction

The Rural economy theme brings together findings from the following Sector Reports:

- Agriculture,
- Biodiversity & Ecosystems,
- Forestry
- Water and
- Soil Sector

Table 3.1, provides a summary of the risks considered as part of the assessment work in this study and provides an indication of how the magnitude of the **moderate emissions scenario** (RCP4.5) changes over time. Further detail of the risks relevant to this theme, with more information on how the magnitude of the risks vary under different scenarios is provided in the scorecard at the end of the chapter (see Table 3.8).

Overview	
<ul style="list-style-type: none"> • The CCRA has identified a range of climate related risks to the Forestry Sector. These risks are likely to have negative impacts on various goods and services provided by forest ecosystems. Wildfires, extended diebacks and loss of productivity due to increases in prolonged major drought events, increases of insect attacks and spread of pathogens and diseases, together with changes in dominant tree species suitability are the main risks identified for the forestry sector of Cyprus. • Agricultural systems are vulnerable to changes in climate and are among the first to feel the effects. Climate change presents both threats and opportunities. In terms of crops yield there is variation not only between the scenarios but also between different geographical areas for the same crop. • Negative impacts on outdoor farming productivity and animal welfare are likely to occur. • Increased energy demand in indoor farming is expected. 	
Threats	Opportunities
<ul style="list-style-type: none"> • Increased risk of wildfires • Forests and woodlands are expected to be further affected by pests, pathogens and diseases • <i>Pinus brutia</i> productivity will decrease • Climatically suitable area for key forest species will decrease • Increased soil erosion • Negative impacts on livestock production (mostly occurred in animals that are farmed outdoors) • Increased energy demand for indoor farming systems • Significant decrease in the yield of the July sowing potato 	<ul style="list-style-type: none"> • Increased yield for grapevines and olive tree plantations located in the western coastal areas as well as in higher elevation areas

Table 3.1 Summary of rural economy impacts with an indication of direction, magnitude and confidence

		Confidence	Timing	
			2050s	2080s
Opportunities				
AG1e	Crop yield using grapevine as a reference C3 fruiting berry	L	2	1
AG1a	Crop yield using wheat as a reference C3 rain fed arable crop	M	1	1
AG1d	Crop yield using olive as a reference C3 tree	L	1	1
Threats & Opportunities				
AG1b	Crop yield using potato (November sowing) as a reference irrigated vegetable crop for Spring-Summer production	M	2	1
Threats				
AG2	Livestock production	L	1	2
W3	Irrigation Supply Deficit	L	1	2
AG1c	Crop yield using potato (July sowing) as a reference irrigated vegetable crop for Autumn production	M	2	2
BD6	Increased soil erosion	H	2	2
F01	Increased risk of wildfires	H	2	2
F03	Increased risk of drought damage / loss of productivity	M	2	3
F04	Changes in tree species suitability	H	2	3
F02	Increased risk of pests, pathogens and diseases	L	3	2

3	Positive - High consequences	H	High
2	Positive - Medium consequences	M	Medium
1	Positive - Low consequences	L	Low
1	Negative -Low consequences		
2	Negative - Medium consequences		
3	Negative - High consequences		

3.2 Livestock production

Goats and sheep farms in Cyprus are scattered throughout the country and operating under semi-intensive or free-range management. According to data of the Department of Agriculture in 2013 there were 2.413 holdings with 402.369 animals (226.067 sheep and 176.302 goats). Athiainou had the largest number of sheep (11.204 animals) and Kofinou had the largest number of goats (4.916).

In 2013, 230 cattle farms were operating with a total number of 57.683 animals. Of these, 211 were dairy units with 24.700 Holstein dairy cows. Most of the animals are bred in Larnaca (49%) and Nicosia (32%). The Communities with the largest number of cattle are Athienou and Idalion.

The total population of pigs in 2013 in Cyprus was to 322.505 and were bred in 68 facilities. The total number of sows in December 2013 was 31.115 of which 30.827 were reared in intensive farms. The majority of pigs and sows are found at Nicosia (65%).

In 2011, from the total of 96 poultry farms, 47 were in Nicosia, 28 Larnaca, 113 in Limassol, 6 in Paphos and 4 in Famagusta. From these holding, 53 are used for chicken meat production and 30 for laying. Meat production is mainly taking place in Nicosia and less in Larnaca and Limassol, while laying in Nicosia and Larnaca. Reproduction is taking place only in Nicosia.

In this CCRA it was not possible to directly quantify the losses of the livestock production. Instead, a qualitative assessment was made using the mean summer Temperature humidity index (THI).

The analysis suggests due to increasing temperatures all livestock will face significant heat stress conditions in the summer period. This stress will be further deteriorated in case of additional extreme weather events (e.g. heat wave, drought).

The most pronounced impacts of CC will be felt by animals that are farmed outdoors. Indoor systems can also experience heat stress however, if building designs will be developed with ventilation etc. in place to help keep the animals comfortable the climate change impacts may be addressed. Increased energy demand in indoors farming is expected in order to maintain temperatures within the zones of thermal comfort, resulting in increased cost of farming.

3.3 Crop Yield

Agriculture, together with fisheries and forestry, accounts for 2% of Cyprus' GDP (2010). Despite this relatively low contribution, which has steadily declined due to development of other sectors, agriculture continues to be a vital sector of Cyprus' economy.

In 2012, from a total area of 925.100 ha, Utilized Agricultural Area (UAA) represents 132.500 ha or 14,3% of the total. Land that is not cultivated (either fallow or unsuitable land) represents more than 20% of the UAA. Annual crops cover 55% of the Agricultural Land while 21,5% of it is cultivated by trees (mainly olive trees, carobs and vines). Potatoes, barley, wheat,

water melons and tomatoes are the most important annual crops while grapefruits, orange trees, olive trees, carobs and bananas are the most important permanent cultivations respectively. In 2010 organic farming was applied in almost 1,7% of the total Agricultural Area.

Due to climatologic conditions and development, Cyprus will always be short of water. Land availability on the island surpasses water availability. The result is that despite considerable ground and surface water development, only a small proportion of the land is irrigated. More specifically, the irrigated areas occupied 24% of the cropland, but were responsible for 70% of the total national crop production, while consuming 48% of the blue and green water used by crops. The rain-fed areas produced on average 273×10^3 ton/yr, fuelled by 277×10^6 m³/yr of green water. This water may otherwise have returned back to the atmosphere without much local benefit. As thus, water availability (including annual precipitation) is a vital issue for the production of crops.

The possible impacts of climate change on crop productivity in Cyprus were estimated using crop modelling outputs and previous research findings.

FAO's crop model AquaCrop was applied for crop simulation using climatic, crop, soil, farm management data derived from complementary research in the context of the present study. Four reference crops (wheat, potato, olive, grapevines) were simulated representing the majority of the crop productivity in Cyprus. Wheat was simulated under rain fed conditions. Potato was projected in two different growing periods, the first established in November and the second in July. Moreover, potato represented an important vegetable crop with a significant agronomic importance for Cyprus. Finally, olive and grapevines were estimated based on previous research and literature findings.

Concerning RCP4.5 scenario, AquaCrop simulations showed that wheat is going to be favoured in the areas of Mountain and Inland Cyprus for both periods 2041-2060 and 2071-2090 compared to the reference period. In the case of RCP8.5 scenario the positive effect of climate change on wheat was even higher and was expanded to the Western area too. A serious limitation of the current study was that the impacts of climate change on the quality of the grain were not defined because of the constricted research and field information.

In the case of potato, the projection for the two growing periods (November and July sowing), gave quite controversial results. Specifically, in almost all the cases yields of the July sowing were significant lower compared to November indicating that potato growing in summer is going to face serious climatic restrictions.

Regarding olive trees and grapevines the findings were almost identical. Possible both crops are going to shift their main production areas moving to higher altitudes now considered relatively cool as the Western or Mountain Cyprus. The magnitude of the projection is expected to be greater in the RCP8.5 scenario than RCP4.5. On the other hand, grapevines face greater level of uncertainty regarding yield's quality due to the fact that the projected conditions are going to downgrade late varieties which are more sensitive to higher temperatures and drought conditions.

The outputs of the AquaCrop simulations classified on the basis of the expected yield changes are presented in the following Table.

Table 3.2 Expected yield change for reference crops

	Western Coastal Areas	Southern Coastal Areas	Higher Elevation Areas (Mountain)	Continental Lowland Areas (Inland)	South-eastern Coastal Areas
RCP4.5, 2050					
Wheat	0>Y>5%	-5%<Y<0	Y>20%	Y>20%	0>Y>5%
Potato (November sowing)	-20%<Y<-5%	-20%<Y<-5%	-5%<Y<0	-5%<Y<0	-20%<Y<-5%
Potato (July sowing)	-20%<Y<-5%	-20%<Y<-5%	-20%<Y<-5%	-20%<Y<-5%	-20%<Y<-5%
Olive	5%>Y>20%	-20%<Y<-5%	5%>Y>20%	-20%<Y<-5%	-5%<Y<0
Grapevine	5%>Y>20%	-20%<Y<-5%	5%>Y>20%	-20%<Y<-5%	-5%<Y<0
RCP8.5, 2050					
Wheat	-5%<Y<0	-5%<Y<0	0>Y>5%	Y>20%	-5%<Y<0
Potato (November sowing)	-5%<Y<0	-5%<Y<0	0>Y>5%	0>Y>5%	-5%<Y<0
Potato (July sowing)	-20%<Y<-5%	-20%<Y<-5%	-20%<Y<-5%	-20%<Y<-5%	-20%<Y<-5%
Olive	5%>Y>20%	-20%<Y<-5%	5%>Y>20%	-20%<Y<-5%	-20%<Y<-5%
Grapevine	5%>Y>20%	-20%<Y<-5%	5%>Y>20%	-20%<Y<-5%	-20%<Y<-5%
RCP4.5, 2080					
Wheat	5%>Y>20%	0>Y>5%	5%>Y>20%	5%>Y>20%	0>Y>5%
Potato (November sowing)	0>Y>5%	0>Y>5%	0>Y>5%	0>Y>5%	0>Y>5%
Potato (July sowing)	-20%<Y<-5%	-20%<Y<-5%	-20%<Y<-5%	-20%<Y<-5%	-20%<Y<-5%
Olive	5%>Y>20%	-20%<Y<-5%	5%>Y>20%	-20%<Y<-5%	-20%<Y<-5%
Grapevine	0>Y>5%	-20%<Y<-5%	0>Y>5%	-20%<Y<-5%	-20%<Y<-5%
RCP8.5, 2080					
Wheat	5%>Y>20%	5%>Y>20%	Y>20%	Y>20%	5%>Y>20%
Potato (November sowing)	0>Y>5%	-20%<Y<-5%	5%>Y>20%	5%>Y>20%	-20%<Y<-5%
Potato (July sowing)	-20%<Y<-5%	-20%<Y<-5%	-20%<Y<-5%	-20%<Y<-5%	-20%<Y<-5%
Olive	5%>Y>20%	-20%<Y<-5%	5%>Y>20%	-20%<Y<-5%	-20%<Y<-5%
Grapevine	5%>Y>20%	-20%<Y<-5%	5%>Y>20%	-20%<Y<-5%	-20%<Y<-5%
Legend					
Yield Change	Y<-20%	-20%<Y<-5%	-5%<Y<0 0>Y>5%	5%>Y>20%	Y>20%

3.4 Irrigation water supply

Effective water demand management is one of Cyprus' priorities as a fundamental condition for the exercise and application of a sustainable water policy. Various measures aiming at further improving the good practices for water consumption and reuse are being implemented by the Ministry of Agriculture, Rural Development and Environment.

The implementation of the Water Framework Directive (WFD), which aims at protecting and improving the status of waters, is also a priority. At the same time, it is important to strengthen the resilience of the aquatic ecosystem, in order to adapt to climate change. In this context, the implementation of the 1st River Basin Management Plan and Drought Management Plan adopted in June 2011 and the recent 2nd River Basin Management Plan continues, while the process for their review and update is well underway. Moreover, following the completion of the Flood Hazard and Flood Risk Maps, a Flood Risk Management Plan is being developed. In the field of waste water, the priority is the full implementation of the Urban Waste Water Treatment Directive.

Particular importance is also given to the implementation of other relevant Directives, as well as to the relevant national legislation for the protection, monitoring and management of water resources.

In order to address water scarcity, which is one of the most serious problems faced by Cyprus, the optimum use of non-conventional water resources, such as desalination and recycling are being promoted. In particular, with the completion of all desalination units, except the Paphos desalination plant which is planned for the coming years, the dependency of the large urban, suburban and tourist centers on rainfall has been eliminated. Recycled water for irrigation and recharge purposes is a growing resource. More and more quantities of tertiary treated recycled water are used for the irrigation of agricultural crops and recharge of aquifers.

The main water supply sources in Cyprus are the dams and their reservoirs, groundwater sources, via boreholes, the desalination plants and recycled water. The water supply to different users - consumers is, primarily, through Government owned and run water-works 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.

Two features regarding the water resources of Cyprus exert the key defining influence on the development of the water sector; the overall water scarcity arising from an imbalance of natural water resources against demands and the very high temporal variability of rainfall and, consequently, of surface runoff. This high variability appearing in an environment that is water-scarce even in multi-year average terms, results in periods of severe drought, at least from the point of view of the water users.

The traditional multi-year regulation of water resources has been based on the exploitation of groundwater sources. These provided the means of smoothing the effects of the high

variability in rainfall. Groundwater resources were, subsequently, complemented in their regulatory role by the numerous large dams that were constructed.

More recently, two new technology-based sources have been developed; desalination which taps a practically inexhaustible source at the penalty of high energy consumption and recycled water that is being introduced into the irrigation water balance at rapidly increasing rates.

Many of the dams are linked between them as well as with other sources (groundwater, desalination and recycled water) and with consumption points, forming multisource-multipurpose water management systems. The two most important, by far, are the Southern Conveyor and the Pafos systems with a third, lesser, system being based on Evretou and smaller dams as well as groundwater sources.

These integrated water management systems operate under fairly complex rules. These rules have been revised in the Review of **Water Policy** that was drafted in the framework of the 1st River Basin Management Plan of Cyprus.

Irrigation demand may increase due to two factors:

- Increased Potential Evapotranspiration
- Decreased effective rainfall due to an overall reduction in rainfall depths.

Estimates of potential increase in demand were carried out for the four climate modelling scenarios (for more details see Water Sector Report). The FAO software CROPWAT was used, for a FAO reference crop, with the in-built climate database of FAO (CLIMWAT) which uses the meteorological station of Ayios Nikolaos as a reference for Cyprus. Two different sets of estimates were carried out; one for an all-year crop (e.g. perennials) and one for a Spring-Summer crop. The results are summarized in tables 3.3 and 3.4. For each basic scenario, one with increased rainfall decrease was added, leading to 8 scenarios per set.

For the 12 month crop, the increase in theoretical demand ranges from 2,7% (2050 RCP 4.5) to 15,33% (2080 RCP 8.5) and is maximized at almost 23% for an added scenario that corresponds to 2080 RCP 8,5 but with higher rainfall reduction of up to 30%.

For the Spring-Summer crop, the increase in theoretical demand ranges from 2% (2050 RCP 4.5) to 10% (2080 RCP 8.5) and is maximized at 11% for an added scenario that corresponds to 2080 RCP 8,5 but with higher rainfall reduction of up to 30%.

Table 3.3 Estimation of increases in irrigation requirements for a 12 month crop

Scenarios	Total Evapotranspiration (mm)	Effective Rain (mm)	Deficit (mm)	Increase in Irrigation Requirements
Historic	1.372	340	1.032	
2050 RCP 4.5	1.399	339	1.060	2,66%
2050 RCP 8.5	1.429	340	1.089	5,50%

Scenarios	Total Evapotranspiration (mm)	Effective Rain (mm)	Deficit (mm)	Increase in Irrigation Requirements
2050 RCP 4.5 with 5% Rainfall Decrease	1.399	323	1.076	4,24%
2050 RCP 8.5 with 15% Rainfall Decrease	1.429	289	1.140	10,45%
2080 RCP 4.5	1.414	336	1.077	4,39%
2080 RCP 8.5	1.504	314	1.190	15,33%
2080 RCP 4.5 with 15% Rainfall Decrease	1.414	289	1.125	8,99%
2080 RCP 8.5 with 30% Rainfall Decrease	1.504	238	1.266	22,67%

Table 3.4 Estimation of increases in irrigation requirements for a Spring-Summer crop

Scenarios	Total Evapotranspiration (mm)	Effective Rain (mm)	Deficit (mm)	Increase in Irrigation Requirements
Historic	672	27	645	
2050 RCP 4.5	685	27	658	2,04%
2050 RCP 8.5	700	27	673	4,31%
2050 RCP 4.5 with 5% Rainfall Decrease	685	26	659	2,24%
2050 RCP 8.5 with 15% Rainfall Decrease	700	23	677	4,94%
2080 RCP 4.5	692	27	666	3,21%
2080 RCP 8.5	737	25	712	10,35%
2080 RCP 4.5 with 15% Rainfall Decrease	692	23	670	3,80%
2080 RCP 8.5 with 30% Rainfall Decrease	737	19	718	11,28%

The predictions for the overall irrigation demand in Cyprus needs to take into account that an action plan is underway, for the reduction of water use in irrigation through changes in crops and cultivation practices as well as improvement in the management of irrigation schemes towards increasing efficiency.

The savings through this action can more than compensate for the increases predicted in almost all of the scenarios. Therefore, in the water balance calculations, it has been assumed that the overall result will be neutral and future average irrigation demand will remain at present levels at approximately 143 million m³ per year.

From the supply-demand balance drafted in the Water Sector Report, it is proved that irrigation demand deficits may become evident due to climate change. By availing reduced water quantities for irrigation, there may be a considerable reduction in the annual crop yields. In summary, the demand projections are presented in the following table:

Table 3.5 Water Demand Projections (MCM)

Demands (MCM)	Historic	Year 2050	Year 2080
Water Supply, tourism and industry	81	86	88
Irrigation	143	143	143
Totals:	224	229	231

From the above data, an approach was made to allocate the water resources availability and allocation for the 75% driest hydrologic year and the median hydrologic year. Irrigation deficits are assessed for the 75% driest year, which corresponds to a check at 75% reliability level. This is a generally accepted reliability level for irrigation. The resulting irrigation deficits are presented in the following table.

The following graph gives a representation of the influence of the reduction in average surface runoff due to climate change to the projected irrigation deficit.

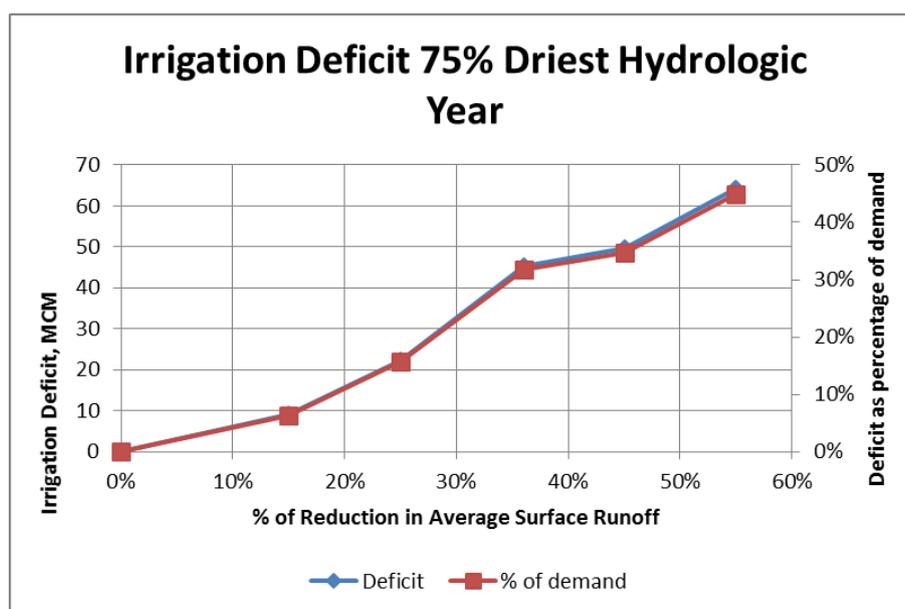


Figure 3.1 Irrigation deficits as a water volume and as percentage of total irrigation demand

According to the analysis based on data, representing the average multi-CC model results, notable increase in irrigation deficit is expected only in the distant future (2% for the moderate and 22% for the more pessimistic CC scenario). Using data from a single CC model (SMHI-MOHC) in the 2050s the increase in irrigation deficit is estimated to 15% for the moderate and

35% for the more pessimistic CC scenario. In the 2080s, the increase is estimated to 35% for the moderate and 50% for the more pessimistic CC scenario.

Table 3.6 Irrigation Deficit (%)

Irrigation Deficit (%)	2050s		2080s	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Multi-model Scenario Results	0	0	2%	22%
SMHI-MOHC model	15%	35%	35%	50%

Irrigation water supply is intrinsically vulnerable because it is distributed to large and complex systems. In well-run utilities, human capital in the form of trained staff and financial capital to invest in upgrading to agricultural technologies and new infrastructure makes the irrigation water supply potentially highly resilient to climate change. But, it could not be resilient in practice if resilience was reduced by factors such as excessive leakages, supply in intermittent mode etc.

The decrease in the available water resources in Cyprus due to climate change has caused in past severe restrictions in the supply of water for domestic and irrigation uses. Also, costly measures were implemented for securing the absolutely necessary quantities of potable water (e.g. by importing water, intensifying the desalination plants operation).

For agriculture, the actual water allocation is prepared through governmentally managed schemes and is dependent on availability and based upon a quota system. More specifically, farmers apply for their required volumes for the irrigation season at the beginning of the year and their main water sources are ground and surface water, received mostly by the dams. Private boreholes are also supposed to be exploited and since clearly these boreholes draw water from the same aquifers, they should be factored into models for water delivery. Deficits of supply cause considerable loss in agricultural production and income. The future development of agriculture will be greatly dependent on the effects of climate change. Reduced availability of irrigation water and less nutrient uptake may cause reduction in yields.

People occupied in the agriculture or touristic industry are more vulnerable to climate change effects on the water sector, since it is more likely that their activities will be more vulnerable to water deficits and/or increased costs for water supply.

3.5 Land suitability

Future changes in **land suitability** are acknowledged to be an important factor influencing the future composition and profitability of agricultural land use. This is because changing soil characteristics and agroclimatic conditions greatly influence crop selection, agronomic husbandry practices and the economics of production.

The principal soil aspects that affect soil fertility and are susceptible to climate change are soil biodiversity, organic carbon content, available soil moisture, erosion, salinization and desertification. Rising temperatures lead to loss of organic carbon from soils as the organic content is decomposed and mineralized with accelerated rate. Desertification phenomena cause the conversion of productive lands into non - productive. Long dry periods along with regular strong seasonal winds are the main causes for wind erosion, while the force of raindrops, surface and subsurface runoff and river flooding are the main causes for rain water erosion. Soil salinity is one of the most serious agricultural problems. The cause of this process is the accumulation of salts in soil capillaries leading to a sharp decrease in plant fertility. Salt concentration left in plant capillaries, with insufficient amount of nourishing substances leads to plants dying.

Soil fertility in Cyprus experiences a declining trend. The phenomenon of erosion has affected the arable land in Cyprus and specifically the arable land and the land used for permanent crops. Indicatively it is mentioned that, during the period 1995 – 1999, 56% or 1130 km² of agricultural land, was eroded.

Land desertification is one of the most serious environmental issues at global, national, regional and local scales.

According to the United Nations Convention to Combat Desertification, 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”. 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 favouring 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 be 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.

According to the analysis presented in the Soil Sector Report, desertification in Cyprus is an important process of land degradation especially in the olive and cereal cultivation zone, in pine forested areas and shrubby grazing lands. The main process of land degradation and desertification is soil erosion.

The island of Cyprus is mainly characterized by critical and fragile type areas to desertification, 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.

Based on the climate change as assessed in projections RCP4.5 and RCP8.5, such process is expected to become more acute, if as forecasted the annual rainfall will decrease and the air temperature will increase, adversely affecting the derived aridity index. Soil erosion is expected to be more severe under climate projection RCP8.5. Land desertification is a serious threat under the reference period climatic conditions, and it is expected to be aggravated under climate projections RCP4.5 and RCP8.5.

Many areas characterized as fragile to desertification under the reference period climatic conditions will be converted to critical areas to desertification if the forecasted climate change would occur. In addition, several areas characterized as prone to desertification are expected to change to fragile and the vulnerability to desertification will increase. Furthermore, changes in the vulnerability to desertification within the same type of environmentally sensitive areas are expected under the predicted climatic scenarios. For example, fragile areas of sub-type F2

are expected, in many cases, to change in sub-type F3, which means increasing sensitivity to desertification.

Table 3.7 Distribution of environmentally sensitive areas to desertification

Environmentally sensitive areas to desertification (ESAs)	Reference period	2050		2080	
		RCP4.5	RCP8.5	RCP4.5	RCP8.5
	area (ha)				
Critical-C3	452	647	1.015	1.810	2.627
Critical-C2	181.000	225.305	229.835	249.360	253.680
Critical-C1	214.133	253.736	251.991	255.100	253.122
Fragile-F3	121.304	168.676	166.327	161.389	159.090
Fragile-F2	185.661	157.161	156.406	144.823	146.100
Fragile-F1	104.168	30.134	30.356	25.616	24.242
Potential-P	36.207	12.694	12.130	9.995	9.377
No threatened-N	6.981	1.552	1.848	1.813	1.669
Other areas	72.145	72.145	72.145	72.145	72.145
TOTAL	922.051	922.051	922.051	922.051	922.051

3.6 Forestry

Pinus brutia is the only commercial species in Cyprus. The total area covered by *P. brutia* is around 138.000 ha, with only 30% characterised as productive. Due to the low growth rate and the existence of under stocked areas, the annual cut covers only 2% of the local demand for wood. Thus, forestry contribution to the economy of Cyprus is negligible.

Risks related to forest ecosystems are further discussed in Chapter 4.

3.7 Adaptive Capacity

Both the inherent adaptive capacity of forest ecosystems and the structural and organisational adaptive capacity in Cyprus are characterised as high. Ongoing adaptation measures can limit the projected climate change impacts. Additional measures may be needed in order to reduce forest vulnerability to climate change. These measures may either aim to reduce forest sensitivity to adverse climate change impacts or increase adaptive capacity to cope with the changing environmental conditions.

There are a number of adaptation practices and measures to mitigate the effects of climate change on Agriculture. Short-term include:

- There are a number of adaptation practices that vary depending on the region and the range Change in crop establishment date (sowing or planting).
- Change in inputs (fertilisers and pesticides).
- Measures to conserve water.

Some long-term that require major structural interventions are

- Change the choice of crops and the use of agricultural land.
- Crop Breeding.
- Change and development of farming methods and management.

It is noted that Cyprus can benefit from new Common Agricultural Policy (CAP), since during the next 7 years, CAP is going to invest more than 485¹ million Euros in Cyprus's farming sector and rural areas. With the support of the CAP Cypriot farmers can take simple, proven measures to promote sustainability and combat climate change. 30% of direct payments will be linked to three environmentally-friendly farming practices: crop diversification, maintaining permanent grassland and conserving 5% of areas of ecological interest or measures considered to have at least equivalent environmental benefit [28].

¹ Total allocation of Direct Payments and Rural Development for the period 2014-2020

3.8 Summary of risk metrics

Risk metrics related to rural economy as a result of climate change are presented below.

Table 3.8 Scorecard for rural economy

Metric Code	Metric Name	Confidence	2050s		2080s	
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
AG1e	Crop yield using grapevine as a reference C3 fruiting berry	L	2	2	1	2
AG1d	Crop yield using olive as a reference C3 tree	L	1	1	1	1
AG1a	Crop yield using wheat as a reference C3 rain fed arable crop	M	1	1	1	2
AG1b	Crop yield using potato (November sowing) as a reference irrigated vegetable crop for Spring-Summer production	M	2	1	1	2
AG1c	Crop yield using potato (July sowing) as a reference irrigated vegetable crop for Autumn production	M	2	2	2	2
AG2	Livestock production	L	1	2	2	3
BD6	Increased soil erosion	H	2	2	2	3
F01	Increased risk of wildfires	H	2	2	2	3
W3	Irrigation Supply Deficit	L	1	2	2	3
F03	Increased risk of drought damage / loss of productivity	M	2	3	3	3
F04	Changes in tree species suitability	H	2	3	3	3
F02	Increased risk of pests, pathogens and diseases	L	3	2	2	2

3	Positive - High consequences
2	Positive - Medium consequences
1	Positive - Low consequences
1	Negative -Low consequences
2	Negative - Medium consequences
3	Negative - High consequences

H	High
M	Medium
L	Low

4. Natural Environment

4.1 Introduction

The natural environment is the complex of the biological and physical environment, crucial to human health and wellbeing, as it provides us with a wide range of ecosystem services. Human induced environmental changes have been well documented both in local and global scale [29, 30]. Land use and land cover changes are already influencing biodiversity and ecosystems. Climate change is expected to further increase current pressures on biodiversity and ecosystem services.

The CCRA has identified a range of climate related risks to natural environment, including changes in habitats and species distribution and suitability, increased soil erosion, loss of coastal habitats due to sea level rise, increased risk of wildfires and land desertification. These risks are likely to result in loss of important habitats and species, while other sectors including agriculture and forestry will also be impacted. In addition, indirect risks emerging from socio-economic factors can act synergistically and amplify the effects of climate change. Vulnerability to climate change varies among different ecosystems and species, with coastal habitats, freshwater ecosystems and wetlands as well as mountainous ecosystems being the most at risk.

Cyprus has already experienced the effect of climate change, with prolonged major drought events, wildfires and desertification being well-known phenomena in many parts of the island. An adaptation strategy to Climate Change has been prepared, while various measures and policies are implemented by the government of the Republic of Cyprus aiming at the protection of biodiversity and ecosystems. Among others, the importance of the Natura 2000 Network must be highlighted, although its efficiency in terms of climate change must be addressed. Still, there are many uncertainties as far as it concerns climate change impacts on natural environment and there is an urgent need for empirical studies and long-term monitoring of species and ecosystems so as to better understand and predict the response of biodiversity and natural environment to changing climatic conditions.

Overview	
<ul style="list-style-type: none"> The CCRA has identified a range of climate related risks to biodiversity and ecosystem services. Several of these risks require a cross-sectoral approach as there are important interactions with other sectors, such as forestry, agriculture, marine and fisheries but also building environment, soil and business. In total, 27 risk metrics were found to have direct or indirect impacts on natural environment. The great majority of the identified risks represent threats for the natural environment. These risks are likely to have negative impacts on various goods and services provided by natural ecosystems. The magnitude of climate change impacts can be moderated by the implication of adaptive strategies, conservation and management practises. For a number of risks (e.g. pests, diseases and invasive species, coastal evolution due to sea level rise) there is a great uncertainty in future predictions. 	
Threats	Opportunities
<ul style="list-style-type: none"> Changes in distribution of important habitat and species, species unable to find suitable microclimate/habitats or unable to track changing climate space Increased soil erosion Major drought events and productivity loss Land desertification, soil moisture deficits and drying Increased risk of wildfires Increased risk from invasive species, pests, pathogens and diseases Coastal changes due to sea level rise Agricultural intensification 	<ul style="list-style-type: none"> Better conditions for some flora and fauna species, although this will tend to favour generalists, opportunistic and/ or ruderal species that are more adaptable over the specialists. It is further suggested that direction generalist species could be of particular importance in the maintenance of ecosystem functions in the future under predicted future environmental conditions with more frequent, abrupt, and extreme events [33]. Climate induced agricultural land abandonment could be an opportunity for some habitat and species

Table 4.1, provides a summary of the risks considered as part of the assessment work in this study and provides an indication of how the magnitude of the **moderate emissions scenario** (RCP4.5) changes over time. Further detail of the risks relevant to this theme, with more information on how the magnitude of the risks vary under different scenarios is provided in the scorecard at the end of the chapter (see Table 4.2).

