

# Climate Change in Cyprus: Impacts and Adaptation Policies

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## Abstract

This paper provides an overview of facts and projections related to climate change in Cyprus until the end of the 21st century. It highlights the main climate change impacts foreseen and presents recommendations for the preparation of a national adaptation strategy. Coping with climate change is possible, provided that proactive actions are taken by both the public and the private sector. Public authorities need to set clear priorities and implement well designed policies. Most importantly, adequate monitoring mechanisms should be set up in order to provide much needed data which can send early warnings to policy makers and the public and can help avoid large natural and economic damages at a later stage. Enabling private adaptation investments and properly pricing the use of natural resources are key priorities for investing in a climate resilient economy.

**Keywords:** Climate change, natural resources, pricing.

## 1. Introduction

According to the current scientific consensus, warming of the global climate system seems to be unambiguous, as is now evident from observations of increases in global average air and ocean temperatures, melting of snow and ice and rising global average sea levels (IPCC, 2007). In the European continent, Mediterranean Europe is expected to experience the most adverse climate change effects. Therefore, Cyprus is located in a hot spot and is projected to face significant temperature increases and decline in rainfall levels. As a result, serious negative effects of climate change should be expected in the coming decades in various sectors.

This paper provides an overview of facts and projections related to climate change for Europe, Mediterranean and Cyprus until the end of the 21st century. It highlights the main climate change impacts, focuses on specific effects on Cyprus and presents recommendations for the preparation of a

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national adaptation strategy. What follows is based on a review by Shoukri and Zachariadis (2012) of the most important recent studies on climate change, including reports from international, European and Mediterranean institutions, as well as from research projects and scientific articles. We have also benefited from information gathered through personal communication with public authorities, non-governmental organizations and researchers.

In general, it is expected that climate change will exacerbate the pressures on the country'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, agricultural production, nature, human health, energy needs and tourist inflows. These are explained in more detail in this paper.

Such effects, however, are not inevitable. Coping with climate change is possible, provided that proactive actions are taken by both the public and the private sector. Therefore, this paper ends with a list of adaptation measures by sector and discusses economic and fiscal aspects of such policies. Public authorities need to set clear priorities and implement well designed policies in order to mitigate the main adverse impacts outlined in the paper. Adapting to climate change will involve both private and public expenditures which, if carefully implemented, may help the society avoid larger costs from serious climate change induced damages in the future.

## **2. Climate projections for Europe and Cyprus**

According to the United Nations Intergovernmental Panel on Climate Change (IPCC), climate change is a change in the state of the climate that can be empirically identified (e.g. using statistical tests) by changes in the mean and/or the variability of climate properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. As anthropogenic emissions of greenhouse gases are primarily responsible for recent climate changes, it is the control of these emissions that can help stabilise the earth's climate. Therefore, the United Nations Framework Convention on Climate Change (UNFCCC) focuses specifically on anthropogenic climate change, i.e. 'the change of climate that is attributed directly or indirectly to human activity, that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods'.

Recent observations confirm that the global mean temperature has increased by 0.8°C compared with pre-industrial times for land and

oceans, and by 1.0°C for land alone. Europe has warmed more than the global average (1.0 and 1.2°C, respectively), especially in the south-west, the north-east and mountainous areas. Projections suggest a further temperature increase in Europe, higher than the average warming predicted on a global scale (EEA, 2008).

Despite the many uncertainties associated with climate model simulations, many features of the simulated climate change in Europe and the Mediterranean are qualitatively consistent among the different models employed by the scientific community. Thus the most important projections for Europe are summarised below (IPCC, 2007; EEA, 2008):

- Temperature increases from 1.0°C to 5.5°C should be anticipated by the end of the 21st century, which are higher than projected global warming (1.8-4.0°C), with the largest warming over Eastern and Northern Europe in winter, and over Southern Europe and Mediterranean in summer.
- Changes in rainfall show more spatially variable trends across Europe. Annual rainfall changes are already exacerbating differences between a wet northern part (an increase of 10-40 % during the 20th century) and a dry southern part (a decrease of up to 20% in some parts of Southern Europe).
- The intensity of rainfall extremes has increased in the past 50 years, and these events are projected to become more frequent.
- Dry periods are projected to increase in length and frequency, especially in Southern Europe.
- The annual number of precipitation (rainfall) days is very likely to decrease in the Mediterranean area.
- The risk of summer drought is likely to increase in Central Europe and the Mediterranean.
- High-temperature extreme events like hot days, tropical nights and heat waves have become more frequent. According to projections, Southeast Europe will be among the most affected world regions in the years to come.
- Sea level and sea surface temperature of some European seas could rise more than the global average.

