WATER MANAGEMENT FOR SUSTAINABLE AGRICULTURE IN CYPRUS QUANTITY: DEMAND AND SUPPLY MANAGEMENT

Mr. Nicos TSIOURTIS, senior Water Engineer, Water Development Department
Nicosia, CYPRUS

1. INTRODUCTION

Cyprus with a total area of 9250 sq.km is inhabited by approximately 750,000 people. Its climate is typically Mediterranean with hot, dry, long summers and rainy mild winters. The average precipitation for the whole Island, in a normal year, is 500 mm where the evaporation is around 2000 mm. The rainfall varies from 300 mm in the plains to l,200 mm on the Troodos mountain. About 80% of the rainfall comes in the winter months. Being an Island the only conventional water is the one that originates from the precipitation which is estimated around 900/year, 600 MCM as surface runoff and 300 MCM as groundwater. The high temperatures, the winds, the low air humidity and the high solar energy, during the summer months, result in high evaporation which makes irrigation a necessity. Since there are no perennial rivers in Cyprus the only way to provide water for irrigation and other needs during summer is from reservoirs (surface or groundwater). About 50% of the total area of the island is arable but only a small fraction of this is irrigated due to the very limited water resources. Out of the 500,000 hectares of arable land only 36,000 hectares are now irrigated.

2. WATER AND IRRIGATION DEVELOPMENT

Groundwater, being much easier and cheaper to develop, was utilized first. Thousands of boreholes were drilled by the private sector and the Government for domestic, industrial and irrigation uses. By l 960 almost all aquifers were overexploited and the Government had to start developing the surface water resources for promoting further development. With the surface water, being almost intact because of high development costs, the Government embarked on a water development program which provided for the construction of surface reservoirs, the recharge of the overpumped aquifers, the control of the pumping from aquifers and the saving of water from over-irrigation. As a result of this program the surface storage capacity has been increased from 6.00 MCM in 1960 to 297.00 MCM in 1990, where the irrigated land increased from 20,lO0 hectares to 36,400 hectares (not including land in the areas occupied by the Turkish army). During the same period the available water increased from 160.00 MCM to 260 MCM. The increase of irrigated land was due to new projects as well as due to water saving from the use of improved farm irrigation systems.

3. WATER INSTITUTIONS IN CYPRUS

The water resources management is governed mainly by the following laws:

a) **The Government Waterworks Law** which gives property rights of almost all water, surface and groundwater, to the Government, safeguarding private water rights. The Government, according to this law, has the right to plan, design, construct, operate, maintain and manage

waterworks, sell water to individuals, to semi-governmental and other organizations dealing with water distribution and retail selling. The Government may fix water charges according to use, per cubic meter or per surface area etc. In accordance with this law the Government plans the development of the available water resources and allocates them to the various sectors. The management of the waterworks is given to Government agencies or semi-governmental organizations with the task of operating, and maintaining the works, selling the available water and collecting the water charges.

b) **The Irrigation's Division Law**, which gives the right to a group of individual land owners, at the approval and under the control and supervision of the local District Officer to construct, own, operate, maintain and manage local irrigation schemes. The Land owners form an Irrigation Division (a Water Users Association), and have the right to manage their waterworks and the water that is controlled by their works. The Government in these cases contributes to the cost of construction by grants and by long-term low interest loans. Under this law the water is allocated to the land and not to the land owner, thus emphasizing the fact that water may be used only for irrigation of a specific perimeter of land. The management of these projects, which are very local (they are usually confined within the perimeter of only one village and are simple to operate and maintain), is carried out by an Irrigation Committee, elected by the beneficiaries and chaired by the District Officer. The operation, maintenance and other costs are born by the beneficiaries. The design and construction of the projects is carried out by a Government agency and technical assistance is given continuously to these organizations. The water volume controlled by these organizations is relatively small around 34% of the total available water.

c) **The Village Water Supply Law**, which gives the right to the inhabitants of a village to form the Village Water Commission, at the approval and under the supervision and control of the District Officer, to construct operate maintain and manage a local waterworks for supplying water to their houses. Although they are by law independent organizations the capital cost of these projects, which are local and simple, are heavily subsidized by the Government and technical assistance is given free of charge by a Government agency.

d) **The Water Boards Law (Domestic water supplies)**, which gives the right to municipalities to form Water Boards at the approval of the Government and under the control and supervision of the Government, with the right to construct waterworks for supplying water to the inhabitants of the municipalities. These Organizations (non profit), provide their own financing for the projects and they fully recover their costs. The practice so far, with one exception, is for these organizations to provide the distribution of water to their customers and leave the bulk supplies of water for their needs to the Government.