Table 4.1 Summary of natural environment risks with an indication of direction, magnitude and confidence

		Confidence	Timing	
			2050s	2080s
Opportunities				
AG1e	Crop yield using grapevine as a reference C3 fruiting berry	L	2	1
AG1a	Crop yield using wheat as a reference C3 rain fed arable crop	M	1	1
AG1d	Crop yield using olive as a reference C3 tree	L	1	1
Threats & Opportunities				
AG1b	Crop yield using potato (November sowing) as a reference irrigated vegetable crop for Spring-Summer production	M	2	1
Threats				
AG2	Livestock production	L	1	2
BD2	Species unable to track changing climate space	H	1	2
BD8	Increased soil moisture deficits and drying	M	1	2
BE4	Effectiveness of Green Spaces	M	1	2
AG1c	Crop yield using potato (July sowing) as a reference irrigated vegetable crop for Autumn production	M	2	2
BD6	Increased soil erosion	H	2	2
BD11	Changes in primary productivity	M	2	2
BD12	Agricultural intensification (i.e. human use of NPP)	L	2	2
BD10, F01	Increased risk of wildfires	H	2	2
BD1	Species unable to find suitable microclimate/habitats	H	2	3
BD3	Changes in distribution of priority species	M	2	3
BD4 & D5	Increased risks from pests, diseases and invasive species	L	2	3
BD7	Coastal evolution impacts	H	2	3
BD9	Major drought events, Impact on Water Quantity and Increased Societal Water Demand	M	2	3
F03	Increased risk of drought damage / loss of productivity	M	2	3
F04	Changes in tree species suitability	H	2	3
MA4	Shifts affecting producers and consumers	M	2	3
F02	Increased risk of pests, pathogens and diseases	L	3	2
MA6	Changes in fish catches and gene pool	M	3	3
MA7	Exerting pressure on fish physiological thermal limits	M	3	3
S1	Land desertification	H	3	3
MA3	Potential disruption of fish production	M	3	3

3	Positive - High consequences	H	High
2	Positive - Medium consequences	M	Medium
1	Positive - Low consequences	L	Low
1	Negative -Low consequences		
2	Negative - Medium consequences		
3	Negative - High consequences		

4.2 Changes in distribution of important habitat and species, species unable to find suitable microclimate/habitats or unable to track changing climate space

Projected increases in temperature and decreases in precipitation for Cyprus are expected to affect distribution of habitats and species while others non-climatic factors could also act synergistically to amplify the negative effects of climate change. Across Europe several plant species have shifted their distribution towards more favourable climatic conditions (northward or uphill) over the last years. The extent to which species and habitats will be able to find suitable microhabitats depends not only on their ability to track climate change, but also to the availability of areas that would offer favourable microclimatic / habitat conditions. According to our simulation model results climate change is expected to lead to range shifts for several habitat types and species, including priority species. Climate induced potential distribution changes have also been found for the four key forest species of Cyprus: *Quercus alnifolia*, *Pinus nigra*, *Pinus brutia* and *Cedrus brevifolia*.

Shifts in species ranges and loss of suitable climate space will result to changes in community composition, species interactions and biodiversity patterns. Species richness and functional diversity are essential components of ecosystem function as well as resilience and response to environmental perturbations. Thus, potential losses arising from shifts in climate zones would have a direct effect on ecosystem services including provisional services and cultural values that species or habitats supply in specific areas. Changes in tree species suitability and climate induced distribution shifts of the key forest trees are expected to have significant impacts in terms of both Wood Forest Products and Non-Wood Forest Products as well as indirect benefits provided by forests (biological diversity, carbon sequestration, recreation etc.).

The Natura 2000 network in Cyprus comprise 61 site and represents about 28% of the Republic of Cyprus area, which is a relative high proportion compared with other European countries. 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. In general, it seems that the Natura 2000 network is well designed. This could aid the inherent adaptive capacity of the sector, enabling species movements across the landscape. The leading management authorities of the Natura 2000 Network in Cyprus are the Department of Forests (DoF) and the Department of Environment (DoE), which both have important experience in the conservation and protection of natural ecosystems.

4.3 Major drought events and productivity loss

Water availability is an essential resource for both humans and ecosystems. Cyprus is already facing intense problems of water shortage and drought, which are expected to intensify as a result of climate change. Several habitat types among different habitat groups are sensitive to changes in water quantity. Among them, there are habitat types like the endemic Peat grasslands of Troodos (6460), which conservation absolutely depends on the hydrologic development of the area. Forests and other wooded lands in Cyprus suffer considerably by

drought and water stress that in certain years can be particularly intense. Due to the existence of long, dry and hot summers as well as the low levels of winter precipitation between 1993 and 2000, a significant number of trees dried out in the forests of the island

Climate change is expected to exacerbate the pressures on Cyprus's natural resources, which are already stressed due to the island's semi-arid climatic conditions. As a consequence, adverse effects are projected on water availability, with subsequent effects on water-dependent ecosystems, flora and fauna species. Furthermore, a climate induced reduction in forest productivity could lead to decrease efficiency to store C.

Cyprus has already experienced severe droughts and water scarcity events, with desertification being a well-known phenomenon in many part of the island. Increased demands for water have led to dams' constructions dating back to 1900 and severe overexploitation of water resources. Extended trees dieback, such as the extended diebacks of several tree species after the prolonged drought period of 2005- 2008, are also documented. Nowadays, conservation measures are applied in order to restore aquifers and ecosystems through management plans. Monitoring and management of water bodies, is implemented according to the WFD, which was incorporated in the legislation of Cyprus (Law No. 3812/2004) and will enforce the existing Law 82/30 for Public Rivers Protection. Cyprus has also prepared management plans for drought, water quality and quantity, protected areas (in accordance with the EU Directives for Habitats and Bird), as well as for the river basin management. Meanwhile, the intensification of soil monitoring and the implementation of the CAP and of the Convention to Combat Desertification are expected to help erosion control and limitation of drying. As far as it concerns Forestry Sector, the DoF has taken action considering the implications of droughts and high temperatures and prepared a Short-term Action Plan for the Confrontation of the Implications of Drought in Cyprus state forests.

4.4 Increased soil erosion, land desertification, soil moisture deficits and drying

Soil erosion is a significant process of land degradation and, consequently, desertification. Desertification in Cyprus is an important process of land degradation especially in the olive and cereal cultivation zone, in pine forested areas and shrubby grazing lands. Desertification and soil erosion risks due to climate change have been extensively studied in the Soil Sector. As far as it concerns natural environment soils provide a number of ecosystem services including buffering and moderation of the hydrological cycle, physical support for vegetation, retention and delivery of nutrients to plants, disposal of wastes and dead organic matter, renewal of soil fertility and regulation of major element cycles. Most of the above ecosystem services are also linked to biodiversity and ecosystems health and ability to respond to disturbances. At the same time, soil moisture and water availability are key factors that regulates the growth and the survival of various plant species. Thus they have a direct effect on supporting ecosystem services such as primary production and nutrient cycling. A shift towards drier soils has implications for the overall functioning of many ecosystems. Existing knowledge of these interactions is limited but suggests that there are key thresholds beyond which a change in soil moisture leads to major step changes in ecosystem processes.

Many simulation studies have projected significant changes in species distribution and ecosystem functioning associated to soil drying under climate change scenarios across the Mediterranean region. For Cyprus, there are not many empirical studies that quantify the effects of soil moisture deficit on plant performance. For the purposes of the CCRA, in order to quantify changes in soil moisture a simple index (SPEI) of potential soil moisture deficit was estimated based on the daily RCM simulations for both the baseline and the climate change reference periods. According to our findings soil moisture deficit is expected to increase in Cyprus, a fact that together with even more severe expected soil erosion and land desertification, could have a direct effect on biodiversity and ecosystem services.

Cyprus has already experienced severe droughts and water scarcity events. Nowadays, conservation measures are applied in order to restore ecosystems through management plans, while a number of actions and measures to counteract erosion, especially as far as it concerns coastal zone has been implemented. Intensification of soil monitoring and the implementation of the EU Common Agricultural Policy (CAP) and of the Convention to Combat Desertification are expected to help combat the risk of soil moisture deficit and drying.

4.5 Increased risk of wildfires

Fire represents an important component of the dynamics of Mediterranean terrestrial ecosystems. At the same time wildfires are the most important abiotic risk in the Mediterranean region, affecting many different Sectors including Biodiversity, Forests, Agriculture and Built Environment. Forest fires are considered as the most catastrophic agent for both forests and other wooded ecosystems in Cyprus.

Climate change is expected to increase fire frequency and intensity. This enhanced fire regime could have important impacts for forests, biodiversity and ecosystem functioning. Key changes include: shifts in species composition, reduction in vegetation productivity and soil retention ability, increased CO₂ emissions and loss of habitat for fauna species among others. These would have direct impacts on a number of ecosystem services, as well as an increase in the restoration cost of forest fires. For the purpose of the CCRA the Canadian Forest Fire Weather Index (FWI) was estimated across Cyprus. According to the analysis results differences in mean annual FWI and number of days of extreme FWI are expected under the two climate change scenarios (RCP45 and RCP85) for the two reference periods (2050 and 2080). In accordance with previous studies [32], the greatest differences in FWI are expected on the mountain range of Troodos.

Several measures are taken by the DoF in order to control and avoid forest fires, including fire prevention, fire pre-suppression, early detection and suppression measures, as well as reporting of forest fires. According to Kolström et al. [31] Cyprus is among the few European countries that have improved their infrastructure for fire detection, control and suppression to meet increasing fire risks under climate change. Nevertheless, and despite the great efforts and the good results of recent years, the problem of fires still exists and is expected to further increase under projected increases in temperature, decreases in precipitation and major drought events.

4.6 Increased risk from invasive species, pests, pathogens and diseases

Invasive alien species (IAS) and climate change, together with land use change and changes in the nitrogen and carbon cycles, are identified as the top four drivers of global biodiversity loss. IAS, pest outbreaks and diseases form an important threat for natural ecosystems and biodiversity of Cyprus.

Several IAS, including fungi, plants, mammals, birds and invertebrates are already recorded as established in terrestrial ecosystems of Cyprus. Among them species with impacts on ecosystems services, biodiversity, public health and/or economic activities can be found such as the Tree of heaven (*Ailanthus altissima*), The Red palm weevil (*Rhynchophorus ferrugineus*), the Common slider (*Trachemys scripta*), the Red swamp crayfish (*Procambarus clarkia*), the Giant reed (*Arundo donax*), the Orange wattle (*Acacia saligna*) etc.

IAS also represent an exceptionally important threat for the marine environment of Cyprus. Apart from impacts on biodiversity, some invasive species such as *Lagocephalus sceleratus* and *Fistularia commersonii* can also negatively affect the fish stocks by voraciously feeding on juvenile and adult populations.

The Gypsy moth *Lymantria dispar* and the processionary moth *Thaumetopoea wilkinsonii* represent the most important pests for Cypriot forests and other wooded lands.

Extreme weather events and increases in annual and seasonal temperatures could favour the establishment and expansion of invasive alien species in new habitats, as well as altitudinal range expansions of pests. Climate change and particularly drought could also increase the danger of pest outbreaks in the forest and woodlands of the island.

IAS, pests and pathogens may be directly affected by climate, their lifecycles may be regulated by temperature or precipitation or they might have threshold values under / over which they are not able to survive. Diseases can have complex development cycles, interacting with various hosts and vectors and so the characteristics of one disease may not necessarily be relevant for another. This makes analysis and modelling of their future trend and status difficult to predict. Adaptive strategies need to involve international co-operation and include research and development on monitoring, prediction, outbreak triggers, risk assessment and management strategies. Adaptation strategies need to be developed rapidly to deal with the combined threat of climate change and IAS. It is important to draw attention that early detection is crucial for minimizing the costs of control programmes and the risks of further dispersal and establishment of IAS.

4.7 Coastal changes due to sea level rise

In Cyprus, extended dune systems, including stabilized dunes with shrubs and dune slacks, can be found in few places (Apostolos Andreas at Karpasia, Akamas), notably in connection with wetlands, i.e. Ammochostos, Agia Eirini and the salt lakes of Akrotiri and Larnaka. Based on their unique geographical, economic and ecological characteristics, the coastal regions have been serving as the most important supports for human benefits. Cyprus coastal is a high valuable and vulnerable area, since it is under strong development pressures. Predicted sea level rises will have significant impacts on coastal and intertidal habitats, including changing geomorphological processes, further habitat loss and increasing the vulnerability of infrastructure. According to UNEP-MAP RAC/SPA [34] sea level rise is presently mainly caused by thermal expansion, not ice melting. As a result a higher increase should be expected in areas where sea water temperature has more possibility to increase, such as in enclosed seas.

In the framework of the current report the impacts of climate change on coastal and halophytic habitats and sand dunes has been assessed using projected sea level rise as the main driver of change. Based on the analysis results significant changes in the area covered by many of these habitat types are projected, with some habitat types losing most of their available area. Nevertheless, it must be highlighted that the analysis performed contains several uncertainties and various limitations. Future analysis should incorporate more factors in order to get a better estimate of the potential habitat loss.

Given the importance of the coastal zone for biodiversity and the fact that coastal areas are under strong development pressures Cyprus has implemented an Integrated Coastal Area Management Programme (CAMP). In the framework of CAMP specific actions and mitigation measures have been proposed for the protection and sustainable management of coastal areas.

4.8 Agricultural intensification

In agroecosystems, biodiversity performs a variety of ecological services beyond the production of food, including recycling of nutrients, regulation of microclimate and local hydrological processes, suppression of undesirable organisms and detoxification of noxious chemicals. The abandonment of traditional subsistence and the development of intensive agriculture, the use of agrochemicals, along with land-use changes, have already influenced negatively the agroecosystems and the species that live there.

Climate change-induced increases in temperatures, rainfall variation and the frequency and intensity of extreme weather events are expected to add extra pressure on the agriculture system. The rainy season duration is one of the primary factors affecting crop production prospects. Changes in annual and seasonal precipitation patterns can severely impact agricultural production and lead to more intense practices. In addition to seasonal rainfall variability, higher growing season temperatures can have dramatic impacts on agricultural productivity, farm incomes and food security. The above mentioned, together with the application of pesticides and herbicides, can have negative implications for biodiversity.

Climate change may increase current pressures through agricultural intensification, movements of rural populations or crop changes. At the same time, indirect effects of land use changes, such as agriculture abandonment, and agricultural policy measures may have adverse effects.

4.10 Adaptive capacity

According to European Commission adaptation is "an adjustment in the natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities associated with climate change". The objective of adaptation is to reduce vulnerability to climate change and variability, thus decreasing the economic and social costs of climate change. Adaptation action can take the form of policies, practices and projects. In order to assess the adaptive capacity of natural environment to respond to the anticipated climate changes both the inherent biological and ecological capacity and the socio-economic factors that determine the ability to implement adaptation measures was taken into account.

Cyprus is characterized by a rather high structural and organisational adaptive capacity. The DoE and the DoF, under the Ministry of Agriculture, Rural Development and Environment are the two authorities mainly in charge for the implementation of adaptation management policies and practices concerning biodiversity, ecosystem services and forests. The Department of Fisheries and Marine Research (DFMR) is the leading authority in relation to Fisheries, Aquaculture as well as Marine Biodiversity.

The Republic of Cyprus has already implemented various measures in order to minimize the negative impact of climate driven changes on natural environment and to adapt conservation and management practices to these prevailing changes.

Maximum adaptive capacity can be realised when organisational adaptive capacity acts to enhance the natural adaptive capacity already present within an ecosystem. The concept of "adaptive management" could be particularly valuable for this purpose. Ecosystems are typically complex, multi-scale, dynamic systems. Our knowledge of their functions and services is incomplete and guided by data from the past, which is only likely to provide a partial guide to their future responses. Hence, the future has an element of inherent uncertainty and is likely to involve unexpected surprises. Through adaptive management and a more systematic observation and collation of change on the ground should be possible to better contextualise change and learn from it. This requires a better use of organisational resources to share this knowledge and use it to maximise the potential of natural adaptive capacity, and to integrate its benefits into other sectors. It also requires a more flexible approach with regularly reviewed, rather than fixed conservation objectives that may prove unviable in the long term.

4.11 Evidence gaps

Understanding the direct and indirect impacts of climate change on the natural environment is a hard task as there is a great degree of uncertainty and several gaps in existing knowledge. The performed analysis has highlighted several uncertainties in order to progress adaptation in the natural environment. Some of the most important issues are summarised below:

- 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. More research is needed in order to better understand how different species will respond to climate change, and information on how their populations and distributions are already changing.
- Conduct further research to identify practical, robust and cost-effective conservation and management practices that can significantly support goods and services provided by forests and other natural ecosystems.
- Develop policy instruments to support such ecosystem-based adaptation and mitigation measures, in particular where they offer multiple benefits.
- More understanding of how to improve resilience at landscape scale, and its economic benefits. Quantifying/understanding the spatial and dynamic nature of ecosystem goods and services, and their responses to climate change.
- The need to pilot operational scale adaptive management, with scientifically rigorous monitoring and evaluation linked to planning and decision making.
- More data on the economic valuation of ecosystem services for different habitats and species are needed.
- Development of regional/national-level assessments of the climate sensitivity of freshwater and marine ecosystems.
- 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.

4.12 Summary of risk metrics

Risk metrics related to natural environment as a result of climate change are presented below.

Table 4.2 Scorecard for the Natural Environment

Metric Code	Metric Name	Confidence	2050s		2080s	
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
AG1e	Crop yield using grapevine as a reference C3 fruiting berry	L	2	2	1	2
AG1d	Crop yield using olive as a reference C3 tree	L	1	1	1	1
AG1a	Crop yield using wheat as a reference C3 rain fed arable crop	M	1	1	1	2
AG1b	Crop yield using potato (November sowing) as a reference irrigated vegetable crop for Spring-Summer production	M	2	1	1	2
AG1c	Crop yield using potato (July sowing) as a reference irrigated vegetable crop for Autumn production	M	2	2	2	2
BD2	Species unable to track changing climate space	H	1	1	2	3
BD8	Increased soil moisture deficits and drying	M	1	1	2	3
AG2	Livestock production	L	1	2	2	3
BE4	Effectiveness of Green Spaces	M	1	2	2	3
BD6	Increased soil erosion	H	2	2	2	3
BD11	Changes in primary productivity	M	2	2	2	3
BD12	Agricultural intensification (i.e. human use of NPP)	L	2	2	2	3
BD10, F01	Increased risk of wildfires	H	2	2	2	3
BD1	Species unable to find suitable microclimate/habitats	H	2	2	3	3
BD3	Changes in distribution of priority species	M	2	2	3	3
BD7	Coastal evolution impacts	H	2	2	3	3
BD9	Major drought events, Impact on Water Quantity and Increased Societal Water Demand	M	2	2	3	3
F02	Increased risk of pests, pathogens and diseases	L	3	2	2	2
BD4 & D5	Increased risks from pests, diseases and invasive species	L	2	3	3	3
F03	Increased risk of drought damage / loss of productivity	M	2	3	3	3
F04	Changes in tree species suitability	H	2	3	3	3
MA4	Shifts affecting producers and consumers	M	2	3	3	3
MA3	Potential disruption of fish production	M	3	3	3	3
MA6	Changes in fish catches and gene pool	M	3	3	3	3
MA7	Exerting pressure on fish physiological thermal limits	M	3	3	3	3
BU3	Tourist assets at risk from flooding due to SLR	L	*	3	*	3
3	Positive - High consequences	H	High			
2	Positive - Medium consequences	M	Medium			
1	Positive - Low consequences	L	Low			
1	Negative -Low consequences					
2	Negative - Medium consequences					
3	Negative - High consequences					

*Risk is not significant

5. Built environment & Infrastructure

5.1 Introduction

Buildings and transport, energy, water and Information and Communications Technology (ICT) systems are vulnerable to flooding, extreme heat and other climate risks, such as landslides and potential water shortages during major droughts.

Buildings and roads in our towns and cities store heat in the day time and release it during the night. This effect can contribute to buildings overheating in summer and, in major cities, causes the 'urban heat island' effect with evening temperatures several degrees higher than in the surrounding countryside.

Extremely hot conditions can cause poor health and fatalities. They may also cause problems for energy transmission and increase the demand for water and energy.

For the CCRA, infrastructure has been considered as the physical framework for society including transport, energy supply, water supply, drainage and wastewater disposal and ICT. In the urban environment, infrastructure has also been used as a term that includes local roads, paths, parks and other green space (often referred to as green infrastructure).

The built environment consists of man-made structures, especially buildings, together with their surroundings, including infrastructure. This chapter focuses on:

- Buildings
- Urban environment
- Energy
- Transport
- Water
- ICT

Overview	
<ul style="list-style-type: none"> • Functionality of breakwaters, flooding, increased energy demand for cooling and increased use of desalinated water are likely to emerge as significant risks by the 2050s. • Buildings and the main infrastructure sectors (energy, transport, water and ICT) are interdependent. • Vulnerability in one sector can influence others and failure of critical infrastructure components may lead to ‘cascade failures’ with significant consequences. • Energy policy is a major socio-economic driver affecting not only the energy sector, but all sectors that are dependent on energy, including transport, water ICT, businesses and buildings. Decisions on the location and resilience of new buildings and infrastructure, on refurbishment of existing buildings, and on how we shape and maintain the urban environment will have a substantial impact on future climate vulnerability. 	
Threats	Opportunities
<ul style="list-style-type: none"> • Increased sea level, storm surge and wave heights will require modification of breakwaters, by for example replacing existing rocks or adding new one of the required characteristics. • Changes in water availability may increase water supply production from desalination increasing thus the cost of water supply for the public the businesses and the industry. This will also have an impact on the Energy Sector • Increased flooding may affect a significant proportion of buildings. • Increased summer temperatures may affect conditions in buildings and the urban environment and may lead to heat related damage and/or disruption to energy and transport networks. • The ‘Urban Heat Island’ effect may become more common and more significant in large cities and may increase demand for cooling. • Increased subsidence and landslip in some areas may affect sections of the road network and buildings. 	<ul style="list-style-type: none"> • Milder winters may reduce demand for heating, reducing costs for businesses and the public, and reducing carbon emissions.

Table 5.1, provides a summary of the risks considered as part of the assessment work in this study and provides an indication of how the magnitude of the **moderate emissions scenario** (RCP4.5) changes over time. Further detail of the risks relevant to this theme, with more information on how the magnitude of the risks vary under different scenarios is provided in the scorecard at the end of the chapter (see Table 5.3).

Table 5.1 Summary of buildings and infrastructure impacts with an indication of direction, magnitude and confidence

		Confidence	Timing	
			2050s	2080s
Opportunities				
BE3	Energy demand for Heating	M	2	2
Threats				
MA1	Breakwaters exposed to significant risk of instability	L	3	3
W2	Higher cost of water supply due to increased desalination	L	2	3
BE1	Energy demand for cooling	M	2	2
FL2	Number of properties at significant likelihood of flooding	M	2	2
BE4	Effectiveness of Green Spaces	M	1	2
W3	Irrigation Supply Deficit	L	1	2
FL3	Flooding of transport infrastructure, critical utilities and archaeological sites	L	1	1
FL4	Insurance premiums for flood risk	M	1	1
FL5	Land affected by coastal erosion and wave overtopping	L	1	1
BE5	Overheating of Buildings	H	1	1
MA2	Down-time of Shipping Operations and sea sports	L	1	1
EN1	Energy Demand by Water Suppliers	L	*	1
BE2	Urban Heat Island	H	?	?
BE6	Subsidence	L	?	?
EN2	Electricity Turbine Efficiency	L	?	?
EN4	Power Station Cooling Processes	L	?	?
EN5, 6	Transmission Capacity	L	?	?
EN7	Heat Related Damage/Disruption	L	?	?
TR1	Cost of carriageway repairs	H	?	?
TR2	Disruption and delay due to flooding of the road network	L	?	?
TR3	Subsidence & landslides	L	?	?

3	Positive - High consequences	H	High
2	Positive - Medium consequences	M	Medium
1	Positive - Low consequences	L	Low
1	Negative -Low consequences		
2	Negative - Medium consequences		
3	Negative - High consequences		
?	Magnitude not assessed (no data)		

* Threats that have some significance only under the more pessimistic scenario

5.2 Interdependencies

There are significant interdependencies between buildings, infrastructure and the urban environment. Resilience in one sector is dependent on the resilience in another. Some of them are the following:

- Most buildings are reliant on the provision of energy and water;
- Energy is required to run desalination and water treatment plants, pumping stations, wastewater treatment works, etc.;
- Transport, water and energy sectors are reliant on ICT for their monitoring and control systems;
- ICT is reliant on energy to power devices and enabling infrastructure;
- Access to properties for rescue and limiting damage during or following extreme events (such as flooding) is reliant on the transport network; and
- Emergency services are reliant on the transport network and dependent on such things as adequate water pressure for putting out fires.

These interdependencies are expected to increase in the future. These interdependencies mean that the vulnerability of one sector can influence the vulnerability of the other sectors and failure of one element can lead to other 'cascade failures'.

Buildings not only place demands on infrastructure (most significantly energy and water), but by improving their resilience to future changes in climate (such as providing adequate insulation and shading, recycling water, etc.) they can also impact positively on the infrastructure upon which they depend.

5.3 Adaptive Capacity

The effects of climate change on buildings and infrastructure will not be limited to direct impacts on assets from extreme events or long-term changes. As buildings and infrastructure play such a significant role within the economy, society and the environment, each is affected by and impacts upon the other.

Future use of buildings and infrastructure will be influenced by efforts taken towards climate change mitigation and climate induced changes in behaviour and demographics, including the urban-rural balance and an ageing population. Examples of future influences on buildings and infrastructure, other than climate change, include the following:

- The **economy** (within the constraints of legislation/regulation) controls the overall energy consumption. This can even manifest itself at the individual household scale; it has been widely reported that during recessions carbon emissions drop as people find it more difficult to afford to heat their homes and fuel their cars.

Energy use is closely linked with economic output, hence the recession or sluggish growth of years 2009-2012 had a clear effect on national energy consumption. The dramatic changes in the economic environment following the events of March 2013 are expected to considerably affect energy use in the rest of this decade. As a result of declining economic activity and private consumption in years 2013-2014, non-electricity energy consumption in 2020 is projected to drop to a different extent in each sector of the economy, and by 7,9% over the whole economy – or 119 ktoe. National energy consumption in 2020 is expected to decline by 12% in comparison to the previous forecasts – from 2409 ktoe to 2120 ktoe [19].

As a result of the recent economic recession, final electricity demand in Cyprus has decreased during 2011-2013, and due to adopted efficiency measures is not expected to rise to 2010 levels before 2022 [22].

- A **low carbon** future would have far reaching implications particularly for building design and renovation; transport type and usage; and energy generation and usage. The rising cost of carbon will affect every aspect of buildings and infrastructure. The links between this and climate change adaptation requires further research.

In addition, many of the decisions related to buildings and infrastructure have long-term implications because of the design life of many of the structures involved. This means that decisions being made now need to anticipate relevant consequences of climate change to limit the potential for maladaptation and increase overall system resilience.

In Cyprus, the replacement rate of the existing building stock remains slow and the improvement of the existing buildings should be a priority.

The largest percentage of the building stock of Cyprus has no basic insulation and as a result the power consumption is high while no thermal comfort conditions are achieved. **Nearly zero**

energy consumption buildings are a priority for Cyprus. To this end Cyprus, has conducted a special study for their definition and specifications and has established a Nearly Zero Energy Buildings Action Plan (9/2012). By 2020 approximately 75.500 (existing and future) buildings will be of energy class A and B and they will comprise 13% of the total building stock [23].

People of low income may be more vulnerable to climate change impacts, including flooding, heatwaves and any disruption or any increase in costs for services. For example, those in poor quality dwellings or workplaces will be least able to adapt these buildings in response to changing climate. Also, social groups unable to afford heating or cooling to meet acceptable standards of thermal comfort are more vulnerable to major health impacts.

Energy policy is a major socio-economic driver affecting not only the energy sector, but all sectors that are dependent on energy, including transport, water, ICT, businesses and buildings.

Water policy is also a very significant tool for sustainable water resources management and meeting the water demand for all sectors.

5.4 Buildings

Cyprus, in the framework of the Floods Directive has designated 19 Areas of Potentially Significant Flood Risk (APSFs). According to the preliminary Flood Risk Management Plan the number of people, presently at a significant risk of flooding for the 5% frequency event (T=20 years) is 5.370 [20]. This number will rise to 15.170 due to urbanisation. These figures do not include people affected by coastal flooding, flooding of areas served by pumping stations, flooding in other flood prone areas. Assuming that the number of people per property is 3, the number of properties at significant likelihood of flooding (5%) is estimated to 1800.

It is noted that no public hospitals or private clinics are within the APSFs. Regarding heritage buildings, there are four (4) monuments of archaeological interest within the APSFs, while 28 monuments in the proximity of them may face a higher risk to flooding due to CC².

² Data from WDD geodatabase drafted in the framework of the Flood Risk Management Plan

5.5 Urban Environment

The Urban heat island (UHI) is a phenomenon whereby an urban area experiences elevated air temperatures due to anthropogenic modification of the environment and is usually more evident at night. During heat waves the local effect of an UHI is superimposed on the regional temperature field and as a result heat stress is enhanced. Both the intensity and the spatial structure of the observed thermal contrast of the UHI depend on various parameters, such as the structure of the urban tissue, the population density and its associated heat release, the land use patterns, the vegetation cover, the surface topography and relief etc. In general terms, the UHI is becoming more intense as city sizes increase.

The intensification of urbanization evidenced in Cyprus during the last 30 years has caused a rapid growth of the size of the Cyprus' main cities. The existence of the UHI phenomenon in the four large cities of Cyprus is documented in the literature.

Nicosia, which is located in the centre of Cyprus, is most the vulnerable to UHI during the warm period. On the contrary, the other urban areas (Larnaca, Limassol and Paphos), which are close to the coastline, are lesser affected by UHI during the warm period. These areas also demonstrated high UHI intensities during the cold period.

Although UHI intensity does not necessarily increases under climate change, the UHI does exacerbate the frequency of extreme heat events as experienced by urban dwellers.

Understanding the UHI, both in the present-day climate and its future evolution under climate change, is an active and rapidly evolving area of research. Urban climate models, which run at city at city level, neighbourhood and street scales are necessary in order to quantify the effect of urbanisation processes on local environmental conditions both in present day and future.

A precise relationship between elevated night time temperatures during heatwave events and the magnitude of consequences for human health and comfort is unclear and has not been assessed as part of this CCRA. The analysis showed that the thresholds of perceived temperature for heat wave events will be exceeded more frequently in the future and the UHI effects will further contribute to the impacts of heatwaves.

Green infrastructure has a dual function in combating the UHI effect. Firstly, its inherent cooling and shading capacity reduces the heat vulnerability of the surrounding area. Secondly, it provides valuable climate refuges, to which local residents can go for temporary respite from extreme heat. There is also an important association between access to green spaces and better mental and physical health. Green infrastructure can take many forms from large open spaces such as parks to smaller scale features such as domestic gardens and street trees.

Under prolonged hot, dry conditions, evapo-transpiration of the green space slows down, eventually shutting down if the vegetation becomes completely parched. Consequently, the cooling effect of the green space is effectively switched off. Without adaptation, this could become an ever more frequent occurrence as summers become hotter and drier. Clearly this also has consequences for the Urban Heat Island and overheating.

The CCRA analysis focused on large scale green space. It is projected that the reduction in the 'effective area' of green space could be about 42% by the 2080s, (more pessimistic climate change scenario). The range of projections by the 2050s is from 1% to 5% while the range of projections by the 2080s is from 4% to over 40%.

It is essential to consider buildings within their immediate and wider environment and across all potential climate impacts. For example, external temperatures are higher within the Urban Heat Island, increasing the risk of building overheating. However, green and blue infrastructure can help cool urban areas. Thus, the UHI effect is closely linked to both building overheating and to the availability and effectiveness of urban green (and blue) space. This means that resilient building design needs to be carried out in conjunction with effective land use planning, so that buildings can benefit from suitable locations within the built environment, for example, to help maximise water and energy conservation and to minimise flood risk.

The UHI effect, overheating of buildings and the effectiveness of green space all relate to thermal comfort (both indoor and outdoor) and, therefore, to heat-related health problems.

These summer heat issues also have clear interdependencies with the business and tourism sectors. For example, productivity is affected by overheating in buildings. However, warmer summers may also have positive consequences for tourism industry.

There is also a dependency between the expected reduction in heating demand and the increased energy demand for cooling.

5.4 Energy

The energy sector across the island is characterized by the very high dependence on imported sources of energy, the dominance of fossil fuel products in the energy mix, the continuous rise of energy demand, and the rising degree of renewable energy sources exploitation and penetration, although further significant investment in renewable energy sources, and in particular solar power, is needed. In addition, the energy system is small and isolated with no interconnections. Cyprus has newly found amounts of offshore natural gas reserves. Energy security is overall a major matter to address.

In terms of supply, oil and oil products dominate, accounting for 94% of total primary energy supply, and for 96% of electricity production in 2013. The remaining 5% are renewables, of which about 20% are imported in the form of biomass. The high energy costs are further undermining private companies and significant investments in energy efficiency improvements as well as alternative sources of energy are urgently needed to increase competitiveness and help corporate restructuring efforts. As an EU Member State, Cyprus' energy policy is aligned with the EU energy strategy. In line with the EU's 20-20-20 target, Cyprus aims to increase the contribution of Renewable Energy Sources (RES) to the final energy consumption to 13% of the total by 2020, and increase the contribution of RES to 16% of total electricity production and 10% of energy use in the transport sector [21].

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 and
- Self-producer installations (internal combustion units)
- RES that include Biomass/Biogas units, Wind Turbines & wind Farms and Photovoltaic systems.

All existing conventional electrical power supply stations are located in the coastal zone. The future Liquefied Natural Gas (LNG) plants of Vasiliko will be also located in the coastal zone

Power stations of Cyprus are not associated with the floodplains defined in the framework of the Floods Directive (APSFs). 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 C14 APSFR (T=100 and T=500).

The analysis showed that regarding Sea Level Rise (SLR) there are no impacts on the existing 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 inland installations are well away from the coast and are protected from sea level rise.

