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Experiences for drought management plans in Cyprus

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SUMMARY – Cyprus is the third largest island of the Mediterranean Sea with an intense Mediterranean climate. The annual water availability is less than 500 m^3/capita including sea water desalination and re-use of the treated domestic effluents. The natural water resources are almost fully developed with a master plan whose implementation lasted for 30 years starting in 1970. During the period 1970-2000 Cyprus suffered from 8 drought events lasting for 15 years out of 30, with rainfall below 85% of the average. A reduction of 15% of the rainfall brings an average reduction of the water resources of 30-40%. To accommodate the drought and minimize their adverse effects Cyprus was forced to modify its water policy by the introduction of seawater desalination, and accelerate the construction of new water projects and the recycling of the domestic effluents and to intensify the use of water demand methods and finally to develop and implement drought mitigation plans. Cyprus prepared and implemented drought mitigation plans successfully. This paper presents the procedure followed for the preparation of drought mitigation plans in Cyprus.

Key words: Drought, drought mitigation plan.

Introduction

Cyprus is an island in the North Eastern end of the Mediterranean Sea, covering an area of 9251 square kilometers with a Mediterranean Climate and annual precipitation around 500 mm. It is a member of European Union since May 2004. The country's economic activity is centered on the services, which contribute more than 75.6% to the GNP, the industry contributing 20% and the agriculture contributing only 4.4%.

The developed water resources of Cyprus in the areas under Government control are very limited amounting to 307 million cubic meters (or 429 m^3/capita), made up from 197 million cubic meters surface water, 110 million cubic meters from groundwater, 30 million cubic meters from desalination of seawater (introduced in 1997) and 6 million cubic meters from treated recycled domestic effluents. About 75% of the water supply is consumed for agriculture and the remaining for domestic and industrial purposes.

The development of the natural water resources was made over a period of 30 years (from 1970-2000) by the implementation of a Master Plan which was prepared in the 1970's. Cyprus with very limited water resources is vulnerable to droughts because it has developed almost all its natural water resources, with most of its aquifers depleted, and no perennial rivers. Due to climatic changes which resulted to 15% reduction of the precipitation, the water availability has decreased by as much as 40% compared to the original quantities estimated in the 1970's with all projects yielding less water, while the demand is increasing because of population increase (movement caused by the Turkish invasion in 1974 of 200,000 people to the Cyprus governement controlled area of the island) and the rising of the standard of living.

Droughts frequency and severity

During the years 1970-2000 Cyprus suffered from a total of seven drought events, four drought events of one year duration and with rainfall 68-82% of the average, one drought event of two years duration and with rainfall varying from 53-68% of the average and three drought events with three years duration each with rainfall varying from 40-84% of the average. With semidry Mediterranean climate a reduction of 15-20% of the rainfall contributes to a reduction of approximate 40% of the surface and groundwater resources availabilities. The above indicates that 50% of years were drought years with rainfall less than 85% of the average and water resources less than 60%.

Water deficits caused by drought and other effects

Although the water resources of Cyprus were estimated in accordance with a Master Plan prepared in the 1970's and taking into accounts the hydrological data available since the 1900's, after the implementation of the Master Plan, water shortages were observed due to the following reasons.

(i) Due to repeated severe, long duration droughts as outlined above.

(ii) Due to climatic changes: a detailed hydrological study proved that the average rainfall of the island from 1972 and later is by 15-20% less than the normal precipitation measured during the period 1900-1970, reducing the natural water resources by 40%.

(iii) Due to the Turkish invasion in 1974, which resulted to the forced displacement of more than 200,000 people from the north part of Cyprus to the southern part of the island and the colonization of the north part by more than 200,000 colonizers from Turkey. The population of the island increased by approximately 200,000 people increasing the water demand proportionally.

The overall results of all three factors was the creation of water deficit from all Government water projects in Cyprus (surface water) as is shown on Fig. 1 below.

