Irrigation Advisory Services and Participatory Extension in Irrigation Management

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IRRIGATION ADVISORY SERVICES IN CYPRUS

by

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IRRIGATION ADVISORY SERVICES IN CYPRUS[1]

1 Country profile

1.1 Area and population

Cyprus is the third largest island in the Mediterranean with an area of 9 250 km². Since 1960 is an independent state, however the area under government control the last 27 years is around 5 810 km² only, hence the following report refers mostly to this area which amounts up to 63% the total area of the country. Geomorphologically the island is dominated by two mountain ranges, the Pentadaktylos along the northern coast rising up to 1 024 meters and the Troodos in the center rising to 1 951 meters. In-between, the Mesaoria plain, together with the coastal plains provide most of the land for crop production under dry farming or irrigation. In the mountains zone the land is very fertile but limited. It must also be noted that approximately 20% of the area of Cyprus is covered by natural forests (pine trees and low bushes). The population is around 750 000.

1.2 Climate

Cyprus has an arid Mediterranean-type climate characterized by long hot and dry summer with average max. Temperature 36°C in the central plains and 27°C on Troodos. The evapotranspiration in July-August reaches 9mm/day. During the short cool and wet winters the average min. temperature drops to 5°C in the plains and 0°C on the mountains. The average annual precipitation is about 470mm and ranges from 300mm in the central plain, to 1000mm on Troodos Mountains. Most of the rain occurs during a short period between late November and early March and provides the island with all water needed for agriculture, domestic and industrial uses.

1.3 Agriculture

Throughout its long history Cyprus has been a predominantly agricultural country and until recently the contribution of agriculture to the national Gross Domestic Product ((GDP) was the largest among the various sectors of economy (Table 1). However, the last two decades the development of other sectors has led to a gradual decrease of the contribution of agriculture to the GDP, which at the moment hardly exceeds 5,5%. Similarly, the value of agricultural exports dropped to 29,2% of the total value of domestic exports and employment in agriculture, in full time, decreased to 10,1% of the total economically active population. Nevertheless agriculture is still and it will always be a dynamic sector of high socio-economic importance, mainly due to its role in meeting the food requirements of the country, in maintaining the countryside and in providing employment and income to the rural population.

Table 1. **Main Indicators of the Agricultural Sector (1960 – 1995)**

Indicator		1960	1965	1970	1975	1980	1987	1995
Share of G.D.P.	%	16	20.6	15.9	15.7	10	7.8	5.5
% Of Total economically active population	%	40.3	38.9	35.7	17	16.8	13.7	10.1
% Of total Domestic exports	%	28.1	45.5	44.3	35.6	22.7	22.5	29.2

[1] The author of this paper belongs to the team of the specialists who worked in the Department of Agriculture and promoted the irrigation advisory services in Cyprus. However, he makes no claim of originality, and indeed has borrowed freely from the findings of all those mentioned and others, and is deeply indebted to each.

1.4 Land use

The last census (1996) showed that the total cultivated agricultural land under the control of the Republic was around 200 000ha. Most of the cultivated land around 185 000ha (85 –87%), is planted with rain fed temporary crops (cereals, food and feed legumes, green fodder, industrial crops) in the plains, as well as with vines, almond trees, olives, nuts, etc. in the upland and mountain zones and the lowland coastal and dry-land zones. The systematically irrigable land planted with fruit trees, grapes, vegetables, potatoes and other varies from year to year according the water availability from 30 000 to 40 000ha.

SIZE OF HOLDINGS AND NUMBER OF OWNERS

Agricultural land is privately owned and the great majority of farms (98%) are small family enterprises with no significant differentiation between districts and regions. For traditional reasons of inheritance, farm land has been fragmented to very small sizes. The mean size of holding is 4,5ha ranging from 2,7ha in the mountains to 5,6ha in the hilly vines and the plains dry land zones. It usually consists of separated parcels located in one or more villages (or towns). The modal size is less than 0,67ha. Irrigated land is only a small fraction (one eighth of the holding). Cypriot agriculture is based on small-scale farming. The total number of holders is around 42 500.

2 Water resources

The island's renewable water quantities were estimated in the early nineties based on long- term rainfall records (1916 – 1980) The estimated figures, which are included in every official report (FAO AQUASTAT, DFID UK and other), proved to be far from the real present situation in the island. Since 1970 rainfall has decreased by some 100mm and a marked decline of the surface and groundwater resources has been observed. A reassessment of the island's hydrology is in process under an FAO/TCP project.

2.1 Conventional resources

Similar evaluation of the annual water crop for the island can be made on the basis of the 1951 – 1980 (the latest 30 year period for which there is information for the whole island). For this period the mean annual rainfall is 478mm over an area of 9 250 km². It corresponds to 4 420 million m³ (MCM) of water per year. The greater part of this, about 83% returns to the atmosphere through evapotranspiration and the balance of 17% i.e. 81mm or 750MCM is the annual total water crop that remains available for use. From these available quantities around 480MCM is the surface run off and 270MCM is direct underground recharge.

The 480MCM surface run off is utilized as follows:

- Dams yield 152MCM
- Spate irrigation 38MCM
- Groundwater recharge (indirect) 140MCM
- Run off to the sea (surface) 150MCM

As it is concerned with the total quantity of 410MCM of underground recharge (270MCM direct recharge plus 140MCM indirect recharge) the situation is estimated to be the following:

- Pump water 240MCM

- Sub-surface run off to the sea 230MCM
- Deficit (annual) 60MCM

From the above the natural renewable water in Cyprus can be estimated as the sum of the Dams yield, the spate water and the pump water, minus the groundwater deficit i.e. 152+38+240 = 430MCM – 60MCM = 370MCM.