The efficiency of thermal power stations depends upon the temperature interval of the steam/gas upstream and downstream. Water is the most effective cooling medium and

therefore either river or sea water (as in Cyprus) is extracted in this process. Increased sea water temperatures would result in a decrease in the efficiency of a thermal power station. Additionally, water can be discharged at or below regulated threshold temperature values. Increased temperatures may result in these thresholds being met more frequently. This could be reduced by changing the cooling system used or reducing the total electricity production. In Cyprus, according to the environmental licensing of the Power stations, cooling waters can be discharged to the sea provided that there is less than 10°C difference between the receiver and the discharged water.

During heat waves, sea water is warmer, resulting to insufficient cooling of the generating units leading to less efficient – and therefore more costly – power generation.

Sea Surface Temperature (SST) increases in the entire Mediterranean Sea and the Levantine sub-basin with higher than average SSTs occurring from 1998 and onwards. The Levantine Basin is warming at a slightly faster rate than the entire Mediterranean Sea and SSTs in both are increasing at least more than 2 times as much as the global SSTs.

It is likely that a site-specific analysis would be necessary to carry out a quantitative analysis on this risk since it is likely to depend on many local factors. Adaptation measures include closed-cooling circuits and higher pumping rates by installing of pumps with a bigger flow.

Electricity transmission and distribution networks are susceptible to faults caused by weather-related phenomena.

Climate change is likely to result in some electricity transmission losses due to higher average temperatures. Heat waves may considerably increase resistance of power lines as increased air conditioning coincides with higher transmission demand and low generating capacity (due to reduced cooling capacities of thermal power plants).

Climate change may increase the risk of failures in the electricity transmission system due to higher temperatures, higher humidity and deposition of dust on insulators, thus leading to a higher need for cleaning insulators, which results in more frequent outage of generating units or transmission lines and decreases in the available electric power.

Consumption of energy is particularly sensitive to weather, since large amounts of energy cannot be stored and thus energy that is generated must be instantly consumed. Although energy requirements are linked to climate conditions, the relationship of energy demand and temperature is not linear. The variability of ambient air temperature is closely linked to energy consumption, whose maximum values correlate with the extreme values of air temperature (maximum or minimum). Daily energy consumption shows a clear seasonal pattern. Average daily energy consumption shows two peaks, during summer and during winter months. The present-day energy demand is typically highest during the summer months as a result of increased use of air conditioning.

According to the results of a 2009 a typical household in Cyprus annually consumes 6.288 KWh of electricity. The percentage of households that uses air conditioning for space cooling during

the hot period of the year is quite high (80,8%). On average, during the hot period, households cool only 50 sq. metres of their residence compared to the 168 sq. metres total average area of their residence. The air conditioning units are of relatively modern technology, since more than 70% have been installed in the last decade, of which about half in the last five years. The annual energy consumption of a typical household for space cooling is 1.107 KWh of electricity, while the average installed capacity of air conditioning units per household is of the order of 32.300 Btu (or 9,47 KW) [24].

Cooling of households accounts for about 6% of the total electricity consumption in Cyprus. Electricity consumption for cooling in star hotels is estimated approximately to 2% of the total electricity consumption in Cyprus [22].

With increased temperatures, it is likely that energy demand for cooling may also increase due to an increased uptake of air-conditioning systems in both residential and non-residential buildings (this would be an autonomous adaptation response to warmer conditions).

Increased cooling requirements would have an impact on the Energy Sector since it must be able to meet any changes in energy demand. Future changes in cooling demand are likely to depend upon many factors including changes in building stock, changes in the uptake of cooling systems, population size and behavioural change as well as changes in climate.

Cooling degree days (CDD) are projected to increase, with much greater impacts on the eastern parts of the island, with Nicosia and Larnaka been influenced the most. The CDD (household weighted) in Cyprus under the moderate scenario, in 2050s may increase by 71% while in the distant future and under the more pessimistic climate change scenario may increase by 200%.

Under the moderate scenario, in 2050s, energy demand for household cooling can rise up to the 12% of the current total while in the distant future and under the more pessimistic climate change scenario can rise up to the 20%.

Further risks posed by increased demand for cooling would be the potential for increased GHG emissions if the increased demand is met by increased fossil fuel consumption and the potential for increased contribution of waste heat exacerbating the urban heat island effect and reducing the efficiency of cooling systems.

Impacts on society and wellbeing could be significant if demand for cooling is not met. Failure to meet cooling demand could also reduce workplace productivity.

Warmer winters in future years are likely to see reduced space heating demand from end users and a reduction in overall fuel bills, increasing the opportunity to lift people out of fuel poverty. There will also be an opportunity for new build design to incorporate lower heating capacity loads.

A typical household in Cyprus (2009 data) is estimated to consume for its total energy needs a quantity of 1.142 kgoe (kilograms of oil equivalent) and **44,8% of it is used for space heating.**

Nearly all households (98,4%) use some kind of equipment/system for heating part of their residence during the cold period of the year. The majority of households uses portable heaters as the main equipment for space heating (39,3%), while a notable proportion is equipped with a central heating system (29,2%) and air conditioning split units (16,9%). The use of fireplaces (7,3%), EAC storage heaters (4,8%) and stoves or other equipment (0,9%) is less frequent. On average, households heat only a surface area (54%) of about **90 sq.** metres, compared to a total average area of **168 sq.** metres of their residence. The grand majority of households (68%) operate their main space heating equipment for 3 to 4 months per year, while a proportion of 46,2% uses their heating equipment for 3 to 5 hours a day. The annual energy consumption of a typical household for space heating comprises on average 642 KWh of electricity, 331 litres of heating oil, 42 litres of kerosene, 50 kg of liquefied petroleum gas and 231 kg of biomass. If these figures are expressed in kilograms of oil equivalent (512 kgoe in total), it is resulting that the main energy product used for space heating is **heating oil (55%)** followed by biomass (16%) and electricity (11%) [24].

Actual Heating Degree Days (HDD) can provide an indication of the expected heating demand relative to a baseline external temperature. Actual HDD are projected to decrease, with much greater impacts felt in the mountainous part of the island. The actual HDD (household weighted) in Cyprus under the moderate scenario, in 2050s may decrease by 22% while in the distant future and under the more pessimistic climate change scenario may decrease by 53%, resulting in relative reductions in energy demand for space heating. 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 of the average area of the buildings is heated during winter and the majority of the dwellings are lacking of thermal comfort.

There are other factors that may also affect demand for energy, for example, as well as having a growing population, that population is ageing and, therefore may use less or more energy at different times of day or during the year. 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.

It is important to note that energy demand is a function of many parameters, only some of which are weather-related. The Government's energy policy of moving towards a low carbon future is expected to have a more significant effect on future energy demand than direct climate change impacts. A low carbon economy would in all likelihood be a combination of improved energy efficiency and increased diversity of energy sources.

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 [22]:

- 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 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.

To reduce the dependence of drinking water on rainfall, the Government of Cyprus has resorted to operating seawater desalination plants, which produce large amounts of fresh water to address the needs. Although seawater desalination seems to be a fairly satisfactory method of producing fresh water, it is a very energy-demanding process and therefore raises the issue of energy production required especially during the summer where energy demand is already at the highest level (due to air conditioners). Additional annual electricity consumption in desalination plants in the distant future under the more pessimistic CC scenario can be up to 243 GWh (6% of the current energy consumption). Additionally to these impacts, the increase in GHG emissions from changes in energy use must be considered.

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. This also has cost implications stemming from oil prices, as the total amount of oil used is imported.

5.6 Transport

5.6.1 General

The Cyprus transport network (comprising road, air and water transport³) plays a vital role in economic and social activities, providing access for people to services and movement of materials and goods.

The main means of transport in Cyprus is the car. As shown in Eurostat row data for 2012 the per 1.000 inhabitants passenger cars ownership is 549/1.000 inhabitants. This fact sheds light on the high energy use of the transportation sector which accounted for 53,82% of the final energy consumption in 2013. Besides car transportation, the share of public transport and bicycle use is very low. Moreover, it must be noted that there is no railway transportation in Cyprus, pointing out that motorways substitute the only significant infrastructure of the island (excluding seaports and airports).

Nowadays major efforts are made to promote and improve the public transport enhancement programme that was introduced in 2007 by the Government which aims, among others, to reduce gas emissions. To this end, a Contract Management Unit was created in 2014.

The implementation of the current public transportation system, despite the increase in passenger numbers, is considered unsatisfactory and the initial targets set by the Ministry of Transport, Communications and Works cannot be met. The Ministry, in an effort to upgrade and make public passenger transportation more attractive, has set short-term goals such as to optimise routes, by reducing unprofitable lines and increasing the frequency of those lines that have denser ridership. Medium-term targets relate to fleet renewal, to improve infrastructure (bus stops, stations, use of telematic technology), to improve the image of the service to the general public, to increase passenger ridership and to reduce subsidies. Finally, the long-term target is the complete restructuring of the passenger transportation system and the establishment of a well performing system responsive to the needs of society.

Cyprus Island is located in the north-eastern corner of the Mediterranean basin, at the intersection of major international and regional shipping routes. It fulfils the role of a hub for a number of key trading areas of world significance. Cyprus is an international transshipment centre for Europe-Far East trade. Due to its excellent strategic location, it is very important for the country to maintain and improve its maritime links with the rest of the world. Cyprus has one of the biggest merchant fleets within the EU in terms of flagged fleet. Cyprus ports handle imported and exported cargo to and from the island, the transshipment of container traffic and

³ Cyprus has no railways and currently there are no government plans to invest in rail transport. In addition, it has no navigable inland waterways.

passenger traffic, either as a port of call within a Mediterranean cruise or as a specialist 'mini-cruise' for tourists visiting Cyprus.

Air transport is very important for the tourism sector. Cyprus has a wide network of air routes connecting Cyprus with Europe, Africa and Asia. It has become a major international transit station, with excellent connections within the entire region.

Climate impacts on transport involve:

- Damage to infrastructure
- Damage and disruption to transport modes

All modes of transport can be affected by the weather, in particular by extreme weather conditions and the variability from day-to-day. Extreme weather can cause serious disruption to the transport system and is likely to remain a challenge for the maintenance and operation of existing infrastructure.

As the climate changes, disruption caused by cold, snow and ice may occur less frequently, whereas there may be an increased risk posed by both heat and by flooding. Extremes of weather can be accommodated in the design of transport elements and infrastructure; the variability of the climate from year to year and the unpredictable nature of that variability can often be more difficult to accommodate. Flooding incidents are more likely to damage a section of road at a specific point, sometimes very local. However, it can cause much wider impacts if this breaks a key network link.

Excessively high temperatures can lead to deformation of road surfaces and to very unpleasant travelling conditions.

Road usage may increase due to economic growth or a growth in tourism; it may decrease due to fuel prices and the low carbon agenda. There may be an increase in demand for air travel as the tourism season expands.

The transport networks play a vital role in business supply chains, including getting the workforce to and from the workplace, the supply of materials and goods, as well as supporting social and leisure activities. They also play a vital role in evacuation and rescue activities associated with extreme events.

All elements of society are reliant on the transport sector, for supply of goods to homes and communities, for travel to work or socially and to distribute products and services. The cost of transport can have a disproportionate consequence for those with a lower income or who rely upon cheap transportation costs to make their business effective. As the costs of transport increase then charges to customers are like to increase as a consequence, again having potential to disproportionately impact those on lower incomes.

The response to climate mitigation and the very long-term nature of transport infrastructure related investments mean that the transport sector will be vulnerable to the adequacy of

planning and design decisions in the light of climate change. Where impacts are being well managed, it can be taken as evidence that there is a degree of adaptive capacity demonstrated in the sector and that adaptation is well supported by good governance (through design standards, land use planning).

5.6.2 Road transport

The **road network** has a total length of 12.604 km of which 257 km is paved. Approximately 66% of the network is paved. The Public Works Department is responsible for the maintenance of 2.460 Km of paved road network. The average annual cost of maintenance was 12.660 €/Km in 2009 and 15.042 €/Km in 2010.

Damages due to high temperatures on road asphalt highly depend on the type of asphalt applied and the binder types used. An increase in future temperatures is predicted by all CC models used in this study. Due to insufficient data, a response function relating the cost for road repairs due to heat was not derived.

Cyprus, in the framework of the Floods Directive, has identified areas with a potential significant flood risk (existing or likely to occur). In these areas (APSFRs), there is risk of flooding of the existing road network, however there are no analytical about the length of the flooded road network. Three (3) of the flood risk areas are associated with motorway flooding:

- C09. Ormideia River. (A3 Motorway Larnaka Airport - Ayia Napa is flooded under all return periods)
- C15. Vathias river and tributary. (A1 Motorway Nicosia – Limassol under T=100 and T=500)
- C16. Old and new Garyllis river bed. (A1 Motorway Nicosia – Limassol under T=100 and T=500)

It must be noted that A1 Motorway belongs to the Orient/East-Med Corridor.

For these areas, in the preliminary Flood Risk Management Plan, measures are foreseen for the high probability floods (T=20).

The Pafos District of western Cyprus is considered to be the most landslide-prone terrain in Cyprus.

The high winter rainfalls which occur in the highlands of the Pafos region have a profound effect on the initiation and/or reactivation of landslides

A response function linking the length of road potentially affected by landslide and winter precipitation was considered, however due to lack of available data, it was not possible to be established. There are significant variations regarding winter precipitation between different models. According to the SMHI - MPI total winter precipitation is expected to decrease in Pafos area, whilst the extreme precipitation events (>50mm) will appear more often.

There is high uncertainty regarding the damage to road infrastructure due to flooding and landslides since there is disagreement between the models on how precipitation will evolve in the future.

There is high certainty regarding the damage to road infrastructure due to higher temperatures, however here were no sufficient quantitative data to produce robust metrics. Moreover, pavement damage due to extreme heat is highly uncertain as the lifespan of the existing infrastructure is probably less than the future periods of the assessment (2050s, 2080s) and heat-resilient materials can be applied on planned reconstruction works.

There is a difference in physical vulnerability between the different classes of the road network (local roads as opposed to the Motorways that are being designed and constructed to a greater heat-resilient specification than is standard for other roads).

5.6.3 Air transport

Today, aircraft and helicopters are designed to operate virtually anywhere in the world and, as such, the climatic design is advanced. Airports are designed to be kept open every day of the year in all weather conditions.

Milder winters may benefit the transport sector in the long-term, as disruption and delay caused by snow and ice may reduce. However, the natural variability in the weather will mean that extreme events will still occur and any benefit is unlikely to be experienced in the near-term.

The impact of adverse weather events for aviation is usually measured in flight cancellations and delays. Incidents and accidents are counted but rare due to the high safety standards of the aviation sector. From a safety perspective, the most sensitive flight phases regarding weather conditions are the arrival and departure procedures. Adverse conditions may make procedures infeasible leading to delays or cancellations of flights. In addition, the infrastructure provided at airports has a high potential to be impacted by adverse weather events. In this case, part of the equipment or infrastructure is usually unavailable during a certain time period leading from handling delays up to flight cancellations.

According to the European Organisation for the Safety of Air Navigation and its Central Office for Delay Analysis (CODA) Cyprus' airports do not face significant weather related delays (strong winds, snow, low visibility and thunderstorms).

Rare extreme events that had an impact on the Cyprus airports involve the tornadoes of 22/1/2004 that hit both Pafos and Larnaka airports. On the 19th of December 2002, the corridor of the Larnaka airport was flooded, hindering the landing of two civil aircrafts.

During 2003-2005, 85 dust transport events were observed in Cyprus. According to the Larnakas' airport spokesperson, due to high levels of dust and the low visibility 24 flights, 12 departures and 12 arrivals were cancelled in 08/09/2015.

Regarding the vulnerability of the airport infrastructure due to sea level rise, the Larnaka airport is the most vulnerable (the elevation of the Runway 22 is at 1,8 m). However, projected sea level rise won't be a major threat until 2080s.

5.6.4 Ports and shipping

Breakwaters are designed to provide protection to boats, shipping activities, to erodible materials and other activities for the wellbeing of the natural and man-made environment. These works must be stable at extreme environmental events. The main parameter that affects the stability of a breakwater with a given rock size and density and slope of surface is the wave height acting on the breakwater. The wave height in the coastal zone is limited by the depth (depth-limited wave height) which is about 78% of the water depth. Practically all breakwaters which are for coastal protection are built in water depth of the order of 3-4m and hence the maximum wave height that affects the stability of these breakwaters is depth limited. The breakwaters of the ports, marinas, large fishing shelters do go into greater depths and parts of these works are attacked by depth limited wave heights and parts by non-depth-limited waves.

A sea level rise will have as a consequence the increase of the depth-limited wave height.

An increase in wave height will have an impact on the stability of breakwaters exposed to a non - depth-limited wave heights.

For breakwaters at 3,5m water depth a sea level rise by 0,5 will increase the required mass of rocks by 44% and a sea level rise will increase the mass by 98%. If on top of this sea level rise due to melting of ice and expansion of ocean water there is an increase in sea level due to increased storm surge then the consequences will be worse.

These changes are significant and will require modification of the works, by for example replacing existing rocks or adding new one of the required characteristics.

For the breakwaters in deeper waters, the wave heights may not be depth limited.

Breakwaters in coastal waters (depth limited wave heights) are exposed to increased risk of instability due to increased water depth as a result of sea level rise and increased storm surge. Breakwaters in deeper water (ports and large harbours/ shelters) are exposed to increased risk of instability due to potentially increased wave heights. The confidence of the predictions of changes in sea level, storm surge and wave heights is low due to the inability of climate prediction models to model these parameters and due to lack of data of past years to make projections for the future.

Shipping operations and sea sports are associated with limiting weather conditions. For example:

- Ships may not be berthed on the jetty
- Ships may not be berthed in the open sea anchorages
- Vessels may not enter or leave the harbour
- Supply vessels may not approach offshore platforms
- Supply boats may not approach the fish farms

Wave conditions may change adversely the existing down-time.

Down time of shipping operations and sea sports due to adverse sea conditions have significant impact on the economy. Prolonged down time periods may have deadly impacts on say fish stock in fish farms, shortage of fuels etc. Climate predictions model predict negligible change in the number of days of extreme wind speeds and this risk will remain at its present levels.

As more and more activities will depend on down time, climate change presents an opportunity to study and analyse the present statistics of down time of the various activities.

Based on current predictions the wind speed is not expected to change significantly and the number of days with extreme wind speed will remain of the same order.

5.7 Drinking Water supply

If the Country's Water Policy is followed at all times, no water supply demand deficits are predicted, even for the worst-case scenario, i.e. RCP 8.5 for the 80 yrs drought. However, higher cost of water supply due to increased desalination are expected.

Regarding the analysis in this CCRA, the following are noted (see also section 3.4):

- Water supply is fully satisfied under all scenarios. However, for most scenarios full utilization of production capacity is required, which would lead to higher overall cost of potable water.
- Environmental releases from dams are satisfied under all scenarios with deficits undertaken all by irrigation.
- Irrigation deficits are assessed for the 75% driest year, which corresponds to a check at 75% reliability level. This is a generally accepted reliability level for irrigation.

The following graph gives a representation of the influence of the reduction in average surface runoff due to climate change to the projected increase in desalination production.

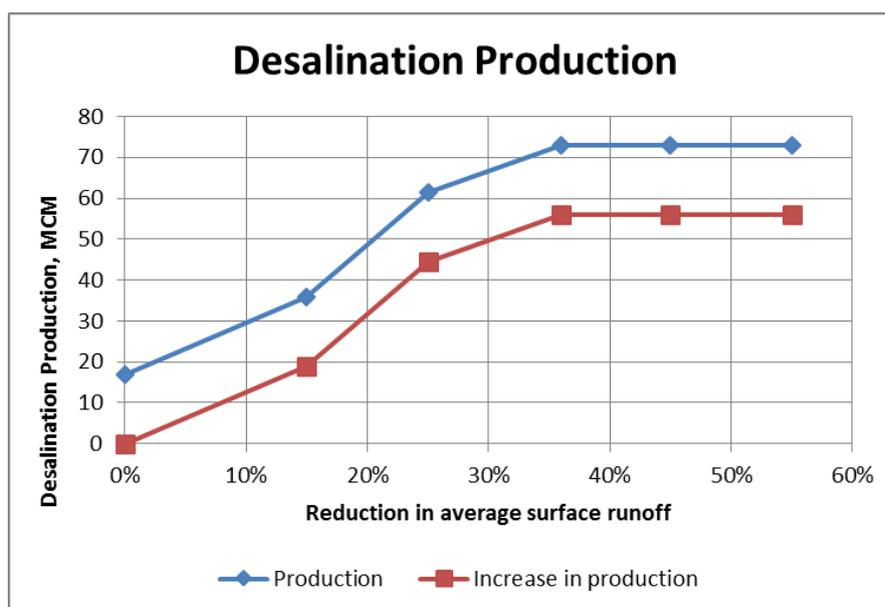


Figure 5.1 Desalination production and increase in production for current levels

According to the analysis based on data, representing the average multi-CC model results, notable increase in Desalination Production is expected only in the distant future (7 MCM for the moderate and 50 MCM for the more pessimistic CC scenario). Using data from a single CC model (SMHI-MOHC) in the 2050s the increase in Desalination Production was estimated to 45 MCM for the moderate and 56 MCM for the more pessimistic CC scenario. In the 2080s the increase in Desalination Production was estimated to 56 MCM for both CC scenarios.

Table 5.2 Increase in Desalination Production (MCM)

Quantities (MCM)	2050s		2080s	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Multi-model Scenario Results	0	0	7	50
SMHI-MOHC model	45	56	56	56

Taking that the annual extra volume of desalinated water for the selected climate change scenarios would range between 7 – 56 MCM, by considering a cost of 0,70 €/m³ (based on the average tariff), the loss would exceed by far €1 million per year.

Uncertainties, particularly in the longer term (2050s, 2080s), are large not only due to potential changes in climate and population, but also to developments in water efficiency and technology for sustainable water management. Climate change provides an excellent opportunity for institutional change, allocating authorities and resources to competent bodies/ persons.

Desalination is provisioned to continue supplementing the freshwater sources. In Cyprus, there are noted significant developments in understanding good desalination practice and in decreasing energy demand and hence costs for production of desalinated potable quality water. Nevertheless, desalination remains an energy-intensive process and therefore has a significant carbon footprint and cost of operation. Policies for its future use need to take account of these impacts and further research is required to increase deployment of desalination technologies driven by low-carbon energy and lower costs.

The decrease in the available water resources in Cyprus due to CC has caused in past severe restrictions in the supply of water for domestic and irrigation uses. In addition, costly measures were implemented for securing the absolutely necessary quantities of potable water (e.g. by importing water, intensifying the desalination plants operation).

People occupied in the agriculture or touristic industry are more vulnerable to climate change effects on the water sector, since it is more likely that their activities will be more vulnerable to water deficits and/or increased costs for water supply.

5.7 Information and communications technology

The use of Information and Communication Technologies plays a key enabling role to achieve smart, sustainable and inclusive economy and society. The use of ICT in all vital sectors of the economy of Cyprus like education, health, tourism, transport and generally in the exercise of every business activity is of paramount importance to the development of Cyprus into a regional service centre and to the attraction of foreign investments. The use of ICT is a catalyst to the increase of productivity and economic growth. It has direct impact on the increase of GDP, the creation of new high-value jobs, the modernization and productivity increase of the public sector, the increase of transparency and the promotion of democracy and culture [25].

Cyprus has a fully digital network with reliable high-speed international connectivity via eleven fibre optic submarine cables, including the world's longest optical submarine telecommunications cable, SEA-MEWE-3, which links directly with South East Asia, the Middle East and the rest of Western Europe. Cyprus' network boasts 100% broadband coverage, with DSL network capacities of at least 2Mbps, while telecommunications costs are among the cheapest in Europe. Satellite communications are an important part of business in Cyprus and the country has developed a simple, flexible and competitive licensing model. Cyprus has already issued three (3) authorisations, resulting in one satellite in operation and four (4) new satellites expected to be launched in the next three years. In addition, Cyprus has secured a significant amount from EU structural funds for the deployment of step-change technology, for the roll-out of Fibre-To-The Home (FTTH) networks. By 2020, FTTH networks are expected to extend to every private residence [26, 27].

Telecoms and Privatisation Mobile operators in Cyprus offer high speed broadband mobile access through 3G and 4G technologies, with constant investment in new technologies. Cyprus also boasts some of the most cost-effective call rates within the EU and plans to proceed with the authorisation of new frequency bands (800/2600 MHz) by early 2016, which will give the opportunity for current and new providers to further enhance their networks in terms of speed, capacity and quality of service. Increasing numbers of technology companies are choosing to locate their operations in Cyprus, attracted by the island's high-quality services, skilled workforce and favourable tax and business environment. The Cypriot Government also offers financial incentives for innovative small and medium-sized enterprises setting up on the island. State-owned operator Cyprus Telecommunication Authority continues to dominate the market offering a full range of telecommunications services. Other key players with a prominent role in the telecoms landscape are MTN, Primetel and Cablenet [26].

ICT infrastructure is vulnerable to extreme weather damage or disruption and increasing temperatures (particularly heatwaves) and more frequent flooding are the main areas of concern for the future.

The broader ICT infrastructure is relatively resilient to disruption, because the telecommunications grid is much more distributed (than, for instance the energy grid) as a variety of technologies are being used. Very few impacts would be expected to affect the

entire national ICT network. The majority of impacts would cause disruption at the level of individual organisations or local geographical areas. Some of the more remote parts of the country may be particularly vulnerable, where the network is limited.

However, the national ICT network is only part of the international network, upon which users are becoming increasingly reliant. The sector has links to many parts of the world that may experience significant impacts from climate change, such as India, China, South America etc. Therefore, resilience of ICT infrastructure overseas, including the submarine fibre-optic cables, is also very important.

The impacts of CC on the ICT infrastructure are not evaluated in this CCRA.

5.8 Summary of risk metrics

Risk metrics related to buildings and infrastructure as a result of climate change are presented below.

Table 5.3 Scorecard for Buildings and Infrastructure

Metric Code	Metric Name	Confidence	2050s		2080s	
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
BE3	Energy demand for Heating	M	2	2	2	3
MA1	Breakwaters exposed to significant risk of instability	L	3	3	3	3
BU3	Tourist assets at risk from flooding due to SLR	L	*	3	*	3
W2	Higher cost of water supply due to increased desalination	L	2	2	3	3
BE1	Energy demand for cooling	M	2	2	2	3
BE4	Effectiveness of Green Spaces	M	1	2	2	3
W3	Irrigation Supply Deficit	L	1	2	2	3
BE5	Overheating of Buildings	H	1	2	1	3
EN1	Energy Demand by Water Suppliers	L	*	*	1	3
BU2	Loss of staff hours due to high internal building temperatures	M	*	*	*	3
FL2	Number of properties at significant likelihood of flooding	M	2	2	2	2
FL5	Land affected by coastal erosion and wave overtopping	L	1	2	1	2
FL3	Flooding of transport infrastructure, critical utilities and archaeological sites	L	1	1	1	1
FL4	Insurance premiums for flood risk	M	1	1	1	1
MA2	Down-time of Shipping Operations and sea sports	L	1	1	1	1
EN3	Flooding of Power Stations	L	*	*	*	1
BE2	Urban Heat Island	H	?	?	?	?
BE6	Subsidence	L	?	?	?	?
EN2	Electricity Turbine Efficiency	L	?	?	?	?
EN4	Power Station Cooling Processes	L	?	?	?	?
EN5, 6	Transmission Capacity	L	?	?	?	?
EN7	Heat Related Damage/Disruption	L	?	?	?	?
TR1	Cost of carriageway repairs	H	?	?	?	?
TR2	Disruption and delay due to flooding of the road network	L	?	?	?	?
TR3	Subsidence & landslides	L	?	?	?	?

3	Positive - High consequences
2	Positive - Medium consequences
1	Positive - Low consequences
1	Negative -Low consequences
2	Negative - Medium consequences
3	Negative - High consequences
?	Magnitude not assessed (no data)

H	High
M	Medium
L	Low

*Risk is not significant

5.9 Other Risks

According to the Terms of Reference Risks on people and the built environment should investigate “risks directly affecting people and/or buildings, including through health impacts from heat and cold, pressure gradient winds, thunderstorms, droughts, dust in the lower atmosphere, **earthquakes/tsunami**, flood risk, water availability and quality, analysis of the effects of climate change on vulnerable groups, effects of climate change on wellbeing, risks/adaptation through blue and green infrastructure”.

The abovementioned risks, excluding earthquakes and tsunamis, were evaluated in the framework of the applied methodology. Earthquakes and tsunamis were excluded from the analysis since there is no strong link between CC and increased seismicity rates in the study area (see following paragraph).

5.9.1 Earthquakes and Climate Change

There is already plenty of evidence that human activity can trigger earthquakes. The melting of glaciers driven by global warming portends a seismically turbulent future. When glaciers melt, the massive weight on the Earth's crust is reduced, and the crust “bounces” back in what scientists call an “isostatic rebound.” This process can reactivate faults, increase seismic activity, and lift pressure on magma chambers that feed volcanoes.

All over the world evidence is stacking up that changes in global climate can and do affect the frequencies of earthquakes, volcanic eruptions and catastrophic sea-floor landslides. Not only has this happened several times throughout Earth's history, the evidence suggests that it is starting to happen again [35].

Right now, the Earth is still responding to the end of the last ice age some 20,000 years ago when temperatures began to rise, causing large ice sheets to retreat.

Glaciers melting and the associated rebound of the land (isostatic rebound) may produce a myriad of impacts including increased frequency of earthquakes. Based on evidence from former melting events, it is predicted that isostatic rebound may decrease fault stability margin and increase thrust faulting events such as earthquakes and aftershocks [36, 37].

On a global level, there has been no significant increase in either volcanic eruptions or earthquakes as a result of the warming over the past century.

There is, however, evidence that earthquakes and volcanic eruptions **over a hundred years** would cluster. The main reason is melting ice. There is far less ice now, of course, than at the end of the last ice age. But the planet is warming much faster, so sea level may rise as fast as it ever did before. While sea level rose just 0,17 metres over the 20th century, most glaciologists expect sea level to rise around a metre by the end of the 21st century. This would add an extra tonne per cubic metre to undersea and coastal faults.

The good news is that it will probably weigh down and stabilise faults beneath the sea floor. The bad news is that it will create extra stress at the coast and it could add enough stress to trigger a quake on faults that straddle the coast, or run parallel to them, such as the San Andreas fault in California, the North Anatolian fault in northern Turkey, and the Alpine fault in New Zealand.

Glacial isostatic rebound is considered as the main mechanism for promoting crustal deformation, fault movement and seismicity [38, 39, 40]. However, the lack of glaciers in Cyprus at present day and over the last 5-6.000 years deny any prominent role of postglacial rebound processes in the study area.

In Cyprus there is no strong evidence linking earthquakes with CC, since:

- There are no glaciations in Cyprus to support an isostatic postglacial rebound that can increase seismicity rates.
- Sea level rise of a few cm up to several dm are incapable of triggering or modulating tectonic activity

In the following paragraphs data on geodynamics and seismic hazard are given.

5.9.1 Geodynamics

Cyprus is situated along the Alpine-Himalayan belt and constitutes the tectonic boundary between the African and Eurasian lithospheric plates in the region. The Hellenic and Cyprus double arc system, have been evolving from the subduction of the remnants of the Tythean ocean and Africa beneath the Eurasia plate. Both arcs were originally connected forming an approximately E-W trending subduction zone, but later have been separated forming a more complex plate boundary [41, 42]. The Cyprus Arc initiates from the Antalia Gulf, where it joins the Hellenic Arc, crosses west and south of the Cyprus island and extends towards the gulf of Iskenderun in the east where it joins the Eastern Fault of Anatolia. Seismic activity is concentrated in the west and south of the island and along an approximately arcuate zone in the sea, also in the west and south (Figure 5.2).

Arc-normal convergence implies the occurrence of thrust faulting. In addition, southwestward trench retreat also causes an extension internal to the outer-arc domain, such that preexisting N120°E-striking thrust faults have been reactivated as normal to oblique normal faults during the Pliocene and Quaternary [43].

The segmentation of the originally E–W trending arc is associated with the collision of the Arabian promontory of the African plate with Eurasia and the ensuing Pliocene–Recent westward extrusion of the Anatolian plate into the Aegean domain [44, 45]. The effects of the extrusion of Anatolia are confirmed by analogue modelling [46], geomagnetic observations [47], seismicity [48] and geodetic measurements [49].