### 3. Climate change impacts by sector

On a global scale, climate change is associated with a wide range of consequences, such as changes in rainfall levels, sea level rise, droughts, glaciers loss, melting of snow and ice sheets and extreme weather events like heat waves, floods and storms. These primary effects of global warming are leading to successive cumulative impacts on various sectors. Table 1 provides an overview of the type and magnitude of these effects in Europe. It is evident that Mediterranean Europe is expected to experience the most adverse climate change effects compared to other European regions. Therefore, this section highlights the major impacts and focuses on the most vulnerable sectors for Cyprus.

TABLE 1

*Summary of climate change impacts in Europe and their intensity*

Climate change indicator	Northern Europe	Central & Eastern Europe	Mediterranean
Direct losses from weather disasters	M(-)	M(-)	H(-)
River flood disasters	M(-)	H(-)	L(-)
Coastal flooding	H(-)	M(-)	H(-)
Public water supply and drinking water	L(-)	L(-)	H(-)
Crop yields in agriculture	H(+)	M(-)	H(-)
Crop yields in forestry	M(+)	L(-)	H(-)
Biodiversity	M(+)	M(-)	H(-)
Energy for heating and cooling	M(+)	L(+)	H(-)
Hydropower & cooling for thermal plants	M(+)	M(-)	H(-)
Tourism and recreation	M(+)	L(+)	M(-)
Health	L(-)	M(-)	H(-)

Source: Behrens et al. (2010).

Notes: H: High; M: Medium; L: Low; (+): Positive impact; (-): Negative impact.

#### 3.1. Water resources

Temperature rise has already affected the water cycle globally, as observed by the occurrence of events such as reduced rainfall, altered patterns of snowfall as well as melting of snow and ice caps, increased frequency and intensity of droughts, and increasing water temperature and changes in soil humidity. The above events pose direct and cumulative impacts on water resources. In turn, stressed water resources pose adverse effects on economic sectors like tourism, industry, agriculture and food production;

they may additionally lead to further adverse societal impacts, changes in land use and economic activities and further urbanisation.

The Mediterranean is very likely to face continuous droughts and hence suffer from increasing water scarcity, declining crop yields and desertification. Water availability may fall by 20-30% under a 2°C increase global warming scenario and by 40-50% under a 4°C warming scenario. Summer water flows may be reduced very substantially. Water demand for agriculture, which has already risen considerably in Mediterranean areas in the last decades, is projected to continue, thus increasing competition for water between sectors and uses (EEA, 2008). Problems related to the quality of drinking water will be exacerbated.

In Cyprus, serious water scarcity is highlighted by the Water Exploitation Index, which reaches about 45%, indicating severe stress on water resources and unsustainable water use (Eurostat, 2010). This Index expresses the available water resources compared to the amount of water used in a country (European Commission, 2007). Moreover, Cyprus possesses the lowest amount of annual freshwater resources per capita in the EU (Eurostat, 2010; European Commission, 2007). The country has already experienced severe droughts and water scarcity events, the most pronounced recent one being in year 2008, where it had to import water from Greece to satisfy drinking water demand and to impose restrictions on household supply. Furthermore, Cyprus is severely over-stressing groundwater resources since it is exploiting groundwater beyond what has been set as the ecological limit. In 2007 it extracted more than 100% of the groundwater available for annual abstraction (Eurostat, 2010).

According to a recent study, which extends up to year 2030 only, annual costs of water shortages in the residential and industrial sector may reach €88 million at 2009 prices. Out of these, €16-32 million will be additional costs because of reduced water availability due to climate change (Zachariadis, 2010a).

### **3.2. Ecosystems and biodiversity**

Apart from their ecological value, ecosystems provide various valuable services that human well-being depends on, like food, water, energy, purification of water and air, primary production, cultural services etc. Overexploitation of those services and natural resources, bad land use practices and unsustainable development have rendered ecosystems more vulnerable to climate change and thus less capable of adapting. Climate change impacts on ecosystems create chain effects that can intensify global warming, since ecosystems play an important role in climate regulation.