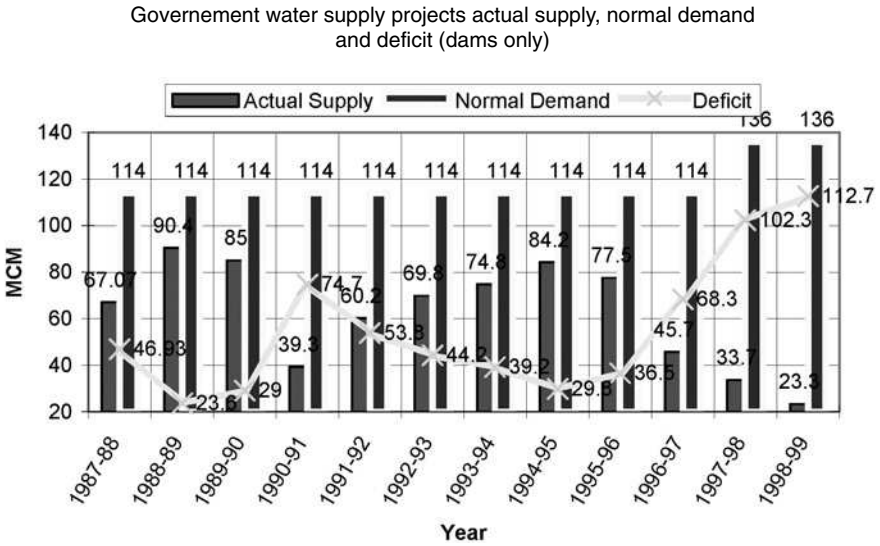

Fig. 1. Water deficit caused by the meteorological droughts, the climate change and the Turkish invasion.

From Fig. 1 it is seen that starting in 1987 the water deficit represented some 47 MCM out of the 114 MCM been the normal demand, reducing to some 23.6 MCM in 1989. In 1991 the water deficit reached the level of 74.7 MCM and then gradually over the years 1991 to 1995 decreased to 29.8 MCM. During the years 1995 to 99 the deficit jumped to 112.7 MCM out of the 136 MCM been the normal demand. In 1997 the Government introduced desalination producing some 14 MCM per year used mainly for the satisfaction of the domestic needs. The figure shows that Cyprus has over the years acute water shortages caused by drought and other reasons for which drought mitigation plans have to be prepared and implemented.

Considerations for preparation of drought mitigation plans

With severe water shortages in all major water projects affecting the economic, social and environmental sectors of the country the Government was forced to prepare and implement drought mitigation plans. The plan's objectives were to satisfy the essential water demand, and minimize the adverse effects on the economy, the social and environmental sectors. The drought mitigation plans were based on the following:

(i) That the Government owns almost all surface and ground water resources (more than 99%) of the island.

(ii) The Government has the right to build and operate waterworks and sell water at prices approved by the parliament. The Government has the right to reduce water supply according to water availability. The Council of Ministers is the policy maker for water resources management of the island.

(iii) The Water Development Department (WDD) of the Ministry of Agriculture, Natural Resources and the Environment is the Government agent for implementing the Government policy, including water cuts and drought mitigation measures concerning water supply.

(iv) The water resources management is governed mainly by the Government Waterworks Law which is very general and vests all powers to the Council of Ministers.

(v) Water Supply institutions for domestic or irrigation water are governed by existing laws and regulations approved by the Government and the Cyprus Parliament.

(vi) The existing laws governing the management of the water although not very modern allow the Government to take actions in cases of water shortages to take the necessary measures to mitigate adverse effects, taking into consideration health, economic and environmental needs.

(vii) The consumers (potable, irrigation and industrial) have certain rights that the Governments always respect and take into account when considering drought mitigation plans.

General procedure for the preparation of hydrological drought mitigation plans

The drought mitigation plans were prepared by the Water Development Department of the Ministry of Agriculture Natural Resources and the Environment. The preparation of the drought mitigation plans is a part of the monitoring process, which is related with the collection of the water availability and water consumption data carried out by the Water Development Department in its monitoring program. The drought plan preparation process adopted and used in the 1990's and early 2000's was carried out in four steps as is shown on Fig. 2.