5.9.2 Seismicity and seismic hazard

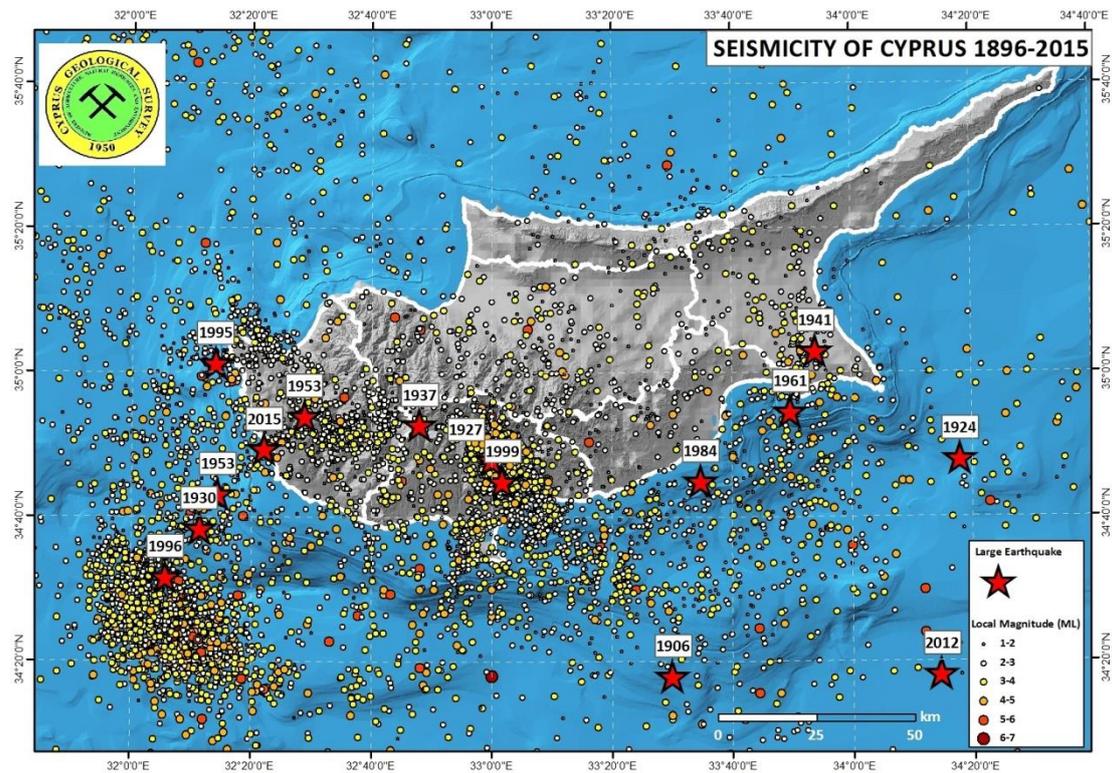


Figure 5.2 Map showing the distribution of earthquake epicentres (colour scale denotes the magnitude scale) recorded by seismological networks during 1896-2015 [50]

Seismicity is confined along the Cyprus arc (with very strong magnitude events up to $M \sim 7,5$) but is also distributed northwards the plate tectonic boundary with several active faults that can generate lower magnitude events ($M \sim 6,5$). Earthquakes generated from the arc are stronger releasing more energy, but are more distant from the towns of Cyprus, whereas the earthquakes generated by smaller active faults distributed within the island are less powerful, releasing less energy, but they are proximal to human habitation and can cause also significant damage. Overall, seismic activity is concentrated in the west and south of the island. Approximately half of the earthquakes occur at depths higher than 26km and up to 75km (Figure 5.3), implying a lower hazard threat. Shallow earthquakes that nucleate within the seismogenic layer of the crust (up to 15km depth) occur predominantly in the southern shores of Cyprus and are posing a higher hazard to the coastal communities.

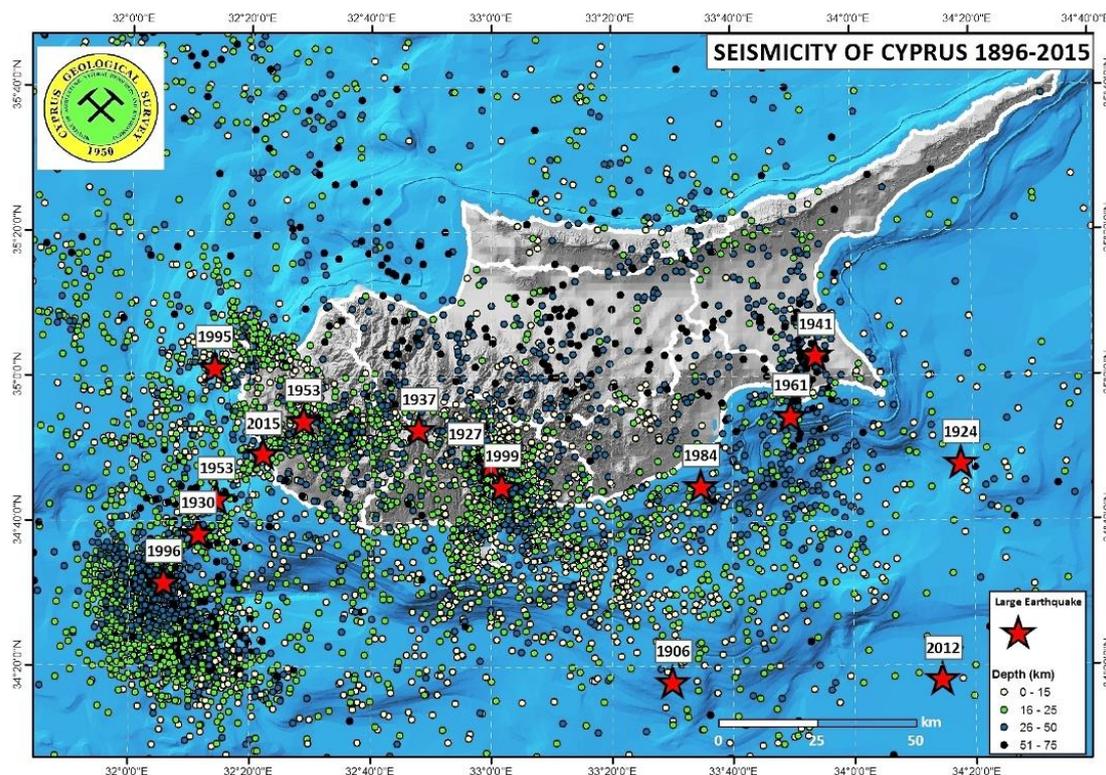


Figure 5.3 Map showing the depth distribution of earthquake epicentres recorded by seismological networks during 1896-2015 [50].

The statistical analysis of the historical data gives a theoretical return period of one catastrophic earthquake every 120 years, while a similar analysis of instrumental recordings of the last 100 years provide the results presented in table 1 below. Overall, there is one event of $M \geq 6,0$ every 75yrs and one of $M \geq 6.6$ every 166 years. However, due to the small and incomplete historical statistical sample these numbers should be adopted with caution, unless they have been fault specific seismic hazard studies [51]. Earthquakes $M \geq 6.0$ can produce significant damage depending on their focal depth and their distance from populated areas. If these events are shallow (up to 15km depth), they can generate surface ruptures and thus can cause either a **tsunami** if located offshore or extensive damages in infrastructures if located onshore. In such cases one of the neotectonic active faults outcropping in the area would have been activated.

Table 5.4 Statistical elaboration of instrumentally seismicity data [52]

Magnitude (Ms)	Return period (years)	No. of earthquakes in 100 years
4,6-5,0	8	12,5
5,1-5,5	26	3,8
5,6-6,0	36	2,8
6,1-6,5	75	1,3
6,6-7,0	166	0,6

The historical record is approximately 2000yrs old, but still incomplete for several periods [53]. Overall, it has recorded 26 damaging earthquakes. The southern and southwestern part of the

island has experienced the most damaging earthquakes. This is why this part of the island belongs to the highest seismicity zone of 0.25g of the Cyprus seismic code (Figure 5.4). Overall, the town of Pafos has experienced several severely damaging earthquakes in the past and in particular in 15BC (intensity IX), 76AD (intensity IX), 342AD (intensity X, total devastation), and in 1222 (intensity IX).

The strongest instrumental earthquake was recorded in 9 October 1996 Ms=6,5 to the southwest of Cyprus again close to the town of Pafos (2 fatalities and 20 injuries). It generated damages in Pafos and Lemessos. However, the most catastrophic events within the last century occurred in 10th of September 1953 (M=6,0 and M=6,1) and damaged severely the town of Pafos and 158 villages [54]. Overall 40 people lost their lives, 100 injured and 4000 remained homeless since 1600 buildings were destroyed beyond repair and approximately 10.000 suffered significant damage.

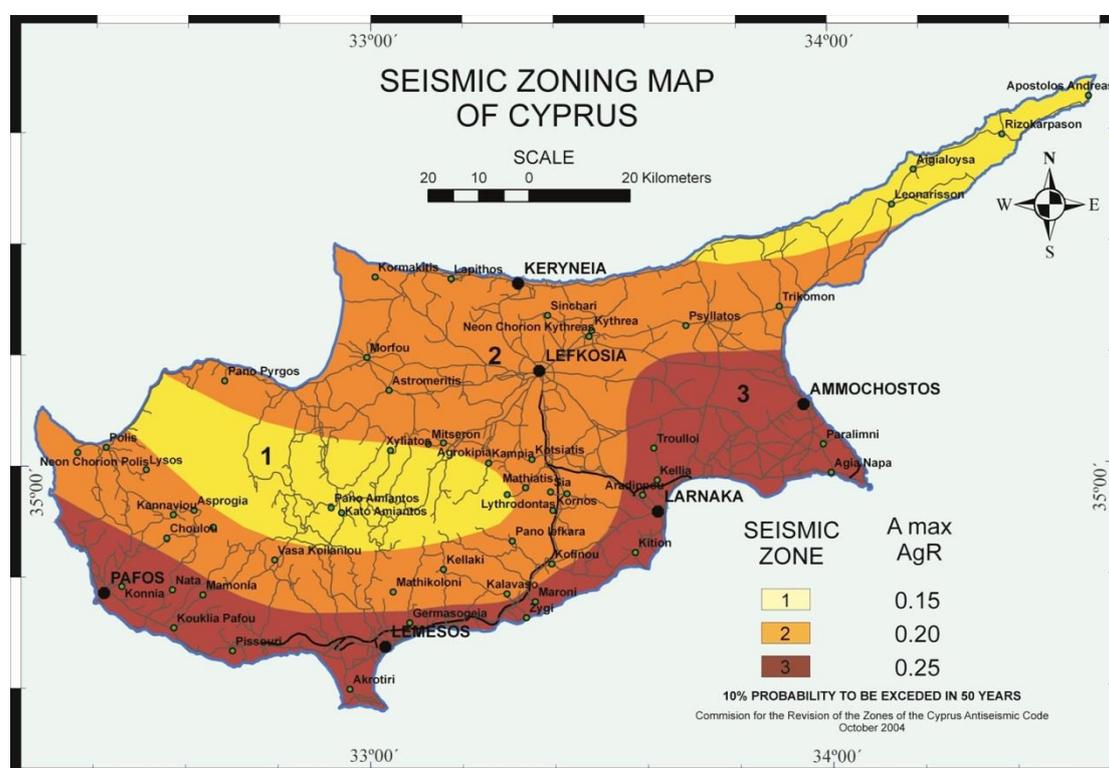


Figure 5.4 Seismic Zoning Map of Cyprus defined by the Commission for the Revision of the Zones of the Cyprus Antiseismic Code (October 2004). The map contains three zones of different values (0,15g, 0,20g and 0,25g) of the maximum expected ground acceleration (PGA) with 10% probability to be exceeded in 50 years, where $g=9,81m/s^2$.

Despite the recorded history of destructive earthquakes, the first guidelines for seismic design in Cyprus were imposed after 1986 and the first seismic design code was introduced on a voluntary basis in 1992 and was then made compulsory in 1994 [55]. On January 1st 2012, the national code harmonized with the Eurocodes, including Eurocode 8 for the design of seismic resistant structures. Therefore, the majority of structures have been designed without any

seismic provisions, which increases their vulnerability to seismic loads [56]. The seismic code divides the island in three zones with different values (0,15g, 0,20g and 0,25g) of the maximum expected ground acceleration (PGA) with 10% probability to be exceeded in 50 years . Recent studies support that peak ground acceleration distributions obtained for a return period of 475 years for rock conditions indicate higher hazard along the southern coastline of Cyprus, where the expected ground motion is between 0,3 and 0,4g [57], higher than the maximum design value (0,25g) of the seismic code.

Insurance for catastrophe risk is widely offered in Cyprus. All risks can be insured except drought. In particular, earthquake and storms are the most popular. Coverage includes material damage as well as business interruption in commercial and industrial premises. Historical data on insurance costs from 1990 up to 2010 for Cyprus [58] recorded two major losses. One event occurred in 1995 due to earthquakes with total losses of 3.318.000€ and the second in 2003 due to storms with total losses of 10.297.000€. Solvency II is an EU legislative programme to be implemented in all 28 Member States, that introduces a new, harmonised EU-wide insurance regulatory regime. Solvency II is scheduled to come into effect on 1 January 2016. Cyprus according to the new Solvency II for insurance has an Earthquake risk factor of 2,12% for the standard formula which is the highest in Europe [59]. The latter has been debated since Cyprus is regarded as a state facing a moderate rather than the highest seismic risk in Europe [58].

5.9.3 Tsounamis

Tsunamis can occur in European waters due to earthquakes caused by the African Plate drifting northwards underneath the Eurasian Plate. Ten percent of all tsunamis worldwide occur in the Mediterranean. On average, one disastrous tsunami takes place in the Mediterranean region every century. Geological research and historical records report of many powerful tsunamis that have taken the lives of thousands over the ages. Greece and southern Italy are mostly affected [60].

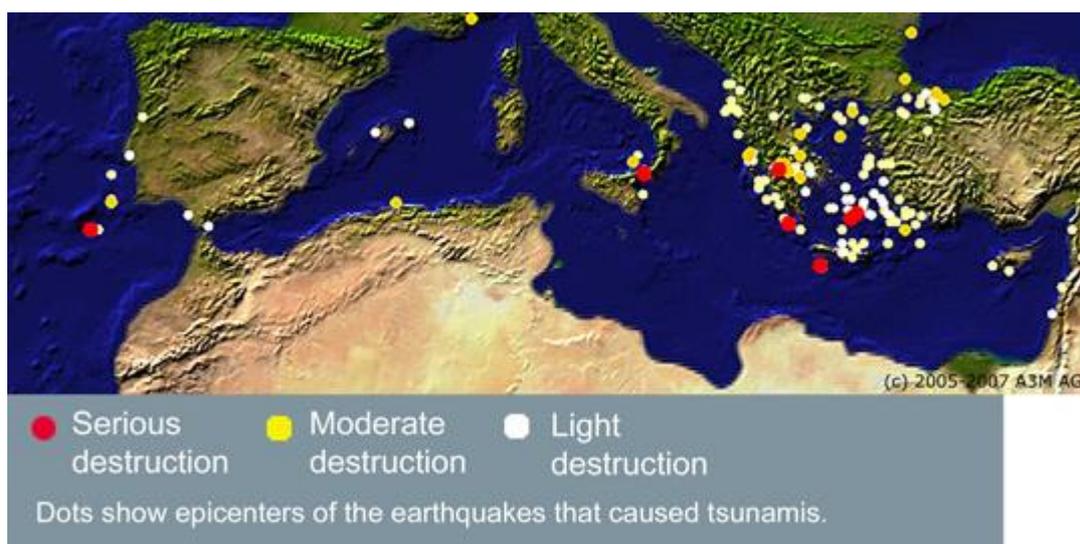


Figure 5.5 Map of historical occurrences in the Mediterranean Sea [60]

The Mediterranean Sea is considered vulnerable to tsunamis not only because the area is seismically active, but also because coastal ports are very close to high-risk tsunami epicenters. An earthquake in the Mediterranean could trigger a tsunami that could reach Cyprus within an hour, giving very little time to evacuate and shut down industrial buildings such as power plants and factories [61].

CSnet (Cyprus) Ltd of Limassol, Cyprus, was teamed with the Oceanography Centre of Cyprus to develop and deploy a prototype Tsunami Warning and Early Response system for Cyprus (TWEREC). This system consists of an array of seismometers and very sensitive pressure sensors configured in an Offshore Communications Backbone (OCB) seafloor array, covering several hundred kilometres of seafloor off the southern coast of Cyprus [62].

The warning and early response system will incorporate both proven tsunami detection techniques as well as new approaches under evaluation by CSnet, in an effort to develop a highly reliable, yet cost-effective, system that can benefit the developing regions of the world most vulnerable to tsunamis.

6. Human health and wellbeing

6.1 Overview of risks

Climate change affects humans both directly and indirectly. Direct impacts are caused by extreme weather events (such as heat waves, floods etc.) while indirect effects include mainly the consequences of environmental changes and ecological disturbances due to climate changes, such as diseases carried by insects, food contamination by the increase of temperature and/or relative humidity, food and water-borne diseases by groundwater contamination and/or air pollutants.

Rising temperatures, changing seasonal rainfall patterns, drought conditions and increases in the frequency of floods and hot could have an impact on people's homes, workplaces and lifestyles and may result in substantial increased disruption to health care provision and services.

Warmer conditions, particularly related to heatwaves, would lead to an increased risk of overheating of homes. The quality of housing and local neighborhoods is an important consideration for overheating, with those social groups considered more vulnerable to significant health impacts.

Warmer conditions in work places, hospitals and schools are also important in terms of the health of vulnerable groups including elderly and very young people.

There is evidence that green space reduces the urban heat island impacts as evaporation and transpiration from plants, and their shading effects can cool the atmosphere. Therefore, provision of green infrastructure is a key design consideration that can help to adapt existing and new development to a changing climate.

The health sector faces a number of challenges in the future, not all of which are associated with the climate, but which could be more difficult to tackle in a changing climate environment, including an ageing population and various inequalities in the use of health care (including hospital services) and wider social inequalities.

Health inequalities may also be exacerbated as a result of disrupted access to services, poorer housing conditions and a reduced ability to adapt to a changing climate in lower socio-economic groups.

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

Heatwaves 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 Plan that was drafted within the framework of the Floods Directive

As temperatures increase, mainly during summer months, this can have a subsequent effect on the number of premature deaths as a result of heat related illnesses (i.e. cardio-vascular and respiratory diseases). These deaths tend to increase above a set temperature threshold, with the threshold and rate of increase varying between regions. Temperature mortality (heat-related) has been addressed by assessing the change in mortality rate based on published exposure response functions, threshold temperatures and data on maximum daily temperature and daily death counts.

Temperatures increase may also increase the number of hospital admissions as a result of heat related illnesses. Hospital admissions attributable to heat are more difficult to attribute than heat related deaths.

Ground-level ozone can directly affect human health. Acute exposure to ozone may cause irritation to the eyes and nose and very high levels can cause damage to the airway lining. Mainly in spring and summer months increased sunlight and warm temperatures, there can be a noticeable increase in ground-level ozone. This can lead to increases in daily mortality and hospital admissions linked to respiratory diseases. Particulate matter (PM₁₀ and PM_{2,5}), has also been associated with daily mortality. PM₁₀ is often used as an air pollution indicator when assessing a possible confounding effect on the temperature–mortality relationship.

Heat-related mortality and morbidity are the main challenges that the Sector will face due to climate change. Illness associated with exposure higher levels of air pollution (and potentially pollen) is also expected to increase but there are no sufficient data to quantify this risk.

Climate change presents complex socioeconomic challenges, which could act as risk magnifiers in the future, particularly for vulnerable populations.

Cyprus can be considered as a country with high aging population. This poses a serious challenge to the health and pension system of Cyprus.

The population groups that are most vulnerable to heat waves are the elderly, persons with pre-existing chronic diseases, people confined to bed, children, population groups with low socio-economic status, workers in outdoor environments. The occupations most at risk of heatstroke, include construction and agriculture/forestry/fishing work. Considering the fact that a high percentage of immigrants labourers, work in outdoor environments, the risk for the particular vulnerable group is high.

Senior citizens (>65 years) are mostly sensitive to direct climate change effects such as thermal stress during heat waves and health stress during other extreme weather events. The elderly population can face unequal access to healthcare, as they are often unable to travel long distances to the nearest health facility. Children (<14 years) is another high-risk group to heat waves because they do not have fully developed temperature regulation mechanisms and are unable to change their environments without help from adults. The very young are at higher risk of death while older children have more heat stress due to time spent in exercise – playing outdoors.

It is likely that certain risks are not going to be evenly distributed, with urban populations (especially Nicosia) appearing to be more affected by heatwaves and heat-related mortality due to Urban Heat Island. In the urban areas where the air pollution levels are elevated, heat waves are more frequent. Furthermore, the increases in temperatures would be higher in the interior than on the coast of Cyprus, which leads to higher adverse health implications on the population living inland.

Most risks in the health sector are strongly correlated to social demographics. The elderly for example are typically more vulnerable to most health impacts, and a projected ageing population is likely to increase these risks.

Heat related deaths are a function of several factors, including the age distribution of the population, levels of deprivation, and social capital (i.e. social networks and contacts). However, the relationship between temperature related mortality, deprivation and social capital is very complex and not possible to characterise within this assessment.

Higher temperatures may cause an earlier and possibly longer pollen season. More days with high pollen concentrations would result in more people with hay fever and pollen asthma.

Annual excess heat mortality due to CC in the 2050s can increase by 94% under the moderate CC scenario and up to 126% under the more pessimistic CC scenario. In the 2080s can increase by 104% under the moderate CC scenario and up to 268% under the more pessimistic CC scenario. Annual excess heat morbidity expressed in terms of patient-days in hospital per year, will also increase proportionally.

Overview	
<ul style="list-style-type: none"> Climate change (particularly the frequency of floods, hot weather and droughts) may affect homes, workplaces and lifestyles, which in turn can affect people's health and wellbeing. Socially deprived groups and those with compromised health (including older people and the very young) would be expected to be more vulnerable to these climate change threats. The health and wellbeing of the population in the future may be influenced by socio-economic changes, including the economy, government policy, an ageing population and individual lifestyle choices. 	
Threats	Opportunities
<ul style="list-style-type: none"> Increased temperatures may lead to increased levels of mortality and morbidity. Increased flooding may lead to increased number of deaths and injuries. Increased ozone levels may lead to increased levels of mortality and respiratory hospital admissions. Increased temperatures combined with increased periods of time spent outdoors may lead to an increased risk of the number of skin cancer cases and deaths. 	<ul style="list-style-type: none"> Warmer winters in future years are likely to see reduced space heating demand from end users and a reduction in overall fuel bills, increasing the opportunity to lift certain social groups out of fuel poverty. Increased temperatures combined with increased periods of time spent outdoors could lead to increased vitamin D levels and improved physical and mental health of people.

Table 6.1, provides a summary of the risks considered as part of the assessment work in this study and provides an indication of how the magnitude of the **moderate emissions scenario** (RCP4.5) changes over time. Further detail of the risks relevant to this theme, with more information on how the magnitude of the risks vary under different scenarios is provided in the scorecard at the end of the chapter (see Table 6.2).

Table 6.1 Summary of health and wellbeing impacts with an indication of direction, magnitude and confidence

		Confidence	Timing	
			2050s	2080s
Opportunities				
BE3	Energy demand for heating	M	2	2
Threats				
HE1	Temperature mortality	M	3	3
HE2	Temperature morbidity	L	3	3
W2	Higher cost of water supply due to increased desalination	L	2	3
BE1	Energy demand for cooling	M	2	2
F01	Increased risk of wildfires	H	2	2
FL1	Number of people exposed to significant likelihood of flooding	M	2	2
BE4	Effectiveness of green spaces	M	1	2
BE5	Overheating of buildings	H	1	1
BE2	Urban Heat Island	H	?	?
HE3	Air pollution	L	?	?
HE4	Pollen and allergens	L	?	?
3	Positive - High consequences	H	High	
2	Positive - Medium consequences	M	Medium	
1	Positive - Low consequences	L	Low	
1	Negative -Low consequences			
2	Negative - Medium consequences			
3	Negative - High consequences			
?	Magnitude not assessed (no data)			

6.2 Adaptive capacity

There is evidence that population acclimatisation and adaptive capacity (e.g. increased use of air conditioning and gradual physiological adaptation) can influence the level of certain health risks associated with climate change. For example, people can become gradually acclimatised to higher temperatures and there are indications that European regions with hot summers do not have significantly higher annual heat related mortality rates than cold regions.

Public health protection measures such as warning systems, health alerts, public awareness campaigns and home-based prevention advice can help reduce the health risks of higher temperatures associated with climate change; providing these is a sign of capacity to adapt to short term climate risks.

Heat wave plans have been shown to reduce heat-related mortality in Italy, but evidence of effectiveness is still very limited. There is little information about how future changes in housing and infrastructure would reduce the regional or local future burden of heat-related mortality or morbidity.

Creation and protection of green infrastructure to reduce the UHI phenomenon and improve air quality must be a priority can be an adaptation measure.

The public health response of Cyprus in heat waves is based at forecasting heat waves, issuing warnings and providing advices for self-protection from heat waves, through the mass media (television, radio, newspapers, public websites). In addition, during severe heat waves the government, in order to protect its citizens from adverse health effects, recommends a curfew between the high risk hours of the day. Also, there are communal centres fully air-conditioned to accommodate people with no access to an air-conditioned environment during days of elevated temperatures. However, the protection of the population from heat waves is not always possible.

6.3 Summary of risk metrics

Risk metrics related to health and wellbeing as a result of climate change are presented below.

Table 6.2 Scorecard health and wellbeing

Metric Code	Metric Name	Confidence	2050s		2080s	
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
BE3	Energy demand for heating	M	2	2	2	3
HE1	Temperature mortality	M	3	3	3	3
HE2	Temperature morbidity	L	3	3	3	3
W2	Higher cost of water supply due to increased desalination	L	2	2	3	3
BE1	Energy demand for cooling	M	2	2	2	3
F01	Increased risk of wildfires	H	2	2	2	3
BE4	Effectiveness of green spaces	M	1	2	2	3
BE5	Overheating of Buildings	H	1	2	1	3
FL1	Number of people exposed to significant likelihood of flooding	M	2	2	2	2
BE2	Urban Heat Island	H	?	?	?	?
HE3	Air pollution	L	?	?	?	?
HE4	Pollen and allergens	L	?	?	?	?

3	Positive - High consequences
2	Positive - Medium consequences
1	Positive - Low consequences
1	Negative -Low consequences
2	Negative - Medium consequences
3	Negative - High consequences
?	Magnitude not assessed (no data)

H	High
M	Medium
L	Low

7. Business & Industry

7.1 Overview

The Business, Industry and Services sector is highly vulnerable to a changing climate, both extreme (acute) events and incremental (chronic) climate change. The degree to which individual organisations are vulnerable to CC depends on their level of sensitivity and adaptive capacity. Across the sector, current vulnerability to climate-related impacts can be divided into the following common themes:

- **Assets:** Fixed and workforce (e.g. infrastructure damage, workforce exposure to health and safety risks).
- **Operations:** Supply of services, customer demand and regulatory environment (e.g. financial performance, markets shift due to change in public attitudes and / or legislation).
- **Procurement:** Raw materials, supply chain and logistics (e.g. supply of water, energy and materials, reliance on vulnerable transport networks).
- **Environment:** Natural and built, plus local community (e.g. climate sensitive resources and conflict over their use).

Overview	
<ul style="list-style-type: none"> • All aspects of businesses are affected, including fixed assets, workforce, procurement (raw materials, supply chains, logistics), operations (supply of services, customer demands, regulation), and environmental and social performance. • Climatic factors have the potential to disrupt businesses' supply chains by affecting availability of natural resources and raw materials, or by causing distribution delays. • Insurance and banking may face problems related to accurate pricing of risks, shortage of capital after large loss events, and by an increasing burden of losses that can affect markets and insurability. 	
Threats	Opportunities
<ul style="list-style-type: none"> • The main threats facing businesses are related to flooding, heat and water resources. • Increased energy costs for summer cooling. • Increased cost of water supply. • Loss of assets due to sea level rise (including natural assets such as beaches). • Reduced yields of certain crops. • Loss of productivity due to overheating and warm weather periods. 	<ul style="list-style-type: none"> • Changes in domestic weather conditions increase market opportunities (e.g. agriculture may benefit from increased yields and tourism and leisure industries from better weather conditions). • Reduced winter heating costs.

These impacts have the potential to create the following consequences for individual businesses and collective sub-sectors within the Business, Industry and Services sector:

- Financial performance (revenue loss / gain)
- Additional costs (capital expenditure (capex) and operational expenditure (opex))
- Operational disruption

- Loss of staff work hours
- Corporate reputation
- Elevated stakeholder interest
- Additional regulatory requirements
- Contractual issues
- New market opportunities and product diversification.

Due to the diverse nature of the sector it has not been possible to provide a comprehensive picture of all of the potential climate change risks that the sector is likely to face. For the purposes of this CCRA, the assessment of risks and opportunities for the sector was based on a number of subsectors, specifically:

1. Financial services
2. Tourism
3. Food and beverages and
4. Primary extractives (oil, gas and mining)

These 4 sub-sectors are used as illustrative examples to highlight the range of climate-related issues and challenges the sector, as a whole may face. They are of particular significance for the following reasons:

- They play an important role in driving growth in the economy
- They rely on large fixed assets
- They have complex supply chains (e.g. food and beverages)
- They rely substantially on natural assets (e.g. tourism).
- Financial services have been a major contributor to GDP and employment until recently. In addition, other businesses, including trading, real estate activities and professional services (lawyers, accountants) are closely intertwined with the financial sector. The banking sector was restructured in 2013.
- Tourism is a very important sector of Cyprus economy, attracting millions of tourists every year and providing economic growth and employment for the country.
- Food and Beverages industry has an important contribution to the Cyprus economy and a high dependency on water, temperature and droughts. Water is a critical resource and raw material in this industry.
- Exploration for oil and gas offshore the Republic of Cyprus is in a developing phase. A known hydrocarbon system exists in the vicinity with large hydrocarbon discoveries. The Government's objective is to make Cyprus not only a hydrocarbons producer, but a gas export hub for the region, and negotiations are under way for the development of an liquefied natural gas (LNG) compression and export facility at Vassiliko.

The direct contribution of **Travel & Tourism** to GDP was $1.136,8 \times 10^6$ € (6,8% of total GDP) in 2013, and has been forecasted to rise by 5,2% pa, from 2014 to 2024, reaching $2.070,9 \times 10^6$ € (10,5% of total GDP) in 2024. The direct contribution to GDP reflects the 'internal' spending on Travel & Tourism (total spending within a particular country on Travel & Tourism by

residents and non-residents for business and leisure purposes) as well as government 'individual' spending i.e. spending by government on Travel & Tourism services directly linked to visitors, such as cultural (e.g. museums) or recreational (e.g. national parks).

The total contribution of Travel & Tourism to GDP was $3.443,6 \times 10^6$ € (20,6% of GDP) in 2013, and is forecast to rise by 5,1% pa to $6.067,7 \times 10^6$ € (30,9% of GDP) in 2024. The total contribution includes its 'wider impacts' (i.e. the indirect and induced impacts) on the economy. In 2013, Travel & Tourism directly supported 27,000 jobs (7,8% of total employment). This is expected to rise by 2,2% pa to 35,000 jobs (9,0% of total employment) in 2024. In 2013, the total contribution of Travel & Tourism to employment, including jobs indirectly Visitor exports, generated $2.227,2 \times 10^6$ € (27,2% of total exports). This is forecast to grow by 5,4% pa, from 2014-2024, to $4.200,8 \times 10^6$ € in 2024 (34,4% of total).

Visitors arriving in Cyprus reached 2.626.160 in 2013. The vast majority of visitors 91,5% were tourists who stayed at least one night in Cyprus, 7,9% were cruise-ship visitors who spent the night on board of their ship and 0,5% were same-day tourists who visited the country and left on the same day.

Tourist arrivals reached 2.405.387 in 2013. Europe has been, as usual, the traditional tourist market for Cyprus. In 2013, the United Kingdom was most important source of tourism to the island and its share was 37% of the total tourist traffic, followed by Russia with 25%, Sweden with 5%, Germany and Greece with 4% and Norway with 3%.

During the last decades, Cyprus has developed its tourist accommodation infrastructure to a great extent in order to meet the needs of the increasing incoming tourism. According to the Cyprus Tourism Organization (CTO), in the end of 2013 the tourism accommodation infrastructure in Cyprus consisted of 800 licensed accommodation units, with a total bed capacity of 87.102 beds.

The Cyprus **industrial sector** in 2013 registered a **negative growth rate** in real terms for a third year in a row. On the basis of provisional estimates, this rate (as measured in terms of value added at constant market prices of 2005 by the chain linking method) for the whole of the sector recorded a decrease of 9,2% in 2013, compared to a decrease of 8,2% in 2012 and 5,3% in 2011. Specifically, according to provisional figures, manufacturing recorded a decrease of 9,8%, mining and quarrying 31,0%, electricity supply 7,8% and water supply, sewerage and waste management 3,7%. The gross output of the industrial sector at current market prices decreased in 2013 by 13,6% and reached **€3.935,3 million**, compared to €4.556,9 million in 2012. Value added at current market prices is estimated to have reached €1.350,1 million compared to €1.558,7 million in 2012, recording a decrease of 13,4%. The contribution of the sector to the GDP at current market prices reached **7,8%**, from 8,3% in 2012.

In 2012, 5.591 enterprises were operating with their main activity in the industrial sector. These enterprises engaged 35.579 persons and their contribution to the Gross Domestic Product was **€1.558,7 million**.