Forests are a special part of the ecosystem that plays a vital role in maintaining a stable global climate and offers a lot of services and products with economic value. They are purifying water and influencing rainfall patterns, as well as protecting against extreme events, protecting aquifers, improving air quality, and provide shelter to biodiversity. Forests in Europe will be affected by climate change, in terms of distribution, species composition, yields, storms and fires. In South Europe forest area is projected to contract. More frequent and severe summer droughts are likely to lead to reduced productivity, more extensive forest fires and, ultimately, desertification in some areas. Water scarcity and heat stress in the Mediterranean are expected to result in an increased frequency of forest mortality events, which will affect forest diversity.

Mediterranean biodiversity and ecosystems are vulnerable to climate change and predicted to suffer from water scarcity and heat stress because of temperatures above the heat comfort. Moreover, sea-level rise may reduce habitat availability for bird species. Plant species losses of up to 62% are projected for the southern regions of Europe, particularly in the mountainous areas. Natural adaptation to a changing climate may not be sufficient to retain the current value of ecosystem services.

Cyprus has a rich biodiversity - one of the highest in Europe, This biodiversity is currently threatened by the invasion of alien species, epidemics from livestock-borne diseases affecting wildlife and from wildlife mismanagement practices. However, the available evidence cannot yet confirm whether these species are threatened due to climate change or for other reasons. The forests of Cyprus suffered detrimental impacts during 2005 to 2008 due to drought. There are no simulation results about the projected impacts of climate change on Cyprus forests, but concerns are expressed regarding impacts related to temperature increase and rainfall decline.

### **3.3. Agriculture**

Agricultural production is directly linked to climatic conditions. Crop yields are mainly affected by rising temperatures, changing water resources and increasing carbon dioxide concentrations. Mediterranean countries are expected to be severely affected by climate change and will face most adverse effects on natural conditions for crop cultivation, leading to higher economic losses. The crop growing season, the timing of the cycle of agricultural crops and average yields will be affected by a changing climate. More frequent occurrences of weather extremes, such as dry spells and heat waves, will potentially damage agriculture more than changes in the annual average temperature. Pest outbreaks and increase in the

frequency of diseases, induced by higher temperatures, may pose additional risk for crop production. Although many crops show positive responses to elevated carbon dioxide and some moderate levels of warming, higher levels of warming will negatively affect both crop growth and crop yields.

A study carried out recently for Cyprus concluded that climate variability, high temperatures and limited rainfall restrict crop production in Cyprus. Annual crop yields may decrease by 41-43% in the immediate future compared to the recent past (Bruggeman et al., 2011); this can bring about economic losses up to €80 million on an annual basis.

### **3.4. Human health**

Climate change is considered as a direct and indirect threat to public health, even though assessments and projections on the type and extent of the impacts are still surrounded by a high degree of uncertainty. Harmful health impacts of climate change are related to increasing heat stress, extreme weather events, poor air quality, water and vector borne diseases. The direct effects are caused by extreme weather events, and the indirect ones are a result of poor air and drinking water quality, diseases, food insecurity and ecological changes.

Studies indicate an increase in the heat-related mortality rate, with much greater rates in South Europe, due to the greater warming trend in this region. The rise in temperature, heat waves and summer peaks may add considerably to heat-related deaths, especially among elderly people. Considering the ageing of the population this may become a serious problem for the Mediterranean. Additionally, deterioration of air quality in urban areas (due to forest fires and heat-induced increase in atmospheric concentrations of pollutants such as ozone and particulates) will lead to increased morbidity and mortality (allergies, respiratory diseases). The World Health Organisation confirms that the distributional patterns of some infectious diseases (e.g. West Nile virus) are influenced by climate, and are gradually expanding to northern latitudes (WHO, 2003). Moreover, some water and food-borne disease outbreaks – such as salmonella problems – are expected to become more frequent with rising temperatures and more frequent extreme events.

There are no data or projections available for Cyprus regarding climate change impacts on human health. The State General Laboratory of Cyprus is participating in European projects exploring the potential effects of climate change on food safety, but no concrete results have been publicised so far. However, the international experience outlined above makes it

necessary for national authorities to continuously monitor air, water and food quality in order to be prepared for emergency actions if necessary.