In accordance with the Winpenny definition for water shortage, accepted by the FAO, the World Bank and other international organizations, in terms of renewable volume of water per capita per year, Cyprus should be classified as a country facing severe water shortage with 493 m³/head/year. It is also underlined that in Middle East region Cyprus is the only country where its irrigation potential is estimated to be lower than the area equipped for irrigation at present, even including the future availability of non-conventional water (recycled, desalinated etc.)

As it is concerned with the major storage dams of a total capacity of 276MCM, the expected yield is about 120 – 152MCM/year, however the real case during the drought period 1995-1999 was as follows:

- Table 2-1 Water Inflow and Storage in the Dams

Year	1995	1996	1997	1998	1999
Total Dams Capacity MCM					275,456
Water Inflow MCM	109,240	36,240	26,563	27,443	51,666
Water Losses MCM	14,128	10,040	6,559	4,320	6,097
Water Stored at 31 December	106,360	54,256	27,976	13,888	28,580
Water Delivered MCM	82,920	78,135	53,54	40,681	59,734

(MCM millions m³)

Source WDD

2.2 Non-conventional

DESALINATION

Seawater desalination was introduced in 1997 in order to meet the demand for drinking water. Today there are two plants in the southern coast of the island with a total capacity of 80 000 m³ of water per day that amounts around 31MCM per year i.e. more than 50% the annual requirements for domestic water supply. Desalinated water replaces government sources deficit.

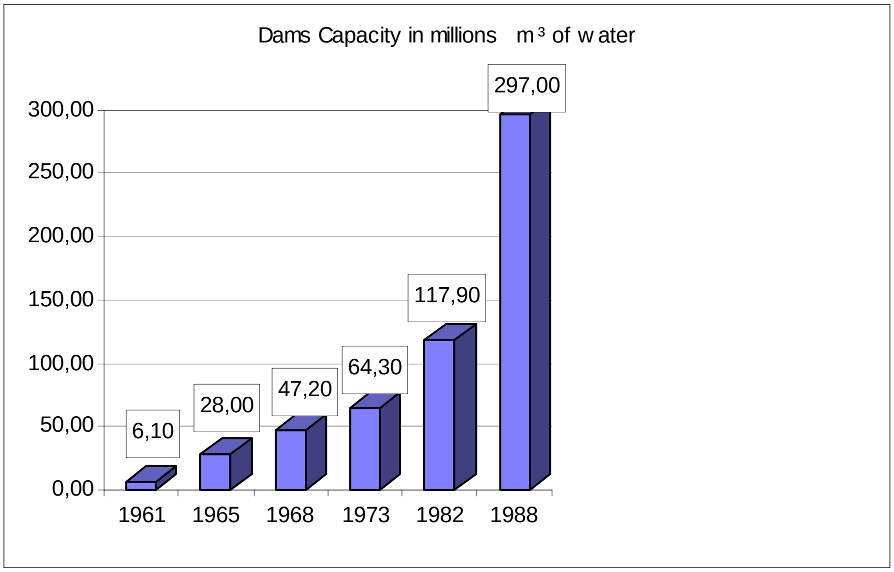
RECYCLED WATER

Several sewage treatments plants are now in operation in Cyprus producing excellent water for reuse in irrigation (agriculture and landscape) in accordance with the standards and code of practice for this type of water. The government has undertaken to cover the cost for the tertiary treatment and reuse of all effluents from municipal treatment plants in the island. For the time being the quantity of recycled water delivered for use in irrigation is estimated around 15MCM per year.

3 Water resources

3.1 Surface water development

The construction of water storage and recharge of major government water works and small private has been a main target in order to tap the available surface run off that used to be lost into the sea. The collection of this water, its conveyance and distribution to the users was an important step towards the solution of the country's water problem. All water development works have now reached their saturation development point. Nowadays the storage capacity of surface reservoirs (dams etc.) is 303MCM, which is near the maximum possible. The WDD has undertaken this major task successfully.



Source: WDD

3.2 Water supply from government water works

The Government Major Water Works comprise of Dams for collection of surface water from river basins, boreholes for utilization of available ground water, and water conveyance and distribution pipe networks. E.g. the contribution of the Southern Conveyor Project is to collect and store surplus water in Kouris dam (115MCM) and to convey it by means of regional closed water carrier 110 km long to another area of the island. There are five major water works divided into irrigation schemes with an average yield of approximately140MCM per year under normal conditions and hundreds of minor other constructions. The Government has undertaken the entire cost of Major Water (Development) Works and water is made available to beneficiaries at a heavily subsidized charge. The WDD is responsible for selling the water either in bulk to the Irrigation Divisions or to private consumers. The costs for construction of Minor irrigation Works such as Irrigation Divisions at the community level are also heavily subsidized (75%), but the beneficiaries through elected committees do the management.

The executive body of the Major Government Water Works management is the Water Development Department (WDD) assisted by the Department of Agriculture (DOA). The services of some other Government Departments are also utilized. The management, maintenance and operation of these Works up to the "farm gate" is responsibility of the Government (WDD).