In 2013, **Manufacturing** contributed 62,7% of the value added of the Industrial sector, followed by mining, quarrying, electricity supply (24,2%) and water supply, sewerage, waste management and remediation (13,2%). The manufacture of food products is the activity with the highest share of persons engaged in the industrial sector, since it occupies 32% of the persons engaged in industry. It also contributes 33% to the value added of the sector.

The Cyprus **financial services** sector is diverse, comprising domestic banks, International Banking Units (IBUs), insurance companies, and other companies that offer financial intermediation services.

Financial and insurance activities contributed 9,2% to GDP in 2012 and provided employment to 19,300 people or 5% of total employment, above the EU averages of 5,7% and 2.7%, respectively. In addition, other businesses, including trading, real estate activities and professional services (lawyers, accountants) were closely intertwined with the financial sector and accounted for about 50% of the economy and employment throughout 2012. The banking sector was restructured in 2013.

The overall adverse economic environment in 2013 had a serious impact on the results of the insurance sector. In 2013, total gross written premiums were reduced to €772 million as compared to €830 million in 2012, representing a reduction of 7%. This was primarily caused by the contraction of the life sector which, due to its nature, is more vulnerable to economic fluctuations and the weak performance of the motor insurance due to the declining of car sales caused by the economic downturn.

Table 7.1, provides a summary of the risks considered as part of the assessment work in this study and provides an indication of how the magnitude of the **moderate emissions scenario** (RCP4.5) changes over time. Further detail of the risks relevant to this theme, with more information on how the magnitude of the risks vary under different scenarios is provided in the scorecard at the end of the chapter (see Table 7.2).

Table 7.1 Summary of Business, Industry and Services Sector impacts with an indication of direction, magnitude and confidence

		Confidence	Timing	
			2050s	2080s
Opportunities				
BU4	Tourism product diversification	M	3	3
BU1	Extension of summer season	M	1	3
BE3	Energy demand for Heating	M	2	2
AG1e	Crop yield using grapevine as a reference C3 fruiting berry	L	2	1
AG1a	Crop yield using wheat as a reference C3 rain fed arable crop	M	1	1
AG1d	Crop yield using olive as a reference C3 tree	L	1	1
Threats & Opportunities				
AG1b	Crop yield using potato (November sowing) as a reference irrigated vegetable crop for Spring-Summer production	M	2	1
Threats				
MA2	Down-time of Shipping Operations and sea sports	L	1	1
BE5	Overheating of Buildings	H	1	1
AG2	Livestock production	L	1	2
W3	Irrigation Supply Deficit	L	1	2
AG1c	Crop yield using potato (July sowing) as a reference irrigated vegetable crop for Autumn production	M	2	2
FL2	Number of properties at significant likelihood of flooding	M	2	2
BE1	Energy demand for cooling	M	2	2
W2	Higher cost of water supply due to increased desalination	L	2	3
MA5	Potential disruption coastal nurseries	M	2	3
F03	Increased risk of drought damage / loss of productivity	M	2	3
MA4	Shifts affecting producers and consumers	M	2	3
MA3	Potential disruption of fish production	M	3	3
MA6	Changes in fish catches and gene pool	M	3	3
MA7	Exerting pressure on fish physiological thermal limits	M	3	3
BU5	Decrease in Tourism arrivals	L	?	?
BU6	Reduced returns for financial institutions	L	?	?
EN5, 6	Transmission Capacity	L	?	?
EN7	Heat Related Damage/Disruption	L	?	?
TR1	Cost of carriageway repairs	H	?	?
TR2	Disruption and delay due to flooding of the road network	L	?	?
TR3	Subsidence & landslides	L	?	?

3	Positive - High consequences	H	High
2	Positive - Medium consequences	M	Medium
1	Positive - Low consequences	L	Low
1	Negative -Low consequences		
2	Negative - Medium consequences		
3	Negative - High consequences		
?	Magnitude not assessed (no data)		

7.2 Business, Industry and Services

This Section summarizes the results for the Business, Industry and Services excluding Tourism. Tourism is analysed in the following section.

7.2.1 Heat and heatwaves

Changes in climate are projected to influence both the heating and cooling energy demand within buildings. Warmer summers are likely to increase the energy demand for cooling, particularly for air conditioning in offices and cooling systems for ITC infrastructure. Through increased ambient air temperatures, as well as heat created by plant and machinery, ICT equipment and lighting, internal building temperatures may increase throughout the year and especially during summer months.

Another possible source of loss for the business sector relates to the impact of drought, due to hot and dry periods, on (some) agriculture and forestry yields with implications on the supply chains.

Increased temperatures and heatwaves may have implications for worker health and safety, productivity and product quality. Heat comfort levels within the work environment influence the productivity. The Department of Labour Inspection (Ministry of Labour and Social Insurance) as the competent authority for safety and health at work, has issued a Code of Practice for the Thermal Stress of Workers (Regulatory Administrative Act 291/2014).

In this CCRA due to lack of available data only extreme climate conditions that lead to 100% work loss were considered. The results suggest that CC is likely to increase the number of days with extreme Humidex values, particularly in Lefkosia and Famagusta, and in the end of the 21st century (2080s). This would lead to potentially high costs, from reduced productivity and lost work time, potentially in the order of hundreds of millions euros annually. Consequently, a high cost ranking was assigned to this risk. These figures assume no adaptation, which is unlikely, particularly in the private sector. Faced with rising temperatures, workplaces and companies are likely to adjust the working environment to avoid falls in productivity and in direct response to occupational health legislation/guidance. The indicative results above may therefore be an over-estimate of the actual costs likely to occur. Confidence of the ranking was considered low given that productivity losses will occur before these extreme conditions of Humidex are met.

7.2.2 Floods and Sea Level Rise

In Cyprus, manufacturing units are mainly sited in Industrial Areas, Industrial / Craft Zones and Crafts Areas. Throughout Cyprus there are 12 Industrial Areas, and more than 45 Industrial/Craft Zones.

Commercial and industrial installations are sited within the 19 designated Areas of Potentially Significant Flood Risk (APSFs). The following APSFs have the most significant implications with industrial zones:

- CY-APSR02 Egkomi Industrial Zone
- CY-APSR06 Dali Industrial Zone
- CY-APSR16 Limassol Industrial Zone

Regarding the Industrial Areas, a small part of the Strovolos Industrial Area is located within the CY-APSR04.

Industrial facilities located near the coastline are: Cement factory of Vassilikos, ECOFUEL LTD active in treatment and disposal of hazardous wastes facility, KEAN LTD, ETKO LTD, LOEL LTD, SODAP LTD, KEO LTD and Cyprus Canning Company LTD that are food and beverages industries

Where business premises flood, there is the potential for damage to the property itself, but also to the equipment, materials and stock on the site. In addition, the disruption caused by the flood may interrupt operations or affect supply chains.

The direct non-residential property damages due to floods and Sea Level Rise were not assessed in this CCRA.

7.2.3 Water Supply

The amount of water provided for public water supply, agriculture and industry is sensitive to the annual water balance.

As illustrated in the Water Sector Report, industrial demand constitutes only 1% of total demand. Therefore, any increases due to climate change would be insignificant in terms of the effect in the total water balance.

However, some source of loss for the business and industry sector may be the higher cost of water supply due to increased desalination.

Shortages in irrigation water supply can have indirect effects in food and beverages industry. The results suggest that there is an increased risk in irrigation supply deficit due to climate change.

7.2.4 Supply chains

Many climatic factors (e.g. heat, precipitation, flooding) can disrupt supply chains. Climatic factors have the potential to disrupt businesses' supply chains by affecting availability of natural resources and raw materials, or by causing distribution delays. The climate is also a factor in the market demand for goods. If extreme weather events affect key suppliers, and no alternate supply is available, then supply chains are severely interrupted. Each of these risks could increase as the climate changes.

Interruptions can occur in both international and domestic supply chains, while supply chain disruptions are costly to business.

Increasing globalisation, outsourcing and just-in-time approaches to inventory already create significant risk exposure. It may be more difficult to map out and understand supplier relationships (supply chain visibility) and contain costs under continuing climate change. Climate-related disruptions all over the globe would not only affect suppliers in their own locations, but would also have consequences for domestic businesses.

The transport networks play a vital role in business supply chains. In the 2003-2013 period, ports handled 99% of the imported goods and 99,7% of the exported good, indicating that the share of freight shipped by air is very low. Sea transport is very important for Cyprus and disruptions in port operations will have a major impact in supply chain

7.2.5 Fisheries

The Cyprus fishing fleet consists of a coastal, polyvalent and trawler fleet. The main target species are the benthic, benthopelagic and large pelagic fish. The main gears in use are bottom nets (trammel and gill nets), bottom long lines, trawls and surface long lines. In addition, a sport fishery exists utilising a range of gears.

Marine fishing areas in Cyprus are generally confined due to the geomorphology of Cyprus' coasts (small shelf extension). Thus, fishing effort of benthic habitats is concentrated in a relatively narrow zone along Cyprus' coasts which adds to the problem of overfishing of fish populations.

Aquaculture in Cyprus contributes significantly to the production of fishery products, reduces fishing deficit and thereby reduces the negative trade balance. Regarding marine aquaculture, nine fattening farms are operating, all using offshore cage farming techniques.

The most important cultured marine fish species are the seabream and seabass. Along with the fattening units, three private marine fish hatchery stations are operating as well as a shrimp hatchery/breeding unit. The three marine fish hatcheries are operating in an intensive basis, in coastal areas.

Bioproductivity in the eastern Mediterranean is poorer in comparison to the bioproductivity of the western Mediterranean and to the world. The lack of freshwater inputs affects marine phytoplanktonic primary productivity and thus impacts fisheries production.

A variety of problems occur in marine fisheries due to the increasing presence of non-indigenous species. One such problem is the Lessepsian pufferfish *Lagocephalus sceleratus* which is toxic and actively damages fishing gear by eating commercially important species such as cephalopods from their nets. Additionally, some species such as *Siganus spp.* although also invasive from the Red sea have become commercially important species for the Cyprus fishery.

The future vulnerability assessment of the fisheries sector in Cyprus indicated only one vulnerability to climate changes, which is related to the potential reductions in the quantity and diversity of fish stocks. The vulnerability is rated as of limited importance despite the fact

that some fish species as well as the rate of Invasive Alien Species (IAS) intrusion seem to be sensitive to changes in climate while the fisheries sector is considered to be already exposed to changes in Sea Surface Temperature (SST) and to the intrusion of IAS due to the geographical proximity of Cyprus to the channel of IAS entrance. Although several adaptation measures have been undertaken, the adaptation potential especially for pelagic fishery is limited.

The spread and establishment in the Mediterranean of non-native invasive species is well documented. Consequences of this process are complex and diverse. Negative and positive effects, for example, have been documented and seem to be related to environmental, biological and human factors. Native species are being outcompeted and replaced, and eventually would force the fishing sector to target other species.

Although invasive species is an existing important threat for the marine biodiversity of Cyprus as well as for the production of target species in marine systems the available data are scarce and do not allow a detailed assessment of this disruption.

Even though there is no consensus on the projected SST, Sea Surface Salinity (SSS) and Ocean Acidification (OA) of the Mediterranean Sea, the effects of Climate Change on the fisheries and the marine habitats in general, are real and documented. Fish assemblages on endemic species are projected to experience negative impacts on their distribution and abundance. By the end of the 21st century, almost 25% of the Mediterranean Sea continental shelf is expected to experience a total modification of endemic species assemblages.

It is possible that the projected changes, such as contraction of range and stock size, will occur faster. The reason for that is because models tend to be too conservative and most important of all, because very seldom the potential synergistic effects of Climate Change manifestations are considered.

7.3 Tourism

7.3.1 Introduction

Climate and weather are important factors in tourist destination choice, and the tourist sector is susceptible to extreme weather. The age of tourists, the climate in their home country and local economic and environmental conditions (e.g. water stress, tourist development) are also critical.

Impacts on coastal tourism can occur from direct impacts of extreme events on tourist infrastructure (e.g., beach resorts, roads), indirect impacts of extreme events (e.g., coastal erosion), and short-term adverse tourist perception after the occurrence of extreme events (e.g. heatwaves, flooding, storms, storm surges). The presence of coastal tourism infrastructure may exacerbate beach reduction and coastal ecosystems squeeze under rising sea levels. Coastal tourism is highly vulnerable to weather, climate extremes, and rising sea levels.

The above mentioned impacts focus on the direct climatic impacts of climate change to tourism (suitability of locations, seasonality in demand, operating costs/energy demand). There are also some indirect impacts:

- Indirect environmental change impacts (e.g. water availability, biodiversity loss, increased natural hazards, damage to infrastructure).
- Indirect impacts of mitigation policies on tourist mobility (e.g. national / international policies that seek to reduce greenhouse gas emissions).
- Indirect societal change impacts (e.g. reduction in the distribution of global GDP, national / international security).

7.3.2 Heat and heatwaves

In this CCRA in order to investigate what the likely impacts of climate change could be for tourism, we applied climate projections to the **Tourism Climatic Index** (TCI), developed by Mieczkowski in 1985, and in addition to consider the **Beach Climate Index** developed by Morgan et al. in 2000.

The TCI allows quantitative evaluation of a region's climate for the purpose of **general tourism activity**. The TCI is based on the notion of "human comfort" and consists of five subindices. The five sub-indices and their constituent variables are as follows:

- daytime comfort index (maximum daily temperature and minimum daily relative humidity),
- daily comfort index (mean daily temperature and mean daily relative humidity),
- precipitation,
- sunshine, and
- wind (average wind speed)

The index is weighted and computed as follows:

$$TCI = 2 \times (4 \times CID + CIA + 2 \times Sun + 2 \times Prec + Wind)$$

where CID = daytime comfort index, CIA = daily comfort index, PREC = precipitation, SUN = sunshine, and Wind = wind speed. With an optimal rating for each variable of 5, the maximum value of the index is 100. Based on a location's index value, its suitability for tourism activity is then rated on a scale from -30 to 100. Mieczkowski (1985) divided this scale into 10 categories, ranging from ideal (90 to 100), excellent (80 to 89), and very good (70 to 79) to extremely unfavourable (10 to 19) and impossible (9 to -30).

The TCI applies only to these more general forms of tourism activity and is not applicable to more climate-dependent activities such as winter sports. Furthermore, the TCI cannot be used to predict tourist arrivals. The index is designed solely to indicate levels of climatic comfort for tourism activity and does not take into consideration the existence and quality of vital tourism infrastructure such as transportation and attractions. Thus, a region with a high TCI may experience low levels of tourism arrivals, and vice versa, because a multitude of other factors besides climatic conditions influence tourism activity.

Morgan *et al.* developed the Beach Climate Index (BCI) to classify climatic conditions for beach use. BCI is based on Mieczkowski's Tourism Climate Index (TCI) that was modified according to responses of north European beach users at sites in the UK and various Mediterranean locations.

The BCI index is made up of four smaller components (sub-indices) that, after weighting, add up to a maximum score of 100 (ideal conditions). The weights are based on the importance that the beach users attached to each of the four components. Beach users expressed the importance values on a Likert scale between 1 (not important) and 9 (very important). The Likert scores for each component were added, and these aggregated scores were subsequently scaled so that they added up to 1.

The resulting equation is as follows:

$$BCI = 0,18 \times TS + 0,29 \times P + 0,26 \times W + 0,27 \times S$$

In which

- BCI is the beach climate index,
- TS is the thermal sensation,
- P is the precipitation,
- W is the wind and
- S is the sunshine.

Thermal sensation is related to skin temperature. Skin temperature in turn is a function of the effective air temperature, proportion of sunshine, and wind speed, in addition to several individual characteristics which were set to representative values for North Europeans.

BCI values below 40 are seen as unfavourable, the range between 40 and 60 as acceptable, values from 60 to 70 as good, between 70 and 80 as very good, and scores above 80 as excellent for beach tourism.

According to the analysis:

- BCI indicates that despite the projected warming, Cyprus will still have excellent weather conditions for beach tourism in summer season and data suggest that future climate change is likely to result in an improvement of those conditions in spring and autumn (out the current peak season) thus extending the tourist season.
- TCI indicates that conditions for alternative forms tourism and sightseeing activities are improved in winter and spring seasons for all scenarios. The most dramatic changes are expected in 2080s under the RCP8.5 scenario. Summer and autumn seasons will face negative impacts under all scenarios. However, those impacts are not significant since conditions will be better than good in most of the cases. The most negative impacts are expected in Nicosia area in 2080s under the RCP8.5 scenario during the summer season.

It was not possible in the current analysis to quantify changes in tourist visits. Tourist arrivals are also dependent on changes in the climate in their home country. Results from studies suggest that if better climate conditions were to be found in northern European countries as a result of climate change, it would have only a moderate effect on destination choice, with the large majority of respondents stating they would still travel to the Mediterranean for their beach holidays. Other studies conclude that climate change will not have a major impact (before 2050) on beach tourism in the Mediterranean because sunbathers like it hot.

Results from studies regarding Northern European tourists with a Mediterranean destination confirmed the importance of climate as a destination attribute. For beach tourism, the absence of rain is found to be more important than a “comfortable temperature”, while “high temperatures” are considered unfavourable by only a few respondents. This is consistent with the findings that “heat waves” are considered as “not too negative”, and that heat waves are considered the least important climate change impact.

Tourists may be particularly affected by heat waves, as they may not be used to such kind of phenomena and may not know how to protect themselves from such events. All age groups are considered sensitive to heat waves while the most sensitive age group is the elderly. However, it must be noted that the elderly people (such as pensioners) who are more sensitive to heat waves prefer to travel in Cyprus during the autumn and spring when there are no heat waves.

7.3.3 Floods and Sea Level Rise

Studies on beach tourism highlight the vulnerability of coastal tourism facilities to Sea Level Rise (SLR). Tourists are averse to artificial coastlines, so that hard protection measures against sea level rise would reduce the attractiveness of an area. A major asset of Cyprus, its beaches, are threatened by coastal erosion and future SLR. Reduced aesthetics of coasts due to erosion could have a negative impact on tourism preferences.

In this CCRA, the following scenarios of SLR were examined:

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

The vulnerability analysis of the coastline, due to SLR, was limited to the areas that Government of Cyprus exercise effective control and to the sovereign base areas of Akrotiri and Dhekelia.

Low altitude and mild morphology sandy beaches were considered as vulnerable zones. Therefore, the rocky segments of coastline, as well as ports and jetties, were excluded from the analysis while particular emphasis was given to the coastline adjacent to Bathing Water Areas. In order to calculate the area of the beach that will be affected if sea levels rise, it was considered that an average slope of 2,5% is a good approximation of the sandy beaches of Cyprus. This translates to a mean 20m retreat by 2050 and 40m retreat by 2080.

By combing the predicted sea level rise with the presumed slope, it was calculated that the length of the beach that will be affected is approximately 121km, which is about 31% of the total under study coastline.

There is a probable risk of beach area loss of approximately 2,5km² for 2050 and additional 1,6 km² for the year 2080 (resulting in a total loss of 4,1 km² by 2080s). Data suggest that by 2050s the sandy beaches will face a loss of high magnitude.

Regarding Bathing Waters Areas in Cyprus, in a total of 113 areas, it is estimated that 98% (111 areas) is affected by SLR.

Due to the narrow width of most of the sandy beaches, a significant area loss is expected. Coastal erosion is expected to exaggerate the CC impacts.

The consequence of the estimated change in beach area is to contribute to increased pressure for space in most of the beaches, when demand is already high in the summer months and potentially may increase in the future. Beaches particularly exposed to loss of area could experience reduced popularity, as overcrowding dissuades visitors and as a consequence, the local tourist economy suffers.

7.3.4 Water Supply

According to the Water Policy Report tourism accounts for 18% of total annual potable water demand. There is no reason to expect the demand per tourist to be more sensitive to temperature when compared to domestic demand. Discussions with hotel managers reveal that, in fact, tourist demand rates are constantly high and not affected appreciably by temperatures. The latter affect resort demand mainly due to increased irrigation of green spaces.

However, an important reason for an increase in annual demand, due to climate change, would be the lengthening of the peak tourist season due to a longer period per annum with appropriate temperatures for beach tourism.

It is assumed that the high tourism season will be extended by 20% by 2050 and 30% by 2080. It is, furthermore, assumed that the annual demand for tourism will increase at the same rate as the length of the high season (i.e. 20% and 30% respectively). Under these assumptions, taking into account that under present conditions tourism constitutes the 18% of total demand and adding also an increase in domestic demand of 2,5% and 3,5% for 2050 and 2080, the estimates for the order of magnitude of total increases become:

- For 2050, an increase in potable water demand due to climate change of 5,7% rounded up to 6%.
- For 2080, an increase in potable water demand due to climate change of 8,4% rounded up to 9%.

Drinking water supply (for industry and tourism) vulnerability is reduced due to the adaptive capacity of Cyprus for increasing drinking water supply mainly with the use of desalination plants. However, increased operation of the desalination plants in the future will also increase energy demand and thus the emissions of Greenhouse Gases, unless renewable sources of energy are used.

Tourism industry has also increased water demand for irrigation of green areas. The current Tourism Strategy of Cyprus promotes the development of golf tourism, which however will substantially increase the sector's water demand for the irrigation of golf courses.

7.4 Insurance and Banking

Insurance and banking may face problems related to accurate pricing of risks, shortage of capital after large loss events, and by an increasing burden of losses that can affect markets and insurability. However, risk transfer, including insurance, also holds potential for adaptation by providing incentives to reduce losses.

Banking is potentially affected through physical impacts on assets and investments, as well as through regulation and/or mitigation actions by changing demands regarding sustainability of investments and lending portfolios.

The potential climate change impacts on the financial sector (assuming no adaptation) are summarized in the following figure.

Insurance	Inaccurate pricing, and costlier repairs	Some big markets uninsurable	Limited capital for property insurance	Some insolvencies, huge annual damage
Banking	Insurance cover in place	Customer defaults due to extremes	Collateral values fall, projects fail	Major projects shelved, lending falls
Fund Management	Real estate refits rise, some corporate securities volatile	Volatile commodity markets, corporate downgrades	Real estate stressed, clients have less disposable income	Economic slowdown, some public sector defaults



2050

Figure 7.1 Potential CC impacts on the financial sector (assuming no adaptation)

In Cyprus, according to the Law on Immovable Property (Tenure, Registration and Valuation) commonly owned buildings are compulsory insured against fire, lightning, and earthquake for a sum corresponding to their full replacement value. There is also government spending in compensations of extreme events' consequences: In December 2014 the Ministry of Interior spent approximately €1 million on compensation of flood-hit homeowners in Kokkinotrimithia and Larnaca.

7.5 Adaptive Capacity

There could be significant consequences if financial institutions fail to take note of the impacts of climate change on the environmental or social performance of their investments.

In the medium to long term:

- Hotter summers are likely to increase the risks of overheating
- Hotter, drier summers are also likely to increase pressure on water resources and energy sector
- Sea-level rise is likely to adversely affect coastal areas.

Appropriate adaptive design through new building regulations could reduce the risk of the overheating of buildings (effective summer shading, appropriate use of building insulation etc). According to existing policies, by December 31, 2020 all new buildings must be Nearly Zero Energy Consumption (nZEB) and after December 31, 2018 all new buildings occupied or owned by public authorities, must be nZEB.

Tourism industry can benefit from the findings of the European initiative Nearly Zero Energy Hotels (neZEH) that aims to accelerate the rate of large scale renovations of existing hotels into Nearly Zero Energy Buildings by:

- providing technical advice to committed hoteliers
- undertaking training and capacity building activities.

neZEH is a response to the European Directive on the energy performance of buildings (2010/31/EU, EPBD recast), contributing directly to the EU 2020 and 2050 targets and supporting Member States to their national plans for increasing the number of Nearly Zero Energy Buildings.

The dynamic nature of the tourism industry and its ability to cope with a range of major shocks, including SARS, terrorism attacks, or natural disasters (e.g. the Asian tsunami), suggests a relatively high adaptive capacity within the tourism industry overall. The capacity to adapt to climate change is thought to vary substantially between sub-sectors, destinations, and individual businesses within the tourism industry.

Climate change is slowly entering into decision-making of a range of tourism stakeholders (e.g., investors, insurance companies, tourism enterprises, governments, and tourists); studies that have examined the climate change risk appraisal of local tourism officials and operators have consistently found relatively low levels of concern and little evidence of long-term strategic planning in anticipation of future changes in climate. There is also some evidence that local tourism operators may be overestimating their adaptive capacity.

Projected changes in climate will need careful consideration in both regional and local tourism development, management and planning. Climate change will not only affect tourism through changes in thermal conditions, but also through ecosystem change, impacts on infrastructure and services, effect on access and transport prices, and even changes in economic growth and

prosperity. This leads to challenges relating to the carrying capacity of the destination, which can be grouped into four categories:

- Physical capacity: the point at which site facilities or access routes become congested.
- Ecological capacity: the level at which unacceptable change starts to occur in floristic composition, soil structure and wildlife populations.
- Perceptual or social capacity: the point at which the recreational experience starts to deteriorate.
- Economic capacity: the threshold beyond which the investment needed to sustain environmental quality becomes prohibitive.

Finally, regarding tourism and as other studies suggest, the Mediterranean is likely to remain Europe's prime region for summer-time beach tourism for at least the next 50 years. Coastal managers in Mediterranean destinations are advised to focus some of their attention on other climate change impacts such as sea-level rise or water availability, and include environmental quality and diversification of activities in their strategies.

7.6 Summary of risk metrics

Risk metrics related to Business, Industry and Services Sector as a result of climate change are presented below.

Table 7.2 Scorecard for Business, Industry and Services Sector

Metric Code	Metric Name	Confidence	2050s		2080s	
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
BU1	Extension of summer season	M	1	2	3	3
BE3	Energy demand for Heating	M	2	2	2	3
BU4	Tourism product diversification	M	3	3	3	2
AG1e	Crop yield using grapevine as a reference C3 fruiting berry	L	2	2	1	2
AG1a	Crop yield using wheat as a reference C3 rain fed arable crop	M	1	1	1	2
AG1d	Crop yield using olive as a reference C3 tree	L	1	1	1	1
EN3	Flooding of Power Stations	L	*	*	*	1
MA2	Down-time of Shipping Operations and sea sports	L	1	1	1	1
AG1b	Crop yield using potato (November sowing) as a reference irrigated vegetable crop for Spring-Summer production	M	2	1	1	2
AG1c	Crop yield using potato (July sowing) as a reference irrigated vegetable crop for Autumn production	M	2	2	2	2
FL2	Number of properties at significant likelihood of flooding	M	2	2	2	2
BE5	Overheating of Buildings	H	1	2	1	3
AG2	Livestock production	L	1	2	2	3
W3	Irrigation Supply Deficit	L	1	2	2	3
BE1	Energy demand for cooling	M	2	2	2	3
W2	Higher cost of water supply due to increased desalination	L	2	2	3	3
BU2	Loss of staff hours due to high internal building temperatures	M	*	*	*	3
BU3	Tourist assets at risk from flooding due to SLR	L	*	3	*	3
MA5	Potential disruption coastal nurseries	M	2	2	3	3
F03	Increased risk of drought damage / loss of productivity	M	2	3	3	3
MA4	Shifts affecting producers and consumers	M	2	3	3	3
MA3	Potential disruption of fish production	M	3	3	3	3
MA6	Changes in fish catches and gene pool	M	3	3	3	3
MA7	Exerting pressure on fish physiological thermal limits	M	3	3	3	3
BU5	Decrease in Tourism arrivals	L	?	?	?	?
BU6	Reduced returns for financial institutions	L	?	?	?	?
EN5, 6	Transmission Capacity	L	?	?	?	?
EN7	Heat Related Damage/Disruption	L	?	?	?	?
TR1	Cost of carriageway repairs	H	?	?	?	?
TR2	Disruption and delay due to flooding of the road network	L	?	?	?	?
TR3	Subsidence & landslides	L	?	?	?	?

3	Positive - High consequences
2	Positive - Medium consequences
1	Positive - Low consequences
1	Negative -Low consequences
2	Negative - Medium consequences

H	High
M	Medium
L	Low

3	Negative - High consequences	
?	Magnitude not assessed (no data)	*Risk is not significant

8. Global security

This chapter presents risks associated with food security, conflict, or migration that could affect Cyprus.

8.1 Food Security

Food security is defined as the state in which people at all times have physical, social and economic access to sufficient and nutritious food that meets their dietary needs for a healthy and active life. Food security is a complex sustainable development issue, linked to health through malnutrition, but also to sustainable economic development, environment, and trade [63, 64].

Food security has four major components and each of them is sensitive to climate change. For food security to be achieved, all four components must be attained and maintained, simultaneously [65]:

- **Availability.** The existence of food in a particular place at a particular time.
- **Access.** The ability of a person or group to obtain food.
- **Utilization.** The ability to use and obtain nourishment from food. This includes a food's nutritional value and how the body assimilates its nutrients.
- **Stability.** The absence of significant fluctuation in availability, access, and utilization.

The first component of food security, **availability**, addresses the question of whether food exists locally. Where food is, or is not, is in part a function of production types, rates, and locations. Food production occurs through the cultivation of crops and livestock, fishing, and hunting outside of cultivated systems. Production forms the foundation of food availability, providing calories and nutrients for human consumption. The processing, packaging, and storage of food also contribute to food availability, as do trade and the transportation systems that enable it. Climate change influences food availability and **stability** through each food-system activity. Climate can also interact with external stressors (e.g., conflict) and with the natural-resource base (e.g., soils) to alter the stability of food supplies. Increased risk can also result from agricultural expansion into less optimal lands in response to climate trends. The literature suggests that world food production needs to increase by 60%–100% to feed a larger, wealthier, and more urban global population. Relationships between climate and agriculture are well documented. Agricultural production is governed in large part by climate conditions and is a central consideration for food availability. Internationally, agriculture is widely regarded as one of the sectors at most risk from a changing climate. In the future, producing food sustainably in a changing and uncertain climate will become a higher priority given the rising pressures on land and natural resources due to a growing population. However, climate change is just one of a number of stresses on agriculture and responses to these threats need to be sensitive to ecosystems and the diversity of benefits that agriculture provides, and not just to food production.

The second component of food security, **access**, addresses whether an individual or community has the resources necessary to acquire food. Access involves prices (trading); proximity to food (availability); retail outlets (wholesaling/retailing) or farmable lands (producing); and the social and cultural norms that shape food distribution and preferences. There is high uncertainty about future changes in real food prices, even in the absence of climate change. Socioeconomic models that include climate change generally show an increase in food prices, implying that climate change is likely to diminish other gains in food accessibility that might be achieved under any socioeconomic development scenario. Climate and weather have demonstrable effects on food prices, transportation infrastructure, and the costs and operations of food distributors, affecting food access and stability. Food access is strongly influenced by additional factors outside of the food system, such as household income. The adaptive capacity of food access to changes in climate is potentially very high but varies enormously between high-income and low income countries and individuals, between urban and rural populations, and the ways in which each of these develops in the future.

Food **utilization** is the ability of individuals to make use of the food otherwise available and accessible to them. Nutritional outcomes are frequently measured in terms of malnutrition, which manifests as undernutrition or overnutrition. Climate has a number of potential and observed effects on food utilization, which include contamination of the food supply, the nutritional composition of food, and a body's ability to assimilate available nutrients. Climate change affects food safety by influencing vectors of food contamination and levels of toxins in food. Elevated atmospheric carbon dioxide leads to lower protein content in important global food staples.

Many factors aside from climate change influence future food systems and food security. The most relevant include technological and structural changes in food production, processing, distribution, and markets; increasing population, demographic changes, and urbanization; changes in wealth; changes in eating habits and food preferences; disasters and disaster response; and changes in energy availability and use. Some of these amplify the effects of climate change and increase the risks to food security (e.g., population growth), while others appear likely to diminish risk and to help offset damaging climate-change impacts (e.g., increasing levels of wealth). Food security, food systems, and climate change are each multifaceted topics. Their interactions are likewise complex and are affected by a wide range of environmental and socioeconomic factors. It is nevertheless clear that there are multiple connections between changing climate conditions and food systems and that climate change affects food systems in ways that alter food-security outcomes [65].

Some key findings on a recent study on Global Food Security include [65]:

- Climate change is very likely to affect global, regional, and local food security by disrupting food availability, decreasing access to food, and making utilization more difficult. Climate change is projected to result in more frequent disruption of food production in many regions and in increased overall food prices. Climate risks to food security are greatest for poor populations and in tropical regions. Wealthy populations and temperate regions that are not close to limiting thresholds for food availability,

access, utilization, or stability are less at risk. Some high-latitude regions may actually experience near-term productivity increases due to high adaptive capacity, CO₂ fertilization, higher temperatures, and precipitation increases. However, damaging outcomes become increasingly likely in all cases from 2050–2100 under higher emissions scenarios.

