THE IMPACT OF CLIMATE CHANGE IN WATER RESOURCES IN CYPRUS AND POSSIBLE HUMAN HEALTH EFFECTS

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INTRODUCTION

Climate is often described as the synthesis of weather recorded over a long period of time. It is defined in terms of long-term averages and other statistics of weather conditions, including the frequencies of extreme events. [1]. Also climate is not static and can be defined as weather patterns change from day to day, over a range of time frames from years, decades and centuries to millennia, and on longer time-scales corresponding to the geological history of the earth. These naturally occurring changes, driven by factors both internal and external to the climate system, are intrinsic to climate itself. However climate changes unfortunately are driven not only from natural processes. Human's activities have influence climate through building cities and altering patterns of land use. Also, human activities contribute to climate changes through a range of activities since the industrial era of the mid-19th century, such as accelerated use of fossil fuels, broad scale deforestation and land use changes. This processes enhanced greenhouse effect results from an increase in the atmospheric concentrations of the greenhouse gases, such as carbon dioxide and methane that is widely believed to be responsible for the observed increase in global mean temperatures through the 20th century.

The greenhouse effect is a natural process that plays an important role in shaping the earth's climate. It is responsible for the relatively warm and hospitable environment near the earth's surface where humans and other life-forms have been able to develop and prosper. However the relationship between the enhanced greenhouse effect and global climate change is far from simple since increased concentrations of greenhouse gases affect the atmosphere, but also the oceans, soil and biosphere. Therefore the greenhouse effect is one of the large number of physical, chemical and biological processes that combine and interact to determine the earth's climate [1].

It is generally accepted though that Green House Gas(GHG) emissions are the major contributor to anthropogenic climate change. In order to assess their impact on global climate, baseline emissions scenarios have been developed and are presented in the IPCC Special Report on Emissions Scenarios (SRES) [2]. IPCC Intergovernmental Panel on Climate Change was created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) for the risk assessment of climate change and for providing information on options for mitigation and adaptation the scientific. The IPCC is a scientific intergovernmental body and its purpose is to convene committees of scientists that are nominated by their governments to consider the scientific literature in peer-reviewed publications of the scientific, technical and socio-economic information available relating to climate change, its environmental and socio-economic impacts, and from time to time to publish periodic "Assessment Reports" of what the published scientific literature reveals. The tasks of the IPCC have been divided into three separate Working Groups, each of which is expected to draw up an Assessment report approximately once every five years relating to the specific realms of published research they have reviewed.

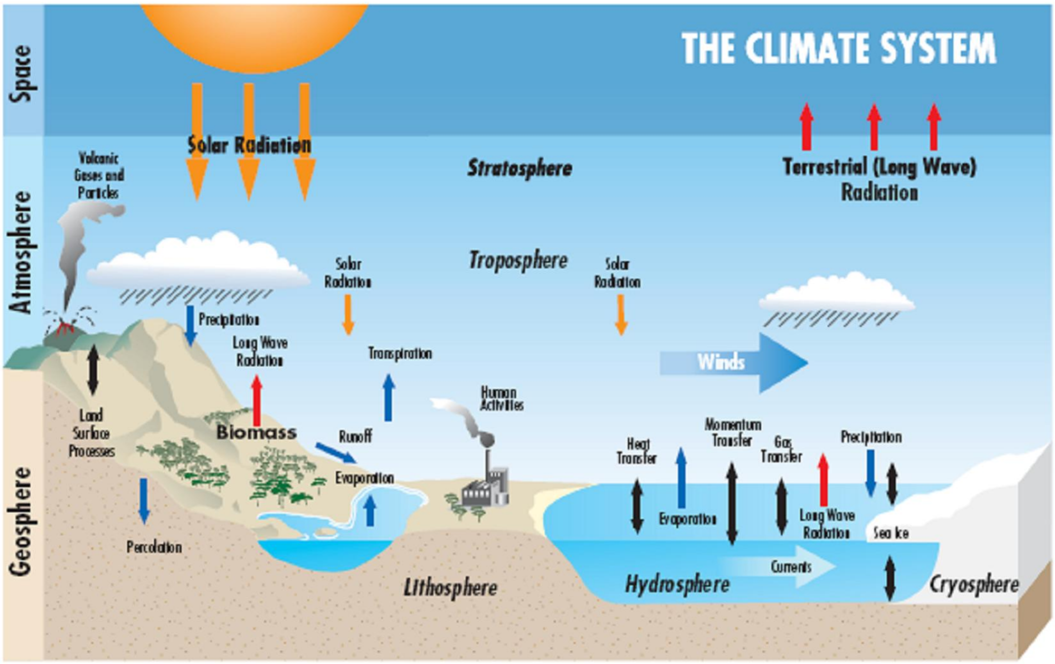

Figure 1: The components of the global climate system consisting of the atmosphere the geosphere (which includes the solid earth, the oceans, rivers and inland water masses and the snow, ice and permafrost and the biosphere. The figure also shows the main physical processes that take place within the climate system and thus exert an influence on climate [1].

The main findings of IPCC fourth Assessment Report (AR4) published in 2007 are:

- The temperature increase is widespread over the globe
- Temperature increase is greater at higher northern latitudes
- Average Arctic temperatures have increased at almost twice the global average rate in the past 100 years
- Land regions have warmed faster than the oceans
- Observations since 1961show that the average temperature of the global ocean has increased to depths of at least 3000m
- The ocean has been taking up over 80% of the heat being added to the climate system
- Increases in sea level are consistent with warming
- Global average sea level rose at an average rate of 1.8 mm (1.3 to 2.3) per year over 1961 to 2003 and at an average rate of about 3.1 mm (2.4 to 3.8) per year from 1993 to 2003
- Since 1993 thermal expansion of the oceans has contributed about 57% to the estimated sea level rise, decreases in glaciers and ice caps about 28% and losses from polar ice sheets 15%
- Observed decreases in snow and ice extent are consistent with warming
- Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7% (2.1 to 3.3) per decade
- Mountain glaciers and snow cover on average have declined in both hemispheres
- The maximum areal extent of seasonally frozen ground has decreased by about 7% in the Northern Hemisphere since 1900, with decreases in spring of up to 15%.

- From 1900 to 2005, precipitation increased significantly in parts of the globe, whereas precipitation declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Globally, the area affected by drought has likely increased since the 1970s [3].

CLIMATE CHANGE AND WATER RESOURCES

For the next two decades a warming of about 0.2°C per decade globally is projected for a range of SRES emissions scenarios. Even if the concentrations of all GHGs and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected. Moreover, there is strong evidence that global sea level gradually rose in the 20th century and is currently rising at an increased rate and is projected to rise during the 21st century at even greater rate. Estimates for the 20th century show that global average sea level rose at a rate of about 1.7 mm per year. The average rate of sea - level rise from 1961 to 2003 was 1.8 mm/year and increased to 3.1mm/year from 1993 to 2003. Climate model projections, satellite data and hydrographic observations show that sea level is not rising uniformly around the globe. In some regions, rates are up to several times the global mean rise, while in other regions sea level is falling. Satellite observations (since early 1990s) provide more accurate sea level data, which are confirmed by coastal tide gauge measurements. Global average sea level is rising mainly because of: (a) thermal expansion of warming ocean water (b) addition of new water from: ice sheets of Greenland and Antarctica, from glaciers and ice caps (c) addition of water from land surface runoff [3].

Based on a future warmer climate, current projections indicate that precipitation generally increases in the areas of regional tropical precipitation maxima (such as the monsoon regimes) and over the tropical Pacific in particular, with general decreases in the subtropics, and increases at high latitudes as a consequence of a general intensification of the global hydrological cycle. Globally averaged mean water vapor, evaporation and precipitation are projected to increase. Southern Europe and Mediterranean will experience decreased precipitation, and extensive summer drying [2].