### **3.5. Coastal zones**

Coastal areas are likely to be exposed to increasing risks over the coming decades due to further climate change and sea-level rise. Anticipated impacts include damages from floods and storms, soil erosion, sea water intrusion and salination of groundwater reservoirs, and degradation of coastal ecosystems and wetlands. The impact of climate change on coasts is exacerbated by increasing human-induced pressures. The direct impacts of human activities on the coastal zone have been more significant over the past century than impacts directly attributed to climate change. Coastal erosion is observed on many shorelines around the world, but it is uncertain to what extent it is associated with human activities or results from global warming. It is anticipated that coastal erosion rates will increase and existing defences may provide insufficient protection.

Studies project that the expected rise in sea level will entail the submersion of low lying coastal areas in the Mediterranean. According to the European Commission, under a scenario of a 0.5 metre rise in the sea level by 2100 the population exposed to the risk of coastal flooding will double in certain regions (Athens, Naples, Lisbon and Barcelona), leading to a considerable loss of assets. Foreseen erosion and flooding are expected to cause damage to coastal infrastructures (roadways, airports, sewerage systems etc), resulting in substantial economic losses.

Greek authorities project that the impacts may be significant in the coming decades in the country. According to a projection based on 0.5 m SLR by 2100, 15% of the current total area of coastal wetlands in Greece is expected to be flooded; estimated economic losses exceed €350 million. In Israel, research studies have shown that sea level in the Israeli coast is expected to rise by some 0.5 metre by 2050 and by approximately 1 metre by 2100. An estimate of the Israel's Ministry of Environmental Protection is that 8.4 km<sup>2</sup> of beaches may be lost by the year 2060, with an economic damage of NIS 4-5 billion (about €1 billion).

The coastal zone of Cyprus, defined as 2km inland from the coastline, represents 23% of the country's total area. The island has a total 735 km shoreline, of which about 385 km are under Turkish occupation since 1974. The shoreline subject to erosion is 110 km long, or 30% of the coastline under control of the Republic of Cyprus. Uncertainty exists regarding the net value of sea level rise, since reports argue that vertical land movement is counteracting this potential effect. 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. Increased erosion and sea level rise could worsen the serious problem that Cyprus faces with seawater penetration to coastal aquifers and their salination.

### **3.6. Energy supply and demand**

Climate change will have a direct effect on both the supply and demand of energy. There will be positive effects to hydropower production in northern Europe due to higher rainfall levels and glacier melt. Conversely, hydropower production in southern Europe is projected to decrease by 25% or more by 2050 and up to 50% by the 2070s, as the hydropower sector highly depends on water. Furthermore, extreme heat waves can pose a serious threat to uninterrupted electricity supply, mainly because cooling air may be too warm and cooling water may be both scarce and too warm. As a result, energy demand may not be able to be met in the warm period. Additional capacity may need to be installed adding extra cost to energy production. Extreme weather events, flooding and storm surges could damage infrastructure in vulnerable areas causing power outages. On the demand side, energy requirements for heating in winter will decrease in higher latitudes while demand for summer cooling will rise in South Europe.

For Cyprus, a recent study assessed the impact of climate change on electricity use, based on the assumption that average temperature in the Eastern Mediterranean is expected to rise by about 1°C by 2030 (Zachariadis, 2010b). It projects that electricity consumption in Cyprus may be about 2.9% higher in 2030 than in the “no climate change” scenario. The welfare loss because of additional electricity needed to achieve the same thermal comfort with the “no climate change” scenario can reach €15 million in 2020 and €45 million in 2030 (at constant prices of year 2007). The present value of costs for the entire period 2008-2030 may exceed €200 million, and average costs borne per household are expected to be approximately €30 per year in 2020 and rise to €80 per year in 2030. Additionally, extra peak electricity load requirements in the future because of climate change may amount to 65-75 MW in 2020 and 85-95 MW in 2030, indicating increased requirements for reserve capacity.

Climate change may also 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. During heat waves, sea water (which is the cooling agent of power generating units in Cyprus) is warmer, resulting to insufficient cooling of the generating units leading to less efficient – and therefore more costly – power generation.