- Climate change risks extend beyond agricultural production to other elements of global food systems that are critical for food security, including the processing, storage, transportation, and consumption of food.
- Climate risks to food security increase as the magnitude and rate of climate change increase. Higher emissions and concentrations of greenhouse gases are much more likely to have damaging effects than lower emissions and concentrations.
- Effective adaptation can reduce food-system vulnerability to climate change and reduce detrimental climate-change effects on food security, but socioeconomic conditions can impede the adoption of technically feasible adaptation options.
- The complexity of the food system within the context of climate change allows for the identification of multiple food-security intervention points, which are relevant to decision makers at every level.
- Accurately projecting climate-change risks to food security requires consideration of other largescale changes. Ecosystem and land degradation, technological development, population growth, and economic growth affect climate risks and food security outcomes. Population growth, which is projected to add another 2 billion people to Earth's population by 2050, increases the magnitude of the risk, particularly when coupled with economic growth that leads to changes in the types of foods demanded by consumers. Sustained economic growth can help to reduce vulnerability if it reduces the number of poor people and if income growth exceeds increases in food costs in vulnerable populations. Analyses based on scenarios of sustained economic growth and moderate population growth without climate change suggest that the number of food-insecure people could be reduced by 50% or more by 2040, with further reductions over the rest of the century. Such analyses should not be misinterpreted as projections, since climate change is already occurring, but they clearly indicate that socioeconomic factors have large effects on food insecurity.

Food prices and food-price shocks have significant impacts on human security. They do so through reduced access to, and production of, food that affects both consumers and food producers [17].

It is well established that food security is determined by a range of interacting factors including poverty, water availability, food policy agreements and regulations, and the demand for productive land for alternative uses. It is also established that many of these factors are themselves sensitive to climate variability and climate change. Specific observed food prices have, however, multiple causes and complex dynamics between markets, non-food demand for agricultural land, and the impact of adverse weather and droughts on the major agricultural producing regions. Spikes in food prices have particularly acute impacts on food insecurity at the domestic level, even in the absence of climate stresses. There was, for example, high regional variation in self-reported food insecurity following the global 2008

price spike: the reported food insecurity was especially serious across Africa and Latin American countries. The 2010–2011 food price spike has been estimated to have pushed 44 million people below the basic needs poverty line across 28 countries [17].

Food availability can also be affected by domestic production of food, particularly for those countries where there are restrictions on food imports. There are, therefore, multiple pathways by which consumers including agricultural wage labourers in low-income countries are affected. Declines in agricultural productivity linked to climate variability and losses in maize production, for example, have been shown in Zambia to reduce real urban incomes and to influence urban poverty for a portion of the population. Food prices and food availability also affect socio-political stability and in the case of the 2008 - 2009 and 2010 - 2011 food price spikes have been associated with food riots. High food prices affect food access and food availability, but such insecurity is highly conditional on the responses of markets and governments and hence is variable. 14 countries in Africa experienced food riots in 2008 and that they are characterized by higher levels of poverty, restricted food access and availability, are more urbanized, and have more oppressive regimes and stronger civil societies than those countries that did not experience riots. The linkages between food riots and climate change are therefore dependent on responses of multiple private and state actors and it is generally concluded that it is difficult to attribute causality. Food prices, food access, and food availability are critical elements of human security. There is robust evidence that food security affects basic-needs elements of human security and, in some circumstances, is associated with political stability and climate stresses. But there are complex pathways between climate, food production, and human security and hence this area requires further concentrated research as an area of concern [17].

Cyprus is relying on imports to covers its needs for cereals since the self-sufficiency rate for cereals is estimated at 10%. Subsidies for wheat production are quite high. In this context, the possible future abolition of the aid is expected to affect negative the viability of the industry. Large quantities of cereals are imported to meet the needs of consumers and livestock. The degree of self-sufficiency in potatoes, citrus and table grapes exceeds 100%, since these products are the main export products. Cyprus has a high self-sufficient rate in pork (93%), eggs (90%) and poultry meat (80%).

Given the high dependence of Cyprus on imports of agricultural products and the projected irrigation deficit that will possibly reduce the domestic crop yields and thus domestic food production, it can be assumed that global CC will have an impact on price volatility of food and agricultural market.

The socioeconomical impacts of agricultural price volatility matter on global level include the following aspects [66]:

- The assumption is that countries likely to be most concerned by macro-economic impacts of agricultural price volatility are developing or emerging economies. Importing countries faced with exceptionally high prices may also experience deterioration in the balance of payments and deterioration in their public finances. Food price increases can

have major repercussions on the whole economy. For low-income food-importing countries, high food prices can result in inflation and high import bills which in turn worsen the current account balance. Fiscal measures, such as cuts in import tariffs and in taxes on food, subsidization of food consumption, and increased demands on risk management instruments entail increased budgetary costs that will have to be met by increased government borrowing and budgetary discipline.

- Looked at from the demand side, significantly higher food prices are disastrous for the poor especially in developing countries where up to three-quarters of their total income may be spent on basic foodstuffs. Food price inflation can also be a serious issue in middle income countries, where many consumers expend as much as half of their budget on basic foods. Even in the developed countries significantly higher food prices can create hardship for the least well-off, who tend also to devote a larger share of household spending to food. Nevertheless, consumers in developed countries face wider choices in terms of their ability to adjust spending on different types of foods and most developed countries have safety net mechanisms that are well suited to delivering targeted assistance to the most affected.
- Profitability of livestock enterprises will be affected especially if these costs cannot be fully passed on to consumers. Volatile feed prices are also problematical for livestock producers; such uncertainty is detrimental to investment and production decisions, particularly where the physical production cycle is long. Poor smallholders who do not have access to credit may have difficulty financing the crucial inputs needed and stay in business.

European Union has the responsibility in ensuring food security in Europe and seeks to build resilience to food crises. To this end, in 2010 adopted a policy framework to assist developing countries in addressing food security challenges. Moreover, food security is also addressed in the reformed CAP. However, there is a debate on the challenges of food security in European level [67, 68, 69, 70].

8.2 Human migration

Human migration involves movement over a significant distance and duration. Human migration has social, political, demographic, economic, and environmental drivers, which may operate independently or in combination. Many of these drivers are climate sensitive [17, 18, 71].

People migrate either temporarily or permanently, within their country or across borders. Migration can be defined in terms of temporal and spatial characteristics: it is a permanent or semi-permanent move by a person of at least one year that involves crossing an administrative, but not necessarily a national, border. Permanent migration, as well as temporary and seasonal migration, are prevalent in every part of the world, and are driven by economic and other imperatives. The most significant contemporary overall trend in migration continues to be major movements of people from rural to urban settlements. The proportion of the global population that is urban has risen from 10% in 1900 to more than 50% in 2009 and is projected to reach 59% by 2030. Around 80% of all migration is presently within countries. Existing global migration trends mapped onto ecological zones show that the past 4 decades have seen out-migration from mountain regions and from drylands. Net migration to coastal zones is estimated as having been more than 70 million people in the 1990–2000 census period [17, 18].

It is now increasingly recognized that environmental degradation and climate change are major drivers in both forced and voluntary migration, and that this trend is set to continue and substantially increase in scale in decades to come. The main possible pathways through which climate change could affect migration are [17, 18, 71]:

- Intensification of natural disasters that will affect ever more people and generate mass displacement.
- Increased warming and drought in some regions will reduce agricultural potential and undermine “ecosystem services” such as clean water and fertile soil.
- Sea level rise, which makes coastal areas and some island states increasingly uninhabitable resulting in relocation of their population
- Competition over natural resources, which leads to conflict and displacement of inhabitants.

Abundant historical evidence exists to suggest that changes in climatic conditions have been a contributory factor in migration, including large population displacements in the wake of severe events such as Hurricane Katrina in New Orleans, Louisiana, USA, in 2005, Hurricane Mitch in Central America in 1998, and the northern Ethiopian famines of the 1980s. However, the evidence is not clear cut, with counterexamples also available of migration being limited due to economic hardship (e.g., during the Sahel drought of the mid- 1980s in Mali).

The spatial dimension of climate-related migration is most commonly **internal** to nations (e.g., from affected regions to safer zones). In this context it is also worth pointing out that internal migration for other (predominantly economic) reasons may actually expose populations to

increased climate risk. For instance, there are large cities in developing countries in low-elevation coastal zones that are vulnerable to sea level rise. Increased migration to these cities could exacerbate the problems, with the migrants themselves being especially vulnerable.

Migration can also be **international**, though this is less common in response to extreme weather events, and where it does happen it usually occurs along well established routes. For example, emigration following Hurricane Mitch tripled from Honduras and increased from Nicaragua by 40%, mainly to the southern states of the USA (already a traditional destination for migrants), and was aided by a relaxation of temporary residency requirements by the USA. The causal chains and links between climate change and migration are complex and can be difficult to demonstrate, though useful insights can be gained from studying past abandonment of settlements. Thus, projecting future climate-related migration remains a challenging research topic.

Human migration is one of many possible adaptive strategies or responses to climate change. Displacement refers to situations where choices are limited and movement is more or less compelled by land loss due to sea level rise, flooding or extreme drought. A number of studies have linked past climate variability to both local and long-distance migration. In addition to yielding positive and negative outcomes for the migrants, migration indirectly transmits consequences of climate variability and change at one location to people and states in the regions receiving migrants, sometimes at long distances.

Climate variability has been associated with rural urban migration. **Urbanization** is a pervasive aspect of migration which brings benefits but, in the climate change context, also significant risks. It is difficult to establish a causal relationship between environmental degradation and migration. Many authors argue that migration will increase during times of environmental stress and will lead to an increase in abandonment of settlements. Given the multiple drivers of migration and the complex interactions that mediate migratory decision making by individual or households, the projection of the effects of climate change on intra-rural and rural to- urban migration remains a major challenge.

Environmental migration refers to human migration where environmental risks or environmental change plays a significant role in influencing the migration decision and destination. Migration may involve distinct categories such as direct, involuntary, and temporary displacement due to weather-related disasters; voluntary relocation as settlements and economies become less viable; or planned resettlement encouraged by government actions or incentives. All migration decisions are multi-causal, and hence it is not meaningful to describe any migrant flow as being solely for environmental reasons. Migration should not always be regarded as a problem; in those circumstances where it contributes to adaptation (e.g., through remittances) it can be part of the solution[17, 18, 71].

Data on past population relocations as a response to natural disasters in Cyprus are limited. It is known that two villages of Paphos District (Agios Photios and Statos) were relocated after heavy precipitation events that took place in the 1966-1969 period and the subsequent damaging landslides.

The most tremendous population relocation that took place in the island was the result of the Turkish invasion. In 1974, Turkey invaded Cyprus, claiming a right of intervention under the Treaty of Guarantee and de facto dividing Cyprus into Greek Cypriot and Turkish Cypriot sections. As a result, approximately 160.000 -200.000 Greek Cypriots fled their cities and villages, while around 40,000 Turkish Cypriots living in the South were coerced into or chose to abandon their houses and move to the North [72, 73].

Displacement figures in the island are one of the highest in the world taking into consideration, that the population in 2006 included approximately 660.600 Greek Cypriots and 265.100 Turkish Cypriots, including settlers with permanent residency. Unavoidably, since 1974 Turkish and Greek Cypriots developed uneven responses to their refugee experience; generally speaking, Turkish Cypriots aimed to consolidate their presence in the North, expressing no desire to return to the South, while Greek Cypriots retained a strong desire to maintain rights of return to their ancestral villages and towns in the North. Successive Turkish governments actively encouraged tens of thousands of mainland Turkish citizens to settle in Cyprus. Exact numbers remain are unknown [72].

The urbanization process in Cyprus has coincided with the transition from a dominantly rural-based economy to a commercial and industrial economy that favoured the growth of towns. Since World War II, urban centres in the island had been growing at a fast rate. Whereas in 1946 only 26% of the total population lived in towns, by 1973 this had risen to 42%. It is also important to highlight that most problems faced by the four major urban centres, have been the result of the influx of the refugees who have been evicted from their homes in the northern part of the island by the Turkish army in 1974 [73, 74].

The flight from agriculture, which became noticeable in the decade and a half after World War II reached a peak in 1974, when the best and most productive agricultural land fell under Turkish occupation. In 1960, some 40,3 % of the economically active population were agricultural workers; in 1973, the figure were down to 33,6 % employed in this sector [75].

Urbanization took place under conditions that generally spared the island the problems often connected with migration of large numbers of unemployed farm workers to urban centers. For one thing, urbanization occurred in a period of prosperity and increasing economic activity, and employment was available. In addition, farm workers generally left their villages only when they had found work in urban areas [75].

Net migration (the balance between in-migration and out-migration) in Cyprus has been positive from 1983 to 2011. As from 2012, net migration has been negative, starting from - 629 in 2012 and reaching -15.000 in 2014. Long-term immigrants⁴ (Cypriots and foreigners arriving for settlement or for temporary employment for 1 year or more) were 9.154 in 2014,

⁴ Immigrants are persons who enter Cyprus with the intention to settle in Cyprus or to stay for one year or more.

compared to 13.149 in 2013. The number of emigrants⁵ (Cypriots and foreigners who had resided in Cyprus for at least one year) was estimated at 24.154 in 2014 compared to 25.227 in 2013 [76].

In 2014 Cyprus had the highest rates of emigration (28 emigrants per 1 000 persons) in EU countries followed by Luxembourg (20 emigrants per 1 000 persons) and Ireland (18 immigrants per 1 000 persons). Regarding the gender distribution of immigrants to the EU Member States in 2014, there were slightly more men than women (53 % compared with 47 %). Cyprus had the highest share of female immigrants (70 %). Also, in Cyprus the number of persons born in other EU Member States was higher than the number born outside of the EU-28 [77].

In relative terms, the EU Member State with the highest share of non-nationals was Luxembourg, as non-nationals accounted for 46 % of its total population. A high proportion of non-nationals (10 % or more of the resident population) was also observed in Cyprus, Latvia, Estonia, Austria, Ireland and Belgium [77].

In most EU Member States, the majority of non-nationals were citizens of non-member countries; the opposite was true only for Luxembourg, Slovakia, Cyprus, Ireland, Belgium, the Netherlands, Hungary, the United Kingdom, Malta and Austria. More specifically, in Cyprus, nationals comprised 80,5% of the total resident population and foreign citizens 19,5%. Citizens of another EU Member State were 12,9% of the total resident population while non-EU citizens were about 6,6% of the total resident population [77, 78]

According to the 2011 Census, the Cypriots comprised approximately 79,4% of the census population (90,6% in 2001), non Cypriots the 20,3% (9,4% in 2001) while the 0,3% didn't state its citizenship. From the 170.383 non Cypriots, 17% originated from Greece, 14% from United Kingdom, 14% from Romania, 11% from Bulgaria, 6% from Philippines, 5% from Russia, 4% from Sri Lanka, 4% from Vietnam, 2% from Syria, 2% from India, 2% from Poland, 2% from Ukraine and the rest 18% from other countries [79].

In January 2016, there were approximately 59.000 valid residence permits. Most the permits (32%) are for domestic employment, 13% are for general employment, 12% are immigration permits and 11% are residence permits for international protection. The main countries of origin for entry permits are Bangladesh, India and Nepal, while the main countries of origin for residency permits are Philippines, Russia and Sri Lanka [80].

Gregoriou *et al.* (2010) analysed the factors, economic and non-economic, that drive international migration flows towards Cyprus from of 52 "sending" countries, covering the period 1998-2006. According to their analysis [81]:

⁵ Emigrants are persons who have left Cyprus with the intention to settle abroad or to stay for one year or more. This category includes persons who depart from Cyprus after staying more than one year in the country on the expiry of their contract of employment or students after completion of their studies.

- Not only economic, but other factors as well, may influence a person's decision to migrate.
- Income levels and income gaps appeared to be a significant driving force of migration towards Cyprus. Income gaps, unemployment conditions are the most important factors and certainly influence migration trends. The analysis showed that the relative income gap is an important element of the decision to migrate. Hence, Cyprus, had being a relatively prosperous EU member state, was an attracting pole for foreign migration.
- Labour market conditions, or relative conditions, were not found to be very significant.
- In addition, non-economic factors such as a common spoken language between "sending" countries and Cyprus, the distance between them and "network effects" generated from the stock of migrants in Cyprus, are among the major factors influencing a person's decision to migrate.
- A link between migration and political factors, or between migration and climatic conditions was not found

While the literature projecting climate-driven migration has grown recently, there is as of yet insufficient literature to permit assessment of projected country-specific consequences of such migration. Nevertheless, the potential for negative outcomes from migration in such complex, interactive situations is an emergent risk of climate change, with the potential to become a key risk at global scale.

In case that environmental immigrants, due to CC, arrive in the Country they will be with limited financial resources. Socio-economic deprivation in general tends to be associated with a lower health status which includes standard of living, lifestyle and occupational risk factors and barriers in access to health services (which can be language, educational or financial barriers). These new immigrants may therefore present a range of challenges for health services, although many of these challenges will probably be similar to those of existing immigrant communities [2].

Immigration could affect the disease burden since many of the particularly vulnerable areas of the world also have a higher rate of endemic disease and immigrants from those areas may enter the country with pre-existing disease or higher risk factors for developing the condition after they have settled in. However, some of these differences in risk factors are associated with lifestyle choices and public health conditions in the originating country, and may disappear after the first generation [2].

On the other hand, an influx of immigrants could also have some benefits for Cyprus. For example, as population growth trends are higher in the developing world, immigration could contribute young people to what is expected to be an ageing population. According to the EUROPOP 2013 *No migration variant Scenario* (obtained by considering the component of international net migration equals zero), the population of Cyprus is predicted to decline by -22% during the period 2015 to 2080. Immigrants may also add to the workforce.

8.3 Conflict

8.3.1 Climate Change and armed Conflict

In the past decade there has been a marked increase in research investigating the relationship between climate change and violent and armed conflict (conflicts that involve more than 25 battle-related deaths in a year). This can include interstate conflicts, intrastate conflicts that involve governments, non-state conflicts in which governments are not directly involved, and one-sided conflicts involving organized violence against civilians.⁶

There is a specific research field that explores the relationship between large-scale disruptions in climate and the collapse of past empires. These studies all show that climate change can exacerbate major political changes given certain social conditions, including a predominance of subsistence producers, conflict over territory, and autocratic systems of government with limited power in peripheral regions. The precise causal pathways that link these changes in climate to changes in civilizations are not well understood due to data limitations. Therefore, it should be noted that these findings from historical antecedents are not directly transferable to the contemporary globalized world.

The literature urges caution in concluding that mean future changes in climate will lead to large-scale political collapse. Most of the research on the connections between climate change and armed conflict focuses on the connections between climate variability and intrastate conflicts in the modern era. For the most part, this research examines rainfall or temperature variability as proxies for the kinds of longer-term changes that might occur due to climate change. Several studies examine the relationship between short-term warming and armed conflict. Some of these find a weak relationship, some find no relationship, and collectively the research does not conclude that there is a strong positive relationship between warming and armed conflict. The large majority of studies focuses on Africa and use satellite enhanced rainfall data collected since 1980.

A global study by Hsiang *et al.* (2011) considers changes in climate over multiple years, and finds that since 1950 and in countries that are affected by El Niño -Southern Oscillation (ENSO) the risk of war within countries rises during an ENSO period [82]. This study is supported by some studies that find associations between deviations in rainfall and civil war, but contradicted by others that find no significant association between droughts and floods and civil war. There is high agreement that in the specific circumstances where other risk factors are extremely low (such as where per capita incomes are high and states are effective and consistent), the impact of changes in climate on armed conflict is negligible .

A growing body of research examines the connections between climate variability and non-state conflicts. There is some agreement that either increased rainfall or decreased rainfall in

⁶ Section 8.3 mostly summarizes the findings of the 5th Assessment Report of the IPCC

resource-dependent economies enhances the risk of localized violent conflict, particularly in pastoral societies in Africa. In all such cases, the presence of institutions that are able to peacefully manage conflict are highlighted as the critical factor in mediating such risks.

In response to the challenges of finding direct associations between changes in climate and violence, some research has examined the effects of changes in climate on factors that are known to increase the risk of civil war. Civil war has been studied extensively using quantitative and qualitative techniques, and there is high agreement about factors that increase the risk of civil war, namely a recent history of civil violence, low levels of per capita income, low rates of economic growth, economic shocks, inconsistent political institutions, and the existence of conflict in neighbouring countries. Nevertheless, almost all studies note the need for convincing theories that explain these associations. Many of the factors that increase the risk of civil war and other armed conflicts are sensitive to climate change. For example, climate change will slow rates of economic growth and impede efforts to grow per capita incomes in some low-income countries, particularly in Africa where the risk of conflict is highest.

Extreme events, which may become more intense due to climate change, can also produce economic shocks, although the direct association between disasters and armed conflict is contested.

Studies have inferred that climate change can undermine the consistency of institutions that provide public goods and hence weaken states and increase conflict risks. **However, there is some evidence that, under certain circumstances, disasters can provide critical opportunities to build peace in conflict settings and to improve governance institutions.**

In summary, there is justifiable common concern that climate change or changes in climate variability increase the risk of armed conflict in certain circumstances, even if the strength of the effect is uncertain. This concern is justified given robust knowledge of the factors that increase the risk of civil wars, and medium evidence that some of these factors are sensitive to climate change. There is also general agreement in the literature that there is a need for theories and data that explain the processes that lead from changes in climate to violence - for example, on how formal and informal institutions help avoid violent outcomes. Confident statements about the effects of future changes in climate on armed conflict are not possible given the absence of generally supported theories and evidence about causality.

8.3.2 Geopolitical Rivalry

Analysis of the actions of states and security institutions show that many states view current and anticipated climate changes as contributing to geopolitical concerns. The ability of states to share resources and provide human security is challenged by climate change impacts. Climate change impacts can create contested claims to territory on land and at sea and, in extreme cases, can threaten the territorial integrity or viability of states (small islands).

The impacts of climate-induced water variability on transboundary water basins constitute a cluster of geopolitical concerns. The high levels of international interdependence on

transboundary rivers such as the Nile, Limpopo, Amu Darya, Syr Darya, Mekong, Ganges, Brahmaputra, Tigris, Euphrates, and Indus connect the conditions of the rivers with national development trajectories. Climate change is expected to disrupt the dynamics of runoff.

Such projections have led to concerns over transboundary tensions, particularly where challenges stemming from rising consumption and growing populations are already present. Research on transboundary conflict and cooperation prioritizes rate of change rather than absolute scarcity in connection with the risk of conflict over water, particularly between states. This focus stems from higher perceived risk of conflict when institutions at local, state, and regional levels have less time to adapt to scarcity or variability by dealing with disputes through diplomatic and other nonviolent mechanisms.

Transboundary basin institutions and international legal mechanisms have demonstrated an ability to manage conflict effectively. Other research emphasizes that these transboundary water institutions receive limited financial and political investment, involve unequal or inequitable cooperation between powerful and less powerful countries, and are present in only a limited number of transboundary basins.

8.3.3 Risk evaluation of global conflict and insecurity

Violent conflict between individuals or groups arises for a variety of reasons. Factors such as poverty and economic shocks that are associated with a higher risk of violent conflict are themselves sensitive to climate change and variability (*High Confidence*).

The only meta-analysis of the literature [83], examining 60 quantitative empirical studies, implicates climatic events as a contributing factor to the onset or intensification of several types of personal violence, group conflict, and social instability in contexts around the world, at temporal scales ranging from a climatologically anomalous hour to an anomalous millennium and at spatial scales ranging from the individual level to the communal level, to the national level and to the global level. Nevertheless, some individual studies have been unable to obtain evidence that violence has a statistically significant association with climate. In detection and attribution of their impact on human conflict, there is *low confidence* that climate change has an effect and *medium confidence* that climate variability has an effect.

Evidence suggests that climatic events over a large range of time and spatial scales contribute to the likelihood of violence through multiple pathways. Results from modern contexts (1950–2010) indicate that the frequency of violence between individuals rises 2,3% and the frequency of intergroup conflict rises 13,2% for each standard deviation change toward warmer temperatures. Because annual temperatures around the world are expected to rise 2 to 4 standard deviations (as measured over 1950–2008) above temperatures in 2000 by 2050, there is potential if other things held constant for large relative changes to global patterns of personal violence, group conflict, and social instability in the future.

These changes may cause future populations to respond to their climate differently than modern populations; however, the influence of climate variability on rates of conflict is sufficiently large in magnitude that such advances may need to be dramatic to offset the

potential influence of future climate changes. The effect of climate change on conflict and insecurity has the potential to become a key risk because factors such as poverty and economic shocks that are associated with a higher risk of violent conflict are themselves sensitive to climate change and in numerous statistical studies the influence of climate variability on human conflict is large in magnitude (medium confidence).

8.3.4 The Cypriot problem

As already mentioned, in 1974 Turkey invaded Cyprus, occupying nearly the 40% of the country's territory. As a result, 70% of the productive resources became inaccessible, economic activity decreased by 33% while 40% of the Greek Cypriot population was forcibly expelled to the southern part of the island.

The Turkish invasion and occupation reduced also water resources. CY-20 Groundwater Body is located in occupied area, while parts of the CY-1 and CY-17 Groundwater Bodies are also located in occupied areas.

The forced displacement of population that followed the occupation led to increased water demand in the center and south of the island and resulted in soil salinization in areas of overexploited aquifers.

Although intensive efforts and government actions were concentrated on land improvement, on the improvement of irrigation methods and on the increase of available water resources for irrigation so as to come within reach of the pre- 1974 levels of production, there are still many problems.

CC impacts on water availability may exaggerate geopolitical pressures between the two Cypriot communities. On the other hand water scarcity also constitutes an opportunity between them to cooperate and thus to contribute towards a mutually secure and prosperous future [84].

9. Cross-cutting issues

This chapter brings together topics from across Themes and Sectors. This includes interdependencies, social vulnerability, and **a focused look on the level of resilience to a small number of plausible extreme events** with multiple knock-on impacts such as a major drought, earthquake/tsunami, flood, heatwave or cold snap.

9.1 Interdependencies

Some of the interdependencies identified in this CCRA include:

Irrigation water deficit may have an impact on crop yield and food industry. Agriculture and other associated businesses along with supply chains may be affected (adverse / beneficial) by changes in plant growth, in crop yield. Frequent flooding of cropped areas can pose a threat on crop production and may also change land suitability for different agricultural purposes

Groundwater quality may be deteriorated through over-pumping. Diffuse pollution can be affected through changes in the intensity of rainfall, drought events and temperature changes.

There is an important interaction between biodiversity and agriculture, since intensive agricultural production systems can lead to biodiversity loss unless appropriate management measures are implemented. Land use changes and soil sealing are among the major threats to biodiversity and are also related with urbanisation, touristic development and infrastructures. Soil erosion and land desertification have an impact on the land suitability for supporting specific types of land use (e.g. olive and cereal cultivation).

Tourism may be affected by changes in biodiversity and the attractiveness of natural areas.

Important interactions between water resources and biodiversity with regard to both the quantity and quality of water availability can be found, particularly as far as it concerns aquatic and wetlands habitats. Impacts on water quality and quantity is also depended on changes in land use and a possible interaction with Agriculture and Touristic Sector can also be found.

The presence of “greenspace” or “green infrastructure” in urban areas can have important benefits for biodiversity.

Wildfires extend across sectors and may also Biodiversity, Agriculture, Forestry and Built Environment.

Invasive non-natives, pests and diseases. Increased risk from pests and diseases have important impacts also for Agriculture, Forestry and Marine and Fisheries.

Buildings, energy, transport, water and ICT are highly interdependent and these interdependencies may increase in the future, due to socio-economic changes. Transport networks play a vital role in supply chains, including getting the workforce to and from the workplace, the supply of materials and goods, as well as supporting social and leisure

activities. They also play a vital role in evacuation and rescue activities associated with extreme events. ICT (both the devices and infrastructure) is also dependent on energy supplies and any disruption in energy supply would have direct consequences for ICT systems. These interdependencies mean that the vulnerability of one sector can influence the vulnerability of the other sectors and failure of one element can lead to other 'cascade failures':

- Most modern buildings are reliant on the provision of energy and water
- Power stations are reliant on the transport infrastructure to deliver fuel
- Energy is required to run water treatment plants, pumping stations, wastewater treatment works, etc.
- Transport is not only reliant on fuel, but also electricity to fuel pumps and to power airports, ports etc.
- Transport, water and energy sectors are reliant on ICT for their monitoring and control systems
- ICT is reliant on energy to power devices and enabling infrastructure
- Access to properties for rescue and limiting damage during or following extreme events (such as flooding) is reliant on the transport network
- Emergency services are reliant on the transport network and dependent on such things as adequate water pressure for putting out fires
- Buildings (or more literally their occupants) not only place demands on infrastructure (most significantly energy and water), but by improving their resilience to future changes in climate (such as providing adequate insulation and shading, recycling water, etc.) they can also impact positively on the infrastructure upon which they depend.
- The UHI increases the risk of building overheating. However, green infrastructure can help cool urban areas. Thus, the UHI effect is closely linked to both building overheating and to the availability and effectiveness of urban green space. The UHI effect, overheating of buildings and the effectiveness of green space all relate to thermal comfort (both indoor and outdoor) and, therefore, to heat-related health problems.
- The summer heat issues also have interdependencies with the business and tourism sectors.
- Productivity is affected by overheating in buildings.
- The Water Industry is an electricity consumer and has limited capacity to continue operations if the supply is interrupted. Therefore, any disruption or failure of the energy supply has severe consequences for water supply.
- Any increase in demand in energy from the water sector would have consequences for the energy sector. Overall changes in the water balance could create increasing pressures on the costs of water.
- ICT is very important for the monitoring and control systems for both the water supply networks and water treatment works.
- Increased disruption to shipping operations may affect supply chains. Increased wave pressure may affect port operations, with a subsequent effect on supply chains.
- Changes in water price (through increased desalination operation) can affect businesses reliant on the public water supply.

The risks of climate change for human health and wellbeing are linked to risks in other sectors, such as water, floods, built environment, agriculture, energy, etc. For example, any unmitigated climate-related impacts on food or water quality and availability will have effects on public health. Extreme weather events (such as floods and heatwaves) causing disruption in IT communications, power generation and distribution, or public transport are likely to affect public health services, including access to hospitals. Furthermore, adaptation/mitigation measures in the built environment, transport, energy, water, agriculture and other sectors will have implications for population health. Also, changes in human health may affect business through seasonal or annual declines in productivity.

9.2 Social vulnerability

Vulnerable groups of people such as those affected by poverty, poor health and disabilities will tend to experience disproportionate negative effects from particular climate impacts. Outdoor workers are more vulnerable to heat related risks. Higher food or water prices are likely to have a greater impact on low income people.

Social vulnerability to climate change is likely to reflect existing patterns of inequality. Under certain demographic scenarios future social vulnerability could increase as an aging population is more vulnerable to heat stress.

9.3 Resilience to plausible extreme events

9.3.1. Introduction

This paragraph focuses on **the level of resilience** to a small number of plausible extreme events with multiple knock-on impacts such as a major drought, earthquake/tsunami, flood, heatwave or cold snap.

9.3.2 Defining resilience

Resilience is the focus of a large and growing body of research. Three widely cited examples are set out below [85]:

- “The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner”. *United Nations International Strategy for Disaster Reduction*
- “The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change” *Intergovernmental Panel on Climate Change*
- “The capacity of a system to absorb disturbance and reorganize while undergoing change”. *The Resilience Alliance*
- “The ability of countries, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stresses - such as earthquakes, drought or violent conflict - without compromising their long-term prospects”. *The UK Department for International Development.*

The EU's definition for resilience is: *the ability of an individual, a household, a community, a country or a region to withstand, cope, adapt, and quickly recover from stresses and shocks such as violence, conflict, drought and other natural disasters without compromising long-term development.*

Most definitions of resilience share four common elements (see following figure) [85]:

- context;
- disturbance;
- capacity; and
- reaction.

Together these elements form a resilience framework which can be used to examine different kinds of resilience (for example, of growth or of governance systems) and help determine the level of resilience that exists.

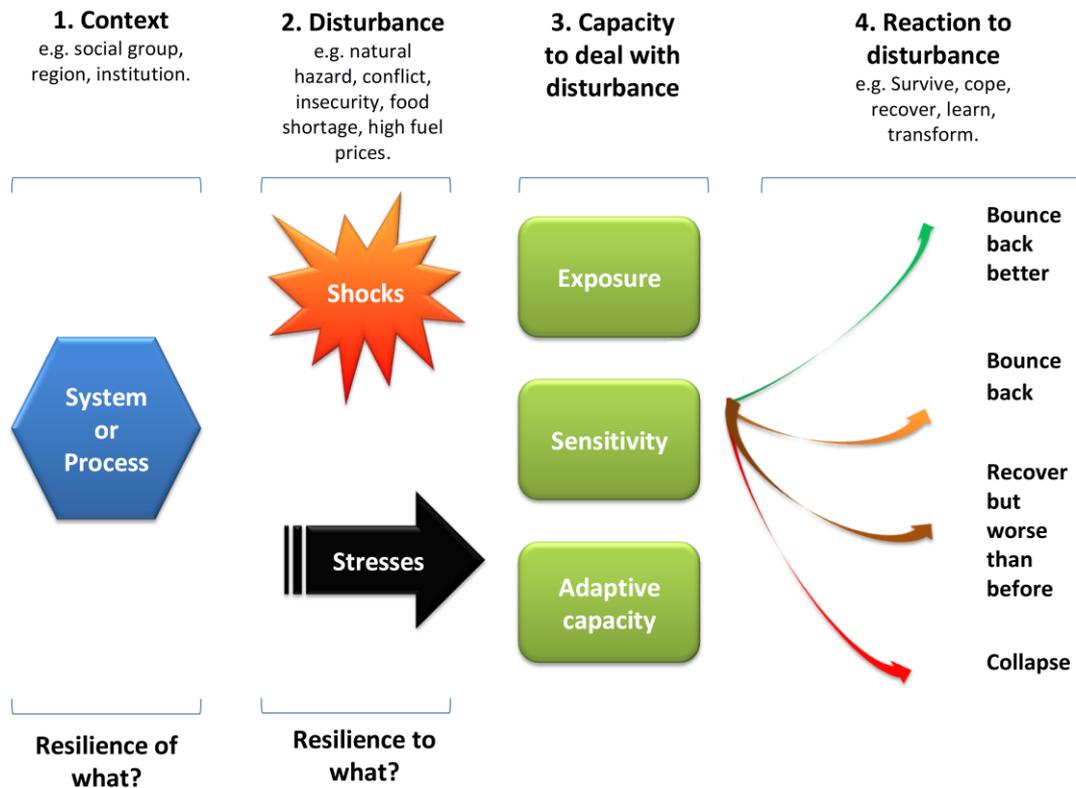


Figure 9.1 The four elements of a resilience framework [85]

The ability of the system or process to **deal** with the shock or stress is based on the levels of *exposure*, the levels of *sensitivity* and *adaptive capacities*.

