

**<WATER, WETLANDS AND CLIMATE CHANGE
Building Linkages for their Integrated Management**

**Mediterranean Regional Roundtable
Athens, Greece,
December 10-11, 2002**

**CYPRUS-Water Resources
Planning and Climate Change Adaptation**

Prepared by:

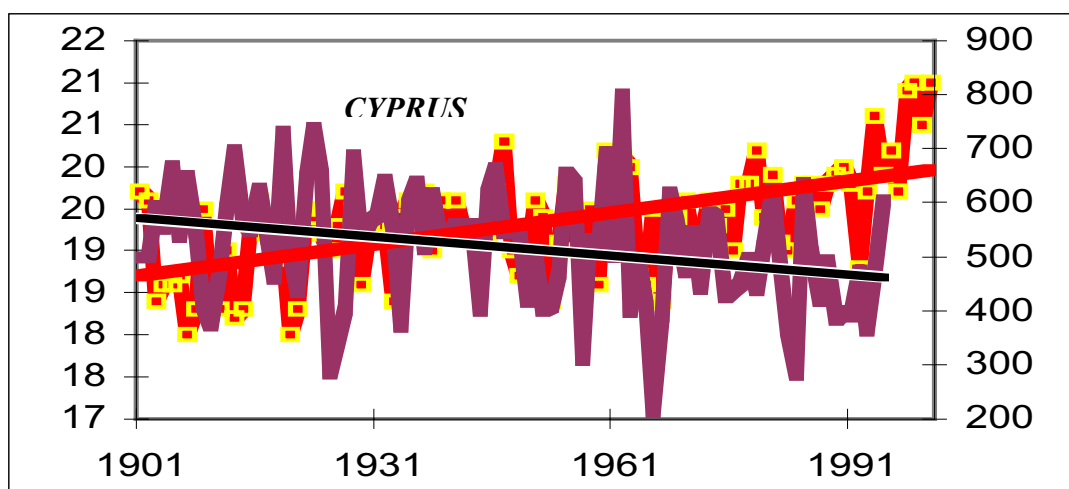
Nicos X. TSIOURTIS

Consultant

Nicosia-Cyprus

Tel +357 22 33 22 226, Fax 357 22 33 22 26,

E-mail: tsiourti@dial.cylink.com.cy



December 2002



Preface

The Global Water Partnership (GWP), the Dialogue on Water and Climate Change, and IUCN-The World Conservation Union, have joined forces to facilitate an exchange of views on the common challenges faced by Mediterranean societies in enhancing their capacities to adapt to climate change.

Scientific consensus is that climate change would have a pervasive influence on the future demand, supply, and quality of fresh water resources in the Mediterranean, and would add pressure to water and environment resources, and coastal systems currently under stress. All sectors of the economy, environment and society may be vulnerable to one degree or another, where steps to increase the capacity to adapt to greater hydrological variability, including more frequent flood and drought extremes are required.

Under Article 4 of the UNFCCC, it was agreed all Parties would develop short, medium, and long-term strategies for climate adaptation in a phased manner, taking into account the different socio-economic contexts. A number of Mediterranean countries are now at the preliminary stages of identifying and formulating specific climate change adaptation strategies and responses, while others have yet to start.

This document is one of twelve country base-line studies and thematic papers prepared as background material for a Roundtable meeting in Athens, Greece in December 2002, to discuss key linkages between climate change, water and wetlands resource and management in the Mediterranean. While the primary aim is to exchange views, perspectives and experience on climate change adaptation planning, the discussion would also explore the opportunities to enhance synergies in responses to the UNFCCC and Ramsar Conventions.

Eight country base-line studies were prepared for:

- | | |
|----------|-----------|
| ☞ Cyprus | ☞ Morocco |
| ☞ France | ☞ Spain |
| ☞ Greece | ☞ Tunisia |
| ☞ Italy | ☞ Turkey |

The four crosscutting thematic papers are:

- ☞ Mediterranean Water Resource Planning and Climate Change Adaptation
- ☞ National Approaches to Drought Preparation in the Mediterranean
- ☞ Adaptation Strategies for Improved Flood Management in the Mediterranean
- ☞ Biophysical and Socio-Economic Impacts of Climate Change on Water and Wetlands in the Mediterranean

Electronic copies of the reports and paper noted above may be downloaded from the web page of The IUCN Centre for Mediterranean Cooperation at www.uicnmed.org. Project funding for this initiative was provided by the Global Dialogue on Water and Climate Change. The IUCN Centre for Mediterranean Cooperation receives core funding from the Spanish Ministry for Environment and the Junta of Andalucia.

Disclaimer:

The views, conclusions, and recommendations contained herein are those of the authors, and are not necessarily the views of the Governments of the countries concerned, the GWP, the Dialogue on Water and Climate Change, or the IUCN.

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Summary

Cyprus is the third largest island in the Mediterranean Sea, with an area around 9251 Sq Km, population around 754.000, and annual precipitation around 503 mm. During the last century it was observed that the climate changed with precipitation reducing at a rate of 1mm per year, where the temperature increased by 0,5°C. The reduction in precipitation and the increase of the temperature had an adverse impact on the availability of the natural water resources, which were reduced by 40% from the estimates made in 1970 at the preparation of the Cyprus Water Master Plan. Extreme climatic phenomena especially droughts are more frequent than before, with droughts causing water shortage and scarcity, and adverse effects on the economy, on the social life and on the environment. Cyprus has developed and implemented a National Water Master Plan, which was prepared in the 1970's, based on the meteorological data available at the time covering the period 1900-1970. After implementing the Master Plan it was realized that the available water resources were by 40% less than originally estimated causing a water crisis. The water crisis caused by the climate change forced the Government to revise the original policy on water resources management plans, which envisaged among others the introduction of seawater desalination by the years 2005-2010. The revised water policy provided for a) the introduction of seawater desalination early in the 1997's, b) the acceleration of the construction of the domestic effluent reuse projects, c) the intensification of the implementation of water demand measures, d) the re-evaluation of the water demand and of the available natural water resources and e) other measures to mitigate the adverse effects resulting from water scarcity.

Cyprus has ratified both the Climate Change Convention of 1992 and the Kyoto Protocol and has prepared a National Strategic Plan for fulfilling its obligations, although the obligations are not yet specifically defined because Cyprus is not included in the List A of the Kyoto Protocol. For the mitigation of climate change Cyprus has set up an Ad-Hoc Committee on Climate Change and is now active in the selection of the measures to reduce/stabilize the emission of the Greenhouse gases to the atmosphere. However the Committee is not concerned with climate change adaptation measures.

Because of the climate change and the immediate impact on the reduction in the availability of the natural water resources, the Government of Cyprus has set up a Drought Management Committee with the responsibility of implementing measures of mitigating the adverse effects from drought and mainly to mitigate water scarcity problems. In parallel to this, realizing the need for additional water the Government decided to introduce seawater desalination for augmenting the water availability and increasing the reliability of water supply from the existing Government Water Projects. The Drought Committee is not a permanent committee but an Ad-Hoc and is energized when Drought Occurs.

Since there is great probability that the climate parameters shall continue to change with further decrease in the precipitation and further increase in the temperature and due to Global Warming the level of the sea surrounding the island shall continue to rise with adverse effects on the coastal aquifers and on the coastal lands used either for agriculture or for other uses, the need for a Strategic Plan for mitigating the climate change effects and for adaptation measures is a must. Cyprus has great experience on mitigating adverse effects due to water scarcity, one of the adverse effects of climate change and this can be shared with other countries. The roundtable discussion during the Athens Conference offers an opportunity for the exchange of experience and know-how and every effort must be made by all participants for a successful fruitful conference. The roundtable conference should be the beginning for thorough discussion of the important issues related to climate change, such as precipitation, temperature, seawater rising, extreme climatic phenomena, their effects on water availability and water demand, the suitable measures for avoiding/minimizing the climatic change in accordance with the Kyoto Protocol, the measures to mitigate the adverse effects and the consideration of adaptation policies for facing the impacts of climate change.