e) **Water Wells Law**, allows to individuals to apply to the Government for a permit to drill a borehole or dig a well for domestic use or for irrigation. The permit is usually granted according to some criteria and some restrictions are imposed. The majority of the boreholes are drilled for irrigation purposes. About 8090% of the groundwater is pumped by individual or communal water schemes, the remaining being pumped by the Government projects.

f) **Other Laws**, allow to towns and villages to form sewage boards with the right to collect, and treat domestic effluents, and dispose them safely either give them for reuse or for groundwater recharge. The formation of sewage boards is subject to the approval of the Government.

From the above it may be concluded that the water management is in the hands of the Government to which the water, surface and groundwater, belongs. The consumers participation to the water management is restricted at the level of waterworks operation, maintenance and management, and the water distribution and use.

Responsibility of water administration at the policy level rests with the Council of Ministers where at the executive level responsibility is divided between the Ministry of Interior and the Ministry of Agriculture Natural Resources and Environment. The Ministry of Interior has the legal power while the Ministry of Agriculture has the technical responsibility.

Waterworks location and areas to be benefited are mainly selected on technical and economic criteria. Social and other criteria are used in genuine exceptional cases to promote non economically justified projects. Public participation to projects promotion is not envisaged in the main law of Government Waterworks, something which causes problems at the stage of water utilization resulting to non utilization of the available water or creating higher demand of water. The Projects constructed under the Government Water Works Law control almost 98% of the surface water. In the case of the Irrigation Division Law, where the Projects are undertaken by the water users, the participation of the consumers is from the very beginning, at the stage of planning, construction and during operation, maintenance and management bearing the cost and financial responsibility. Although the projects constructed under this Law are only small and simple to operate, the users participation is complete at all levels i.e. policy decisions, administrative, economic, financial, technical and others. Water charges are fixed by the Irrigation Committees.

At the level of operation and management of water projects the existing laws allows the limited participation of the users representatives. At this level of participation the users have the prime responsibility to contribute towards the best utilization of the available water volumes, to bill the customers, collect the bills and see that the project is operated and maintained properly. Water charge is fixed by the Council of Ministers and approved by the Parliament.

4. WATER DEMAND MANAGEMENT

The arable land of Cyprus is around 500,000 hectares where the available water resources at present amount to 260 MOM. Assuming that the water demand for domestic needs is around 65.0 MOM the water left for irrigation is around 195.0 MCM. If the average demand for irrigation is 5,000-8,000 m3/hectare then the area that may be irrigated on the average cannot exceed 39,000 hectares or 7.8% of the. arable land or 4.2% of the total area of the island. Present plans for increasing water availability, with the construction of new surface reservoirs, will provide for an additional 27.0 MCM by the year 2020. This increase is not expected to increase the share of the irrigation sector taking into consideration that domestic demand with high priority of supply, will continue to grow. On top of the limited water resources we must take into consideration the water deficits created by droughts and water shortages. With water resources

being limited and finite, with the danger of being scarce due to human activities, such as population growth, misuse and inequitable access, **water demand management** offers a solution to the problem. Water scarcity is caused by population expansion since a fixed amount of water must be divided among more and more people or by water pollution and overuse of existing supplies. The water demand management is applied at both the supply-side and the demand-side and include structural and non-structural approach methods as follows:

A. Demand-Side (on-farm level) water demand management.

A. 1 Structural Approach. This approach includes the on-farm irrigation system, and Water metering.

Modern on Farm Irrigation Systems: By applying improved efficient on farm irrigation systems, water saving is secured and water management is more efficient. Irrigation at the farm level is practiced by modern, efficient irrigation systems with application efficiencies around 80-90%. For the promotion of modern on farm irrigation systems the Government of the Republic has adopted in 1965 the "Improved on Farm Irrigation Systems" Project. At the first stages of the implementation, the Government provided technical assistance, financial aid and a grant. The grant amounted up to 15% of the total cost of the on farm irrigation system with the remaining given as a soft loan. The success of this project is such that almost all irrigation water is applied through modern on farm irrigation systems. The on farm irrigation systems comprise 90% micro-irrigation, 5% sprinkler irrigation and 5% surface irrigation.