- Exposure to risk is an assessment of the magnitude and frequency of shocks or the degree of stress.
- Sensitivity is the degree to which a system will be affected by, or respond to, a given shock or stress.
- The adaptive capacities of actors – individuals, communities, regions, governments, organisations or institutions – are determined by their ability to adjust to a disturbance, moderate potential damage, take advantage of opportunities and cope with the consequences of a transformation. Adaptive capacities allow actors to anticipate, plan, react to, and learn from shocks or stresses.

In the best case, the reaction to a shock or stress might be a ‘bounce back better’ for the system or process concerned. In this case capacities are enhanced or sensitivities and exposures are reduced, leaving a system that is more able to deal with future shocks and stresses. An alternative reaction might be a ‘bounce back’ to a normal, pre-existing condition, or to ‘recover, but worse than before’ – the latter resulting in reduced capacities. In the worst-case scenario, the system or process might not bounce back at all, but ‘collapse’, leading to a catastrophic reduction in capacity to cope in the future.

9.3.3 Major drought

In Cyprus an integrated approach to water management implements measures to ensure water security both now and in the future, accounting for the impact of climate change:

- **Reservoirs.** In order to store as much freshwater as possible, Cypriot governments have constructed numerous dams on key catchments over the course of the years. As a result, the water storage capacity of the island increased from six million cubic meters (m³) in 1960 to 327 million m³ in 2009, making Cyprus one of the most developed countries in terms of dam infrastructure. The water stored in major dams is supplied to both residential and agricultural users; in recent years with adequate precipitation levels, agriculture has consumed about 60% of these water quantities, but during years with less rainfall more than 65% went to residential users, and this fraction increased further in years with extensive drought.
- **Wastewater re-use.** Cyprus also re-uses tertiary treated wastewater, more than half of which is used for irrigation of crops, either directly or through the artificial recharge of aquifers.
- **Desalination.** Cyprus relies increasingly on desalinated water as an additional resource for public water supply and to support holiday resorts in arid areas. The capacity of desalination plants in Cyprus has been designed such that virtually all urban residential water needs can be met by desalination generated water, so that a) water supply to households and firms becomes independent of weather conditions and b) all freshwater reserves are supplied to the agricultural sector in order to restore groundwater reserves, which are currently being depleted due to over-exploitation by farmers. Even under the assumption of a rapid increase in water demand, and despite climate change, desalination can more or less satisfy all water demand of households, industry and tourism.
- **Water pricing.** In Cyprus, a water pricing policy is implemented for water use by all sectors, including domestic use and irrigation.

Cyprus has strengthened its resilience to major droughts through the implementation of relevant European and National Policies such as the Water Framework Directive (River Basin Management Plan), the European Water Scarcity and Droughts Policy (Drought Management Plan), the Water Policy and the new CAP.

According to the European Commission Drought Management Plans (DMP) should be prepared in advance before they are needed, based on relevant country specific legislation and after careful studies are carried out concerning the characterization of the drought in the basin, its effect and the mitigation measures. The main objective of drought management plans is to minimize the adverse impacts on the economy, social life and environment when drought appears. This general objective can be developed through a series of specific objectives that might include:

- Guarantee water availability in sufficient quantities to meet essential human needs to ensure population's health and life.

- Avoid or minimize negative drought impacts on the status of water bodies, especially on ecological flows and quantitative status for groundwater and in particular, in case of prolonged drought, as stated in article 4.6. of the WFD.
- Minimize negative effects on economic activities, according to the priority given to established uses in the River Basin Management Plans, in the linked plans and strategies (e.g. land use planning).

The Water Development Department of Cyprus has elaborated a Drought Management Plan in 2010 in order to address these issues. The DMP of Cyprus structures upon the EU policy on drought management and is closely linked with the Government Water Policy which is based on the WFD criteria and objectives. The main elements of the Cyprus DMP are:

- An early warning system based on hydrological indicators
- A correlation of indicators with thresholds for different drought stages to trigger action
- A set of phase-specific measures to achieve objectives

The actions against drought according to the level of alert may include the notification of responsible operators, raising awareness for sustainable water use, notification of users for consumption reduction, increase in desalinated water production, intensive controls of abstractions and leakages, limits to the abstractions from dams, releases from dams only for river ecosystem protection. In case of extremely high drought actions include:

- Notification of responsible operators.
- Notification of users for consumption reduction.
- Maximization of desalination plants production, when excess quantities storage is possible.
- Status announcement and intensive public notification program.
- Intensive controls for restrictions to uncontrollable abstractions and pumping, as well as for wasting limitations.
- Abstractions from large projects, according to the storage capacity index, but not more than those that correspond to the action “extreme shortage”.
- Monthly regime index calculation and measures received relevant to the upstream abstractions, if this is necessary (index smaller than 5%).
- The environmental releases from dams will be limited to the absolutely necessary for the river ecosystem protection and not for groundwater body recharge.

According to the EU policy on drought, a DMP should provide a dynamic framework for an ongoing set of actions to prepare for, and effectively respond to drought, including periodic reviews of the achievements and priorities, readjustment of goals, means and resources, as well as strengthening institutional arrangements, planning, and policy-making mechanisms for drought mitigation. Effective information, early warning systems and drought risk maps are the foundation for effective drought policies and plans, as well as effective networking and coordination between competent authorities in water management at different levels. In addition to an effective early warning system, the drought management strategy should include sufficient capacity for contingency planning before the onset of drought, and

appropriate policies to reduce vulnerability and increase resilience to drought. When working towards a long-term drought management strategy, it is necessary to establish the institutional capacity to assess the frequency, severity and localisation of droughts and their various effects and impacts on crops, livestock, the environment and specific drought impacts on populations. This is rather a complex process that requires increased capacity, strong institutional structure as well as active administrative and public involvement.

Cyprus has considerably increased its adaptive capacity in coping with drought by adopting the EU guidelines on water and drought management. However, the Cyprus DMP and its Water Policy have recently implemented and have yet to be tested to prove their efficiency in achieving the abovementioned goals.

In the sector of Agriculture, the initiatives of WDD such as the sustainable use of water resources with special attention to halt overexploitation of groundwater and to improve irrigation management increase the resilience of the sector and should be further enhanced. The use of indigenous and locally-adapted plants and animals as well as the selection and multiplication of crop varieties and autochthonous races adapted or resistant to adverse conditions and climatic stress must be promoted.

9.3.4 Earthquake/tsunami

The exposure and sensitivity of Cyprus to seismic activity and tsunamis is described in paragraph 5.9.

Cyprus has increased its resilience to earthquakes through seismic design codes and the operation of the Cyprus Civil Defence and the Seismology Section of the Geological Survey Department :

The first guidelines for seismic design in Cyprus were imposed after 1986 and the first seismic design code was introduced on a voluntary basis in 1992 and was then made compulsory in 1994. On January 1st 2012, the national code harmonized with the Eurocodes, including Eurocode 8 for the design of seismic resistant structures.

The Cyprus Civil Defence of the Ministry of Interior is responsible for improving and strengthening the protection mechanism of civilians, sensitizing the population on prevention and response to disasters issues (including earthquakes) and consolidating basic rules on safety and self-protection, in order to create the circumstances for a society to be ready to contribute effectively in reducing the risks and their consequences. The main mission of Civil Defence focuses on taking measures in response to natural or man-made disasters which might cause serious consequences, the size of which may cause hazards to the life and welfare of citizens or extensive damage to the environment and natural resources of the Republic. These measures to manage the consequences of a disaster include a series of actions for the prevention, preparation, response, design, education and mitigation of the negative results.

The main activity of the Seismology Section is the monitoring of the seismic activity of Cyprus and the broader area of the Eastern Mediterranean. The Seismological Section operates and maintains Seismological Networks [digital (2014) and analogue (1997-2013)], a Network of Accelerometers, and relevant facilities at two independent Seismological Centres, Lefkosia and Mathiatis.

The daily monitoring involves the reception, recording and processing of the seismological data as well as the evaluation of the seismological parameters and the immediate publication of the relevant information at an interactive open-access website. The recordings and evaluation of the local (Cyprus), regional (Eastern Mediterranean) and distant earthquakes can be found in the Monthly and Yearly Bulletins and in seismicity maps, as well as the interactive seismicity website. The Seismological Section is also responsible to collect historic earthquake data (seismological and maroseismological).

When an earthquake is felt, the Seismological Section publishes the relevant information and updates its website with the relevant material (felt earthquake announcements).

The Seismological Section is also responsible to publish seismicity maps, catalogues, leaflets, bulletins and articles related to the seismicity of Cyprus and the broader area of the Eastern Mediterranean.

Other actions that have improved the resilience to earthquakes include the following [86]:

- Cyprus has drafted a Plan to Overcome the effects of Earthquake that is annually tested with the "EGKELADOS" Exercise
- There are trained rescue crews
- There are trained engineers to inspect buildings after earthquakes
- All school buildings and Refugee settlements have been evaluated on terms of seismic vulnerability and a program of seismic reinforcement was implemented

Research on earthquake resilience has introduced new concepts such as Design for all. Design for all is a concept critical to design for resilience. It has been reported that the most vulnerable community groups suffer the most during and after an earthquake. Society will recover as soon as the functionality of these vulnerable groups recovers. Therefore, design for all must be taken into account as design for human diversity and social inclusion benefits the whole community [87].

High resilience to earthquake is a function of the environmental performance during the disaster (for example, the infrastructure's structural performance) and how people behave during and after the disaster. Obviously, the correct strategy to increase resilience would be to minimise losses and reduce vulnerability. To ensure the highest resilience, both high structural performance and high people's behaviour are required as one complements the other. That is, there is no point in ensuring that the infrastructure does not collapse if the people do not know how to prepare before a disaster and how to react during and after the disaster or, vice versa, there is no point in educating and training the people to perform correctly in a disaster if they are all killed by the buildings falling down.

Through design for all, by accounting for the most vulnerable in a community, the whole community will benefit. Therefore, in the context of structural performance, the built environment must be designed for everybody's life safety in the event of a disaster. Robustness, redundancy and alternative load paths must be provided. In design for resilience, ductility, energy absorption, isolation and capacity design are requirements. Limited damage is acceptable (and probably unavoidable) but failure is unacceptable as a building must keep its integrity and functionality. Buildings must be designed so that they have the ability to redistribute loads in the event of one or more structural elements failing.

When considering earthquakes, the probability of a disaster must be incorporated in the initial design of a building. Evacuation measures for the most vulnerable must be included in the design and the functionality during and after an earthquake must be considered. Design for all implies design for human diversity and social inclusion and involves the concepts of accessibility, universal design and inclusive design. Vulnerable groups must be included in the design process from the point of initial conception onwards. For good structural performance, the goal would be to design, construct, redesign or reconstruct in order to minimise the attacking effects of actions from possible disaster sources such as earthquakes, floods, fires, windstorms, etc.

In general, the aim is to provide enough resistance to withstand the disaster action and reduce any damage to an acceptable minimum. In particular, specifically when considering earthquakes, displacements should be minimised. Education and training is the key to achieving satisfactory structural performance and the target groups are engineers, contractors, construction personnel and building owners. Education and training is achieved through university studies, the introduction of recommendations and codes, research, the creation of technical divisions and through holding seminars, workshops, etc.

Regarding the tsunamis as previously mentioned a prototype Tsunami Warning and Early Response system for Cyprus has been developed.

9.3.5 Floods

Cyprus has drafted its 1st Flood Risk Management Plan that foresees measures, implemented by 2021, for the protection of life and properties. These include:

- Horizontal Prevention Measures
- Horizontal Protection Measures
- Horizontal Preparedness Measures
- Horizontal Rehabilitation Measures and
- Specific technical measures and measures for the warning of local communities.

The implementation of these measures will increase the current levels of resilience. However, the since the plan hasn't been implemented yet to be tested to prove its efficiency the level of the resilience cannot be assessed.

9.3.6 Heatwave or cold snap

Extreme temperatures have impacts on human health, agriculture production and animal welfare.

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

The majority of houses and indoor public areas as well as private trade facilities in Cyprus, are air-conditioned. Furthermore, there are communal centres fully air-conditioned to accommodate people with no access to an air-conditioned environment during days of elevated temperatures. However, the protection of the population from heat waves is not always possible.

Several types of infrastructural measures can be taken to prevent negative outcomes of heat-related extreme events. Models suggest that significant reductions in heat-related illness would result from land use modifications that increase albedo, proportion of vegetative cover, thermal conductivity, and emissivity in urban areas.

Reducing energy consumption in the framework of the relevant National Strategy, in buildings will improve resilience, since localized systems are less dependent on vulnerable energy infrastructure. In addition, by better insulating residential dwellings, people would suffer less effect from heat hazards. Financial incentives have been tested in some countries as a means to increase energy efficiency by supporting those who are insulating their homes. Urban greening can also reduce temperatures, protecting local populations and reducing energy demands.

Special attention must be given to improve forest resilience to fires. Sustainable forest management must be further promoted in order to reduce the fuel potential for forest fires. Early warning systems and water supply systems for firefighting and public awareness should be further raised

A cold surge is a weather phenomenon that is distinguished by a cooling of the air. Exposure to cold mandates greater caloric intake for all animals, including humans, and if a cold wave is accompanied by heavy and persistent snow, grazing animals may be unable to reach needed food and die of hypothermia or starvation. They often necessitate the purchase of foodstuffs to feed livestock at considerable cost to farmers. Cold waves that bring unexpected freezes and frosts during the growing season in mid-latitude zones can kill plants during the early and most vulnerable stages of growth, resulting in crop failure as plants are killed before they can be harvested economically.

Frost is the coating or deposit of ice that may form in humid air in cold conditions, usually overnight. In temperate climates it most commonly appears as fragile white crystals or frozen dew drops near the ground, but in cold climates it occurs in a greater variety of forms. Frost is composed of delicate branched patterns of ice crystals formed as the result of fractal process development. Frost is known to damage crops or reduce future crop yields, therefore farmers in those regions where frost is a problem often invests substantial means to prevent its forming. Frosts are rarely severe but are frequent in winter and spring inland and in some years handicap the economically important production of early vegetable crops and main citrus crops.

The most significant result of cold surges is the frost, which is mainly developed under particular conditions with low winds and clear sky at night. Frost nights (temperature below 0°C) cause serious damage to agricultural areas, especially where sensitive crops exist, such as orange and lemon groves. Hail and frost is the third most damaging extreme weather event in Cyprus with quite high compensations provided for the damages caused to almost all crops (€42 million). The loss of crop yields are associated with climatic factors such as frosts, droughts, heat waves, wind storms, hail and floods are presented indicatively (Figure 5.14). Assuming that the amount of compensation provided is directly related to the crop areas

destroyed, the greatest climatic threats for the agricultural production and subsequently for food availability, are frosts and droughts [15].

The destructive effects of hails to crops may be prevented by covering crops with nets, however it requires the timely forecast of the event and the rapid response of farmers for the placement of the net. However, the options for the protection of crops from extreme temperatures are limited [15].

Regarding agriculture even though the capacity to deal with extreme temperatures is limited farmers can cope with their effects with receiving compensation measures.

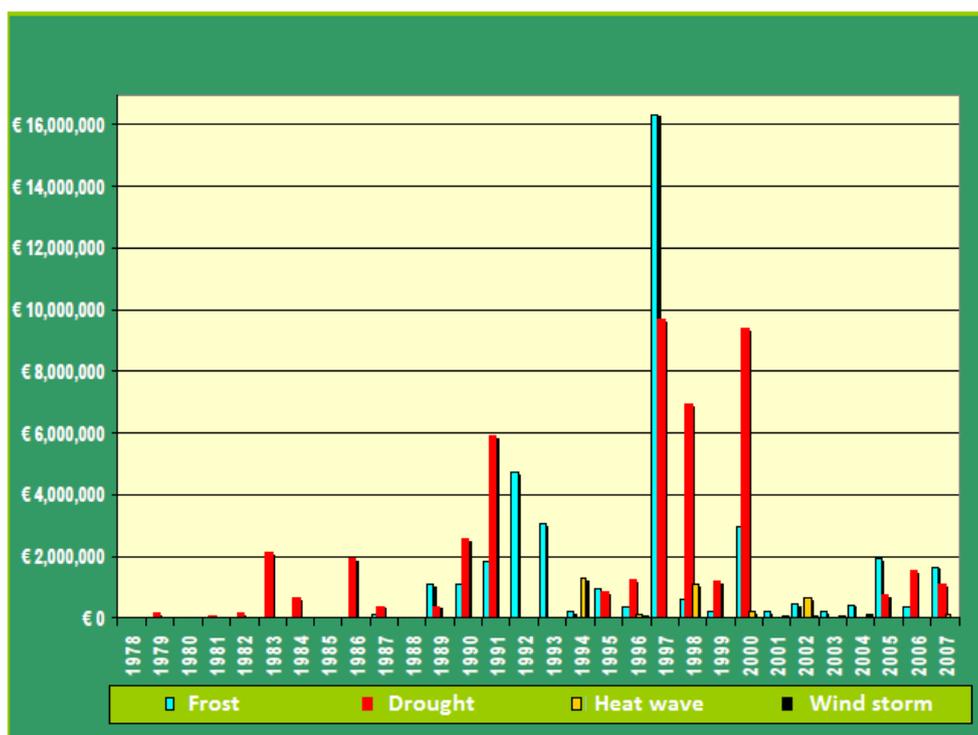


Figure 9.2 Compensation provided for damages to crops caused by frost, drought, heat wave and wind storm in Cyprus from 1978 to 2007 [15].

10. Conclusions

10.1 Risks with high consequences

Moderate CC Scenario – 2050

Under the moderate CC Scenario, the emerging risks that have potentially **high consequences** and medium level of confidence are mainly threats to Human health and marine ecology. The only opportunity (medium confidence) detected is for Tourism Industry, where more favourable climate conditions for sightseeing and alternative forms of tourism are projected. Low confidence threats are expected for the forestry through increased danger of pest outbreaks in the forest and woodlands of the island. Human morbidity due to increasing temperatures is also expected (low confidence). Projected climate changes will an impact on the functionality on coastal infrastructure and thus modification of breakwaters, will be required (low confidence).

Metric Code	Metric Name	Confidence	2050s RCP4.5
F02	Increased risk of pests, pathogens and diseases	L	3
HE2	Temperature Morbidity	L	3
MA1	Breakwaters exposed to significant risk of instability	L	3
BU4	Tourism product diversification	M	3
HE1	Temperature Mortality	M	3
MA3	Potential disruption of fish production	M	3
MA6	Changes in fish catches and gene pool	M	3
MA7	Exerting pressure on fish physiological thermal limits	M	3

More pessimistic CC Scenario – 2050

Under the more pessimistic CC scenario, on the top of the above mentioned risks, additional threats will arise for the marine environment (medium confidence). Potential changes in the seasonality of breeding and/or spawning of targeted species will impose changes in the activities of producers and behaviour of consumers. The production cycle and the catching season, may experience shifts that could affect consumers, who in turn, might chose imported products and/or change their preferences.

While under this Scenario the risk of forest pests is lower than the moderate scenario, there are emerging threats from invasive species affecting all habitat types including forest ones. There is also high confidence that changes in the distribution of key forest species will occur. *Quercus alnifolia* is projected to be the most vulnerable species with an estimated reduction up to 98% even by 2050. This seems to be in accordance with observations of increased species dieback during extremely dry periods. *Cedrus brevifolia* could also lose most of its climatically suitable area especially (82% area loss). *Pinus nigra* is relatively tolerant, but the severe global warming scenario leads to a reduction of 32% of its climatically suitable area. *Pinus brutia* is also tolerant, and a reduction of 45% of its climatically suitable area is foreseen.

Under this scenario despite the opportunities that are projected for the Tourism Industry, there is a threat (low confidence) for the beaches through SLR. There is a probable risk of

beach area loss of approximately 2,5km² that will affect most of the Cyprus Bathing Water Areas.

Metric Code	Metric Name	Confidence	2050s
			RCP8.5
BD4 & BD5	Increased risks from pests, diseases and invasive species	L	3
BU3	Tourist assets at risk from flooding due to SLR	L	3
HE2	Temperature Morbidity	L	3
MA1	Breakwaters exposed to significant risk of instability	L	3
BU4	Tourism product diversification	M	3
F03	Increased risk of drought damage / loss of productivity	M	3
HE1	Temperature Mortality	M	3
MA3	Potential disruption of fish production	M	3
MA4	Shifts affecting producers and consumers	M	3
MA6	Changes in fish catches and gene pool	M	3
MA7	Exerting pressure on fish physiological thermal limits	M	3
F04	Changes in tree species suitability	H	3

Moderate CC Scenario – 2080

Under the moderate CC Scenario, the emerging risks by the 2080s that have potentially **high consequences** and high level of confidence are mainly threats to the natural environment.

There is high confidence that changes in key forest species suitability will occur. *Quercus alnifolia* is projected to be the most vulnerable species with an estimated reduction up to 95% even by 2070. *Cedrus brevifolia* could also lose most of its climatically suitable area especially in the longer term (93%). *Pinus nigra* and *Pinus brutia* are relatively tolerant, and this CC scenario leads to a reduction of 39% and 41% of their climatically suitable areas respectively.

There is also high confidence that biodiversity will be significantly threatened as several habitat types and species will be unable to find suitable microclimate/habitats, whereas coastal and marine biodiversity is also expected to be negatively affected by the SLR and the fact that coastal areas are under strong development pressures. Regarding the natural environment there is also medium confidence that threats will arise from major droughts and changes in the distribution of priority species.

Medium confidence threats arising under this scenario are related with increased human mortality due to higher temperatures, marine biodiversity and productivity.

There is a low confidence risk for high magnitude consequences for the natural environment from invasive species and pests. There are also high magnitude consequences for the human health (low confidence) and the functionality of some coastal works.

Finally, higher cost of water supply is expected (low confidence) due to the increased operation of desalination plants.

There are emerging opportunities for the tourism industry since favourable climate conditions are expected for both beach and alternative forms of tourism.

Metric Code	Metric Name	Confidence	2080s
			RCP4.5
BD4 & BD5	Increased risks from pests, diseases and invasive species	L	3
F02	Increased risk of pests, pathogens and diseases	L	2
HE2	Temperature Morbidity	L	3
MA1	Breakwaters exposed to significant risk of instability	L	3
W2	Higher cost of water supply due to increased desalination	L	3
BU1	Extension of summer season	M	3
BU4	Tourism product diversification	M	3
BD3	Changes in distribution of priority species	M	3
BD9	Major drought events, Impact on Water Quantity and Increased Societal Water Demand	M	3
F03	Increased risk of drought damage / loss of productivity	M	3
HE1	Temperature Mortality	M	3
MA3	Potential disruption of fish production	M	3
MA4	Shifts affecting producers and consumers	M	3
MA5	Potential disruption coastal nurseries	M	3
MA6	Changes in fish catches and gene pool	M	3
MA7	Exerting pressure on fish physiological thermal limits	M	3
BD1	Species unable to find suitable microclimate/habitats	H	3
BD7	Coastal evolution impacts	H	3
F04	Changes in tree species suitability	H	3

More pessimistic CC Scenario – 2080

Under the more pessimistic CC scenario, on the top of the above-mentioned risks, additional threats will arise for the natural environment. There is high confidence of increased soil erosion. In addition, there is high confidence that 14 flora and fauna species and 7 habitats will not be able to track changing climate space. There is medium confidence of increased risk of wildfires and also threats related to changes in primary productivity and increased soil moisture deficits and drying. Additionally, there is (low confidence) high magnitude risk for the natural environment resulting from pressures through agricultural intensification.

Under this CC scenario, major risks emerge for components of the built environment and the energy system. There is (high confidence) risk for building overheating and (medium confidence) risks related to energy consumption (opportunity for heating and threat for cooling) and the effectiveness of green areas in urban areas. An increase (low confidence) of annual electricity consumption is projected due to the increased operation of the desalination plants (243GWh, 6% of the current energy consumption).

Additional threats (low confidence) to the moderate CC are resulting from increased irrigation deficits.

Metric Code	Metric Name	Confidence	2080s
			RCP8.5
AG2	Livestock production	L	3
BD4 & D5	Increased risks from pests, diseases and invasive species	L	3
BD12	Agricultural intensification (i.e. human use of NPP)	L	3
BU3	Tourist assets at risk from flooding due to SLR	L	3
EN1	Energy Demand by Water Suppliers	L	3
F02	Increased risk of pests, pathogens and diseases	L	2
HE2	Temperature Morbidity	L	3
MA1	Breakwaters exposed to significant risk of instability	L	3
W2	Higher cost of water supply due to increased desalination	L	3
W3	Irrigation Supply Deficit	L	3
BD3	Changes in distribution of priority species	M	3
BD8	Increased soil moisture deficits and drying	M	3
BD9	Major drought events, Impact on Water Quantity and Increased Societal Water Demand	M	3
BD11	Changes in primary productivity	M	3
BE1	Energy demand for cooling	M	3
BE3	Energy demand for Heating	M	3
BE4	Effectiveness of Green Spaces	M	3
BU1	Extension of summer season	M	3
BU2	Loss of staff hours due to high internal building temperatures	M	3
F03	Increased risk of drought damage / loss of productivity	M	3
HE1	Temperature Mortality	M	3
MA3	Potential disruption of fish production	M	3
MA4	Shifts affecting producers and consumers	M	3
MA5	Potential disruption coastal nurseries	M	3
MA6	Changes in fish catches and gene pool	M	3
MA7	Exerting pressure on fish physiological thermal limits	M	3
BD1	Species unable to find suitable microclimate/habitats	H	3
BD2	Species unable to track changing climate space	H	3
BD6	Increased soil erosion	H	3
BD7	Coastal evolution impacts	H	3
BE5	Overheating of Buildings	H	3
BD10, F01	Increased risk of wildfires	H	3
F04	Changes in tree species suitability	H	3

10.2 Risks monetisation

Monetisation of risks allows an initial comparison of the relative importance of different risks. 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.

For this CCRA, a **monetisation exercise** was undertaken to allow a comparison of the relative significance of different risks. It is important to note, however, that this exercise focuses on the effect on overall human welfare. The intrinsic value of elements of the natural environment is not always captured, nor is the variation in social vulnerability considered. Therefore, the indicative 'value rankings' determined by this exercise do not always represent all factors that make a particular risk significant; additional non-quantified dimensions need to be considered.

The results only provide a partial picture and they need to be considered alongside the social and environmental considerations.

The total value to society of any risk is taken to be the sum of the values of the different individuals affected. This distinguishes this system of values from one based on 'expert' preferences, or on the preferences of political leaders. Individual preferences are expressed in two, theoretically equivalent, ways. These are:

- The minimum payment an individual is willing to accept (WTA) for bearing the risk; or
- The maximum amount an individual is willing to pay (WTP) to avoid the risk.

However, due to the availability of data, it is sometimes necessary to use alternative approaches (e.g. repair or adaptation costs) to provide indicative estimates.

A variety of methods can be used to determine these costs. These methods can be categorised 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. It should be noted that for several risks, there is limited information on their costs and case studies carried out in Cyprus are very limited.

These three categories of method have differing degrees of uncertainty attached to them, with market prices being the most certain and informed judgement being the least certain.

It is important to stress that the confidence and uncertainty of risks differ. Therefore, care must be taken in directly comparing the results. A further caveat is that whilst an attempt was

made to use the best monetary valuation data available, the matching-up of physical and monetary data will be understood as an approximation only.

The valuation exercise was undertaken only for those risks included in Tier 2 list (see Annex I) and provides a means of identifying the relative significance of these selected risks. Furthermore, it was not possible to provide monetary valuation for all Tier 2 risks. **Therefore, summing up these values doesn't give an overall cost of projected climate change.** The reader should also be aware that there are some overlapping risk categories, i.e. where there is the possibility of double counting.

In the following Table the results of this monetization exercise are presented.

Metric Code	Metric Name	Confidence	2050s		2080s	
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
BE1	Energy demand for cooling	M	-VH	-VH	-VH	-VH
BE2	Urban Heat Island	L	-M	-M	-M	-H
BE3	Energy demand for Heating	M	+VH	+VH	+VH	+VH
BE4	Effectiveness of Green Spaces	L	-L	-M	-M	-H
BE5	Overheating of Buildings	L	-L	-L	-M	-H
BU1	Extension of summer season	M	+VH	+VH	+VH	+VH
BU2	Loss of staff hours due to high internal building temperatures	L	-M	-M	-M	-H
BU3	Tourist assets at risk from flooding due to SLR	L		-VH		-VH
BU4	Tourism product diversification	L	+VH	+VH	+VH	+VH
EN1	Energy Demand by Water Suppliers	M			-H	-VH
F01	Increased risk of wildfires	M	-M	-H	-H	-H
F04	Changes in tree species suitability	M	-M	-M	-M	-M
FL1	Number of people exposed to significant likelihood of flooding	H	-VH	-VH	-VH	-VH
FL2	Number of properties at significant likelihood of flooding	H	-H	-H	-H	-H
FL3	Flooding of transport infrastructure, critical utilities and archaeological sites	L	-L	-L	-L	-L
FL4	Insurance premiums for flood risk	M	-H	-H	-H	-H
FL5	Land affected by coastal erosion and wave overtopping	L	-L	-L	-L	-L
HE1	Temperature Mortality	M	-VH	-VH	-VH	-VH
HE2	Temperature Morbidity	L	-H	-H	-H	-H
MA1	Breakwaters exposed to significant risk of instability	L		-L		-H
W2	Higher cost of water supply due to increased desalination	L	-M	-M	-H	-H
W3	Irrigation Supply Deficit	L	-L	-M	-M	-H

Notes:

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

Cost Ranking:

- Low (L) = €10.000 – 99.000 per annum;
- Medium (M) = €100.000 – 999.000 per annum;
- High (H) ≥ €1m per annum
- Very High (VH) ≥ €10m per annum (where possible to assess between H and VH)

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.

Since Biodiversity Risks are not always easy to be expressed in monetary terms, the main findings of the Biodiversity Sector are presented in the following paragraphs.

For several risks, there is limited information on their costs and case studies carried out in Cyprus are very limited. As a result, most of the examples used come from other countries and an effort to adjust them to the Cypriot socio-economic conditions has been made. For this reason, the provided examples do not present precise costs estimates and should be considered with caution. Some of the risk metrics are easier to monetise, while for others due to the complexity of the driving factors that affecting them or the lack of relevant information is rather hard to do.

It should be also noted that the increasing efforts to value biodiversity and ecosystem services in monetary terms and to articulate such values through markets in order to create economic incentives for conservation is under substantial criticism. More precisely, many studies support that economic valuation is likely to pave the way for the commodification of ecosystem services with potentially counterproductive effects for biodiversity conservation and equity of access to ecosystem services benefits [96].

Although our knowledge on the value of biodiversity, ecosystems and their service is steadily increasing, there is still an apparent lack of quantitative/monetary and well-documented information on the socio-economic benefits derived by natural ecosystems and protected areas [91, 95].

Species unable to find suitable microclimate/habitats or unable to track changing climate space & changes in distribution of priority species (BD1, BD2 & BD3)

Climate change together with land use changes and indirect impacts from human activities could lead to shifts on several habitats and species distribution. The economic costs for the conservation and protection of threatened endangered and rare (TER) species have received substantial attention, but the economic benefits of species protection are often overlooked.

Non-market valuation methods have been employed to estimate willingness to pay (WTP) for numerous TER species over the last few decades [103]. The WTP express the equivalent sum that an individual is willing to pay to maintain the level of use and satisfaction from the use or existence of a good or a service. People value endangered species for different reasons and therefore benefit from their protection in different ways. Endangered and protected species are characterised by non- consumptive and indirect uses, which include activities such as observation (e.g. bird watching) and photography. While both above mentioned activities require on-site active use, individuals may also benefit from indirect use activities, such as enjoyment gained by reading or viewing photographs etc. [101]. Biodiversity and ecosystem function changes driven by climatic shifts could also reflect on ecosystem services with a direct economic and societal impact. One of those key processes is pollination. Worldwide pollination via insects, birds and bats regulates the reproductive success of approximately 87% of flowering plants and about 1.500 crops that yield ca 3 to 8% of global crop production [88, 99].