The important points/issues to be discussed at the roundtable in Athens, must include the practical tools to enable the participants and the national representatives to evaluate the climate change (information and data), the methodology to evaluate the adverse and beneficial effects caused by the

climate change, and to define and select the most effective measures to mitigate the adverse effects. This shall enable the Mediterranean countries to prepare their national strategy plans for adapting to climate change conditions and mitigating the adverse effects caused by the climate change phenomenon.

Part A

Cyprus context

A.1 Location and Geology

Cyprus, is the third largest island of the Mediterranean Sea with an area of 9251 square kilometres, and is situated in the northeastern end of the Mediterranean Sea. The present population on the island is 755.000¹ with a density of 81,6 persons per square kilometre. The total length of the coastline is 782 kilometres. Geologically it is divided into three geological zones, the Pentadactylos or Kyrenia range in the north, made mainly of limestone and rising to 1024 meters above the sea level, the Troodos massif in the central and south, a dome shape highland of mainly infertile igneous rocks, with a high relief rising to an elevation of 1951 meters above the sea level, and the Mesaoria plain, separating the two ranges, composed of flyschtype rocks carried by rivers from the two ranges, not exceeding 180 meters in elevation above sea level. The coastal valleys surround the island with alluvial soils suitable for agriculture. Cyprus has a wide variety of natural vegetation including forest or hardwood, evergreen and broadleaved trees occupying 18,7% of the island's area. The percentage of arable land is about 46,8 of the total, out of which 21% is irrigated in some manner, 4% is perennially irrigated while in a normal year a further 13% can be watered from spate floods. The principal crops in the lowlands are cereals, vegetables, potatoes, citrus and olive trees, where vineyards occupy a large part of the southern and western slopes of the Troodos range. Deciduous fruit trees are grown in the fertile mountain valleys.

A.2 Climate

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.

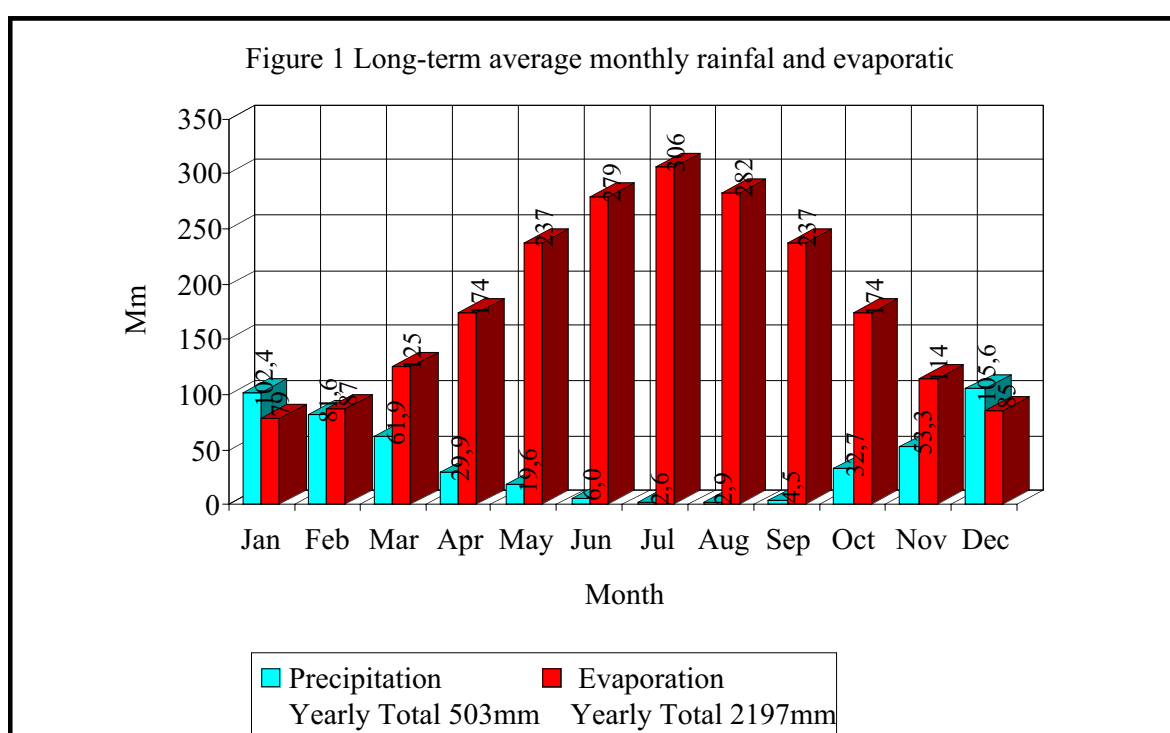
The average annual precipitation over Cyprus is 500mm varying from 300-350 mm in the central plain and the southern coastal areas to 1100mm on the top of the Troodos range, mostly falling in the period November to March. Figure 1 shows the long-term average monthly precipitation for the area of the island under the Government¹ control. The summer mean daily temperatures are 29°C in the central plains and 22°C in the higher parts of the Troodos range, with mean maximum temperatures 36°C and 27°C, respectively. In the winter months the mean daily temperatures are 10°C in the central plains and 3°C in the higher parts of the Troodos mountains, while the minimum are 5°C and 0°C, respectively.

The average annual potential evapo-transpiration (ETp) is 950-1000 mm in the higher parts of Troodos range and 1250-1300 mm in the plain areas. The Precipitation/Evapotranspiration ratio in the plain and hilly areas is less than 0,5, with lowest values of 0,25 in the central plains, where in the mountain areas is greater than 0,5 with values above 0,65 in the western higher parts of the Troodos Mountains. The long-term average monthly potential evapotranspiration is shown on Figure 1. This figure shows that potential evapo-transpiration is higher in summer months where precipitation is almost non-existence, creating the need for water storage if satisfaction of demands is to be secured.

¹ In 1974 Turkey invaded Cyprus and since then it occupies against international law and order 37% of the islands area and depriving basic human rights to one third of the population.

A.3 Current Water Resources And Wetland Resources And Use

Cyprus being an island depends entirely for its natural water resources availability on the precipitation falling on the island. The total annual water crop for the whole of the island was estimated in 1970, based on the climatological and other conditions prevailing at the time around 900 MCM, 300 MCM being the groundwater resources and 600 MCM being the surface water resources, where the wetlands covering an area around 2.668 Has or 26,68 KM² contained only salty water. The source of the water in the two salt lakes, one in Larnaca and the other in Limassol, is from direct precipitation and the runoff from small catchments around the lakes. The salt is present in the soil bed of the lakes that is dissolved in the collected water. The lake's water salinity is initially (in the months of January-April), very low but increases gradually due to evaporation, without replacement. The salt lakes start collecting water in the months of October-November and by next July-August they are completely dry with the salt remaining at the bottom of the lakes. Since the water collected in the salt lakes is salty this is not used for irrigation or domestic use or any other use and is not counted in the water balance. The wetlands form the habitat for birds and some types of fishes.



The water available by source at present after implementing a long term and expensive Water Master Plan is as shown on Tale 2, where the present water use by sector is presented on Table 1.

Table 1. Present water use by sector in the Government controlled areas

No	Description of Use	Quantity in MCM	Percentage
1.	Agriculture	174,4	69
2.	Domestic	67,5	25
3.	Animal Husbandry	8,0	
4.	Industry	3,5	1
5.	Environment	12,5	5
6.	Total	265,9	100
	Water use per capita per year in m ³		352,7

The present water sources are shown on Table 2 below.