All major water works (see table) are divided into several Irrigation Schemes. In all cases the water is conveyed through closed piping system and delivered at the "farm gate" with average pressure of 3,0 bars and a discharge around 5 –7 l/s in order to enable the farmer to install and operate a micro irrigation or a low-medium pressure improved irrigation system.

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• Table 3-1 Major Government Water Works

Work	Capacity MCM	Commanded Area (ha)
Khrysokhou		
Evretou dam		
Pomos dam		
Ayia Marina dam		
Argaka dam		
Total dams	26, 148	
Boreholes*	0, 564	
TOTAL	26, 712	4 200
Southern-Conveyor, Vasilikos-Pentaschinos,		
Yermasoyia-Polemidhia		
Kuris dam		
Kalavassos dam		
Lefkara dam		
Dhypotamos dam		
Yermasoyia dam		
Polemidhia dam		
Kiti dam		
Akhna reservoir		
Total dams	186, 750	
Boreholes*	7, 250	
TOTAL	194, 000	10 000
Paphos		
Asprokremmos dam		
Mayrokolympos dam		
Total	54, 555	
Boreholes* and Diversions*	5, 250	
TOTAL	59, 775	5 000
Nicosia		
Xyliatos dam		
Vyzakia dam		
Kalopanayiotis dam		
Lympia dam		
Total	3,703	2,900
Arminou	4,300	
total		
All Dams	275, 456	
Boreholes*	13, 241	
Grand TOTAL	288, 697	

*For 1999 Source: WDD 1999

3.3 Groundwater

In fact the last four decades groundwater has been exploited beyond its safe yield. Over pumping resulted into the draw down of the aquifers and sea intrusion begun in the coastal plains. Drastic measures were taken, but the groundwater still remains a reliable, clean and cheap water major source for the farmer. The control of over pumping has been achieved through legislation, which gives power to the Government to declare any critical area as a controlled area and restrict drilling, widening or deepening of wells or boreholes. Also the Water Supply (Special Measures) Law has been applied too, aiming to bring under Government control the extraction of underground water from private tube wells. Irrigation Divisions are supplied with water from Government boreholes for collective use of irrigation water. Now the extraction of groundwater from any area in the island is under control and calculated. It is estimated that the extraction over the natural replenishment is vis-à-vis the sea intrusion into most of the coastal aquifers. The Water Development Department (WDD) was responsible for this work properly assisted by the Department of Agriculture (DOA) and the Department of Geology (GD). All three of *them* are under the Ministry of Agriculture, Natural Resources and Environment (MANRE

3.4 Water supply from private boreholes

There are approximately 20 000 licensed private boreholes and other wells. Pumping is controlled and the permissible water extraction for irrigation is calculated on the basis of the specific crop water requirements with minimum 75% application efficiency in a defined commanded area.

3.5 Water demand

In Cyprus the annual water withdrawals, under normal conditions, are approx. 280 millions m³ of water in round numbers. These water quantities are supplied from various sources as shown in the following table.

• Table 3-2 Annual Water Withdrawals

Water Source	QuantityMCM	%
Government Dams	88	31,4
Government Boreholes	20	7,1
Private Boreholes	99	35,4
Other*	73	26,1
TOTAL	280	100

*Other sources include seasonal rivers (wadis), mountain springs, local communities and non-conventional. Source: WDD

3.5.1 The Consumers

The three major sectors of water use are Agriculture (mainly for irrigation), Communities (domestic water supply) and others. In the following table are given approx. figures, which vary from year to year.

• Table 3-3 Annual Water Consumption from the Various Sectors (Average)

Sector	Water Consumption MCM	%
Agriculture	210	75
Domestic Supply	65	23,2
Others	5	1,8
Total	280	100

Note: The last five years the agricultural sector received less quantities of water. Source: WDD

4 Water use in agriculture

4.1 Background

Until the early fifties the entire irrigated area in Cyprus was under traditional surface methods of irrigation The water, supplied either from springs or lifted from shallow wells, was conveyed and delivered to the plants through earth ditches by gravity. Most of this precious commodity was wasted and lost due to seepage, evaporation, deep percolation and luck of efficient technology and know-how.

The mass introduction of deep well boring equipment and pumps since 1946 (a post-World War II phenomenon) had resulted into the rapid expansion of groundwater use for production of a wide assortment of high value fruit and vegetable crops. As a direct result of wasteful of water use pumping had exceeded availability from the aquifers in the main coastal areas for a full decade and water table levels had steadily declined through that period. Meantime intensive planting of citrus was taking place. By 1956 the problems were becoming apparent. Seawater intrusion destroyed the coastal portion of the Famagusta aquifer with serious losses to the citrus industry and the same process had begun noticeably near Limassol and Morphou. In the Western part of the island, where 73% of the island's citrus plantations existed (Morphou Triangle) the groundwater levels were as much as 3 meters below sea level and sea water was already causing salinization of wells.

Cyprus was facing a crisis situation owing to the over pumping, which could be avoided with efficient water use. Since the income from irrigated agriculture was almost ten times higher than that from dry farming, water was a key factor in the island's agricultural development.
Nearly the same and even worse conditions were in existence in the neighbouring countries, where the farm irrigation practices were almost identical to those practiced in the ancient times. In fact irrigation techniques had progressed very little throughout the centuries in the whole region.