In a case study in a US protected area, the mean WTP for the protection of the peregrine falcon (*Falco peregrinus*) and the shortnose sturgeon (*Acipenser brevirostrum*) have been estimated. The mean WTP was between \$17 and \$93 for the peregrine and between \$17 and \$39 for the sturgeon [101]. In a recent review paper the maximum annual WTP was reported to reach up to \$356 [103] for certain marine species. In a case study performed in Greece, the elicitation of the monetary WTP through donation, taxation and admission fee has been studied for two endangered species; the Mediterranean monk seal *Monachus monachus* and sea turtle *Caretta caretta* [109]. WTP and total economic value given for a TER species can be greatly augmented if the role of the species under question can have in ecosystem equilibrium and services is clearly presented to the public. An example is provided for *M. monachus*. At first place, a survey was conducted without concrete link between *M. monachus* and an ecosystem service. Moral, ethical and cultural values have been used to rate the importance of species protection. In the second survey, the information that the presence of a specific density of seals in a regionally specified marine environment (e.g., the northern–eastern Aegean Sea) controls the jellyfish outbreaks in the same area has been added. The respondents then are more likely to emphasize the use-value aspect than the existence- value aspect [100].

A recent European study was performed to estimate the economic value of the benefits provided for tourism, recreation and employment associated to the Natura 2000 network [89]. The visitors to all forest types of the Natura 2000 in Cyprus were willing to pay 2,78€ per visit day to enjoy the recreational benefits of these areas. The total number day visits (in 2001) was estimated around 734.000 [113], which means that the annual WTP was around €2M per year.

In order to get a potential estimate of the cost of climate change risk on species distribution/ extinction, we combined the above results with an estimate of WTP in the form of donation of €22 per person [108] to protect species in Greece. Assuming an equal number of day visits in Natura 2000 sites as for forests (734.000) and taking the severe 2080 scenario with more than 50% of the habitat types facing high to very high risk, a rough estimate of a cost €8M per

year can be given. This figure could be lower as the donation of €22 refers to “high profile” turtle and seal species in Greece, but also higher as the number of day visits refers to year 2001.

Overall, the above examples highlight a significant economic value related to the biodiversity of the island. Endemic and priority species have an important contribution to the island’s biodiversity status. Importantly this value seems to be linked with one of the economic sectors i.e. tourism and should be taken into account when managing both protected and other natural areas.

Increased risks from pests, diseases and invasive species (BD4 & BD5)

The economic costs and benefits associated with species introductions and biological invasions have attracted increasing attention during the past decade. A number of non-native species can offer economic benefits as they have been extensively used in forestry (e.g. some fast growing trees) or as ornamental plants. Nevertheless, there is growing evidence of the significant, negative economic impacts that IAS can have in different sectors including agriculture, forestry and fisheries / aquaculture, public health but also in ecosystem services.

Based on the information on documented costs (i.e. real & estimated costs without any extrapolation or benefits transfer) the total documented monetary impacts of IAS in Europe amount to a total of 12,5 billion € / year. The majority of these costs, i.e. 9,6 billion €, result from the damage caused by IAS whereas the rest, i.e. 2,8 billion €, are related to the control of IAS. Costs related to terrestrial IAS (e.g. vertebrates, plants and invertebrates) form a major part of this estimate. Available information on the documented costs of IAS on different economic sectors highlights that the most economically impacted sector is agriculture, with a total cost of approximately 5,5 billion € [98]. Agricultural pests cause significant economic losses worldwide. Globally, more than 40 per cent of food production is being lost to insect pests, plant pathogens, and weeds, despite the application of more than 3 billion kg of pesticides to crops, plus other means of control. In the US alone, it is estimated that more than US\$18 billion (€ 16 billion) are lost due to insect damage [115]. Another example of particular importance for Cyprus concerns the climate change impacts on the interaction of olive trees and olive fruit fly (*Bactrocera oleae*). A recent study has projected that climate warming will affect olive yield and fly infestation levels across the Mediterranean Basin. These shifts have a direct economic impact, with smaller olive farms in many marginal areas of Europe, more severely affected [106].

In a recent mapping of the extent of several IAS around the salt lake on the Akrotiri, the Port Jackson willow *Acacia saligna* was found to be the most potentially damaging invasive alien species. More precisely, it is considered to be the most likely species to have implications on both human health (through potentially providing suitable habitat for harbouring pest species such as mosquitos) and a detrimental impact on native biodiversity through encroachment into the saltmarsh areas and competition [105]. *A. saligna* is a difficult species to manage, with control methods having to deal with its ability to resprout from roots and the large, persistent seed banks it creates [111]. In a case study in a nature reserve in Israel, the cost for

different containment and/or eradication of *A. saligna* practices has been estimated, together with the annual mean WTP for containment or eradication of the species [112]. Based on the results of this study, when the estimated total economic values based on total value (which includes use and non-use values) for containment and eradication of the invasion were compared to the cost of management, the benefit–cost analysis revealed positive net benefits for the eradication of the invasive species. Depending on which method of eradication treatment is chosen the one-time investment is estimated between US\$ 193.000 and US\$ 397.000 (€ 171.000 and €352.000). The annual mean WTP for eradication of *A. saligna* was US\$ 8,83 (€ 7,83).

Increased soil erosion (BD6)

Several studies have assessed the cost of soil erosion for various areas around the world. The total global water erosion environmental cost is estimated around €15,97 billion [107]. Since September 2006, the European Commission has launched its Thematic Strategy on Soil Protection. The goal of the soil strategy are the protection and sustainable use of soils in Europe, which is to be achieved by protection against further degradation; by maintaining vital soil functions; and where necessary to restore soils to a level suitable for sustained use. In 2010 an effort has been done to quantify the effects that the proposed soil conservation policies are likely to have, and to convert them into money terms [102]. Measures concerning erosion in different sectors, i.e. agriculture, forestry and construction and different erosion degrees from serious to low have been examined. Both on-site and off-site benefits were also considered. Off-site impact depends on the amount of erosion material actually ending up in rivers, lakes, dams and settlements. This amount is measured at the exit of a drainage basin, and expressed as a proportion of total erosion: the Sediment Delivery Ratio. The total net benefit per measure for all different practices aiming at different threats (erosion, compaction, soil organic matter, salinization) and sectors (arable land, soil protection in forests etc) was equal to €4.306 million. Soil erosion in Cyprus has been estimated to 2,89 tn ha⁻¹ y⁻¹ [94].

Coastal evolution impacts (BD7)

According to the European Commission (EC) analysis on the economics of climate change adaptation in EU coastal areas, the value of the economic assets within 500 m of the coastline is estimated at € 500-1000 billions. In addition, 35% (€ 3.5 trillion) of the total GDP of the 22 European coastal member states is generated in an area within 50 km of the coast, where one third of the EU population resides [92]. Under a 1 m SLR, 139.000 km² of land area, 13,6 million people and € 305,2 billion GDP is at risk of coastal flooding in Europe.

In the framework of the PESETA study, the cost of inaction and adaptation in regard to SLR has been estimated in monetary terms at the member state level. The inaction cost is the so called ‘damage cost’ and it is calculated based on three indicators: sea food cost, salinity intrusion cost and migration cost due to land loss. The annual cost of inaction, aggregated at EU level is estimated to be between € 5,6 billion and € 6,7 billion by 2020. However, Cyprus was not included in this analysis, so there are no direct data for the island. Adaptation cost for

coastal erosion in Europe varies greatly among different studies, ranging from € 0,18 billion to € 5,4 billion per year, which in any case is much lower than the relative costs of inaction.

In Cyprus several projects have been implemented during the last decades in order to face coastal erosion. In the period 1993-1996 a coastal zone management project was carried out with the objective to identify proper protection methods and improve the quality of beaches without causing serious impacts on the environment. The project budget amounted to € 1 million. Between 1998 and 2008, Cyprus spent € 0,45 million annually on the implementation of the Master Plans to combat coastal erosion, while in 2008, the amount spent to protect the coastal zones of Cyprus against flooding and erosion amounted to € 0,8 million [92].

Coastal erosion and evolution due to SLR is an existing threat for the coastal zone of Cyprus, which is expected to further increase under climate change scenarios. Although the management and adaptation cost seems rather high, it remains importantly low when compared with the corresponding estimated cost of inaction. Based on the results of a case study performed in the southern Larnaca coastal area, environmental resources were found to be the main people's preference characterizing this area. Results of the WTP survey revealed that most of surveyed groups (permanent residents, vacation house owners, Cypriot visitors and foreign tourists) were willing to pay for the protection of salt lakes as well as for preserving coastal areas from development. Nevertheless, respondents were willing to accept and support actions that would create an infrastructure for better access to the beach and/ or create facilities that improve the coastal area but not distorting or heavily altering the coast through intense development. The overall conclusion was that people value environmental assets in favour of their natural form by almost € 13/ person, a value that on average denotes the opportunity cost of obtaining or retaining the natural state of environmental quality [90].

Changes in primary productivity, increased soil moisture deficits and drying (BD8 & BD11)

Increased soil moisture deficits and drying are expected to severely affect primary productivity as well as to induce the current risk of desertification. In Cyprus, desertification has resulted in extreme losses in the productivity of soil resources, but also in the depletion and degradation of the water resources quality. Productivity is adversely affected by erosion, as the second reduces infiltration rates, water-holding capacity, nutrients, organic matter, and soil biota [97]. Much is known about the effect of erosion in different circumstances on soil productivity, but there is no generally accepted model with which these effects could be predicted from a given amount of erosion [102]. Loss of European agriculture production due to low soil productivity could reach € 319 million. According to an EU report for desertification in the Mediterranean [93] there is little detailed data on the economic costs resulting from desertification, although an unpublished World Bank study suggested that the depletion of natural resources in one Sahelian country was equivalent to 20 per cent of its annual GDP. Cyprus has long realized the need for controlling and managing the phenomenon of desertification and specific measures to prevent and mitigate desertification are applied. Afforestation of 5.000 ha of abandoned and degraded agricultural land with a total cost of approximately €3,5 million and elaboration of a fire protection system covering all areas

outside the state forests with the estimated cost around €3,5 million, together with water management are some of the performed mitigation actions to combat desertification. A rough estimate of the cost of changes in net primary productivity (NPP) can be estimated by multiplying the difference in NPP with "social cost" of carbon which in recent estimates can reach up to \$220 [114]. In Cyprus forests cover around 173.000 ha and other wooded lands around 214.000 ha. Following the severe RCP85 scenario by 2080 a 30% reduction in NPP of forests and a 35% reduction in the NPP of other wooded lands is expected. This would translate to a loss of approximately €7,7M cost of social Cost from forests and €5,4M from other wooded land per year.

10.3 Discussion

Considering the abovementioned risks for the 2050s, the following conclusions can be drawn:

- Human health and wellbeing will be under pressure (increased summer mortality and morbidity due to higher temperatures and heatwaves). The Country should increase its resilience to these phenomena by improving health care structures (infrastructure & organisation) and existing building stock as well as through increasing the green and blue infrastructure.
- There is a number of risks related to the marine environment. However, there is an important uncertainty concerning the findings since there is a significant lack of specific data for Cyprus. More studies needed to be conducted in order to increase scientific knowledge for the revision of this CCRA in the future.
- Cyprus should focus on sustainable tourism development. Favourable climate conditions are projected for tourism industry. However, unsustainable tourism can lead to increased energy and water consumption, waste production and further losses of natural habitats especially in the coastal zone. Loss of beach assets due to SLR that can be further increased by coastal erosion could adversely affect the tourism industry of the island
- Invasive species, pests outbreaks and diseases form an important risk for the natural environment (but also for other productive sectors such as agriculture and fisheries) that has to be addressed in time through adaptation strategies.
- Climate induced changes in the land suitability for key tree species and distribution shifts are expected to have significant adverse effects on forest products (wood, honey etc.) but also on the indirect benefits provided by forests (biological diversity, carbon sequestration, recreation etc.). The high structural and functional connectivity of the forested areas of the Natura 2000 network in Cyprus is a key tool for the mitigation of this risk.
- Further changes in forest management practises are likely to be required in the future in order to reduce drought effects and to enhance growth and quality of the forest stands. Some of the proposed management options include; modification of tending and thinning practises, use of more drought resistant trees in reforestation and plantation actions etc.
- Desertification in Cyprus is an important process of land degradation especially in the olive and cereal cultivation zone, in pine forested areas and shrubby grazing lands. The main process of land degradation and desertification is soil erosion. Land desertification represents already a serious threat for Cyprus and it is expected to be aggravated under CC.

Considering the 2080s, apart from the abovementioned, the following additional risks have to be addressed:

- Cyprus has to increase the resilience of the energy supply system in order to meet the increasing demands for cooling and drinking water supply.

- Increased production of desalinated water will have economic impacts felt across all spectrums of society and will further contribute to GHG emissions
- Agriculture will suffer from production losses due to irrigation water deficits, while livestock production and welfare will also be impacted. Mitigation measures in indoors farming will also increase energy consumption.
- New building design codes should consider the increased risk of buildings' overheating, which could also result in productivity losses.
- Even though Cyprus is among the few European countries that have improved their infrastructure for fire detection, control and suppression the risk of wild fires, it is expected that wildfires will increase under climate change and major drought events. Existing mechanisms of fire prevention and detection should be further enhanced.
- Impacts on human wellbeing as a result of UHI and the reduction in the effectiveness of green areas in urban centres are also expected.
- Many habitat types and species could naturally adapt to climate change by shifting their distribution to more climatically favourable areas. Nevertheless, the loss of important habitats and species is projected, with coastal habitats, freshwater ecosystems, wetlands as well as mountainous ecosystems being the most vulnerable. Implementation of conservation projects in time could moderate the risk of biodiversity loss.
- Changes in primary productivity due to shifting climate patterns could have a direct impact on many provisional, regulating and cultural ecosystem services.

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Annex I Summary of Risk Assessment Method

The components of the CCRA sought to:

- **Identify and characterise the impacts of climate change.**
- **Identify the main risks for closer analysis.**
- **Assess current and future risk, using climate projections and considering socio-economic factors.**
- **Assess vulnerability.**

The risk assessment was done through a series of steps as set out in Figure A1. These steps are explained below.

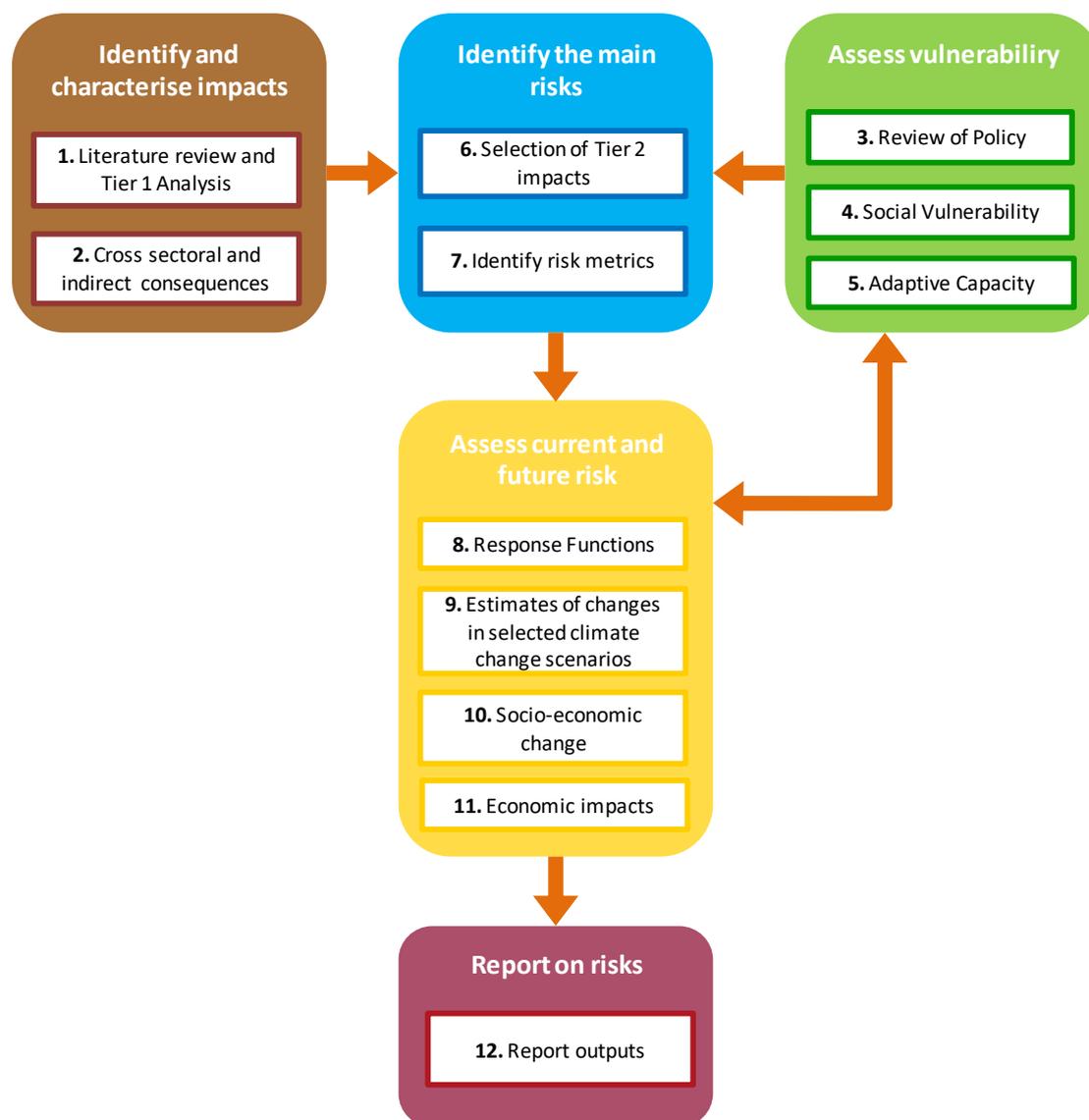


Figure A.1 Steps of the CCRA

1. Identify and characterise the impacts of climate change

Step 1 - Literature review and Tier 1 analysis

This step scopes the potential **impacts** and **consequences** of climate change on Cyprus based on existing evidence and collating the findings from literature reviews, stakeholders organizations and expert opinion. This work develops a Tier 1 list of impacts for each sector. Using the UK CCRA 11 Sector reports as a starting point, a preliminary list of impacts was collated. Impacts were also extracted from recent literature focussed in Cyprus or in the Mediterranean Basin, taking into account the existing and planned activities as well as the special characteristics of each sector.

Step 2 - Cross sectoral and indirect consequences

The Tier 1 lists of each sector in the CCRA were compared and developed further to include cross-sectoral and indirect impacts. The impacts that were identified in this step were added to the Tier 1 list of impacts.

2. Assess vulnerability

Step 3 - Review of Policy

Government policy on climate change develops and changes rapidly to keep pace with emerging science and understanding of how to respond through mitigation and adaptation. Each sector report includes an overview of selected relevant policy as this provides important context for understanding how the risks that are influenced by climate relate to existing policies.

This in turn provides an understanding of the urgency with which adaptation decisions would need to be taken (see Step 6).

Step 4 - Social Vulnerability

The vulnerability of different groups in society to the climate change risks for each sector is considered through a checklist of questions. This information is provided for context based on available data and informed judgement; it is not a detailed assessment of social vulnerability to specific risks.

This analysis however provides an understanding of the potential **magnitude of social impacts** and the **urgency** with which **adaptation** decisions would need to be taken (see Step 6) and where data is available also influences the selection of suitable risk metrics (see Step 7). Note that this step is different from Step 10, which considers how changes in society may affect the risks.

For the purposes of the CCRA, social vulnerability is recognised as a relevant factor in assessing the social consequences of climate change impacts. People who are likely to be most vulnerable to the social impacts of climate change are considered those:

- Living in places at risk
- Who are socially deprived
- Who are disempowered because of lack of awareness, adaptive capacity, support services and exclusion from decision-making.

Within each of these categories, there are a number of social vulnerability characteristics, which are summarised in Table A.1.

Table A.1 Social vulnerability categories and characteristics

Social vulnerability category	Social vulnerability characteristics
People living in places at risk	<ul style="list-style-type: none"> • Location and place
People who are socially deprived	<ul style="list-style-type: none"> • Poor mental and physical health • Fewer financial resources • Living and working in poor quality homes or workplaces
People who are disempowered because of lack of awareness, adaptive capacity, support services and exclusion from decision-making	<ul style="list-style-type: none"> • Limited access to public and private transport • Limited or lack of awareness of risks • Lack of social networks • Little access to systems and support services (e.g. healthcare)

For **each Sector**, as part of the Social vulnerability analysis the above mentioned checklist was taken into account. Similar or overlapping impacts were **grouped** together, where possible, and the following questions were asked of **each group** of impacts:

- Which locations are affected by these impacts?
- Is it spread evenly across regions or not?
- How will people with poor health (physical or mental) be affected by these impacts?
- How will people with fewer financial resources be affected?
- How will people living or working in poor quality homes or workplaces be affected?
- How will people who have limited access to public and private transport be affected?
- How will people with lack of awareness of risks be affected?
- How will people without social networks be affected?
- How will people with little access to systems and support services (e.g. health care) be affected?
- Are any other social vulnerability issues relevant?

Step 5 - Adaptive Capacity

The adaptive capacity of a sector is the ability of the sector as a whole, including the organisations involved in working in the sector, to devise and implement effective adaptation strategies in response to information about potential future climate impacts.

The adaptive capacity assessment influences the risk assessment by improving the understanding of levels of **autonomous adaptation**, which is an important consideration when determining response functions (see Step 8). It also improves the understanding of

decision-making within sectors and contributes to the development of the “urgency” criteria applied to the risk assessment results (see Step 12).

An overview of the adaptive capacity of each sector was carried out through literature review.

3 Identify the main risks

Step 6 - Selection of Tier 2 impacts

The Tier 1 list of impacts for each sector that resulted from Step 2 (see above) was consolidated to select the **higher priority impacts** for analysis in Tier 2. Firstly, similar or overlapping impacts were grouped where possible in a simple **cluster analysis**.

Secondly, the Tier 2 impacts were selected using a **simple multi-criteria assessment** based on the following criteria:

- **Magnitude** – the social, economic and environmental magnitude of consequences;
- **Likelihood** – the perceived likelihood of the impact (or its consequences) occurring;
- **Urgency** – the urgency with which adaptation decisions need to be taken.

These criteria are equally weighted (see Table A.2) and scored following predefined guidelines as detailed in the following tables.

Table A.2 Criteria scoring and weighting

Criteria	Score	Weight
Magnitude / economic	High = 3; Medium = 2; Low = 1	1/3 x 1/3 = 1/9
Magnitude / social	High = 3; Medium = 2; Low = 1	1/3 x 1/3 = 1/9
Magnitude / environmental	High = 3; Medium = 2; Low = 1	1/3 x 1/3 = 1/9
Likelihood	High = 3; Medium = 2; Low = 1	1/3
Urgency	High = 3; Medium = 2; Low = 1	1/3

The formula used to combine scores is the following:

$$100 * \left(\frac{\text{Social} + \text{Environmental} + \text{Economic}}{9} \right) * \left(\frac{\text{Likelihood}}{3} \right) * \left(\frac{\text{Urgency}}{3} \right)$$

This means that the lowest possible score is 3,7 and highest possible score is 100.

Magnitude

Table A.3 Relative magnitude classification criteria

Class	Economic	Environmental	Social
High	Major damage and Disruption	Major or widespread loss or decline in long-term quality of valued habitats	Potential for many fatalities or serious harm or major disruption
	<ul style="list-style-type: none"> Major and recurrent damage to property and infrastructure Major consequence on regional and national economy Major cross-sector consequences Major disruption or loss of national or international transport links Major loss/gain of employment opportunities 	<ul style="list-style-type: none"> Major loss or decline in long-term quality of valued species/habitat/landscape Major or long-term decline in status/condition of sites of international/national significance Widespread Failure of ecosystem function or services Widespread decline in land/water/air quality Major cross-sector consequences 	<ul style="list-style-type: none"> Potential for many fatalities or serious harm Loss or major disruption to utilities (water/gas/electricity) Major consequences on vulnerable groups Increase in national health burden Large reduction in community services Major damage or loss of cultural assets/high symbolic value Major role for emergency services Major impacts on personal security e.g. increased crime
	<i>~ €1 million for a single event or per year</i>	<i>~ 100 ha lost/gained ~ 100 km river</i>	<i>~15.000 affected ~150 harmed ~10 fatalities</i>
Medium	Moderate damage and disruption	Medium-term or moderate loss	Significant numbers affected
	<ul style="list-style-type: none"> Widespread damage to property and infrastructure Influence on regional economy Consequences on operations & service provision initiating contingency plans Minor disruption of national transport links Moderate cross-sector consequences Moderate loss/gain of employment opportunities 	<ul style="list-style-type: none"> Important/medium-term consequences on species/habitat/landscape Medium-term or moderate loss of quality/status of sites of national importance Regional decline in land/water/air quality Medium-term or Regional loss/decline in ecosystem services Moderate cross-sector consequences 	<ul style="list-style-type: none"> Significant numbers affected Minor disruption to utilities (water/gas/electricity) Increased inequality, e.g. through rising costs of service provision Consequence on health burden Moderate reduction in community services Moderate increased role for emergency services Minor impacts on personal security
	<i>~ €100.000 per event or year</i>	<i>~ 10 ha lost/gained ~ 10 km</i>	<i>~1.500 affected, ~30 harmed, ~1 fatality</i>
Low	Minor damage and disruption	Short term/ reversible/local effects sites	Small numbers affected/within 'coping range'
	<ul style="list-style-type: none"> Minor or very local consequences No consequence on national or regional economy Localised disruption of transport 	<ul style="list-style-type: none"> Short-term/reversible effects on species/habitat/landscape or ecosystem services Localised decline in land/water/air quality Short-term loss/minor decline in quality/status of designated sites 	<ul style="list-style-type: none"> Small numbers affected Small reduction in community services Within 'coping range'
	<i>~ €10.000 per event or year</i>	<i>~ 1 ha of valued habitats damaged/improved ~ 1 km river quality affected</i>	<i>~150 affected ~15 harmed</i>

Likelihood

The criteria that apply for the classification of the **likelihood** are presented in Table A.4. The following also apply:

- Likelihood of the consequence is occurring after **autonomous adaptation**.
- The final score should be based on both the **climate variable and the consequence** and **should be the lowest score of the two**. For example:
 - a) There is low confidence that there will be an increase in the frequency of intense storm events, but high confidence that there will be an increase in pluvial flooding, if there is an increase in the frequency of intense storm events. This therefore has a low degree of confidence.
 - b) There is high confidence that there will be an increase in seawater temperatures, but medium confidence that there will be shifts in populations of warm and colder water plankton, if there is an increase in seawater temperatures. This therefore has a medium degree of confidence.
- All emissions scenarios are considered collectively. This is **not a precise exercise at this stage** and requires expert judgement.

Table A.4 Guidance on the classification of likelihood

Class	Likelihood
High	Likely that consequences will occur within the next century <i>(i) High confidence - about 7 out of 10 chance or greater</i>
Medium	About as likely or not to occur in the next century <i>(i) Medium confidence - between 3 and 6 out of 10 chance</i>
Low	Unlikely that consequences will occur within the next century <i>(i) Low confidence - less than 3 out of 10 chance</i>

Urgency

The urgency of decisions is a difficult concept given the uncertainties related to climate change. It aims to identify those decisions required before 2020 and areas with a shortfall in adaptive capacity. It also needs to deal with issues related to flexibility of decisions and potential adaptation pathways. The criteria are set out in summary and more detailed form below. By focusing on “urgent” decisions, the CCRA will help to avoid the risk of maladaptation to climate change. For the classification of the **urgency of decisions** the criteria that are presented in Table 2.5 will be followed. **Year 2020** is chosen as the ‘**high urgency**’ threshold to cover the set of decisions that will be taken, or are likely to be initiated, prior to **the next CCRA**. Major decisions typically take three years or more from initiation to finalisation and are increasingly difficult to influence during this period. This means 2017 to 2020 decisions would be very hard to influence as a result of the next CCRA, which would be more likely to influence decisions taken between 2020 and 2025.

Table A.5 Guidance on the classification of the “urgency of decisions”

Class	Urgency	Response
High	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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. There is some shortfall in adaptive capacity with a limited risk of locked-in maladaptation unless action is taken to raise adaptive capacity 	Watch Carefully
Low	<ul style="list-style-type: none"> 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

Scoring

The scoring for each impact or cluster of impacts was based on expert judgment and feedback from Contracting Authority and the stakeholder organisations. The project Manager supervised scoring carried out in each sector and ensured that a consistent approach was taken across all the sectors.

For the Biodiversity & Ecosystem Services sector a slight adjustment was made to the generic scoring approach set out above based upon the definition of environmental, social and economic criteria.

The first UK CCRA identified more than 700 impacts in the Tier 1 assessment for all sectors. With the time and resources available, it was considered impossible to undertake a detailed analysis of all of the Tier 1 risks, and so a selection process was carried out. The Tier 1 list of impacts resulting from Step 2 was scored in order to select the higher priority impacts for analysis, known as Tier 2 impacts. It was estimated early on that it was only going to be possible to analyse in detail around 100 impacts out of a total of around 700, which meant that the impacts that had a **combined score of around 30 or over were selected**. In this CCRA the same score threshold was applied.

Step 7 - Identifying risk metrics

Once the Tier 2 list of impacts was finalised, the next step was to determine whether the **impact can be measured and, if so, how**. For each impact in the Tier 2 list, one or more risk metrics will be identified. **Risk metrics provide a measure of the consequences of climate change**, related to specific climate variables or biophysical impacts. The risk metrics were developed to provide a spread of information about economic, environmental and social consequences.

4 Assess current and future risk

Current risks

An understanding of **current risks** will be the starting point for the assessment in each sector. This involves a literature review (e.g. CYPADAPT Project) and collecting the best information available on current risks from Government departments.

Future risks

Step 8 - Response functions

Step 8 established how each risk metric varies with one or more climate variables using available data or previous modelling work. This step is only possible where evidence exists to relate metrics to specific climate drivers, and it is highly likely that will not be possible for all of the Tier 2 impacts. This step will be carried out by developing a '**response function**', which is a relationship to show how the risk metric varies with changes in climate variables. Some of

the response functions will be qualitative, based on expert elicitation, whereas others will be quantitative.

It must be noted that the UK CCRA was based on a wide range of existing studies on the impacts of CC in UK. The data availability between UK and Cyprus is not quite comparable.

Given the time restrictions of the current contract and as the terms of reference state “This evidence report will be largely based on available evidence, rather than through commissioning significant new research. The approach to the analysis for each threat or opportunity considered was guided to a large extent by what is or was available during the study period.

Step 9 - Estimates of changes in selected climate change scenarios

The response functions were used to assess the magnitude of consequences due to climate change by making use of climate projections. The purpose of this step is to provide the estimates for the level of future risk (threat or opportunity), as measured by each risk metric.

We provided estimates of future risk under the two (2) most plausible Representative Concentration Pathway (RCPs) scenarios i.e. **RCP8.5** (the most **severe scenario**, featuring the highest emissions and $8,5 \text{ Wm}^{-2}$ of global mean radiative forcing by 2100 relative to the pre-industrial times), and **RCP4.5** (a **medium scenario**, featuring $4,5 \text{ Wm}^{-2}$ radiative forcing in 2100).

The results from these scenarios were 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 were 2041-2060 (2050s) and 2071-2090 (2080s), to assess climate change in mid and late 21st century.

The baseline period against which the changes were computed is **1991-2010**. The 1961-1990 baseline often used in climate change science studies is avoided here, given that climate change has evolved over the past few decades, and therefore 1961-1990 is not representative of the ‘present-day’. The choice of a 20 year length is a compromise between having enough data to give reasonable estimates for the key variables (both their means and extremes) and being relevant for the present-day (e.g. choosing a 30-year period would inevitably move the centre of the baseline period in the mid-1990s, which is too early as a present-day estimate). We avoid having 2015 as the centre of the present-day period, as that would inevitably require using data from 10 years of future simulations (2016-2025, in addition to 2006-2015), and that would diminish the value of any efforts to evaluate this simulation with observations from the recent past.

Step 10 - Socio-economic change

Many of the risk metrics in the CCRA are influenced by a wide range of drivers, not just by climate change. The way in which the social and economic future develops will influence the risk metrics. **Growth in population** is one of the major drivers in influencing risk metrics and

may result in much larger changes than if the present day population is assumed. For some of the sectors where this driver is particularly important, future projections for change in population were considered to adjust the magnitude of the estimated risks derived in Step 9.

Step 11 - Economic impacts

Where possible, an attempt was made to express the magnitude of individual risks in monetary terms. The aim is to express the risk in terms of its effects on human welfare, as measured by the preferences of individuals in the affected population.