Water Metering: Measurement of the water supplied to a farm facilitates the farmer to apply a water management at the farm level. It will facilitate the irrigation scheduling and will enable the farmer to apply the right (necessary) quantities of water for the appropriate crop. Water measurement requires the basic infrastructure and almost all farm-gates in Government irrigation projects or Irrigation Divisions are equipped with a water meter

A.2 Non-Structural Approach: This approach includes water charge, water use rights and water allocation, selection of crops with high water efficiency and irrigation scheduling.

Water Charge: Water charges when wisely applied encourage profitable and efficient use of water and discourage wasteful use. Water charges, on a volumetric basis combined with accurate water measurement, have been applied in Cyprus in almost all irrigation projects. The Water charges are flat for all the crops for normal water demand where excess use of water is charged at full cost which is three to four times the subsidized charge. Water charge is such that irrigation water is used almost exclusively for high value, high input crops such as permanent crops, crops in greenhouses and tunnels and seasonal crops. Water charges are different for different uses depending on the government policy.

Water Use Rights: The land commanded by irrigation projects is entitled to get irrigation water for its irrigation. The volume varies according to water availability in the surface reservoirs or in the aquifers. The available water is divided and allocated among the consumers according to the land area they intend to irrigate. No water market exists and the water belongs to the government.

Crops Choice and Crop Preference: At the planning stage of a project, depending on the water supply reliability and the economics of the project, a certain cropping pattern is selected and proposed to the land owners. Certain crops are not profitable at the fixed water charges and farmers avoid planting such crops. Also during water crises, water delivery is restricted to permanent and high value crops grown in greenhouses or tunnels. This ensures a water demand management at the farm level.

Consumers Awareness: Water demand management can be accomplished by education, training and information on the importance and scarcity of water. With continuous contact with the consumers (in this case the farmers) it is possible to persuade them to reduce water demand. The Government through the extension service of the Department of Agriculture provides training for the farmers on the use of irrigation water and stresses to them the importance of water in life as well its value and scarcity.

Irrigation Scheduling: The frequency of irrigation and the volume of water to be applied at each application have an effect on the volume of water supplied. If the irrigation frequency and the amount per irrigation are properly scheduled then water demand management may be effectively applied. This is achieved by farmers education and continuous training as well as by the creation of the necessary networks for the collection and dissemination of the basic information for irrigation scheduling. At present Cyprus has not the network for collecting the meteorological data for irrigation scheduling but through other means advises the farmers accordingly.

B. Supply-Side (System level) water demand management .

The supply-side water demand management comprise structural and non structural approaches. Through these methods water saving and water consumption are under control thus managing water demand.

B. 1. Structural Approach.

Selection and Design of Modern Efficient Irrigation System: Structures include the reservoirs, the feeder pipelines, the distribution systems, the farm-gate, the water meters, the control valves, the pumping stations, the balancing and regulating reservoirs and any other structure that will safeguard an efficient and effective operation. A good irrigation system is the one that delivers water to a farm at the right flow, the right pressure, at the right time, in the right quality and quantities with the minimum losses. All the above prescribe a system with a high reliability of water supply which encourages the user to use the minimum necessary amount of water being sure that the next irrigation will be on time. The system is designed for minimum losses in conveyance and distribution, avoiding excess pressures and forcing/encouraging the users to use efficient on farm irrigation systems. Almost all irrigation systems in Cyprus are made of closed, pressurized conduits, providing water under constant pressure, at a fixed rate of flow, with a water meter at every farm-gate . Water delivery modes are very flexible being either on full demand or on modified demand. It has been found in the early years of water development that unreliable supply of water increased consumption tremendously with farmers over-irrigating not being sure when the next irrigation will take place.

Water System Rehabilitation: In most cases existing irrigation systems are not efficient and effective facilitating and in some cases imposing water waste and high water consumption. Such systems are open channel systems, with unlined, uncontrolled channels, whose operation and water delivery are not flexible and unreliable, resulting in high water losses, in the use of low efficiency on farm irrigation methods and possibly in unnecessary irritations. These systems may be rehabilitated with a view to increase their supply reliability, their conveyance and distribution efficiencies, and to encourage or facilitate or impose the use of modern on farm irrigation systems.

Water Transfer: Water transfer from excess water supply areas to water shortage areas is a water demand management method. In Cyprus, although small in size, transfer of water, from the relatively wet area (in the southwest) to the dry southeast area takes place. Obviously the cost is comparatively higher but economic and social reasons combined with the need for water demand management led to the transfer becoming a reality.

B.2 Non-Structural Approach: This approach includes water rationing, water charge, organizing water users associations or farmers participation, waterworks committees and monitoring of operation.