Several agencies and individuals, both Cypriot and foreign, studied the water situation, gathered useful information and prepared recommendations to the Government. Among those who studied the situation were the WDD, the DOA, the French S.C.E.T. Mission, the U.N. Special Fund Hydrological and Mineralogical Survey, the U.S.A.I.D. Mission and the various water experts of FAO/UNDP. Following the partial recognition of the problem and its significance to the national economy, Government begun to take the steps required to formulate and put into force workable policy and legislation and to objective plan and implement effective action programs for the alleviation of the problems in the field. Experts were invited from abroad to help with assessment and too offer advice on procedure, legislation and policy.

4.2 Government Policy

The major objective of the Government integrated agricultural policy, as it has always been stated in the many five-year Development Plans, was the raising of farm incomes and the protection of resources and the preservation of the natural environment through

- The efficient use of water at the farm level,
- The control of groundwater extraction, and finally
- The construction of water storage and recharge small private and major government water works

This policy was materialised through programs, projects, legislative and institutional measures. Government expenditure in the agricultural sector has been derived from the Development Budget and has been in the range of 20% of the total development expenditure. Water development and water use received the biggest share. A major supporting element, among others, has been the maintenance for the last four decades of an extensive network of extension services, the DOA, all over the island ready to support the farmers in their daily tasks.

The farmers role in the formation of the Government policy, at the beginning, was passive, but very soon became very important and decisive, since they were more and more demanding through their associations, organizations and political parties. In many cases they demonstrate in the streets putting forward their demands for more assistance and participation in decision making. Private farmers have implemented almost all the irrigation development programs from groundwater. Government's policy was to encourage the formation of "Irrigation Divisions" for better control and efficient utilization of pump water through subsidizing 50% the cost of the project (pumping unit and piping layout). The remaining 50%was granted as loan through the Loan Commissioners. Committees run the Irrigation Divisions. The chairman is the Head of the District Administration and members of the Committee are the elected farmers.

Major and minor irrigation projects based on surface waters (run-off) impounded in dams, were constructed on Government expense and the water is sold to the farmers by unit at subsidized prices up to 66% of the overall island wide weighted average price. In the case of minor projects the Irrigation Divisions are responsible for the management of the whole projects including sources, conveyors and distribution networks. In the case of major projects the dams and big reservoirs and the main water conveyors are managed by the WDD and the Irrigation Divisions manage only the distribution networks within the command area. I n these cases the Government contribution reaches the 75% of the cost in the form of grant and the remaining 25% in the form of a loan.

In 1959 the Water Use Section (WUS)[2] of the DOA was founded and immediately begun intensive studies of the factors basic to any water use improvement program which were: "Crop water requirements", "Moisture holding characteristics of the main irrigated soils", "Comparison trials of water use efficiency using various irrigation systems". Peace Corp Volunteers provided by U.S.A.I.D. had made valuable surveys on water use practices in specific areas, under the guidance of the WUS. By 1963 the results of these studies had brought the WUS well into the farm demonstration phase and the 5-Year "Water Use Improvement Project" (see 5. 5) had been formulated and accepted in principle by Government. Meanwhile WDD was constantly expanding both the scope and quality of their related surveys of groundwater (number of wells, locations, owners, outputs, pumping hours, water levels etc.).

It is of major importance to underline that the efficient use of water at the farm level and the control of groundwater extraction were introduced long before the water development works, which aimed at the saving of winter runoffs and augmentation of supplies. The design and construction of the Government Major Water Works followed ten to fifteen years later and all preliminary studies were based on the results and progress of the water use improvement at the farm level raising the irrigation efficiency at 75%. This made the water development works economically feasible since the commanded areas were increased considerably. Financing these development works from the World Bank and various international funds was not a problem.

4.3 Irrigated area

The Department of Agriculture (DOA) is the responsible Government Department for the implementation of agricultural policy. So, the DOA was assigned to introduce water saving irrigation methods and practices at the farm level. In the early sixties the Water Use Section was established within the DOA in order to promote, apply and monitor the Government projects and programs on improvement of farm irrigation practices island wide, in close collaboration with other Departments of

[2] Mr. Savvas J. Chimonides was appointed as the firstt officer in charge of the WUS.

the MANRE. One of the biggest achievements of the Water Use Section has been the successful implementation of the Water Use Improvement Project since 1965. The rise in farm (field) application efficiency has been the primary target in Cyprus. The following table shows the progress and the changes for the period 1960 – 2000.

Table 4-1 Irrigated Land and Field Irrigation Efficiency in Cyprus (1960 – 2000)

Year	1960	1965	1970	1975*	1980	1985	1990	1995	2000
Irrigated land** (ha 10^3)	23,2	31,6	38,3	23,7	27,2	30,7	36,1	35,5	33,3
Gravity** irrigation. (ha 10^3)	23,2	31,6	28,55	13,48	8,84	Nil	Nil	Nil	Nil
Piped Surface Irrig. (ha 10^3)	Nil	Nil	6,0	2,0	5,0	9,84	12,45	8,35	3,0
Improved Irrigation (ha 10^3)	Nil	Nil	3,75	8,22	13,36	20,86	23,65	27,15	>30,0
Efficiency ****(average)	<45%	50%	56%	64%	71%	80%	80%	82%	84%

**Turkish invasion*

** *Extensively and systematically irrigated. Spate irrigated cereals and legumes from seasonal run off not included*

Source: Phocaides, WUS 1999

The extensively and systematically irrigated area in Cyprus, which is under the control of the Republic, in round numbers, amounts up to 30 000ha (14 000ha fruit trees and other permanent crops, 16 000ha annual seasonal vegetables, potatoes etc). In addition to the above permanently irrigated area another 6 000 – 10 000ha with seasonal crops mostly vegetables is occasionally irrigated in good seasons, see Table 6. The irrigation requirements with an average >80% field application efficiency is approx. 210 000 millions m^3 of water annually. (Table 2-1).