Table 2. Present water availability by Source in the Government controlled areas

No	Source of water	Quantity in MCM	Percentage	Comments
1.	Surface water resources from dams	103,9	39,1	Conventional
2.	Groundwater	129,0	48,5	Conventional
3.	Desalination	30,0	11,3	Non Conventional
4.	Recycled (Domestic effluents)	3,0	1,1	Non Conventional
5.	Total	265,9	100,0	
6.	Conventional water	232,9	87,6	
7.	Non Conventional water	33,0	12,4	

From Table 2 it can be seen that 12,4% of the present water resources is composed of non-conventional water resources coming from desalination and reuse schemes not significantly affected from the climate changes.

A.4 Climate Variability In The Last Century And Future Changes

A.4.1 Global Tendencies

During the last 420.000 years, earth had frequent climatic changes with a pronounced periodicity. The last period of ice started 120.000 years ago and ended 16.000 years ago. Since then the earth is under a thermal period. All climatic changes were caused by the variation of the content of the Greenhouse gasses in the atmosphere, such as Carbon Dioxide and Methane, whose origin was from natural processes. Following the industrial revolution in the 1900's both gasses content in the atmosphere started to increase at high rates which was followed by an increase in the temperature from 0,4 to 0,8 °C in a global level during the period 1860 to 2000. Globally the increase of temperature occurred in two steps the first in the period 1910-1945 and the second in the period 1975-2000. This big increase is mainly to anthropogenic activities and partly to physical processes. The 1990/2000-decade was the warmest period for the northern hemisphere for the last 1000 years due to great increases in summer temperatures. Concerning rainfall this shows an increase in the greater parts of the middle and higher latitude regions of the North Hemisphere but in the largest part of the tropical and subtropical areas the conditions are becoming dryer.

According to the Inter-governmental Panel of Climate Change (IPCC) the great increase of the green house gasses in the atmosphere shall cause by the year 2100, the increase of the temperature of the Planet by 1,7-4,0 °C and the sea level shall rise by 22-75 centimetres. Concurrently the rainfall is expected to increase in most of the tropical regions throughout the year, to reduce in the majority of the subtropical regions and to increase slightly in the higher latitude regions. The rainfall is also expected to decrease in the internal areas of the continental regions of the Northern Hemisphere.

A.4.2 Mediterranean Climate tendencies

While the Global climate shows tendencies for change, the same would be expected to occur in the Mediterranean region. However it is impossible due to the small extend of the area and the high variability of the local climates to come to some reliable conclusions as to the tendencies regarding the climate change in the Mediterranean region. This is becoming even more difficult because of the short duration of observations, which do not allow the analysers to draw safe conclusions. With regard to temperature, from studies carried out, it can be concluded that the evolution during the last 100 years is similar to Global changes with an increasing tendency, although some deviations are observed locally. On the other hand precipitation in the regions surrounding the Mediterranean Sea has decreased during the last century up to 17%, with the exception in the region, which extends from Tunisia to Libya where a small increase has been recorded. Generally there is a tendency for the

reduction of precipitation in the southern Europe where in the majority of the regions in the north an increase is recorded.

A.4.3 Climate Tendencies in Cyprus

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 means that there exists a change to the general circulation and behaviour of the atmosphere in the Mediterranean region. From the records in the Government controlled area it is concluded that the temperature is increasing where the precipitation is decreasing as follow.

a) Precipitation Reduction in the last century. As can be seen from Figure 2 the average precipitation in Cyprus during the 20th century reduced on the average at a rate of one (1) mm a year. The rate of reduction of precipitation is greater in the second half of the century in comparison with the first half of the century. Further in the recent decades the number of years with reduced rainfall has increased and the dry conditions are becoming more serious. In addition the warmest years of the century have been recorded during the last twenty years. During the second half of the century the frequency of reduced rainfall years has increased in comparison to the average precipitation in the years of the first half of the century. Similar results are given by comparing average annual precipitation for the different 30-year periods as shown on Table 3.