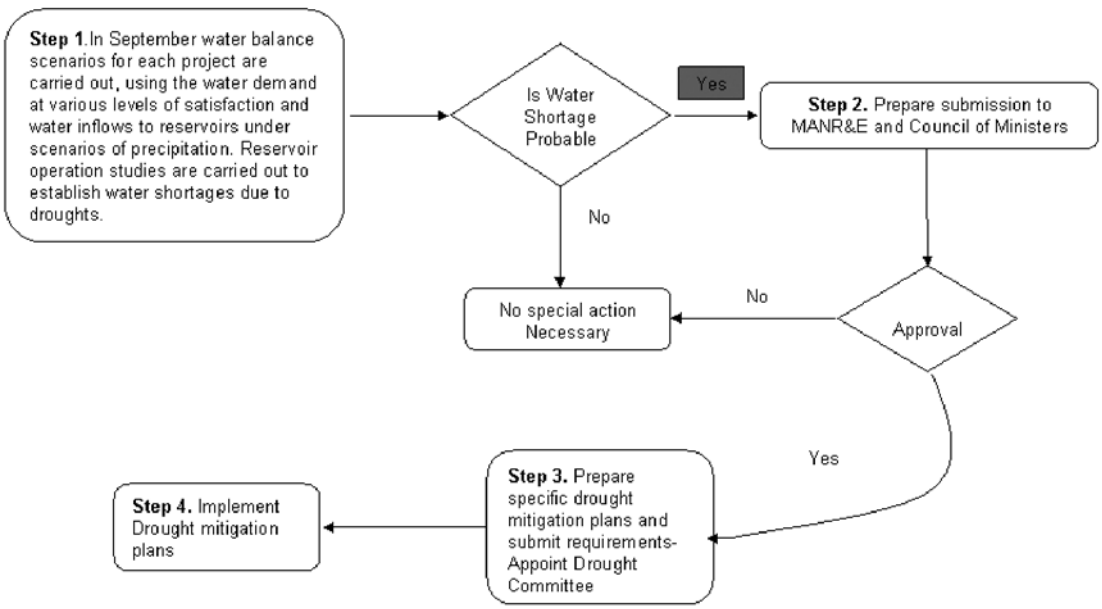

Fig. 2. Drought mitigation Proactive Plan Steps undertaken by the WDD in Cyprus.

Figure 2 shows for each step in summary form the actions that must be taken. The process is lasting for nine months staring early in August and ending next April and includes the preparation for each project of a water balance and water supply scenario taking into account the existing water resources at the time, the probable inflow to the dams and groundwater reservoirs, and the projected water demand for a period starting at the time of preparation of the plan and ending the 31st of December after the end of hydrological year (the maximum planning time at the beginning was from august to end of next years December or 17 months and the minimum from April to December or 10 months). The water balance and water supply scenario for each project is updated every two months using the actual hydrological data, the probable inflow till end of the wet season and various scenarios of water supply depending on the water balance findings. No levels of severity were defined but the adverse impacts were defined and preliminarily are evaluated with proposals on how to mitigate such adverse effects. The final decisions on the water cuts or rationing, water augmentation and compensations in case no technical measures were enough to mitigate the adverse impacts were taken by the Council of Ministers based on proposals of the Water Development Department. It must be mentioned that the existing legislation does not provide anything on drought preparedness plans. Although drought phenomena hit frequently Cyprus, droughts in most instances were dealt "as crisis management phenomena" under the General Disaster Laws. In case of drought, the Government mobilizes in a proactive manner but all its actions were reactive in nature as is explained below.

Preparation of hydrological drought mitigation plans

Based on the above general principles the drought mitigation plans were prepared in a four step procedure as shown on Fig. 2 and detailed herein.

Step 1: early in August before the commencement of the new hydrological year, and every two months thereafter, till the end of next April (during the wet season), the Water Development Department prepares the water balance sheets and water supply scenarios for each project, based on the water resources available at the time, the forecasted water inflows to the dams and to the aquifers during the remaining wet season (October-May) and on the projected water demand till the end of the next year. Different scenarios are developed for different inflows and different levels of demand satisfaction. Each water balance sheet and scenario, covering the period August of the outgoing year to December next year, presenting one scenario depicting a different situation is a spreadsheet containing for each project the available water sources (groundwater, surface, reuse and desalinated water), existing and projected and the water demand (domestic, irrigation, industrial and environmental).