4.4 Irrigation technology

The evolution of the local irrigation techniques from the very primitive to the most advanced ones took place gradually. At the beginning the pump water conveyance earth channels were replaced with closed pipes made of steel, cast iron and asbestos cement, or by concrete and line canals. Hundreds kilometres of reinforced concrete rectangular sections were constructed for river and spring water conveyance to the fields. The first two three years after the implementation of the Water Use Improvement project (1965) the farmers were reluctant to shift from surface gravity to pressurized irrigation systems, mostly for practical difficulties associated with the new techniques influencing the traditional agricultural practices. Instead of the complete irrigation systems they installed only the conveyance and distribution piping networks with hydrants at each plot. This had been the intermediate step. The farmers, later on, adopted the techniques recommended by the WUS and proceeded with the completion of their installations. For young citrus plantations a highly efficient new system was developed the "Hose basin irrigation". A big number of "under-tree Drug hose Sprinkler systems" were installed by late sixties and successfully operated in mature citrus orchards all over the island. In vegetables the "Hose-Furrow" and the "Gated-pipe Furrow" systems were used. For potatoes and forage crops the conventional "Hand-move Sprinkler" was applied. All systems were designed by such way so as to be easily interchangeable with the minimum cost. With the mass introduction of micro irrigation techniques (drip and spray) in early seventies the farmers were ready to adopt all technological innovations ensuring further savings in water and higher yields with less labour and fuel requirements. By the early nineties Cyprus became the top country[3] in the world with improved farm irrigation techniques.

The conventional semi-portable sprinkler technology with quick coupling aluminium or light steel pipes was introduced from Israel, England and W. Germany at the beginning of the sixties, but very soon

[3] "G. A. Cornish" 1997 Modern Irrigation Technologies for Smallholders in Developing Countries - Report OD/TN 87, DFID HR Wallingford, UK

most of the irrigation equipment, technology and know-how were imported from the neighbouring country of Israel. Later (1965 – 67) the thermoplastic pipe industry was founded locally. The local market for the on-farm irrigation equipment generated profit and supported many private companies. Gradually the irrigation equipment technology was developed and new products were manufactured and exported in many countries. There is a link nowadays of the Cyprus irrigation industry with highly advanced international technology.

The Government policy towards the manufacturers has been to assisting them in the improvement of quality of there products through the establishment of standards and quality control. Nowadays all irrigation equipment are made according to the Cyprus standards in compliance with international standards and ISO 9001. The technical staff of the WUS can provide with technical advice and training on planning and designing modern irrigation systems the manufacturers personnel, when requested.

It is not an exaggeration to state that since the last two decades a local school of irrigation exists in the island. It is improved, modern, but simplified in accordance with the local prevailing conditions and requirements. Three kinds of low-pressure micro-irrigation systems cover nearly the 90% of the area under improved irrigation practices. These systems are:

- The Drip irrigation systems in all vegetables, bananas and vines
- The Low-capacity sprinklers systems in potatoes, groundnuts and salad green vegetables, and
- The Mini-sprinkler (under tree) systems in all fruit trees

All three systems have almost the same features and general characteristics. They are seasonal solid installations, i.e. permanently laid in the field during the irrigation season, and the systems networks consist mainly of thermoplastic material (black PE pipes and fittings and in some cases UPVC). They have similar structural designs and the same component parts. The only differences between them are the irrigating lines with the water emitters. In fodder crops (alfalfa, oats, corn, etc.) the conventional sprinkler systems of irrigation with hammer drive slow rotating sprinklers of medium pressure are applied, as well as the reeling boom machines with sprayers.

• Table 4-2 Irrigated crops and annual irrigation requirements

Crop	Area (ha)	Annual Irrigation Requirements m³ (10³)
Permanent Crops	14 000	97 000
(citrus, deciduous, olives, vines, bananas, avocado, other fruit trees, alfalfa)		
Seasonal Crops	16 000	73 000
(potatoes, vegetables, melons		
legumes, groundnuts, strawberries, flowers etc.)		
Other Crops	10 000	40 000*
(mostly seasonal food and feed legumes, green fodder, melons industrial crops and other)		
Total	40 000	210

* The amount of 40 millions m³ is not available every year. Source: WDD and DOA

• Table 4-3 Total Irrigated Area and Water Usage from Various Sources

Source of Water	Permanent Crops		Seasonal Crops		Total	
	Area ha	Water m³ (10³)	Area ha	Water m³ (10³)	Area ha	Water m³ (10³)
Government water	6 160	42 580	6 000	28 400	12 160	71 000

(Dams, Boreholes)						
Private Boreholes	7 840	54 320	10 000	44 600	17 840	99 000
Total*	14 000	97 000	16 000	73 000	30 000	170 000
Other**	-	-	10 000	40 000	10 000	40 000
Grand TOTAL	14 000	97 000	26 000	113 000	40 000	210 000

All figures rounded

* Intensively and systematically irrigated

** Occasionally irrigated depended on water availability

Source: Department of Agriculture

5 Irrigation advisory services

The DOA, by the nature of services provided to the farmers, is an agricultural extension service, and so it has been the Water Use Section (WUS) and all the other Sections of the Department of Agriculture during the last four decades. Water use for crop production (irrigation) has been defined from the early stages as a major agricultural function closely related with all sectors of agricultural practices. It must be underlined that the WUS of the DOA has been the responsible, sole and exclusive agency for the promotion and the implementation of the policy on the on-farm water use in agriculture. It has played the major role in the introduction of improved modern irrigation techniques and practices and the improvement of water management and irrigation efficiency. In Cyprus until lately there were no private agencies providing systematically advisory services on irrigation matters to the farmers, apart from instructions on irrigation equipment installation operation and maintenance.