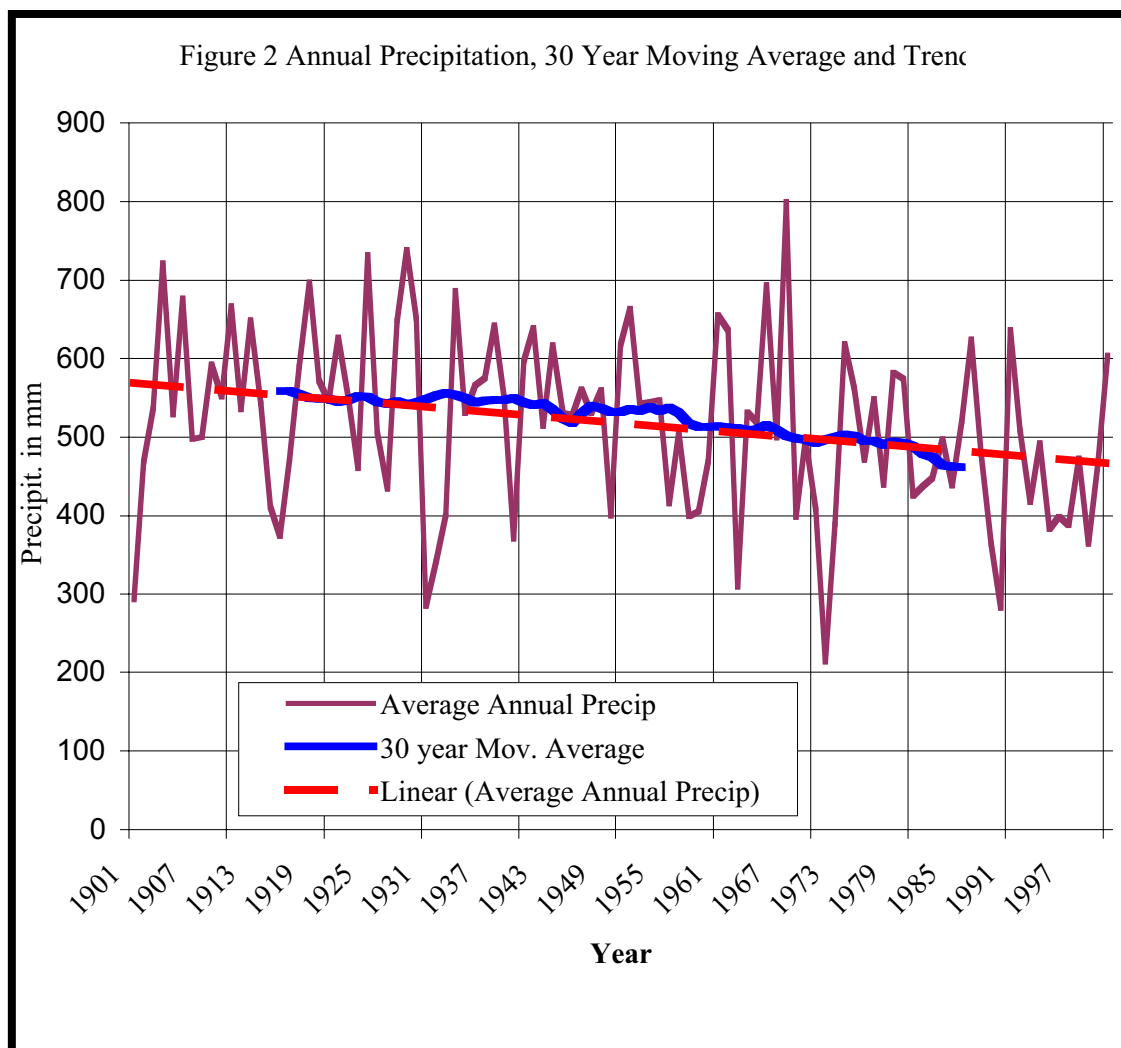
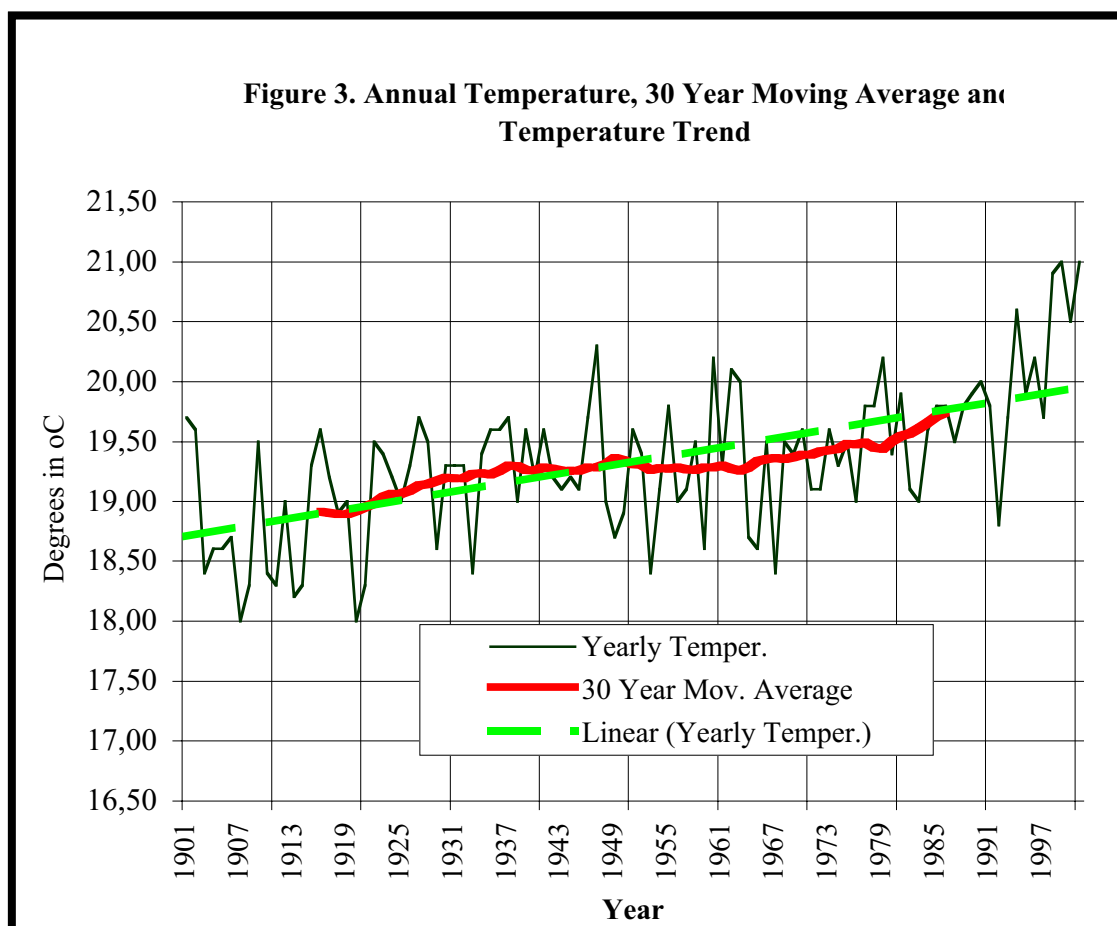


Table 3. Average precipitation for 30-year periods during the last Century

Period	1901-1930	1931-1960	1961-1990	1969-1998
Average Precipitation	559 mm	524 mm	503 mm	464 mm
% Less than first 30years	0	-6,26	-10,02	-17,00

From the records it can also be seen that the last decade of the century (1989-1999), is the period with the lowest precipitation of all the decades of the century, with an average precipitation of 434 mm per year or $-22,36\%$ less than the first 30 year period of the century. Further to the reduction in the precipitation a variability of the monthly distribution of precipitation is observed with an increase in the November precipitation and reduction in the remaining months.

b) Increase in Temperature in the last century. While the precipitation is reducing at an average rate of one (1) mm per year the temperature showed an increase by an average of $0,01\text{ }^{\circ}\text{C}$ per year as it is seen in Figure 3. For the period 1976-1998 it is seen that the rate of increase of the temperature in towns is $0,035^{\circ}\text{C}$ per year and in the rural areas it is $0,015^{\circ}\text{C}$ per year. Although it can be said that the greater part of the increase of the temperature in the towns is due to the urbanization the fact that there is an increase of the temperature in the rural areas, this shows that the temperature increases. Further the fact that there is an increase in temperature is supported from the records, which show that globally the warmest years of the century occurred during the last two decades.



c) The projections for the future. Although it is difficult to draw safe conclusions for the tendencies of the climatic conditions of Cyprus the following can be said at a high risk after considering the results of the various climatological models.

a) Temperature: This may continue to increase in accordance to the Global tendencies. The temperature shall increase by the year 2100 to something between 1,7-4,0 °C, or at a rate ranging from 0,017 to 0,04 °C per year.

b) Precipitation: This is more difficult to project but based on the general trend it may be said that precipitation shall continue to decrease. For the Mediterranean regions the various models although not in agreement show generally a trend of reduction of precipitation with variations as to the rate of reduction. For the area around Cyprus the reduction in precipitation is estimated at a rate of 3% of the average per degree Centigrade of increase of the mean temperature on the Global level. Generally there is a disagreement of the models on precipitation trends in the Mediterranean region, but most of the models show a decrease of the annual precipitation in the larger portion of the regions lying below latitude 40° and 45° and an increase in regions north of latitude 45°.

A.5 International Conventions and Protocols on Climate Change

a) The Framework Convention on Climate Change: In response to the emerging evidence that climate change could have a major global impact, the UN Framework Convention on Climate Change (UNFCCC) was adopted on the 9th of May 1992 and countries were asked to ratify it. Cyprus ratified the Convention in 1997 and put it into effect from January 1998. The objective of the Convention is the *stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous effects on the climate system from anthropogenic activities*. The countries shall achieve the objectives jointly and individually by implementing the following:

- i) Returning to the 1990 emission levels,
- ii) By adopting policies and measures to mitigate climate change and,
- iii) By providing technology transfer and financial resources to help developing countries.

With this Convention the UN Framework Climate Change Committee (UNFCCC) was established for monitoring the implementation of the Convention. The convention sets limits for the increase of gas emissions to the atmosphere during the period 1990-2000.

b) The Kyoto Protocol, a legal instrument: In December 1997 the UNFCCC finalised the negotiations related to the establishment of the Kyoto Protocol on Climate Change, which establishes legally binding targets for the reduction of greenhouse gas emission. The legally binding commitments of the developed countries is to reduce jointly and individually emissions of six (6) greenhouse gases by more than 5% in the period 2008-to 2012, below their 1990 level by the use of the following.