### **3.7. Tourism**

Climate change has the potential to radically alter tourism patterns in Europe by inducing changes in destinations and seasonal demand structure. If unsustainable forms of tourism continue they could exacerbate the negative effects of climate change. More specifically, traditional summer destinations like the Mediterranean are likely to suffer from a decline in tourism in the longer term because of worsening weather and climatic conditions. It is expected that the thermal comfort of tourists and their ability to acclimatise to a region prone to high temperatures and heat waves may be heavily affected, resulting in a gradual decrease in summer tourism; at the same time it could lead to an increase in spring and autumn tourism. South Europe, which currently accounts for more than half of the total EU capacity of tourist accommodation, would face a decline in bed nights, estimated to range between 1% and 4% by the 2080s compared with the 1970s, which is translated to losses ranging from €1.8 to 12.9 million depending on the climate scenario. Water scarcity could affect the sector even more than the consequences of climate change on tourist comfort, substantially limiting its growth and sustainability in some areas.

In line with other Mediterranean countries, Cyprus will most likely face a decrease in summer tourism, associated with a seasonal shift in tourist distribution in spring and autumn.

## **4. The challenge of climate change adaptation**

### **4.1. Adaptation measures**

Adaptation to climate change refers to an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007).

It is widely accepted that even if greenhouse gas emission reduction targets are reached through global action, climate change will take place to some extent, because the emitted greenhouse gases will continue to trap heat and increase the earth's average temperature. Although Cyprus contributes a negligible amount of emissions to global warming, it is likely

to suffer considerable climate change impacts because of its location in one of the most vulnerable regions of the planet. Therefore, the formulation and implementation of a strategy on adaptation to climate change is a *sine qua non* for the country.

In general, the adaptation strategy has a preventive role and the policies and measures aiming to tackle the impacts of climate change should be developed prior to the onset of those impacts. In order to reduce the possible harm to people, property, services and to nature/ecosystems a country must develop a preventive adaptation strategy, which should be revised and updated on a regular basis.

Financial constraints are considered as an inhibiting factor for the implementation of an adaptation strategy. In order to reduce the dependence of the implementation on any financial needs it is advisable, at this stage, to set quick start actions, which are easy to implement and do not require any investments like the horizontal integration of adaptation in all policies full use of existing EU legislation and use of plans and projects already included in the state budget.

For an effective implementation, the adaptation strategy should define the authorities and stakeholders involved in the implementation, adopt a time schedule, make use of proper financing instruments and set a monitoring mechanism. As the adaptation measures will incur both private and public costs, a prerequisite for effective implementation of a strategy for adaptation is the collaboration between the public and private sector as well as public consensus and cooperation. Adapting to climate change will involve all levels of participation and action - individual, social, state, regional to global level.

The adaptation measures outlined below reflect the observed and projected impacts of climate change in Cyprus as summarised in the previous sections.

- For water resources the measures should enhance ecosystem storage capacity, protect surface and groundwater quality, promote good condition of soil, enhance water management and efficient water use, and implement appropriate water pricing to reflect scarcity and environmental costs.
- For biodiversity an inventory of all species has to be compiled and especially those species that are sensitive to climate change should be monitored. Alien species must be recorded in order to prevent their expansion to the extent possible. Sustainable use of ecosystem services and natural resources should be promoted for this purpose.

- Special attention must be given to improve forest resilience to fires by classifying forests according to the risk of fire and establishing early warning systems and water supply systems for firefighting.
- For agriculture, sustainable use of water resources with special attention to halt overexploitation of groundwater and to improve irrigation management should be implemented. Sound use of chemical pesticides/herbicides and fertilizers must be applied to protect soil and water resources from pollution/degradation.
- For the public health sector data must be collected and an inventory must be completed on water and food borne diseases, and disease control and prevention must be promoted. Health and social care systems must develop contingency plans to cope with potential disease outbreaks. The implementation of measures for air quality improvement in urban areas must be enhanced. Air and drinking water quality must be monitored and strict inspections in food production and service industry must be applied.
- For coastal zones, research on sea level rise must be promoted, in order to monitor vulnerable sites and simulate eventual future effects. An inventory of coastal areas prone to erosion risk must be prepared. The possibility to implement additional erosion protecting measures should be examined, like the protection of wetlands and sand dunes.
- For energy supply and demand, energy efficiency improvements are very important. Implementation of proper carbon pricing for all fuels and raising of public awareness play a key role for encouraging energy conservation. Long-term electricity generation plans have to be adjusted in order to account for additional capacity needed due to climate change, giving priority to renewable electricity generation.
- For the tourism sector, guidelines for adaptation to climate change must be developed. The tourism industry should rapidly respond to the expected decrease in summer tourism and to the shift in tourists' distribution to spring and autumn and must take action to combat the emerging competitiveness from other destinations in Europe, which will be favoured by climate change. Additionally, the tourism industry should make investments in infrastructure/technologies to upgrade facilities to face increased temperature and water shortage.
- Society must be informed and mobilised in order to get prepared for climate change adaptation measures. Funds should be foreseen to enable low-income households to afford capital expenditures for adaptation/mitigation measures, in order to avoid 'energy and climate poverty'. The country's Social Security Services need to prepare a

proper strategy and the insurance sector should consider developing new insurance products to cover climate change related risks.