For each inflow scenario and using as variable inputs the water demand and assumed inputs (using again different scenarios of water demand for various levels of water demand satisfaction) and the losses to evaporation, reservoir operation studies, on a monthly base, are carried out for finding out what level of satisfaction for each project can be obtained. The results for each scenario are then evaluated and ranked according to the level of satisfaction and a "Table of Results" is prepared. In parallel a preliminary evaluation of the probability of occurrence of the different inflow scenarios is made. Using the results shown on the "Table of Results" and according to the probability and severity of the drought to occur, the impacts on the economy, on the social life and on the environment are preliminarily evaluated and suggestions are made as to the actions that must be taken. The different scenarios take into account strictly technical data (i.e. hydrological, hydro-geological, agricultural, and environmental).

Step 2: the outcome of the scenarios and balance sheets, the "Table of Results", comments and suggestions are submitted to the Ministry of Agriculture, Natural Resources and Environment for consideration. Normally no actions are taken until the end of January when the two wet months (December and January) are over and the results show that a drought is more probable to occur or not. The scenarios are revised every two months, which allows to the planners to drop a number of them been out of reality because of the changes that already occurred.

Step 3: based on the outcome of the revised scenarios, if a drought is already on, the most probable scenario is chosen and a detailed action plan is prepared early in February, which is referred again to the Ministry of Agriculture, Natural Resources and Environment, and then to the Council of Ministers, for decisions. The plan includes drought mitigation measures, such as water transfer, new

water supply emergency schemes, water cuts, water reallocation, water saving campaigns, etc. For the implementation of the plan an ad hoc Drought Management Committee is formed which meets and examines the implementation of the proposed measures and take decisions concerning the implementation of the measures and the allocation of the funds, on a biweekly basis or earlier if it is necessary. The Drought Management Committee is a multidisciplinary committee with members from the Ministry of Agriculture, Natural Resources and the Environment, the Water Development Department, the Department of Agriculture, the Geological Survey Department, the Ministry of Interior (District Office Level), the Planning Bureau and depending on the occasion under consideration, with officers from other Government Organizations. The Committee does not include any water consumers or their representatives. To a certain extent, however, they are represented by the District Officers.

Step 4: the implementation of the Drought Mitigation Plan starts in May and lasts until the end of the drought phenomenon or until the end of year whichever comes first. The Drought Management Committee does not examine applications for compensations or subsidies to persons or communities suffering from the adverse effects of droughts, and such claims if any are submitted to the Government and decisions are taken by the Council of Ministers.

The funds for financing the implementation of the Drought Management Plans are provided from the Government Budget, either from previously approved funds under the heading "Damages from Drought and Other Natural Calamities" or under the heading "Contingencies and Reserve", under the control of the Ministry of Finance.

From the above it is seen that the action to Drought Management is not proactive but reactive and is based not on the principle of risk management but on the principle of crisis management.

Validation of the drought mitigation planning procedure

The procedure outlined above was implemented and validated in a number of occasions during the period 1990-2000, by the writer. This model is not based on a specific law or regulation but on the necessity to mitigate the adverse effects of water shortage caused by repeated droughts. The model was the best possible under the circumstances of acute water shortage and made best use of the existing institutions and organizations and its success was based on the good will and understanding of all stakeholders.

The model although not covering all affected sectors, is validated in recent drought situations, observing that the model current structure provided satisfaction of the following essential points:

(i) Satisfaction of the basic needs of water with priority in the supply of drinking water but without neglecting altogether the needs for other sectors. This necessitated the reallocation of the very limited water resources available at the time.

(ii) Mitigation of the adverse impacts of the water shortage by promoting water saving measures and methods, and augmenting the water resources availability, where possible, by mobilizing natural water resources, by recycling domestic effluents, by introducing seawater desalination and by using lower quality water, where possible.

(iii) Promotion of the water savings in all sectors of the economy, indicating that water is a problem concerning all consumers irrespective of the priority given to one or the other sectors.

(iv) Raising public awareness and promoting the education of the population on the importance of the water and how to use wisely and efficiently the limited water resources. It was also stressed and understood by all that the best method to mitigate droughts and avoid the repetitions of water shortage due to droughts was to save water when it is available.