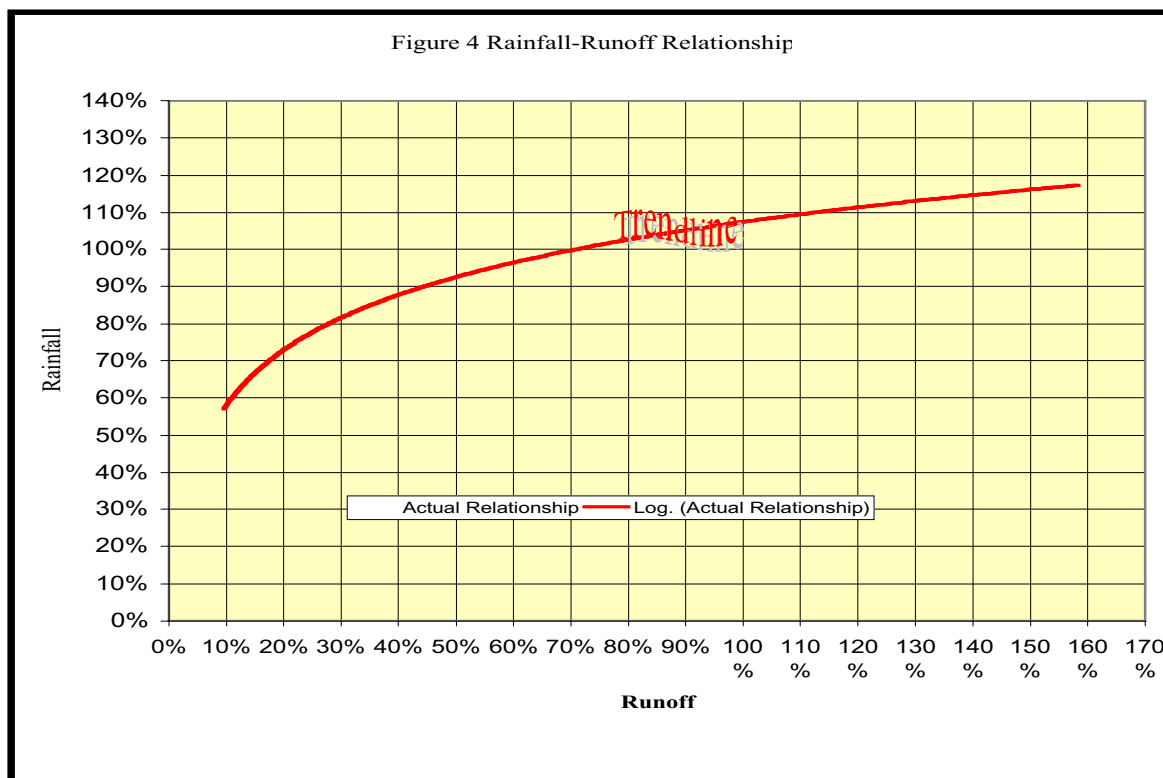
- Voluntary adoption of policies and measure,
- Establishment of an emission trading regimes,
- Joint implementation,
- Protection and promotion of sinks to absorb CO₂ and
- Establishment of a clean development mechanism.

c) Obligations of Cyprus: Cyprus is to become a member of the European Union in May 2004. Within the Kyoto Protocol the European Union undertook to reduce the emissions to the atmosphere by 8% during the period 2008-2012 and according to this each country member of the EU has undertaken its obligation according to the Burden Sharing Agreement signed by the EU countries in June 1998. Since Cyprus was not a member of the EU at the time of agreeing the Burden Sharing Agreement its responsibilities were not decided. However for the period 2008-2012 and provided Cyprus is included in the developed nations list, the most probable obligations would be to reduce emissions to the atmosphere by 8% in relation to the 1990 emissions. Since this would not be possible based on the Expected Evolution Scenario (98% for the period 1990-2010) Cyprus obligations may be included in the second period starting after 2012, but yet no decisions have been taken.

A.6 Climate Change and Effects in Cyprus

The climate change, both locally and globally are expected to have the following effects on the water resources and on their control structures in Cyprus.

- The total average precipitation in mm per year and Km³ per year shall reduce proportionally to the rainfall reduction.
- The actual evapotranspiration and potential evapotranspiration in mm per year and Km³ per year shall increase due to the increase of the temperature.
- The total surface runoff shall decrease at a higher rate than reduction of precipitation as is shown on Figure 4. From the water resources re-evaluation studies carried out recently it was found out that from the climate change that occurred during the period 1970-2000 the total runoff reduced by 40% compared with a precipitation reduction around 13%.
- The crop water demand in mm per year shall increase, which means that more water shall be needed to irrigate one unit area of irrigated land.
- Water demand for general domestic needs per capita shall increase.
- Groundwater volumes in the coastal aquifers shall reduce due to the rise of the seawater, which shall be caused by the global warming and melting of the ice in the poles. Cyprus has long coastal line with all major aquifers being coastal aquifers.
- More frequent extreme events shall create problems to the existing water structures, operational and safety problems as well on their capacity and reliability to develop and control water resources.
- Springs shall dry where stream flows shall reduce.
- Wetlands shall be drying up earlier with adverse effects on the biodiversity and the natural water resources.



A.7 Water Resources and Climate Change Effects

Cyprus has prepared a water master plan in the period 1968-1972 which was based on the climatic parameters of the period 1901-1960. The natural water resources were estimated at that time as shown on Table 4. Following the dramatic changes in the climate and mainly on the precipitation reduction and temperature rise, a re-evaluation of the water resources was made, the results of which are shown on Table 4. The re-evaluation was based on the most recent climatological data including data of the years 1970-2000, during which the precipitation reduced by as much as 13%.

Table 4. Natural water resources availability estimates during the 1970 Master Plan and the 2002 Re-evaluation.

No	Description of Parameters	1970 Master Plan	2002 Re-Evaluation	Difference
1	Average Precipitation, mm per year	503	437,6	-13%
2	Total Precipitation Volume, MCM	4.650,0	4.048,0	-13%
3	Evapo-Transpiration, MCM	3.750,0	3.508,0	
4	Total Water Resources, MCM	900,0	540,0	-40%
5	Total Water Resources/Total Precipitation %	19,4%	13,3%	
6	Surface Water resources in MCM	600	360	-40%
7	Groundwater resources in MCM	300	180	-40%

A.8 Climate Change and Water Uses Vulnerability

Cyprus being an island all its natural renewable water resources depends on the precipitation falling on its surface. This means that reduction of the precipitation due to climatic change has a direct effect on the availability of the natural resources of the island. From Table 2 it is seen that from the total presently developed and used water resources, 87% are conventional and 13% are non conventional. Of the total conventional water resources, which amount to 132,9 MCM, 103,9 MCM are surface water directly related to the climate change, where the remaining 129,0MCM are from groundwater resources being more reliable and less vulnerable to climatic change since groundwater reservoir capacities are 10 times more than surface reservoirs. From the climatic changes, which caused reduction in the precipitation, the following resources and uses are vulnerable.

- **Surface Water resources:** A reduction in rainfall due climatic change shall have a direct and immediate reduction of the surface water resources. Small springs are drying up due to lower groundwater recharge and small stream flows are reduced or dry up because of lower precipitation. The water impounded in the reservoirs is by 40% less than that estimated reducing the supply to domestic, industrial and irrigation users.
- **Groundwater:** A reduction in rainfall shall not affect immediately the yield of the aquifers, but its effect shall be in the medium to long term. On the other hand the coastal groundwater aquifers shall be affected by the rising of the seawater.
- The forestland and the rain fed crops shall be adversely affected by the reduction in the precipitation.
- The economy of the island shall be adversely affected.
- The environment i.e. the wetlands, natural vegetation, the green areas and the biodiversity shall be adversely affected.
- Desertification shall be expanded to more lands.

Part B

Institutions/Processes And Networks Working On Water, Wetland And Climate Change Issues

B.1 Climate Change and Water Uses Vulnerability

B.1.1 Centres and Institutions working on Climate Change

The climate change matters institutions may be classified into four categories as follows:

- a) Data collection and analysis Institutions,
- b) Research Institutions,
- c) Institutions dealing with climate change effects
- d) Policy and decision taking Institutions on climate change matters.