#### **4.2. Economic and fiscal aspects**

As shown in Section 3, some of the eventual climate change impacts are known with less uncertainty than others. Pressure on water resources, energy supply, agriculture, forestry and tourism is well recognised in Cyprus, and national strategies to tackle these problems already exist to some extent. Examples of such policy responses are the national strategy for sustainable development, the sustainable water management strategy, legislation and grant schemes for improving energy efficiency in buildings, and forest protection measures. In general, these policies are well designed and are in line with (or a consequence of) policy initiatives in the European Union. Successful implementation of these policies is a key priority in these sectors.

Other impacts, however, are associated with more uncertainty. Even if it seems likely that public health, biodiversity and coastal infrastructure will be threatened as a result of climate change, the extent and degree of such adverse effects is unknown, mainly because the monitoring and data collection infrastructure is inadequate or simply unavailable in the country. In these sectors, it is important to establish monitoring mechanisms in order to provide much needed data which can send early warnings to policy makers and the public and can help avoid large natural and economic damages.

In times of fiscal consolidation, however, it is questionable whether governmental mechanisms can provide sufficient funds to implement the long list of adaptation measures presented in Section 4.1. In order to prioritise some actions, some remarks are necessary to keep in mind<sup>1</sup>.

It is widely accepted that the cost of some adaptation measures can help avoid much larger costs in the future. To provide a few examples, changing agricultural production towards more heat-resistant crops, improving the energy efficiency of buildings, and investing in order to make the country more attractive for winter tourism can prepare the economy for the future and thereby can reduce the costs of the impacts of climate change in the coming decades.

Apart from public sector costs, many adaptation measures will require expenditures from the private sector such as farmers, home owners and enterprises. Therefore, the direct fiscal cost of such measures is expected to

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<sup>1</sup> See also Jones et al. (2012).

be moderate – unless sudden and strong changes in the climate happen in the future which cannot be avoided through private investments only.

Still, private adaptation measures may prove to be inadequate due to insufficient information or unavailability of private funds, particularly if climate change induced events are abrupt or irreversible (e.g. prolonged heat waves, storms or floods). In this case government intervention and increased public spending will be necessary in order to alleviate the damages. This underlines the need for authorities to install proper monitoring mechanisms and early warning systems in order to inform citizens (e.g. home owners and enterprises in coastal areas) about future risks.

In order to make access to capital easier for the private sector, the government may consider providing economic incentives for climate change adaptation investments in vulnerable sectors (in the form of direct grants, aid or guarantees for specialised private insurance schemes).

Finally, the importance of pricing policies should not be underestimated. Proper pricing of water and energy as well as charges for unsustainable use of resources (such as congestion charging) can become a key priority for mitigating climate change impacts. If prices incorporate the costs of natural resource scarcity as well as the costs of environmental degradation caused by the use of these resources, this can have a double positive effect:

- First, it will discourage the use of these resources. The price elasticity of water, electricity or fuel use is low but is not zero; consumers adapt to higher prices, particularly in the medium and long term. In this way it will become easier for consumers to adapt to a future arid climate.
- Second, it can provide much needed public revenues which can finance investments in adaptation measures. For example, national funds from participation of industries in the EU Emissions Trading System will be partly used for promoting renewable energy investments; a similar approach can be applied for revenues coming from other pricing schemes.

According to the OECD, environmental and natural resource taxes and charges are among the most promising measures to improve public finances without being detrimental to economic growth (Hagemann, 2012). Policymakers in Cyprus should seriously consider including such charges in future policy measures.