Water is important and necessary for all of us. Observed warming over several decades has been linked to changes in the large-scale hydrological cycle like increasing atmospheric water vapor content, reduced snow cover, melting of ice, and changes in soil moisture and runoff. Precipitation changes show substantial spatial and inter-decadal variability. Globally, the area of land classified as very dry has more than doubled since the 1970 and there have been significant decreases in water storage in mountain glaciers and Northern Hemisphere snow cover [4].

Both high and low precipitation extremes can lead to periods with a high amount of total precipitation or with precipitation deficit. The periods can range from minutes to days, weeks or even months (with long lasting rain events or absence of precipitation) [5]. High precipitation extremes can result in fast flash floods, sewerage system failure and devastating floods, affecting large catchments and having longer duration. Floods can result in huge economic losses due to damage to infrastructure, property and agricultural land, and indirect losses in or beyond the flooded areas, such as production losses caused by damaged stock or roads, or the interruption of power generation and navigation. Also they can lead to loss of life, especially in the case of flash floods, and displacement of people, and can have adverse effects on human health and the environment [5]. Furthermore low precipitation extremes can lead to droughts. Drought is characterized by below average water availability. The impacts of droughts on people and the environment result from a combination of the intensity and duration of drought events and the vulnerability of agricultural or water resources systems, including water management policies, the characteristics of regional and local water infrastructure, and social responses to drought situations. The most severe human consequences of drought can be found in arid regions, where water availability is naturally lower. They can affect both high and low rainfall areas and can develop over short periods of weeks and months or much longer periods of several seasons, years and even decades [5, 6]. At the same time, the proportion of land surface in extreme drought at any one time is projected to increase, in addition to a tendency for drying in continental interiors during summer, especially in the sub-tropics, low and mid-latitudes.

Water supplies stored in glaciers and snow cover are projected to decline in the course of the century, thus reducing water availability during warm and dry periods (through a seasonal shift in stream flow, an increase in the ratio of winter to annual flows, and reductions in low flows) in regions supplied by melt water from major mountain ranges, where more than one-sixth of the world’s population currently live [4]. River flow is a measure of sustainable fresh water availability in a basin. Variations in river flow are determined mainly by the seasonality of precipitation and temperature, as well as by catchment characteristics such as geology, soils and land cover. In accordance with the observed changes in precipitation and temperature, there is some evidence for climate-induced changes in annual river flow, as well as in the seasonality of flow. In Europe during the 20th century, climate change is projected to result in strong changes in the seasonality of river flows. Summer flows are projected to decrease in most of Europe, also in regions where annual flows will increase. Regions in southern Europe which already suffer most from water stress are projected to be particularly vulnerable to reductions in water resources due to climate change. This will result in increased competition for available water resources [7, 8].

Furthermore climate change effects such as sea-level rise, shrinking land ice and permafrost areas can affect groundwater especially in southern European countries. Regions with higher precipitation may experience rising groundwater levels that may affect houses and infrastructures. The resulting effects on groundwater quantity are shrinking of fresh groundwater resources, especially in coastal areas and in southern European countries, while brackish and salt groundwater bodies will expand. In addition, the fresh groundwater bodies will become more vulnerable to pollution through reduced turnover times and accelerated groundwater flow [8].

Globally, the negative impacts of future climate change on freshwater systems are expected to outweigh the benefits. By the 2050s, the area of land subject to increasing water stress due to climate change is projected to be more than double that with decreasing water stress. Areas in which runoff is projected to decline face a clear reduction in the value of the services provided by water resources. Increased annual runoff in some areas is projected to lead to increased total water supply. However, in many regions, this benefit is likely to be counter balanced by the negative effects of increased precipitation variability and seasonal runoff shifts in water supply, water quality and flood risks [4].

CYPRUS AND WATER RESOURCES

Until 1997 the main source of water in Cyprus was rainfall. According to a long series of observations, the mean annual precipitation, including snowfall was estimated at 503 mm, and from 2000 until now has been reduced to 463 mm (figures 2, 9).

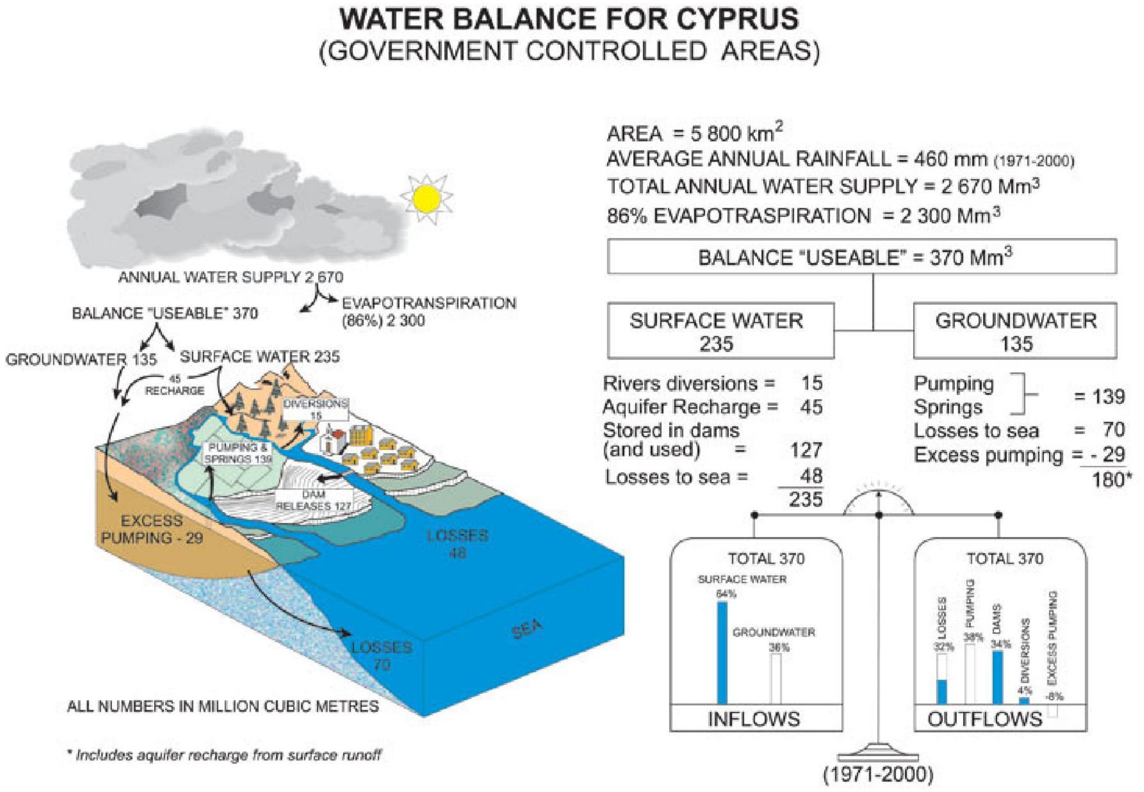

Figure 2: Water balance for Cyprus [9]

The quantity of water falling over the total surface area of the free part of Cyprus is estimated at 2.750 million cubic meters (mcm), but only 10% or 275 mcm is available for exploitation, since the remaining 90% returns to the atmosphere as direct evaporation and transpiration. The rainfall is unevenly distributed geographically with the highest in the two mountain ranges and the lowest in the eastern lowlands and coastal areas. Additionally there is great variation of rainfall with frequent droughts spanning two to four years. The average annual net rainfall of 275 mcm is distributed between surface and groundwater storage with a ratio 1:3 respectively. From the underground storage approximately 1/3 flows into the sea. Domestic use and irrigation are the two main water-consuming sectors in Cyprus. Agriculture accounts for about 69% of the total water consumption and the domestic sector for 25%. The remaining 6% isused for industrial (1%) and environmental purposes (5%). Usually, the tourist and industrial sectors are included in the domestic sector because the system of water distribution in urban areas is common for all uses [9]. The consumption of water for tourist purposes accounts for about 5% of the total water consumption [10, 11].