The institutions named below are not responsible per se for climatic change matters but they are involved directly or indirectly in climate change matters, since climatic parameters and their effects are part of their activities. At the moment there is no decision by the Government to study or analyse in detail the climatic change and matters related to climatic change except those that are included in the UN FCC Convention and the Kyoto Protocol. The institutions involved in one or another way in the climate change matters are the following.

- a) **Meteorological Service of Cyprus (Data collection and Analysis Institute).** This Service is a Governmental department, under the Ministry of Agriculture Natural Resources and Environment, responsible for the weather forecast and provision of meteorological services for the requirements of the civil aviation, the collection of meteorological data and information, the compilation of climatological statistics and monitoring of climatic variations and trends and the preparation of climatological studies and reports. It is also responsible for the provision of weather information and consultative services for applications in various fields such as agriculture, water resources, fisheries, and shipping industry, regional planning and development, tourism, architectural and civil engineering works, renewable energy resources, environmental studies etc.
- b) **Agricultural Research Institute (A research Institute).** This Institute, under the Ministry of Agriculture Natural Resources and Environment, undertakes mainly applied research aimed at providing answers to plant and livestock production problems and determining how the agricultural potential of the island may be best developed. Of importance with climate change and water scarcity are the efforts of the institution to experiment on crop water consumption with the aim of selecting and proposing less water demanding crops, suitable for a water scarcity regions.
- c) **Water Development Department (Institution concerned with climate change effects).** This Institution, under the Ministry of Agriculture Natural Resources and Environment, is dealing with water resources management including water resources inventory, planning, design, construction, operation, and maintenance of water projects. This Department is always confronted with the water shortage problems, which are mostly the result of climate change as outlined above. Data collected by the Meteorological Service are analysed and processed by this Department for the evaluation of the water resources and water demand on the island.
- d) **Department of Agriculture (Institution concerned with climate change effects).** This Department, under the Ministry of Agriculture Natural Resources and Environment is responsible for the improvement of agricultural productivity and competitiveness, further development of comparative advantages, improvement of quality of agricultural products, and structural and institutional modernization. Since good agricultural practices depend mainly on the meteorological parameters for productivity and quality, climate conditions and changes are

important inputs in the analysis related to agricultural production. The Department of Agriculture based on the meteorological data makes plans for promoting the agriculture policy and advises the farmers how much water to apply and when to irrigate, an important parameter defining the water demand.

- e) **Department of Forests (Institution concerned with climate change effects).** This is a Government Department under the Ministry of Agriculture Natural Resources and Environment, which administers the state forests, implements the Government Policy with regard to forests and it is responsible for implementing plans for forest development. Since natural forest survival depends on natural rainfall and ambient temperature, climatic changes affect the development and conservation of the forests in Cyprus. Also the policy on forests affects the availability of natural water resources.
- f) **Environment Service (Institution concerned with climate change effects).** This Service, under the Ministry of Agriculture Natural Resources and Environment, is the coordinating agency for Government Programmes for the protection of the environment, it is chairing the technical committee on the environment impact assessment of projects, advises the Government on environmental policy, and it is mandated to ensure the implementation of the environmental policy. The Environment Service is the coordinator for the implementation of Kyoto Protocol, the Climate Change Convention, and the Ramsar convention.
- g) **Fisheries and Marine Department (Institution concerned with climate change effects).** This Department, under the Ministry of Agriculture Natural Resources and Environment, is responsible for the sustainable management of living marine resources, the development, and research of aquaculture and the protection and research of the marine environment. Water temperature monitoring is the responsibility of this Department.
- h) **Department of Geological Surveys (Institution concerned with climate change effects).** This Department, under the Ministry of Agriculture Natural Resources and Environment, is responsible for carrying out surveys for the location of the geological natural resources. One of the geological resources is the groundwater and this Department is concerned with the natural recharge originating from the precipitation.
- i) **Ministry of Agriculture Natural Resources and the Environment (Policy and decision taking Institution on climate change matters).** This is the Ministry in charge of Agriculture, Natural Resources, and the Environment. This Ministry is responsible for formulating the general policy on the development and conservation of the natural resources, including water, forests, and marine life.
- j) **Council of Ministers.** This is the highest level of executive power in the Republic and has the authority to take decisions on the policy to be adopted on every item including the climate change matters. So far this body did not take any decision to study further the climate change except to ratify the UNFCC Convention and the Kyoto Protocol. However some decisions taken for mitigating the drought phenomenon and water scarcity are to some extent related to climatic changes. Such decisions are the re-evaluation of the natural water resources, which have been found to reduce by as much as 40% due to climatic changes, the reallocation of water resources to meet increasing domestic water demand, the introduction of seawater desalination for increasing water availability and other measures to reduce water demand and water losses.

B.2 Coordination Between Institutions And Organizations

So far no official decision was taken to study the climate change matters except those in connection to the UNFCC Convention and the Kyoto Protocol, which are at the initial stages as will be seen in the next section of this Report. However events have obligated the Government Departments dealing with the water resources management to develop some form of cooperation and coordination on the

meteorological data collection and analysis, on the evaluation of adverse effects from the water scarcity, the development and promotion of measures and policies to mitigate the adverse effects of water scarcity resulting mainly from the climate change and on research and development and to some extent to adapt to the climate change. The cooperation and coordination was initiated by the Water Development Department with the Meteorological Service, the Department of Agriculture, the Agricultural Research Institute, the Geological Surveys Department, the Ministry of Finance, the Planning Bureau, the Environment Service etc, and the Users Associations.

B.3 Committees For Climate Change Matters And Their Duties

a) The United Nations Framework on Climate Change (UNFCCC) Convention and Kyoto Protocol Ad Hoc Committee. Focal point for the implementation of the above two obligations undertaken by the Government of Cyprus is the Environment Service of the Ministry of Agriculture Natural Resources and the Environment. For the implementation of the UNFCCC Convention and the Kyoto Protocol, the Ministry of Agriculture Natural Resources and the Environment, has created an Ad Hoc Committee under the chairmanship of the Environment Service, made up of the coordinator and ten (10) members as follows.

- Director, Environment Service Ministry of Agriculture Natural Resources and the Environment, Chairman, Coordinator,
- Representative of the Ministry of Commerce, Industry, Tourism and Energy, member,
- Representative of the Ministry of Public Works, member,
- Representative of the Planning Bureau, member,
- Representative, Department of Agriculture Ministry of Agriculture Natural Resources and the Environment, member,
- Representative, Department of Forests, Ministry of Agriculture Natural Resources and the Environment, member,
- Representative, Department of Public Works Ministry of Public Works, member,
- Representative, Department of Workers Safety, Health and Welfare Ministry of Labour and Social Insurance, member,
- Centre for Application of Energy, Ministry of Commerce, Industry, Tourism and Energy, member
- Representative of the Statistical Service of Cyprus, Ministry of Finance, member, and
- Representative of the Electricity Authority of Cyprus, member.

The responsibilities of the Ad-Hoc Committee are the following:

- i) To undertake the preparation of the Strategic Plan for the implementation of the UNFCCC Convention and the Kyoto Protocol, regarding the different scenarios of development and gas emissions.
- ii) To select the best scenario and propose measures to implement for achieving the targets set by the Climate Change Convention and the Kyoto Protocol.
- iii) To supervise and coordinate the implementation of the Strategic Plan for the stabilization of emissions of green house gasses in Cyprus.