## 5. Conclusions

According to the current scientific consensus, warming of the global climate system seems to be unambiguous. The Mediterranean Basin is considered amongst the geographic areas that are most vulnerable to climate change, and is expected to experience adverse climate change effects. Therefore, Cyprus is located in a hot spot and is projected to face significant temperature increases and decline in rainfall levels. An apparent trend of temperature increase and rainfall decline has been recorded for the 20th century. Cyprus faces a severe danger for desertification, which is expected to worsen with climate change.

Forecasts from regional climate model simulations for the 21st century highlight the vulnerability of Cyprus to climate change by projecting an increase in maximum temperature of 1.3-1.9°C for 2021-2050 and 3.6-5°C for 2071-2100, and a sharp decrease in rainfall by the end of the century. As a result, several direct and indirect impacts are expected in various sectors. Water resources will be increasingly stressed so that the already existing risk of desertification will increase. The biodiversity of the island may suffer from serious extinction of species and further invasion of alien species. In forests, the impacts may involve frequent forest mortality events and increased forest fire risk. In agriculture, a substantial portion of the island's crop and livestock production will be endangered. In public health, there will be a higher risk of emergence of specific diseases. Coastlines along the island are expected to experience serious degradation and sea water intrusion due to rising sea level. In the energy sector, additional power generation capacity will be needed in order to fulfil rising needs for space cooling during hotter summers and sea water desalination. The tourist sector may experience a significant loss of summer tourist arrivals due to increasingly inconvenient weather conditions during the hottest months of the year. There may also be impacts on the society in general: health deterioration will increase health care expenditures, increase insurance rates and affect labour productivity; adverse effects in various economic sectors may also lead to job losses.

Such effects, however, are not inevitable. Coping with climate change is possible, provided that proactive actions are taken by both the public and the private sector. Public authorities need to set clear priorities and implement well designed policies in line with the projected impacts and the recommendations outlined in this paper. Most importantly, adequate monitoring mechanisms should be set up in order to provide much needed data which can send early warnings to policy makers and the public and can help avoid large natural and economic damages at a later stage. Enabling private adaptation investments and properly pricing the use of

natural resources are key priorities for investing in a climate resilient economy.

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### **References**

Behrens A., Georgiev A., Carraro M., (2010) Future Impacts of Climate Change across Europe. Center for European Policy Studies (CEPS) Working Document No. 324, Brussels.

Bruggeman A., Hadjinicolaou P., Lange M. A., Zoumidis C., Pashiardis S., Zachariadis T., (2011) Effect of climate variability and climate change on crop production and water resources in Cyprus. The Cyprus Institute, Cyprus University of Technology, Cyprus Meteorological Service.

European Commission, (2007). Water scarcity and droughts. In depth assessment; Second Interim Report. Directorate General for the Environment, Brussels.

European Commission, (2009) White Paper – Adapting To Climate Change: Towards A European Framework For Action, Brussels.

Eurostat, (2010) Water statistics, available at [http://epp.eurostat.ec.europa.eu/statistics\\_explained/index.php/Water\\_statistics](http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Water_statistics)

European Environment Agency, (2008) Impacts of Europe’s changing climate – 2008 indicator-based assessment, EEA Report No.4/2008, Copenhagen, Joint EEA-JRC-WHO report.

Hagemann R., (2012) Fiscal Consolidation: Part 6. What Are the Best Policy Instruments for Fiscal Consolidation? OECD Economics Department Working Papers, No. 937, Paris, France.

IPCC, (2007) Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri R. K. and Reisinger A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.



Jones B., Keen M., Strand J., Fiscal Implications of Climate Change. Policy Research Working Paper No. 5956, The World Bank Development Research Group, Washington, DC, January 2012.

Shoukri E., Zachariadis T., (2012) 'Climate Change in Cyprus: Impacts and Adaptation Policies'. Environmental Policy Research Group Report 01-12, Cyprus University of Technology, Limassol, Cyprus. Available at [http://works.bepress.com/theodoros\\_zachariadis/24](http://works.bepress.com/theodoros_zachariadis/24).

WHO (World Health Organisation), 2003. Health and Global Environmental Change. Methods of assessing human health vulnerability and public health adaptation to climate change. ISBN 92-890-1090-8.

Zachariadis T., (2010a) Residential Water Scarcity in Cyprus: Impact of Climate Change and Policy Options. *Water* 2, 788-814.

Zachariadis T., (2010b) Forecast of electricity consumption in Cyprus up to the year 2030: The potential impact of climate change. *Energy Policy* 38, 744-750.