Following the independence of Cyprus in 1960, the Government of Cyprus placed great importance on water management in order to secure an adequate supply of good quality water to the island's inhabitants. The main policy of the Government, implemented through the Water Development Department, was to increase water supply by constructing dams and conveyance infrastructure under the motto "No drop of water to the sea". Due to this policy, the capacity of dams increased from 6 million cubic meters in 1960 to 327.5 million cubic meters today. At the moment more than 100 dams exist in Cyprus [11].

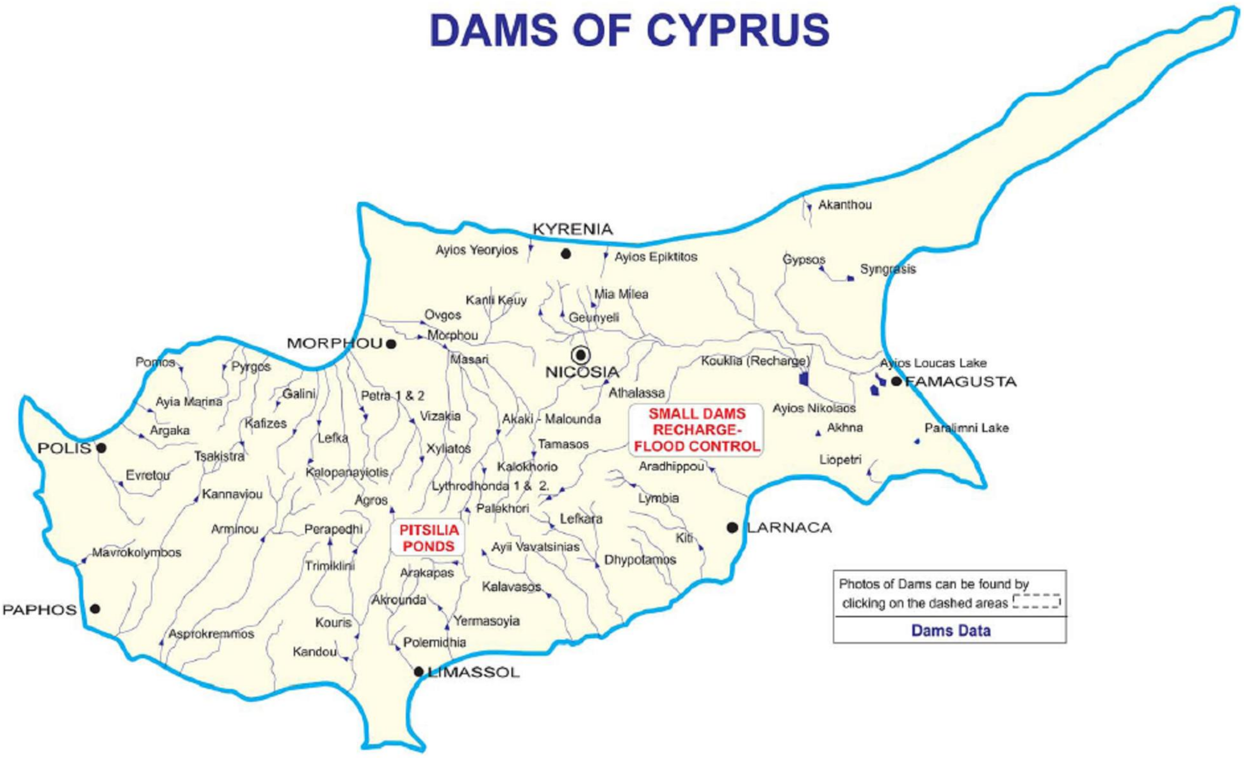

Figure 3: Dams in Cyprus [9].

Additional measures taken included the construction of water treatment plants and the drilling of boreholes to provide water for domestic use and irrigation. In addition, the Government encouraged the installation of improved farm irrigation systems, promoted the application of leakage detection methods on water distribution systems, and imposed a water charge for domestic and irrigation water.

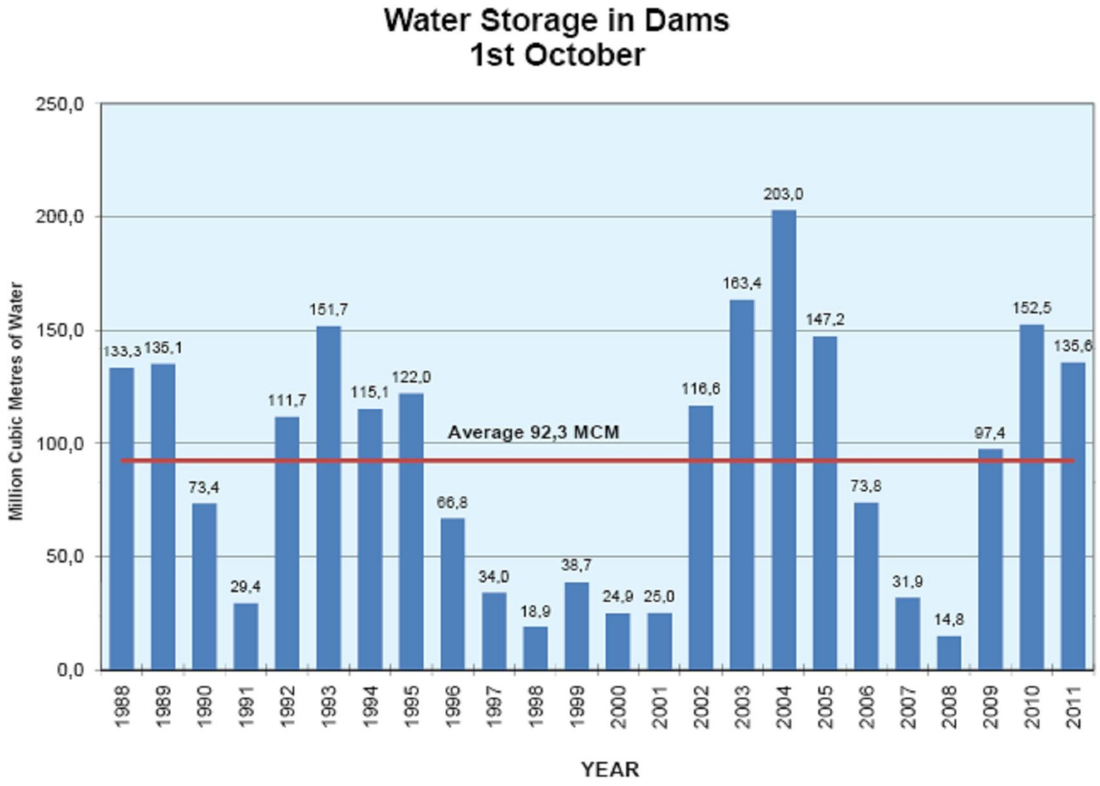

Figure 4: Water storage in Dams form 1988 to 2011 [9]

Despite of these measures, water was still not enough to satisfy the increasing water demand, while the depletion of water resources became more evident. At the moment groundwater, dams, desalination plants and recycled water are the principal sources of water in Cyprus.

Desalination of sea water was first introduced in April 1997 with the operation of Dhekelia Desalination Plant which has a nominal capacity of 40.000m³ of water per day. This plant serves the needs of the free area of Famagusta and part of the needs of Larnaca and Lefcosia. Larnaca Desalination Plant was put in operation on May 2001. The contribution of these Plants to the solution of the water scarcity in Cyprus, is huge. As previously mentioned the two Plants cover almost fully the needs for potable water of the three districts (Lefkosia, Larnaca and free area of Famagusta). At present the yearly needs are about 35–40 MCM of water. The two Plants have the capacity to produce around 30 – 33 MCM per year [9].