The Ad hoc Committee has already prepared a strategic plan for the stabilization of the emissions of Green house gasses to the atmosphere. The Committee is not responsible to study, propose, or promote measures and policies for adaptation to climate change matters other than those strictly related to the limitation of the emission of the greenhouse gasses to the atmosphere.

b) Climate Change Committees

During the last 12 years Cyprus has suffered from water shortage which was caused by prolonged droughts, a climatic phenomenon whose frequency of occurrence has increased during the period 1970-2000. The water scarcity which impeded the potential of the water supply projects to supply water in sufficient quantities, caused by the prolonged periods of drought forced the Government to adopt a number of policies one of which was the formation of a Drought Management Committee with the objective of mitigating the adverse effects caused by the water scarcity. The Ministry of Agriculture Natural Resources and the Environment chair the Committee and its members are the following.

- Representative, Ministry of Agriculture Natural Resources and the Environment
- Representative, Department of Water Development, of the Ministry of Agriculture Natural Resources and the Environment.
- Representative, Department of Agriculture, of the Ministry of Agriculture Natural Resources and the Environment.
- Representative, Department of Geological Survey Department, of the Ministry of Agriculture Natural Resources and the Environment.
- Representative, Ministry of Interior.
- Representative, Planning Bureau.
- Representative, Ministry of Finance.
- Representative of the District Officer.

Other Departments were involved depending on the subject that was under consideration. The Committee was examining proposals or demands by the District Officer, representing the water users or the communities affected by the water scarcity and measures were approved for mitigating the adverse effects. The final decision as to the implementation of the measures was taken either by the Planning Bureau, the Minister of Agriculture Natural Resources and the Environment or the Council of Ministers, depending on the availability of funds or the cost in relation to the budget.

B.4 Discussions on Adaptation Policies for Climate Change Matters

As it was said earlier the Government has not yet taken any official decision for introducing adaptation policies for climate change matters. Since no such decision has been taken no committee has been established for the study of the effects of the climate change. However the water crisis, which was caused by the climatic changes have created the need for discussions and decisions on measures as well on policies that have to be adapted to face the adverse effects. The climate change effects were first observed on the water resources availability, with the surface reservoirs being almost empty, river flows much below the long term averages, the groundwater resources being depleted because of inadequate natural recharge and increased pumpage, the springs drying up late in summer etc. This led to a water crisis, which rendered the institutions in charge of supplying the necessary quantities of water unable to do so. The problem was brought to the Council of Ministers, which decided the following.

- a) Based on the new climatic conditions to Re-Evaluate the natural water resources and the water demand.
- b) To revise the water policy by:
 - Accelerating the implementation of schemes for re-use of domestic effluents and natural water resources projects,
 - Intensifying the implementation of water demand management measures (minimise losses, reduce consumption, minimise wasteful use of water, reallocate water, introduce less water demanding crops etc.),
 - Introduce seawater desalination for increasing the availability of water and increase the reliability of water supply projects,
 - Use of lower quality water thus increasing availability of good quality water for domestic uses.

- c) In case of water scarcity water rationing measures or reallocation of water shall be applied with priorities given to domestic needs, permanent crops and green houses, and lastly for vegetables.

All the above measures are either implemented or under further consideration with appropriate decisions by the Council of Ministers and the involvement of the responsible Departments and Institutions. No special processes were adopted and the institutional and legal framework has been able to support the measures.

However the above measures and policies are not enough to deal with climate changes and matters. It is my impression that the Government within the Kyoto Protocol must appoint a Committee made of such disciplines to deal both with the implementation of the Protocol and to consider and promote measures for the developing of policies for adaptation to the observed climate changes.

B.5 Key Institutions Providing Data on Climate Change Impact

The key institutions that provide data on climate change at present are mainly the Meteorological Service of the Ministry of Agriculture Natural Resources and the Environment, giving information on climate parameters, the Water Development Department, giving information on the availability of water resources and water demand, the Fisheries Department on marine environment data, the Ministry of Labour on emissions to the atmosphere, the Electricity Authority of Cyprus (EAC) on electric power production, the Ministry of Commerce and Industry on fuel consumption for transport and industry other than power produced by the EAC, the Department of Agriculture on crop water requirements and consumption, the Environment Service giving information on the effects on the environment in general and the District Officers on the effects of climate change on the well being, income and social life of the population. These institutions are in place and can provide any information on climate change that comes to their attention in the line of their duties. What is needed is the political decision to energize and intensify the activities on climate change and impacts.

B.6 Research Institutions

Cyprus is a small island with a small number of institutions with limited capacities. So most of the research and analysis is carried either directly by Institutions in other countries or by Cypriot Institutions in cooperation with Institutions outside Cyprus. The institutions that carry some research on climate change are the Agricultural Research Institute (ARI), the University of Cyprus, and the Water Development Department. The ARI is involved directly in applied research on the use of water for irrigation and the Water Development Department and the University of Cyprus are involved in research on the impacts of climate change on the water resources availability.

B.7 Coordination Between Institutions Involved In Climate Change

The Council of Ministers did not yet decided the preparation of any plan for mitigating the effects of climate change and for adapting policies on climate change. However the climate change is already taking place with a reduction in precipitation and the temperature increase. The precipitation reduction led to the reduction in the water availability resulting to a water crisis in two periods one in 1990-91 and the second in the period 1996-2000, which forced the various Departments to start working and cooperating on projects for mitigating the effects. The cooperation included the preparation of scenarios for water demand management, water augmentation by the construction of desalination plants, the reuse of wastewater, the encouragement of the use of water saving measures, the reduction of losses in domestic and irrigation distribution systems, the introduction of less water demanding crops etc. The cooperation was made on administrative, scientific, and technical levels by the transfer of information, of data, of know-how, the research and development, the public awareness, the information of the public about the water situation and promotion of measures through the mass media. The cooperation is carried out as follows.

- There is coordination between the Focal Points of Ramsar, UNFCCC and UNCCD and other Government Departments on how to mitigate adverse effects caused by the draughts and the water

scarcity on the wetlands. If possible water was released to wetlands for keeping the environment under sustainable conditions.

- There is coordination between the water policy authority (Council of Minister and Ministries of Interior and Ministry of Agriculture Natural Resources and the Environment), the Water Development Department, which is the Governments agency for applying the Government Policy and all the water supply agencies (Town Water Boards, Municipalities responsible for domestic water supply, the village domestic water supply authorities, the Irrigation Divisions and other Committees responsible for irrigation water distribution). There is also cooperation between the Water Development Department and the Environment Service, the Department of Agriculture, the Geological Survey Department, the Marine Surveys and Fisheries Department, the Planning Bureau, the Ministry of Commerce and Industry, the Ministry of Interior, the Farmers Associations, the Environmentalists Association and any other institution or organization dealing with water. The coordination during the water crisis was very close and effective, giving the best results. The coordination was governed by the existing legislation but above all was dictated by the need to mitigate the adverse effects.
- It is the opinion of the author that a political decision should be taken on the preparation of Climate Change Plans and the authorities and responsibilities of all concerned must be defined and regulated by Legislation.