The model was validated also from the conclusions of the stakeholders' survey carried out by the MEDROPLAN project team during the study preparation on the following:

(i) *Perception of drought*. The perception by the professionals and the population that droughts are natural phenomena that occur periodically affecting the water resources availability and that the drought mitigations plans should be part of the water resources management plans.

(ii) *Actions*. The Legislators and the Government understood how serious could be the impacts from the droughts and embraced all the plans that could alleviate the adverse effects and relief the consumers, domestic users, irrigators and industrialist from the difficult situation created by the shortage of water. For this purpose they approved and authorized the expenditure of funds for new projects, for promoting water saving, and for compensations to those adversely affected, mainly farmers.

(iii) *Collective approach*. The population understood very soon that mitigation of the adverse effects could not be undertaken individually but only under the direct supervision of experts, who provided the expertise and the know-how.

The validation of the model does not mean that the model is the best or it is always adequate or does not have weaknesses. The main weaknesses of the model are the following:

(i) It is a reactive and not a proactive plan. Although the plan is drafted ahead of time its implementation is commencing after political decisions are taken. Water saving plans and measures contained in the drought mitigation plans, are abandoned once the crisis is over where other measures involving emergency plans for additional water continue to operate thus increasing the water demand and depriving the authorities of a source that could be used again in the future. This occurs often with the drilling and operation of emergency boreholes, which, after the crisis is over, they continue to operate mainly depleting the strategic sources and increasing the permanent water demand.

(ii) *Lack of legal framework.* The procedure and criteria for development of the Drought Preparedness Plan and its implementation are not based on any specific law or regulation. The implementation of most actions is not based on legislative articles but on the good will and understanding of those affected, positively or negatively.

Strengths and weakness

Although the model adopted was the best under the circumstances it has two drawbacks as follows:

(i) *Lack of Legislation.* The lack of legislation defining drought, the preparation of drought mitigation plans, when drought mitigation plans are to be implemented, and when drought is terminating, as well criteria, rules and priorities for water reallocation, who shall be compensated, how much and to what extend, how economic, environmental and economic issues are mitigated, as well as defining the responsible institutions and their powers, etc.), is a serious weakness of the whole system. This weakness was by passed to a certain extend by the generality of the water legislation the power of the Council of Ministers to take decisions and the good will shown by all concerned to cooperate and overcome water shortage/scarcity situations.

(ii) *Lack of specific setup or institution.* The fact that the Water Development Department is dealing with the preparation of the drought mitigation plans is not enough since it is mostly dealing with the parameters of water and not with other parameters such as social, economic and environmental. The lack of team composed from all disciplines with their scope of work clearly defined is a weakness/deficiency of the model resulting to non complete drought mitigation plans.

In conclusion it can be said that the weakness of the existing system is the total absence of legislation for drought preparedness plans, for drought definition and for definition when drought initiates and when drought terminates. Also the absence of legislation defining the obligations, duties, responsibilities and powers of institutions to act under drought conditions is a fatal weakness since neither complete monitoring systems are guaranteed, no integrated drought proactive mitigation plans can be prepared and no organization or institution is named with the duties and responsibilities to act accordingly. The inadequate reactive drought mitigation plans usually lead to high cost measures, but

ineffective in the long term. The institutions also lack experience on risk analysis and drought preparedness plans.

Conclusions

Drought phenomena are becoming more frequent and severe causing acute water shortages. This combined with the fact that all available water resources are developed and allocated to a certain use and with the phenomenon of climate change made the water management issue a critical one. To face this critical situation the Water Development Department of Cyprus developed a continuous process for the preparation of water balance sheets for each water project. Finally this with a combination of water supply scenarios developed into a process for the preparation of drought mitigation plans. This process has been originally implemented in the 1991 drought and since then every year the process is implemented irrespective if a drought will occur or not. The process with many weaknesses proved to be best under the circumstances providing the country with a tool to mitigate the adverse impacts of a drought. The process is continuous keeping the Water Development Department under alert, both at the time of the plan preparation and at the time of implementation of the plans. The plan is proactive in its preparation but reactive in its implementation. The MEDROPLAN project provides the Guidelines to Cyprus and to other Mediterranean countries to implement proactive and risk management plans instead of reactive crisis management plans (www.iamz.ciheam.org/medroplan).