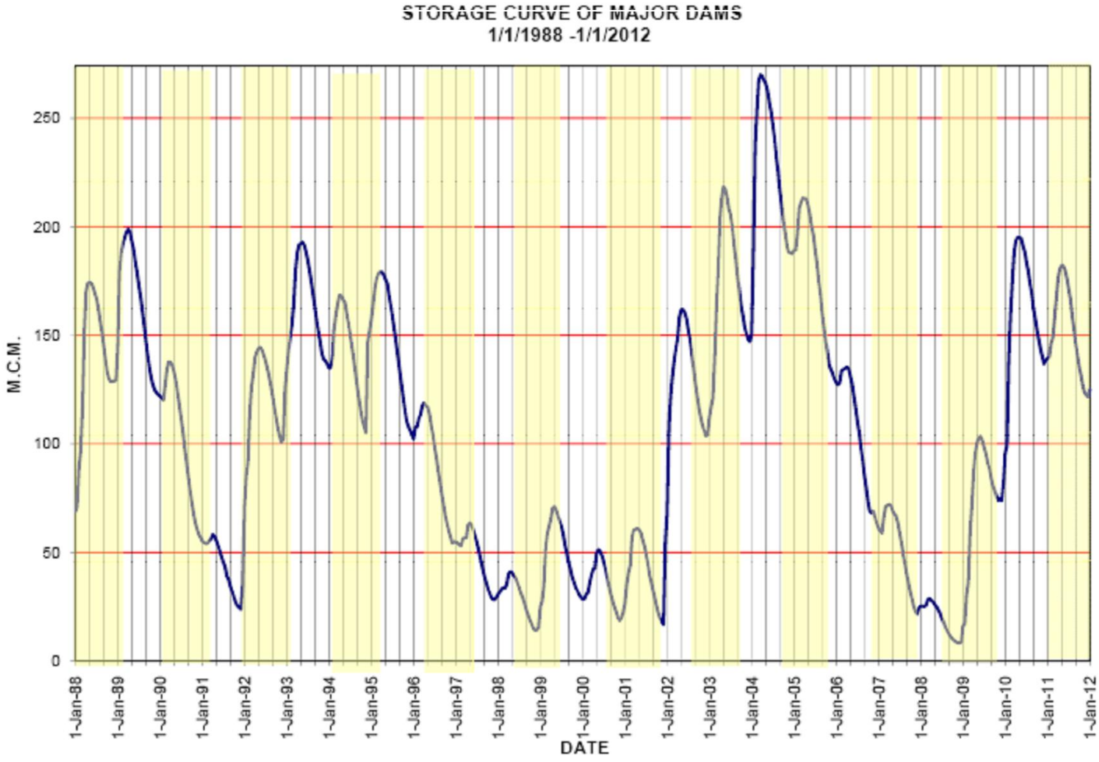

Figure 5: Storage curve for major Cyprus dams form 1988 to 2012 [9].

CLIMATE CHANGE IN CYPRUS AND THE IMPACT ON WATER RESOURCES

The 4th IPPC Report and a number of European reports identified the Mediterranean Basin amongst the most vulnerable geographic areas, due to the combined effect of high temperature increases and reduced precipitation added to existing water scarcity. Satellite altimetry data show that the mean sea level for Mediterranean increased by 2.6 cm in the period 1992 ‐ 2008. This change is not consistent with the global sea level rise that has been rising at a rate of 3.0 ‐ 3.5 mm/year since 1992. This different behavior indicates that being a semi enclosed basin the Mediterranean does not respond linearly to the influences of the open ocean the timescale in question [2] .

Cyprus is the third largest island in the Mediterranean Sea, with an area of 9,251 square kilometers. It is situated at the northeastern corner of the Mediterranean, 330 east of Greenwich and 350 north of the Equator. The island has a typical Mediterranean climate. Hot, dry summers from June to September and rainy, rather changeable winters from November to March, which are separated by short autumn and spring seasons of rapid change in October, April and May [12]. Cyprus has an intense Mediterranean climate, with seasonal characteristics the rainy and mild winter, the warm and dry summer, and the transitional seasons of spring and autumn. The geographical position and the morphology of the island play an important role in the experienced weather and micro-climatic conditions in the various areas and the creation of local effects, while the sea causes considerable local effects in the coastal areas. In July, the hottest month of the year, the mean daily temperature ranges between 29^{0}C on the central plain and 22^{0}C on the Troodos mountains, while the average maximum temperature for these months ranges between 36^{0}C and 27^{0}C respectively. In January, which is the coldest month of the year, the mean daily temperature is 10^0C on the central plain and 3^0C on the higher parts of Troodos mountains, with an average minimum temperature of 5^0C and 0^0C respectively [11].

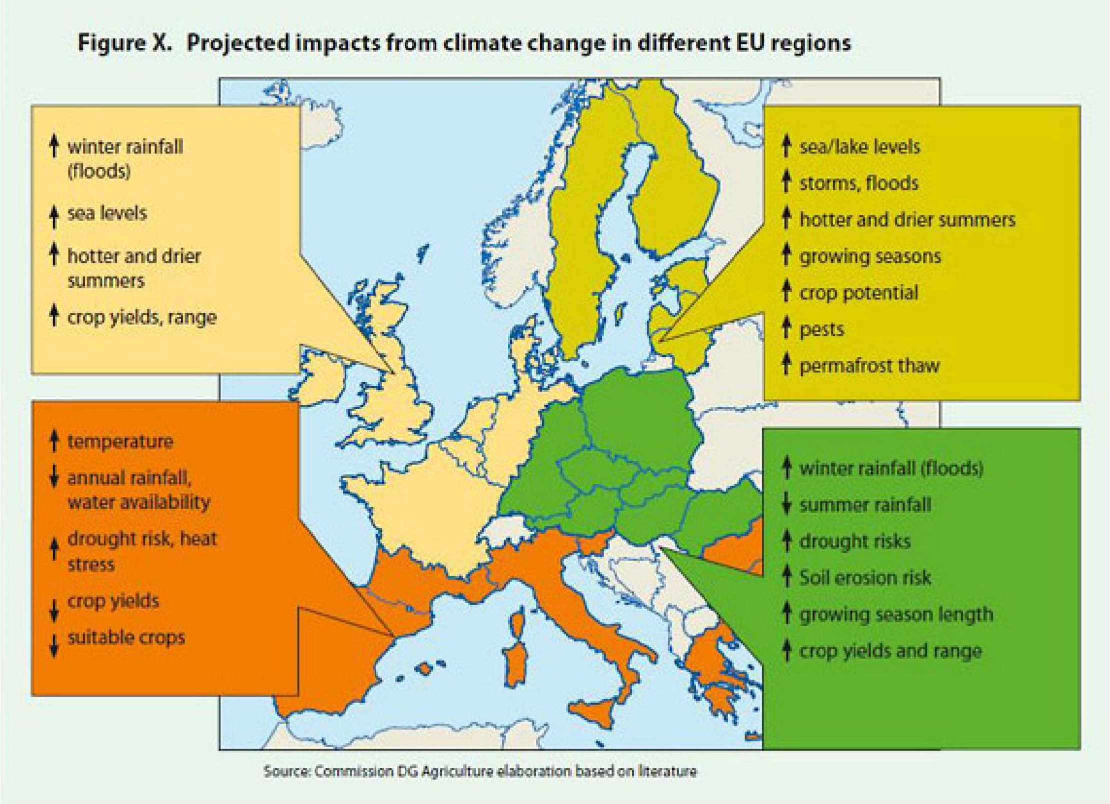

Figure 6: Projected impacts form climate change in different EU regions [13]

The average annual rainfall in Cyprus is about 500 millimeters, the bulk of which falls between the months of November through April. Although precipitation increases with altitude, from 300 millimeters in the central plain and the flat southeastern parts of the island to nearly 1.100 millimeters at the top of the central Troodos massif, most cultivated land is found in the low rainfall zone, about 200 meters above sea level.