Organization of services

At the level of the various projects, (government water works, irrigation schemes, irrigation divisions, private boreholes) the DOA through the WUS is responsible for the application, improvement and management of the water use at the farm level (farm irrigation practices) in close collaboration with other departmental sections, other government services and the farmers (communities and associations). The collaboration of the private sector (manufacturers and suppliers of irrigation equipment) on irrigation technology matters is also requested and provided at considerable extends.

The whole island is considered as an integral project area. However for purposes of administration is divided into six districts (see chart) *Nicosia, Limassol, Paphos, Larnaca, Famagusta, Pitsilia).*

Nicosia is the capital with the central administration (HQs of the DOA). A District Agricultural Officer who is the local representative of the Director of Agriculture heads each district and he is responsible for the supervision and co-ordination of all agricultural activities, water use included, in the various beats in his district. Beats are groups of villages under the responsibility of a “beat agent” who acts as the link between the farmers and the various extension facilities, the irrigation and other specialists at the District Agricultural Office. The District Officers report to the Director. In many cases there is also direct link between the Officer in charge of the Water Use Section at the HQs and the Water Use specialists in the various districts on technical matters.

5.1 Manpower (WUS)

Since the early sixties the Water Use Section has been strengthened with young graduates and technicians mainly with agricultural back round knowledge and higher studies. Under the guidance of the Officer in charge• of the Section and a foreign irrigation specialist they had intensive in-service training as well as abroad on all the topics related with modern irrigation techniques at the farm level such as:

- Survey and Topography
- Soil – Plant – Water Relationships
- Pumps and Pipe Hydraulics
- Measurement of the Water
- Plant physiology
- Soil and Water Salinity (field and laboratory)
- Crop Water Requirements
- Sprinkler Irrigation / Micro-irrigation
- Planning and Designing Pipe Networks
- Irrigation Technology

In the following table there are data on the number of the Water Use employees and the work done in brief during the last three and a half decades. The area covered and the beneficiaries are not the same every year.

• Table 5-1 *Water Use Section Manpower, Area Covered* and Beneficiaries*

Period	Number of Water Use Trained Personnel**		Number of New Beneficiaries (Farmers)	New Area covered ha	Total No of Beneficiaries (Farmers)	Total Area covered ha
	Agriculturists /engineers	Technicians				
1965– 1974	12	38	6 300	11675	6 300	11 675
1975– 1984	11	41	10 300	11 520	12 500	15 410
1985 - 1994	8	40	7 200	5 640	18 700	22 610
1995 - 2000	6	35	1350	1 040	20 050	23 960

* Area covered with Improved irrigation systems and irrigation advisory services

**20% of the above number of employees i.e. 8 – 10 persons is working in the Water Use Laboratory, the Draughtsmanship and administration/registry

Source: WUS Annual Reports 1965-1999

5.3 The Role of the Agricultural Extension Section (AES)

As it is mentioned above the WUS staff carried out the extension work. However, the organization of training for diffusion of information to the farm population concerning new ideas, techniques and practices, as well as the organization of programs and activities for promotion of scientific knowledge and modern technology, was the AES responsibility. Another great task of the AES has been the transmission of information to the DOA and in consequence awareness of the MANRE on the existing situation in rural areas and on problems faced by farm population.

Regarding the support to the WUS activities the extension methodology was intensively used, with an increasing trend towards

- The more personal contacts,
- The systematic advice and follow up of selected installations

- The in-depth group training at the Farmers Training Centres (KEGE)

- The intensive use of mass media and issue of leaflets and bulletins.

- The field trials and demonstrational plots

The emphasis given to the above methods is mainly due to the increasing intensification of production, the necessity to provide on the spot advice on specific problems and to offer short vocational training courses to the farmers. The “beat extension officers and workers” had weekly personal contacts with the farmers. The extension personnel collected most of the farmers’ applications for participation in the Water Use Improvement Project. Mass media, leaflets, bulletins, colour posters, circular letters, agricultural magazine and announcements in the press, were intensively used in collaboration with WUS with the aim of informing the farm population about the government projects and programs regarding the benefits derived from new improvements in water saving techniques, the government financial assistance and incentives to the farmers to adopt the new techniques. Slides for projections and films together with charts plans, maps and pictures on technical matters have been prepared by the AES for use by the WUS personnel. The radio and TV Agricultural programs have been broadcasted twice a week for the last three and a half decades. The water use for crop production has been one of the main themes in many of these programs. The large number of irrigation field trials and demonstrational plots, dealing with new techniques and improved practices, were established with the aid of AES.

Adherence to the improved irrigation techniques and practices introduced by the Government was achieved by properly informed, receptive farmers rather than by discipline.