Water Laws and Institutions: Water Demand Management cannot be properly enforce unless there exist the legal framework which shall define those that are authorized to implement it and what are their responsibilities, duties and extent of their authority. The law must also define the Institutions that are entitled to devise and implement water demand management policies and measures. In Cyprus all powers rest with the Government which has the ownership of the water.

Water Rationing: Water being limited and in most cases in deficit, it is rationed to the farmers in accordance to the crops grown and the area to be irrigated, setting an upper limit of water to be consumed. Preference is given to permanent crops and to high value crops with high water use efficiency and violators are charged with a surcharge which corresponds to the total cost of the water. Consumers violating the law may be prosecuted for utilizing water without the permission of the authorities or consuming excess water.

Water Charge: For every Cubic meter of water delivered to the farmer he has to pay a water charge. Charges are imposed for two reasons; a) for financial, enough money must be collected to finance operation and maintenance of the projects and for the construction of new projects, and b) for economic, water must be wisely, economically and efficiently used. Goods given free of charge are not respected. Water charges are heavily subsidized and their level is fixed in accordance to a number of criteria such as, total cost of water, water law provisions, water loans provisions, farmers income and capacity to pay, crops profitability, quality of service (water quality, pressure, delivery flexibility) location of project and other social, economic and political criteria. There is no need to emphasize the effect of water charge on water demand management.

Creating Water Users Associations Or Farmers Participation: Water users associations, in Cyprus called Irrigation Divisions undertake full responsibility for the management of the available water in their projects. Usually these projects are small, situated in the Troodos

mountains, simple to operate and maintain. In large Government Projects, operated and maintained by the Water Development Department (Government agency) the consumers are organized to contribute towards the management of the available water.

Waterworks Committees: In projects managed by waterworks committees the farmers are represented by elected members. Their participation in the management of the projects and mainly in the water demand management is decisive since they participate on the day to day activities and in the programming of the water allocation and distribution at the beginning of the irrigation season.

Monitoring of operation of waterworks: Real time monitoring of the operation of the waterworks with respect to water delivery/consumption gives the opportunity to the operators to check volumes delivered and intervene to avoid oversupply, overuse, waste and water losses.

5. SOCIAL ACCEPTABILITY OF MANAGEMENT OF WATER DEMAND.

Acceptability of water demand management by the consumers and mainly by the farmers is not always welcomed. Farmers see this as a restriction to their freedom to cultivate anything they wish and usually results in farmers income reduction. On the other hand is the nature's uncontrolled, unpredictable behavior which delivers small quantities of water and in some cases even less than originally planned, the Government's obligation to provide water to a wider range of population and the Governments responsibility and right to see that the limited water resources must be used in the most efficient and effective way. Having said these, the water demand management under the Cyprus conditions is socially accepted by the majority. Of course this requires that the decisions made are justifiable and well documented and those most economically hurt are to be satisfactorily compensated.

6. ENVIRONMENTAL EFFECTS DUE TO WATER MANAGEMENT.

Water demand management is meant to manage the available water resources wisely and to deliver the necessary amounts for sustainable development. In these amounts we must always include those quantities that are required to keep the conservation of the environment. Obviously in the allocation of the water from a project the environment's water needs must be considered like any other justified needs. Cyprus with great water deficits provides water for environmental needs in the Akrotiri area as originally planned.

7. WATER RESOURCES MANAGEMENT

Structural Approach.

Cyprus being a semi-arid country with limited, scarce and finite water resources has, from the very beginning, adopted a water master plan. This master plan provides for the construction of a number of dams, to store and regulate winter flow, distribution systems, water treatment plants, conveyance pipelines, recharge works and other structures which will allow the best utilization of the surface and groundwater for irrigation and domestic purposes. Water transfer was

considered and for this purpose a 16 KM tunnel and an 110 KM pipeline were constructed to transfer water from water surplus areas to water deficit areas.

From the point of view of water collection, dams were constructed where, from the point of conveyance and distribution, special attention was given to minimize (to zero) losses. For this purpose, only closed conduits and lined canals are used. Pumps and regulating tanks are automated with a view of minimizing losses and operational costs. The delivery of water to the irrigators is made at farm-gate at a fixed pressure, at a regulated flow rate, on an on demand or modified on demand mode, and continuously metered.

For real time monitoring and control of the main waterworks a telemetry systems was constructed. This system is provided with remote terminal units reporting to the master-station using a combination of 450 Mhz radio and the Cyprus Telecommunications Authority facilities. A Supervisory Control and Data Acquisition (SCADA) system is to be used to collect, store, process and prepare reports for the operation of the project and could be still enhanced by interfacing it with additional software that would make use of the real- time data continuously gathered. This will enable the operators to spot or provide early warnings of leaks or unauthorized water abstraction from the system, to model the hydraulic operation of the system, to model the spatial and optimal water allocation patterns or generate O&M reports for the project equipment.