During the 20th century, the climate of Cyprus and specifically the two basic parameters, the precipitation and the temperature presented great variability and trends. Similar variability and trends in the climate have been observed in other Mediterranean countries, which mean that there exists a change to the general circulation and behavior of the atmosphere in the Mediterranean region. Observations from the beginning of the 20th century show an increasing trend in the annual mean temperature in Cyprus, with a rate of increase of 0.01°C per year. Overall, a warming of approximately 1- 1.58°C has been observed over the 20th century. This increase exceeds the global value observed for the same period. The rates of change of precipitation and temperature are greater during the second half of the 20th century. Most of the warm years in the 20th century were recorded in the last 20 years. Increase in temperature has been recorded both in towns and rural areas (Figure 7). The enhanced urban heat island effect played an important role in the temperature increase in towns. However the increase in temperature in rural areas is indicative of the regional or global climate changes during the last decades. Moreover, changes in the diurnal temperature range have been recorded during the 20th century. The minimum daily temperatures have generally increased at a larger rate than the maximum daily temperatures, resulting in a decrease in the long‐term diurnal temperature range. This decrease is very similar to some of the coastal stations from southern Israel that shows warming of the minimum temperature, but cooling of the maximum temperature [2].

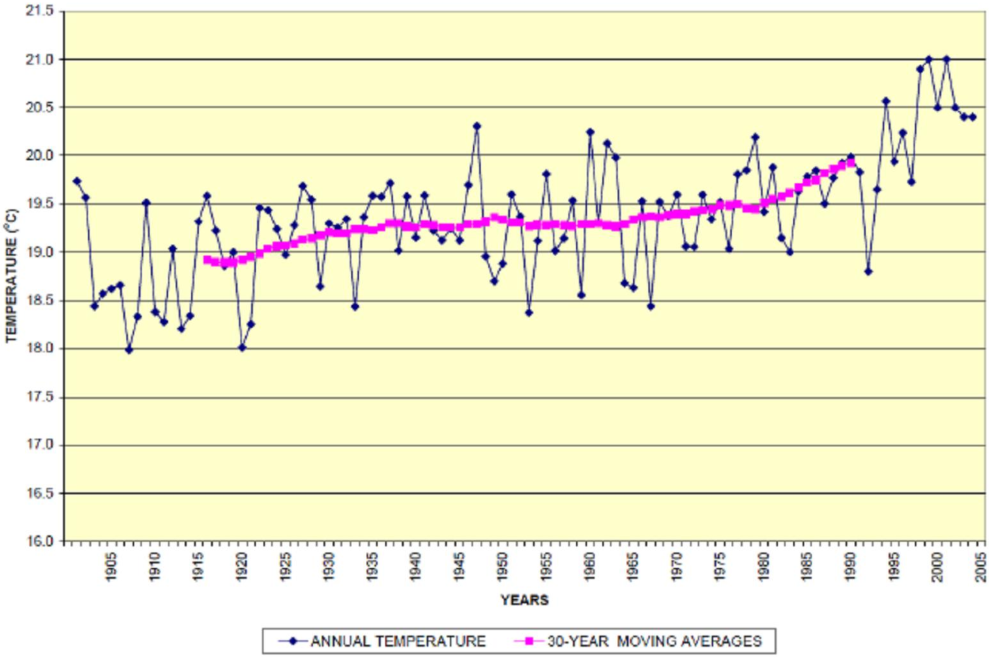

Figure **7**: Nicosia annual mean temperature (1901 - 2005) [2]

Mean annual precipitation demonstrated a decreasing trend in the last century (Figure 8). The rate of decrease was 1mm/year on average.

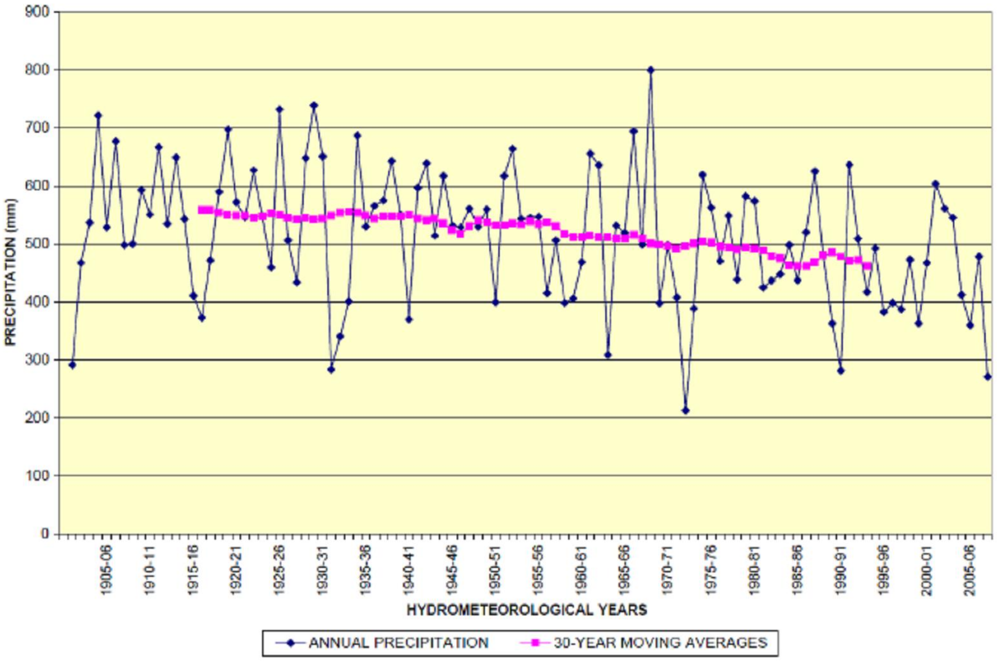

Figure 8: Cyprus annual mean precipitation (1901 - 2008) [2]

The decrease in mean precipitation was larger during the second half compared to that in the first half of the 20th century as a result of the higher frequency of occurrence of low precipitation and drought years. Namely, the average annual precipitation in the first 30 year period of the 20th century was 559 mm and the average precipitation in the last 30-year period was 462mm, which corresponds to a decrease of 17%. The average annual temperature in the period 1991-2007 is 17.7°C or 0.5°C higher than normal (17.2°C, period 1961-1990). The average annual precipitation in the period 1991/92 -2007/08 (17 hydrometeorogical years) is 457 mm or 9% lower than normal (503mm, period 1961-1990). According to the above rate of changes it is expected that by 2030 precipitation will decrease by 10 - 5% and temperature will increase by 1.0 - 1.5°C compared to the reference period 1961-1990 [2].