5.4 The Agricultural Research Institute (ARI)

The ARI of the MANRE was established in 1962 as a joint FAO/UNDP project initially and then it has been fully funded by the Government of Cyprus as a separate Department. It has been a major supporting element to the ambitious agricultural policy and among its other activities it was responsible for research in irrigation. Its contribution to the general advancement of the agricultural sector in the island, through its long life, is widely recognized. However, the Soil and Water Section of the ARI, the subject matter Section, could not follow the accelerating pace of the application of modern irrigation technology at farm level, during the first two decades, for obvious reasons. The execution of experiments for several years, such as the determination of the optimum irrigation requirements on citrus, olive trees and avocados, and the applied research in comparison of irrigation methods has been rather of limited value. Still the promotion of applied and adaptive research, in the mid-eighties, in “constant-feeding fertigation” in vegetables and on the re-use of treated effluent for irrigation, has been of substantial assistance to the WUS extension staff.

5.5 Activities of Water Use Section

The main activities and responsibilities of the Water Use Section of the DOA cover a wide range of specialized topics directly related to the promotion of the on-farm improved irrigation practices. The objective is always the most efficient utilization of the available water for crop production. They are as follows:

- Implementation of the Water Use Improvement Project.
- Soil sampling.
- Survey and topography.
- Planning, designing and supervision of installation of improved pressurized irrigation systems in various irrigated crops.

- Estimating crop water requirements and preparing Irrigation Schedules.
- Laboratory work for the determination of the soil physical characteristics and the soil salinity as related to irrigation.
- Promotion of Fertigation practices in drip - irrigated crops.
- Evaluation of water quality for irrigation.
- Promotion of new irrigation technology and techniques.
- Training the farmers and the suppliers of irrigation equipment in improved irrigation techniques.
- Use of re-cycled municipal water for irrigation.
- Establishment of Field Trials and Demonstrational Plots.
- Advisory work for proper water use management.

Note: ***All services are provided to the farmers free of charge***

The above activities and responsibilities are considered as integral parts of the TORs of the Water Use Section. In addition to these activities the Water Use personnel is engaged with many other activities related with improvement of water use in agriculture such as the Implementation of the Water Supply Special Measures Law", the collection and preparation of technical data needed for the implementation of the major Government water works, preparation of techno-economic studies for the rehabilitation of Irrigation Divisions and Associations (minor Government water works), soil moisture determination and studies for cereals and many other.

In fact the major part of the WUS activity has been carried out within the framework of the Water Use Improvement Project. (see below).

5.6 The water use improvement project

In 1965 the 5-Year "Water Use Improvement Project" was implemented by the Department of Agriculture aiming at the conservation of water resources at the farm level through encouraging the adoption of improved irrigation techniques and the application of irrigation schedules in compliance with the actual crop water needs. Under this project the Government provided the farmers with technical and financial assistance to convert from traditional surface water wasteful farm irrigation methods to modern irrigation systems. Initially the project was planned to give priorities where seawater intrusion was taking place or was a constant thread, but then covered the whole of the island. The Project was planned to continue for the second Development Plan, but it has been extended many times and is still in force until today.

The financial assistance of the Government consisted of low interest loans and subsidies to install improved (closed pipes pressurized) irrigation systems. The technical assistance is free and is given in the form of planning and designing the irrigation system the preparation of the irrigation schedule and the follow-up of the installation operation.

The Project has been applied successfully for the last three decades with remarkable results. Since then a drastic change has taken place in the farm irrigation techniques and there has been a new era in Cyprus agriculture. Primitive methods of irrigation were replaced with advanced ones and new technology was applied, developed and modified in accordance with the local prevailing conditions and requirements. Today nearly 95% of the irrigated area in Cyprus is covered with low-medium pressure improved irrigation systems, mostly micro irrigation, with higher than 80% average water use efficiency. The water saved from the operation of these systems equals the amount needed for the country's domestic requirements. Table 5-2 shows the work progress of the project during the last three decades.

The achievements of the project and the benefits derived to the country and to the farmers are too many. The total irrigated area is under micro irrigation techniques with high application efficiencies resulting into calculated annual savings of approx**. 75 millions cubic meters** of good quality water.

The savings in fuel from pumping and in manpower are very high. The economic return per unit of water increased, as there is an increase in yield ranging from 15% to 75% and a considerable improvement in quality.

An extension of the above project to certain areas in midland areas (E. Mesaoria), where underground aquifer yields saline waters, was the "Saline Water Utilization Project ". It was initiated in 1965, but Very soon the two projects were merged and cover all of the island.

Closely related to the Water Use Improvement Project is the Water Supply "Special Measures" Law (Annex I), which has almost the same objectives and was designated to bring all groundwater abstractions under Government control, thus to maintain the balance of replenishment and abstraction.

Improved pressurized irrigation systems

The planning, design and supervision of installation of improved pressurized irrigation systems for various irrigated crops was a task was given to the WUS and in fact the government personnel have designed all the "agricultural irrigation systems" in Cyprus. Detailed plans, hydraulic calculations, maps with designs and drawings for jointing and installation techniques and bill of quantities are given to the farmers, who proceed with the provision of the equipment and the installation of the systems. The WUS personnel supervise the final testing of the proper operation of the installation. The irrigation specialists do this laborious and very important work, as it uses the whole spectrum of specialized knowledge on irrigation techniques and related subjects.