Part C

Integration of water and wetland resource management policy and practices and climate change

C.1 Most Essential Issues And Opportunities For The Integration Of Water And Wetlands

Cyprus in the 1970 has prepared a Water Master Plan, based on the climatic data of the period 1900-1966. The plan was prepared by the Government of Cyprus with the assistance of an FAO team of experts, and was the result of surveys and investigations carried out on the soils, on water availability, and on population in conjunction with the climatological data available at the time. The planning was based on the Integrated Water Resources Management approach and included the construction of dams and water and wastewater treatment plants, the installation of pipelines and distribution systems and other structures. According to the Master Plan the natural water resources and the recycled domestic effluents would be enough to satisfy the demands up to the year 2005-2010. The implementation of the Master Plan started in 1973 and by 1990 after most of the dams were constructed it was realized that the natural inflow to the dams was much less than originally estimated. From studies carried out it was found out that due to climatic change or variability the precipitation was gradually reducing, with extreme events mostly drought years, becoming more frequent. During the period 1990-2002 Cyprus suffered from water scarcity caused by repeated droughts during the period 1990/1991, 1996/2001, and with an average precipitation around 13% less than the long term average and the inflow to dams by 40% less. This alarmed the institutions dealing with the management of water resources and the water Users and emergency plans were implemented to mitigate the adverse effects. The plans provided for water rationing both for domestic and irrigation purposes, the construction of seawater desalination plants, the intensification of application of water demand approaches and the acceleration of implementation of domestic effluent reuse projects. Wetlands also suffered from water scarcity due to the reduction of precipitation and the exhaustion of the aquifers, which reduced the outflow of groundwater to the wetlands. Efforts were made to satisfy the water needs of the wetlands but this was not always possible due to the acute water shortage.

Following the water crisis the Council of Ministers revised the water resources management policy as follows.

- Intensify Water Demand Management measures.
- Accelerate the implementation of domestic effluent reuse projects.
- Accelerate the implementation of natural water resources projects.
- Introduce seawater desalination plants for augmenting and increasing the reliability of water supply for domestic use and irrigation.
- Introduce a new legislation for water resources management through a Water Entity.
- Re-evaluate water resources availability and water demand. For this a special study was carried out and the results showed that the available water resources are by 40% less than those estimated in the Cyprus Water Master Plan in the 1970, which is the result of the Climate Change prevailing in Cyprus.

Generally the water resources management in Cyprus is carried out in an integrated manner, serving domestic needs, irrigation needs, industrial needs and environmental needs. However due to the water scarcity faced during the last 12 years and the continued over pumping of the groundwater resources the inland aquifers have been depleted and the coastal aquifers are salinized, because of seawater intrusion.

Although nobody is certain whether the climate change which occurred during the last century in Cyprus shall continue with further decrease in the annual precipitation and further increase in the average temperature, one thing is certain that global warming shall continue resulting to the rise of the seawater level affecting the coastal aquifers and the coastal areas. Further the natural water resources reduction, which already has taken place, must be considered for revising the existing water project's

utilization including water reallocation. The approach to the solution of the water problems created by the climate change should be in an integrated manner and for this there must be first a decision by the Council of Ministers. The Decision should provide for a Plan to mitigate the adverse effects created by the Climate Changes on the water resources management in an integrated manner and for policy adaptations towards climate change. The plan should provide studies on the following:

- Climate change adaptation Policies for water and wetland resource management,
- The formation of the enabling system (legal framework, institutional framework, including public and users participation),
- Consideration of measures and options to meet the adverse effects,
- Costs and benefits including environmental benefits from the implementation of such a plan.

C.2 Case Study

As already described above Cyprus has been suffering from drought in the years 1990/1991 and the years 1996/2001. The whole of the island was under stress and the threats on the ecosystem were the following.

- Reduced Rainfall. This deprived the satisfactory irrigation of forests, and of rain fed agriculture.
- Surface runoff was reduced with reduced inflows to dams and wetlands.
- Wetlands did not collect enough water with adverse effects on their biodiversity.
- Recharge of the aquifers was less than normal and aquifers were over pumped to satisfy normal demand resulting to groundwater mining.
- Domestic water supply was reduced endangering quality of life and sanitation of the citizens.
- Water for irrigation was reduced with social, economic, and environmental adverse effects.
- Dry lands posed a threat for fires and uncontrolled fires destroyed great areas resulting to environmental disasters.

The existing legal and institutional frameworks in place although not referring specifically to climate change or droughts when applied wisely and with good will emergency situations created by water scarcity can be faced effectively and efficiently. However the measures were taken at an ad-hoc manner under crisis conditions and not according to a long range planning.

Part D

Toward adaptive strategies-discussion points for the regional round table

D.1 Issues or points for discussion in the regional round table

Climate change is not yet confirmed although in practice many countries including Cyprus are experiencing extreme climatic phenomena such as reduced precipitation and increasing temperature, droughts, floods, higher temperature, which in conjunction with global warming are creating problems to the availability of surface and groundwater resources. Other problems faced in many countries are the floods, more fires eruptions, forestlands are reducing, and wetlands are drying up with social, economic and environmental problems increasing at an alarming rate. The Government of Cyprus was forced to face the results of the climate change or climate variability that resulted to the reduction of the availability of the water resources at an ad-hoc manner by taking short-term measures.

The regional roundtable gives the opportunity for the participants to discuss issues and points that are important for all countries facing the adverse effects of climate change or climate variability. Based on the experience gained during the last twelve years while trying to face extreme climatic conditions the following issues or points of importance are proposed for discussion.

- Data and information needed to define the climate change.
- Methodology for defining the climate change
- Methodology for evaluating the effects on the natural water resources and re-evaluating the natural water resources.
- Methodology for evaluating the effect on groundwater resources due to the sea level rise because of the Global warming.
- Methodology for evaluating the effects of climate change on water demand.
- Legal and Institutional Frameworks for water management under changing climatic conditions and reduced water availability, with the objective of maintaining a sustainable development.
- Public awareness and participation in the studies and measures to mitigate adverse effects of climate change.
- Technical, legal, institutional, economic, social and environmental measures necessary to face the adverse or beneficial effects of climate change such as water shortages, floods, increasing water demand, seawater level rising, fire eruptions because of dryness, etc.
- The role and contribution of each of the stakeholders in facing climate change effects.
- The formulation and approval of climate change adaptation policies.

Reference:

1. Re-assessment of the Water Resources and Demand of the Island of Cyprus. WDD and FAO, Nicosia Cyprus, September 2002.
2. Monthly Bulletins on Monitoring of Variation of Climate Parameters in Cyprus January-December 2000. Nicosia, Cyprus.
3. Climate change in the Mediterranean, by Charalambos Feidias and Demetrios Lalas Athens November 2000. (In Greek)
4. Precipitation Decreasing Trends in Greece and Cyprus since the middle of our century, Amanatidis, T. G., Reparis, C. C., Metaxas, D.A., Paliatsos, A. G. and Bartzis, G.J., 1992, Climate Conference 14-18 June 1992, Bad Durkheim, Germany.
5. _____ π _____ π (Studies of the precipitation series of SE Greece and Cyprus), Hadjioannou, L., Retalis, D., Pasiardis, S., Nicolakis, D., Sakellariou, N., Asimakopoulos, D., Lourantos, 1998.
6. The Mediterranean in Figures-Water resources and Uses in the Mediterranean countries Figures and facts. Jean MARGAT & Domitille VALLEE, Plan Blue March 2000
7. IPCC, 1992: Climate Change 1992: The supplementary Report to IPCC Scientific Assessment, Cambridge University Press, Cambridge.
8. IPCC, 1996: Climate Change 1995, The Science of Climate Change, (Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change) Cambridge University Press.
9. IPCC, 2000: Third Assessment Report, Working Group I Report.
10. Hadley Centre, 1995: Modelling Climate Change 1860-2050.
11. Green peace 1999: Climate Change in the Mediterranean in Greek, by the Green peace office, November 1997.
12. Hoffman, J. S., Keyes D., and Titus, J. G., 1983, Projecting Future Sea Level Rise. US Environmental Protection Agency, EPA 230-09-007, p.121.
13. Mitchell, T. and Hulme, M., 2000: A Country-by-Country Analysis of past and future warming rates. Tyndall Centre Internal Report, No 1 November, 2000, UEA, Norwich, UK, 6pp. (<http://www.tyndall.uea.ac.uk/main.htm>).