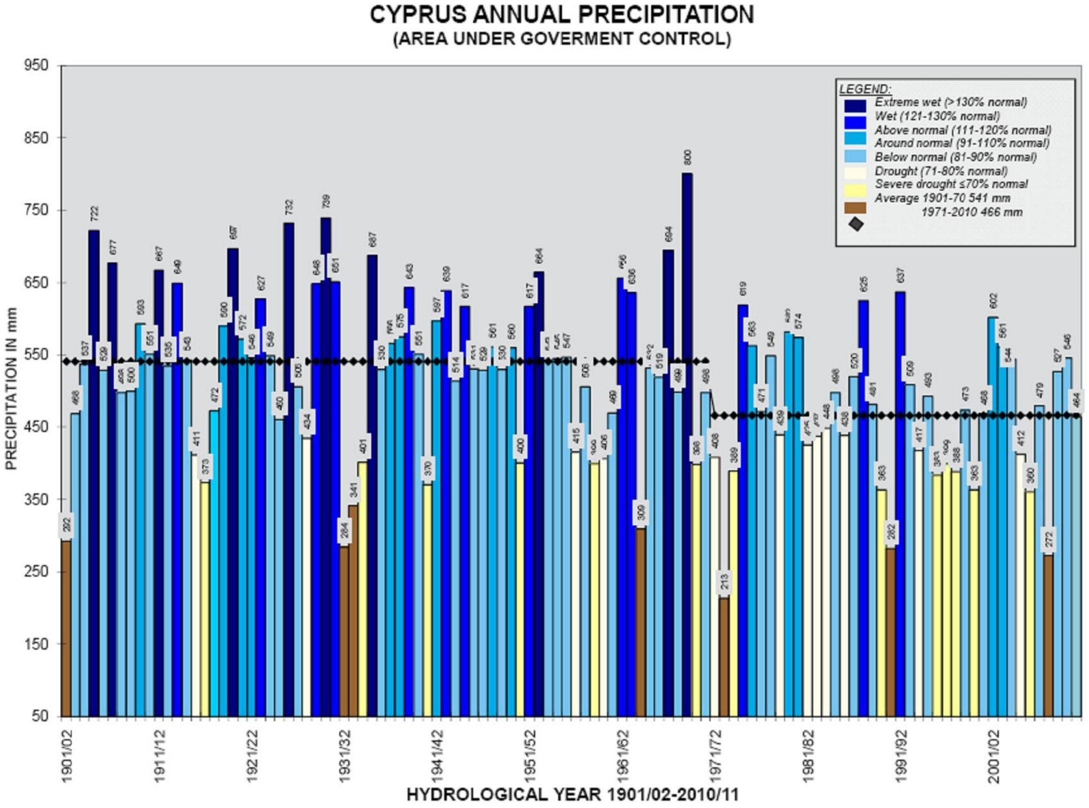

Figure 9: Cyprus annual precipitation [9].

Based on projections, resulting from regional climate model simulations for two 30 year future periods (2021-2050 and 2071-2100), variations in temperature and precipitation confirm the vulnerability of Cyprus to climate change:

➢Maximum temperature. The warming is in the range of 1.3°C to 1.9°C for the 2021-2050 simulation and 3.6 °C to 5 °C for the 2071-2100 simulation (Figure 10).

➢ Minimum average temperature. The simulations indicate an increase of about 1.5 °C for 2021 -2050 and 4 °C for 2071–2100.

➢The temperature seasonal variability varies between 1.3 °C in winter and 1.9 °C in summer for 2021-050. For 2071-2100 it ranges from 3.3°C (winter) to 4.3 °C (summer).

- Precipitation. The future simulations indicate a drop in rainfall amounts. The sharpest decrease is evident seasonally for the 2071-2100 simulation (decrease in winter accompanied with decrease in autumn), whereas for the 2021-2050 simulation, rainfall shows a decrease in winter, but an increase in autumn.
- Dry periods. Both simulations indicate an increase in the dry period with precipitation below 1mm of about 15 days for 2021-2050 and 15 days to 1 month for 2071-2100 [2].

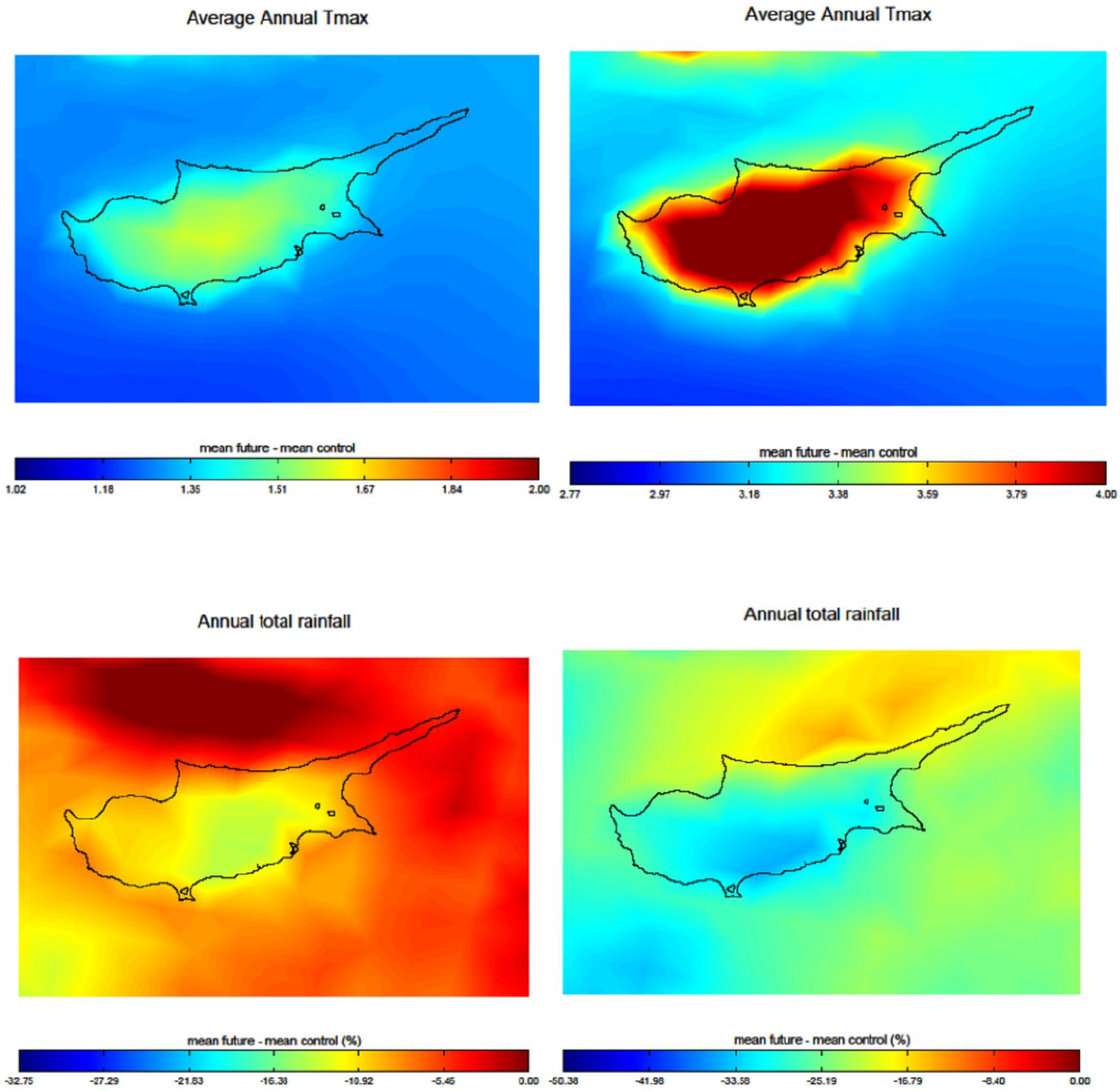

Figure 10: Average annual maximum temperature and precipitation for 2021 - 2050 (left) and 2071 - 2100 (right) [2].

According to the Organisation for Economic Co-operation and Development (OECD) Cyprus is the most affected country of the European Union in relation to water stress (figure 11). Water stress occurs when the demand for water exceeds the available amount during a certain period or in a particular area or when poor quality restricts its use. Water stress is often related to the deterioration of fresh water resources in terms of both quantity and quality. Overexploited aquifers, dry rivers, are typical indicators and at the same time promoters for water stress. The situation is often aggravated by quality problems such as eutrophication, organic matter pollution or saline. Water stress relates water availability and water use and is defined as the ratio of annual water withdrawal from ground and surface water to the total renewable freshwater resources. Hence high water stress indices can either be caused by low availability or excessive high water demand. The OECD defines a water stress index of more than 40% as high water stress, 20% to 40% classifies as medium-high, whilst 10% to 20% is defined as moderate water stress [14].