Non Structural Approach:

Short-term and mid-term forecasting of resources and supply: Since there are no perennial rivers in Cyprus and since water demand for irrigation occurs mainly in the period April to October, almost all water that is needed to satisfy the annual requirements, must be stored in surface reservoirs or ground aquifers. Therefore, surface reservoirs with overannual capacity are constructed, where aquifers are replenished, either naturally or artificially to maintain their annual yields. At the planning stage, simulation models are used to estimate the reservoir's capacities and yields. However during the operation of the reservoirs, in real life, things are altogether different, since the future is always unknown and combined with droughts the programming of next year releases are not very well defined. To overcome this, short term and medium term forecasts are made and simulation studies for different scenarios are carried out to establish the most probable one. Normal and minimum water demands per project are set, according to use and crops, and inflow behavior is analyzed and studied using past records. The level of satisfaction of demand depends on the water in storage and the past and forecasted rainfall pattern operating on a number of rules which must be satisfied. At present the problem of water allocation, with respect to volumes and area, taking into consideration the existing volumes in storage and the most probable inflows, is solved by trial and error for different scenarios of water demand levels, using a two dimension electronic spreadsheet. Under development is a Linear Programming Simulation Model, which will give an optimal water allocation, among competing activities over a number of forecasted inflows each with a different probability to occur.

Real Time Management: In the largest project which controls almost 60% of the surface water (The Southern Conveyor Project) a telemetry system has been installed which provides real time

monitoring and control, which, combined with additional software could measure hydraulic transients in pipelines for leakage detection, unauthorized interventions and establish other characteristics of the system such as changes in carrying capacity etc. The system, through a SCADA system, collects, stores, retrieves, analyses and reports data on the operation and maintenance of the project and individual structures, volumes, pressures, flows, etc. The system also offers the facility of tele-control for turning on/off valves and pumps. Plans are made to interface the SCADA system with management information system to provide simulation and optimization of the operation of the groundwater and surface water resources.

Water Laws and Institutional Aspects: The existing water related laws were enacted before 1960 with minor modifications since then. According to these laws there is not a single umbrella covering water, although one law, the Government Waterworks Law, covers the majority of the water resources. This law states that all surface water, groundwater and wastewater is vested to the Government which has the power to construct waterworks and undertake their management. Individual water rights are safeguarded and government through other law grants permits to communities or legal public or communal bodies to construct waterworks for domestic or for irrigation uses. The government, also through the wells law grants permits to individuals to dig or drill wells or boreholes for irrigation purposes. Responsibility for water administration at the policy level is with the Council of Ministers where at the executive level is divided between the Ministry of Interior and the Ministry of Agriculture, Natural Resources and the Environment. The division of responsibilities creates administrative, economic and technical problems resulting in inefficient water resources management. For the last ten years the Government of Cyprus is considering the revision or updating of the existing water laws which will allow the optimum and most efficient utilization of the limited, scarce, finite water resources. The proposals provide for the formation of a Water Entity, within the government, empowered with the responsibility to assess the available water quantities to issue permits or licensing for use of finite quantities of water and with the right to monitor, and control the water extraction and to intervene where necessary to stop illegal actions of overuse or wasteful use. The Entity will have authority over the total water cycle undertaking the control of wastewater and desalinated water.

8. SUGGESTIONS FOR THE FINAL DECLARATION

Sustainable Water management requires the following to be a successful.

The laws concerning Water Resources Management must be concise and specific as to the responsibilities of those concerned i.e. the Government, the Development authorities, and the consumers. Water ownership must be established and water allocation procedures must be well defined.

The institution's responsible for water development and project management must be given the power and responsibilities to deal with the complete water cycle and always considering the environment as a part of the water management procedures. The duties and obligations of the Institutions towards the consumers and the environment must be stressed and outlined.

The consumers and water users must be aware of the value of the water, of its scarcity, and its impact on the environment and their rights, obligations and responsibilities must be well and precisely defined.

Participation of the consumers and users must be seeked at all levels of water management i.e. from the planning stage to the final stage of project operation. Decisions taken in the presence and participation of the consumers or users will be much easily accepted and adopted.

Modern methods of water management must be adopted and implemented. Water saving must be a way of life to all those dealing with water either being consumers or water users.