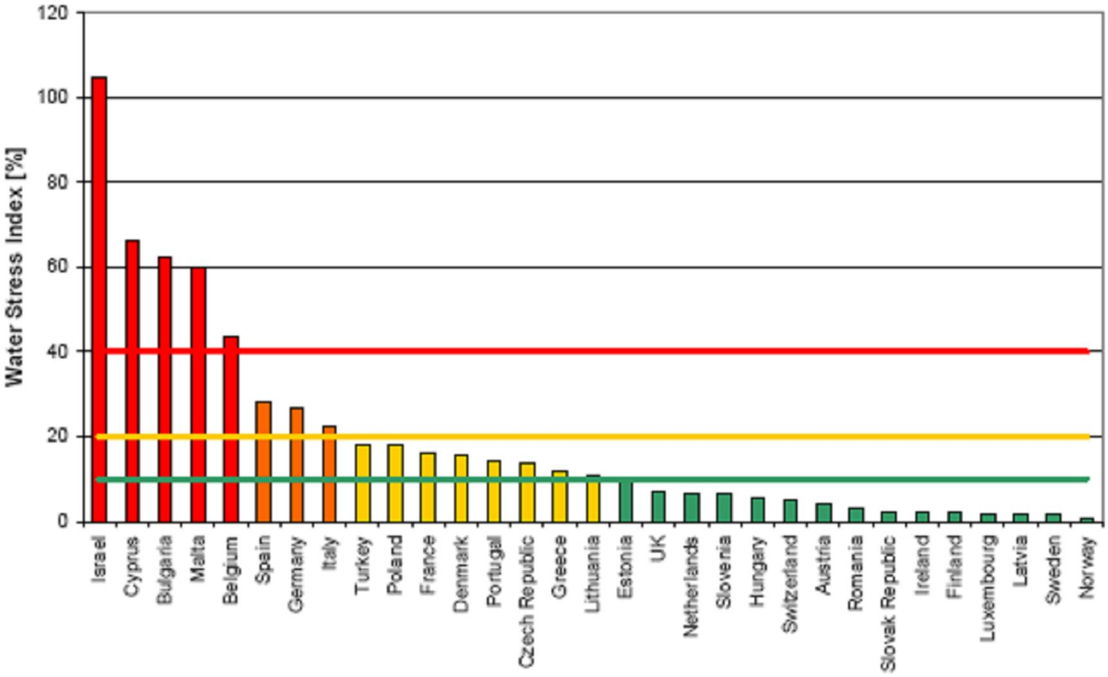

Figure 11: Water stress index for European countries, Israel and Turkey [14]

Moreover due to the limited supply of surface runoff in Cyprus, groundwater has traditionally provided the resource needed for domestic use and irrigation. Throughout the years, the groundwater resources of the island have been heavily overpumped, especially during periods of drought. It is estimated that groundwater resources are overexploited by about 40% of the sustainable extraction level. Cyprus is severely overstressing groundwater resources since it is exploiting groundwater beyond what has been set as the ecological limit [11]. Namely, in 2007 it extracted more than 100% of the groundwater available for annual abstraction. The existing conditions have resulted in saline water intrusion and consequent quality deterioration in coastal aquifers and depletion of inland aquifers. Seawater intrusion in aquifers has also resulted in spoiling valuable underground water storage room and the situation is expected to become worse due to climate change [2].

Also sea level rise due to climate change except of the major consequences in the loss of land, the salination of water sources, the increase in erosion and coastal hazards will also cause serious problems on agriculture since important land with agricultural uses will be lost and by the salination of fresh water they will can't use water for irrigation. The most vulnerable areas to possible sea level rise, likely to face inundation risk and greater exposure to storm surges, are the low lying area of Larnaca and the adjacent salt lake, the Akrotiri peninsula wetland, the Akamas

Coastal/Marine Protected area and especially the Lara/Toxeftra Turtle Reserve, Cape Greko marine caves, and Poli Chrysochous coastline. It is Important to note that most of these areas are protected under various EU Directives and international Conventions (i.e. NATURA 2000, Ramsar). On the other hand some of the most important infrastructures of Cyprus are located in low lying coastal areas like the Larnaca airport, the desalination plant as well as the major power generating stations [2].

The country has already faced severe droughts. In 2008, Cyprus suffered its fourth consecutive year of low rainfall and the drought situation reached a critical level in the summer months. To ease the island's crisis, water was shipped in from Greece using tankers. In addition, the Cypriot government was forced to apply emergency measures, including the cutting of domestic supplies by 25–30% [2]. Furthermore, intensive agriculture and excessive use of fertilizers have resulted in nitrate pollution of many aquifers. Similar nitrate pollution problems appear in aquifers in inhabited areas because of direct sewage disposal in adsorption pits [11].

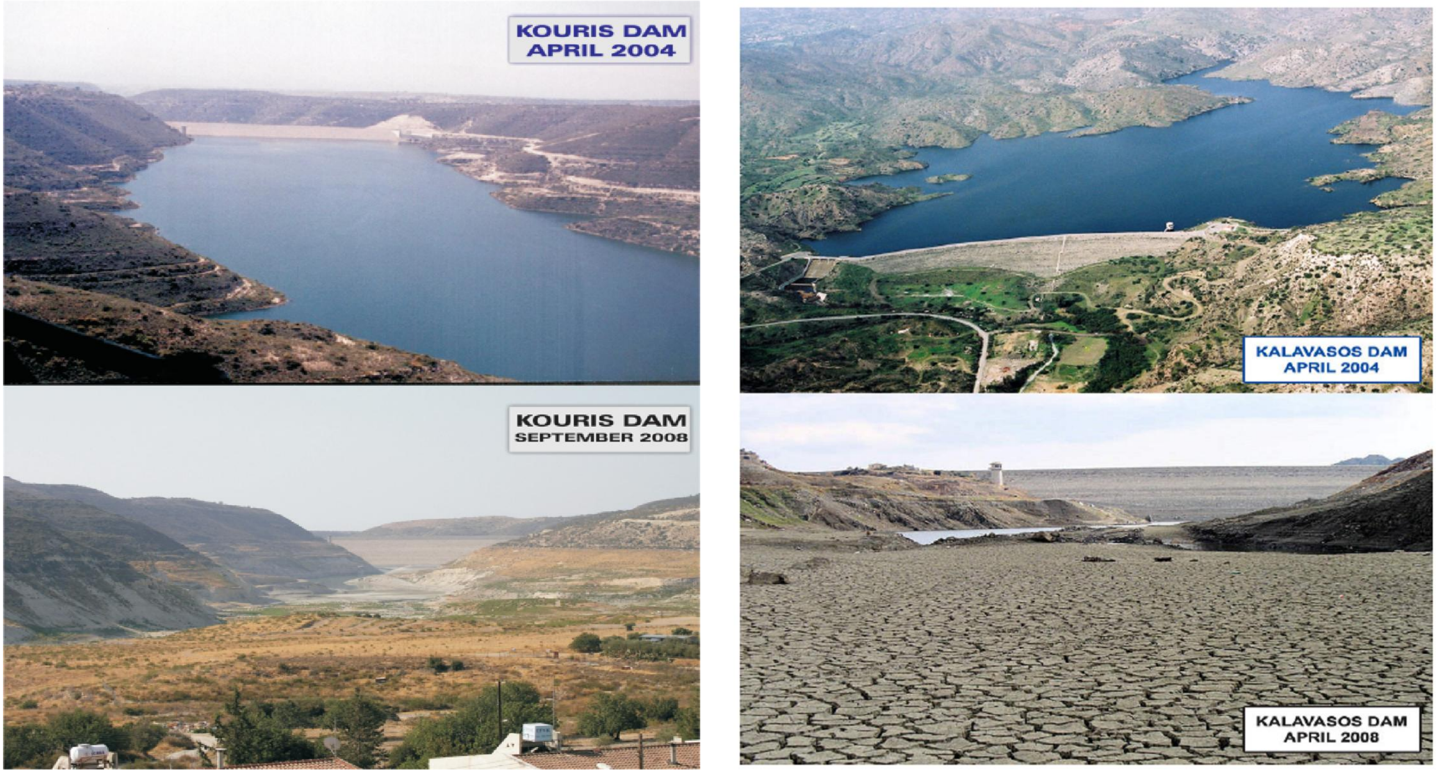

Figure 12: Kouris and Kalavasos dams in 2004 and 2008

POSSIBLE HEALTH EFFECTS

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 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. Climate-change-related alterations in rainfall, surface water availability and water quality could affect the burden of water related diseases. Water-related diseases can be classified by route of transmission, thus distinguishing between water-borne (ingested) and water-washed diseases (caused by lack of hygiene). There are four main considerations to take into account when evaluating the relationship between health outcomes and exposure to changes in rainfall, water availability and quality: (a) linkages between water availability, household access to improved water, and the health burden due to diarrheal diseases, (b) the role of extreme rainfall (intense rainfall or drought) in facilitating water-borne outbreaks of diseases through piped water supplies or surface water, (c) effects of temperature and runoff on microbiological and chemical contamination of coastal, recreational and surface waters and (d) direct effects of temperature on the incidence of diarrheal disease [15, 16].

Access to safe water remains an extremely important global health issue. More than 2 billion people live in the dry regions of the world and suffer disproportionately from malnutrition, infant mortality and diseases related to contaminated or insufficient water. A small and unquantified proportion of this burden can be attributed to climate variability or climate extremes and examples of this are described below. Childhood mortality due to diarrhea in low-income countries, especially in sub-Saharan Africa, remains high despite improvements in care and the use of oral rehydration therapy. However several studies have shown that transmission of enteric pathogens is higher during the rainy season. Drainage and storm water management is important in low-income urban communities, as blocked drains are one of the causes of increased disease transmission [15].

Also reductions in rainfall lead to low river flows, reducing effluent dilution and leading to increased pathogen loading. This could represent an increased challenge to water-treatment plants. During the dry summer of 2003, low flows of rivers in the Netherlands resulted in apparent changes in water quality. Extreme rainfall and runoff events may increase the total microbial load in watercourses and drinking-water reservoirs, although the linkage to cases of human disease is less certain. A study in the USA found an association between extreme rainfall events and monthly reports of outbreaks of water-borne. The seasonal contamination of surface water in early spring in North America and Europe may explain some of the seasonality in sporadic cases of water-borne diseases such as cryptosporidiosis and campylobacteriosis. The marked seasonality of cholera outbreaks in the Amazon is associated with low river flow in the dry season probably due to pathogen concentrations in pools Moreover higher temperature was found to be strongly associated with increased episodes of diarrheal disease in adults and children in Peru. Associations between monthly temperature and diarrheal episodes have also been reported in the Pacific islands, Australia and Israel. In many countries cholera transmission is primarily associated with poor sanitation however in sub-Saharan Africa, cholera outbreaks are often associated with flood events and faecal contamination of the water supplies [15, 16].

Moreover coastal aquifers that may also face higher water temperature and variations in runoff that are likely to produce adverse changes in water quality affecting human health, ecosystems and water use. Lowering of the water level in surface waters and aquifers will lead to elevated concentrations of pollutants due to lower dilution. More intense rainfall will lead to an increase of pesticides and fertilisers runoff, polluting surface and underground waters. Furthermore, higher water temperatures may enhance the release into the atmosphere from surface water bodies volatile and semi ‐ volatile compounds (e.g., ammonia, mercury, dioxins, pesticides). Higher surface water temperatures will also promote algal blooms and increase the bacteria and fungi content. This may lead to a bad odour and taste in chlorinated drinking water and the presence of toxins. Also extreme rainfall and temperature may alter quality deterioration due to sea water penetration from the projected sea level rise [2].

However the World Health Organisation confirms that the distributional patterns of vector borne infectious diseases are influenced by climate, and are gradually expanding to northern latitudes. A number of these vector borne diseases spreading northward are likely becoming an emerging threat in the Mediterranean, which is expected to increase in the near future. Vector borne diseases such as malaria or dengue fever could spread in European regions, and at higher altitudes. Some water and food borne disease outbreaks are expected to become more frequent with rising temperatures and more frequent extreme events and the risk of additional salmonella problems from bathing water quality is likely to grow [2].

In Cyprus however there have not been any studies yet to associate health effects from the impact of climate change on water resources. However is obvious form the data described earlier that Cyprus is experiencing the effects of climate change and the results will be more extreme as time passes. Therefore is mandatory to find ways to expand Cyprus water resources. Since, both surface and underground resources are running out and precipitation is decreasing, maybe desalination should be expanded especially when high temperatures occur. Furthermore, we need to promote alternative ways of irrigation, especially to expand the use of recycled water for irrigation purposes and also to install rain harvesting systems because when we have good periods of precipitation we can use all these water for irrigation rather than losing it, considering that this water runs off to the sea. Appropriate disaster planning and preparedness need to be developed in order to address the increased effects of climate change on water resources and to reduce impacts on health and health systems. Health must be at the centre of all climate change action. Health-system leaders can use their knowledge and authority to inform and influence action in key national processes that guide policy and allocate resources for work on climate change, for instance in preparing national communications, national action programs on adaptation and international agreements.

REFERENCES

1. *The greenhouse effect and climate change,* *www.bom.gov.au/info/GreenhouseEffectAndClimateChange.pdf*.

2. Zachariades, T.; Shoukri, E. *Climate change in Cyprus – Impacts and adaptation policies, Environmental Policy Research Group Report 01-12, 2012, Cyprus University of Technology, Limassol, Cyprus.*

3. M.L. Parry, O. F. C., J.P. Palutikof, P.J. van der Linden and C.E. Hanson *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Climate Change 2007: Impacts, Adaptation and Vulnerability Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA*; 2007.

4. Bates, B. C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Climate change and water,IPCC Technical Paper VI, IPCC Secretariat, Geneva, June 2008.

5. Dankers, R.; Feyen, L., Climate change impact on flood hazard in Europe: An assessment based on high-resolution climate simulations. *J. Geophys. Res.* **2008,** *113*, (D19), D19105.

6. Räisänen, J. H., U.; Ullerstig, A.; Döscher, R.; Graham, L. P.; Jones, C.; Meier, H. E. M.; Samuelsson, P.; Willén, U., European climate in the late twenty-first century: regional simulations with two driving global models and two forcing scenarios. *Climate Dynamics* **2004,** *22*, (1), 13-31

7. Lindstrom, G.; Bergstrom, S., Runoff trends in Sweden 1807-2002. *Hydrological Sciences Journal* **2004,** *49*, 69-83.

8. Milly, P. C. D.; Dunne, K. A.; Vecchia, A. V., Global pattern of trends in streamflow and water availability in a changing climate. *Nature* **2005,** *438*, (7066), 347-350.

9. http://www.moa.gov.cy/moa/wdd/Wdd.nsf/index_en/index_en?OpenDocument

10. *USE AND CONSERVATION OF WATER IN CYPRUS, MINISTRY OF AGRICULTURE, NATURAL RESOURCES & ENVIRONMENT, WATER DEVELOPMENT DEPARTMENT*; 2002.

11. MICHAELIDOU, M.; OMORPHOS, C.; GEORGIOU, A.; SKORDIS, P.; KYRIACOU, K., *Water Management in Cyprus: Challenges and Opportunities, National Report, SEMINAR ON THE ROLE OF ECOSYSTEMSAS WATER SUPPLIERS, Convention on Protection and Use of Transboundary Watercourses and International Lakes, Geneva, 13-14 December 2004*.

12. Adriana Bruggeman; Katerina Charalambous; Manfred A Lange; Panos Hadjinicolaou, Climate change and water scarcity in Cyprus, impacts and adaptation. **2011**.

13. http//ec.europa.eu

14. Hochstrat, R.; Kazner, C. *Case study report Cyprus: Flexibility in coping with water stress and integration of different measures*; 2009.

15. Confalonieri, U., B. Menne, R. Akhtar, K.L. Ebi, M. Hauengue, R.S. Kovats, B. Revich and A. Woodward, 2007: Human health. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 391-431.

16. Sirbu, D.; Curseu, D.; Popa, M.; Popa, M. S., WATER RESOURCES AND HUMAN HEALTH IN THE FRAMEWORK OF CLIMATE CHANGE. *International Water Technology Journal,* **2012,** *1*, (3), 200-209.