Note: WU Section specialists design the Landscape irrigation in National parks, universities, schools, high ways and all public places. The private engineers deal exclusively with residential turf irrigation systems and Golf courses

- Table 5-2 Design and Installation of Improved Irrigation Systems 1965 – 2000 (Through the Water Use Improvement Project)

Years	Systems Designed			Systems Installed		
	No of Farmers	Area Ha	Cost CY Pounds.	No of Farmers	Area Ha	Cost CY Pounds.
1965	143	504	82458	9	22	3289
1966	310	850	178970	90	313	47061
1967	486	960	206936	138	300	46542
1965-74	4721	8760	2016038	2751	5670	1079278
1975-84	7744	8642	5886548	7305	8415	6272773
1985-94	5399	4230	5951740	6520	5490	7057830
1995-2000	1001	782	1135830	1001	782	1135830
Total	18865	24728	14990156	17577	21992	15545711

Source: Phocaides WUS

The Water Use Sectiondesigned an additional area of about 10 000ha and the farmers installed the systems from their own without participating in the Project for financial assistance.

Laboratory analysis

Field and laboratory work is carried out every year for the determination of soil physical characteristics and the soil salinity as related to Irrigation in new and old areas accordingly. Thousands of soil and water samples are taken from the fields every year and analysed in the WU Section Central Laboratory, which is fully equipped with the all necessary equipment and apparatus like every soil and water laboratory in the world. In the following table there is the total number of tests carried out during a normal year the last decade.

Table 5-3 Tests carried out by the Water Use Section Central Laboratory annually

Kind of Tests	Number of Samples
15 Atm. Percentage	148
Moisture Equivalent	42
1/3 Atm. Percentage	175
Bulk Density Determination	-
Electrical Conductivity of Saturation Extract	7 580
Electrical Conductivity of irrigation Water	1 345
Existing Soil Moisture	390
Total	9 680

(Average numbers) Source: WUS Annual Reports 1986-1999

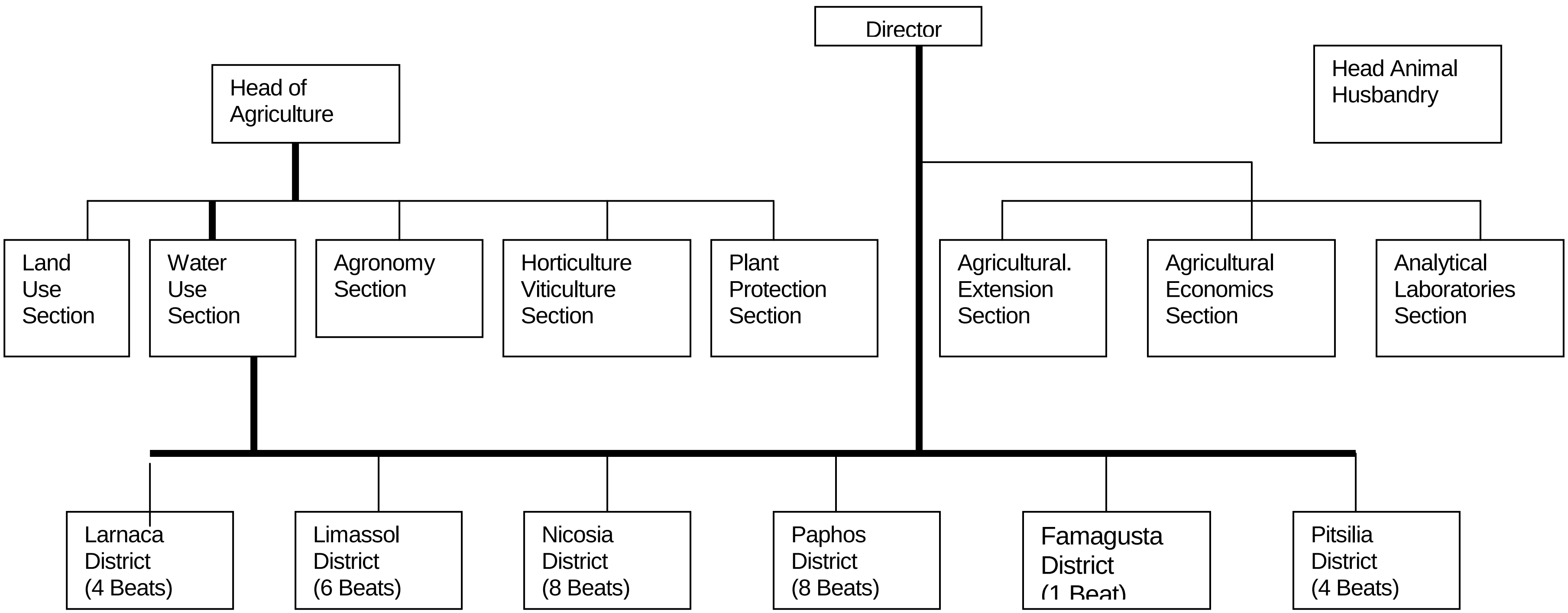
COSTS AND BENEFITS

For every system design a proper techno-economic analysis was made for final approval. The cost included the cost for all the component equipment, the installation and maintenance, and in several cases the booster pumps, the water meters, the land levelling and other (laboratory, field, transportation equipment etc.). The benefits included the water savings (fuel and labour included), increase in yield 5 – 45% and gross income from area can be saved from destruction (calculated on the basis of amounts of water savings). Calculations for the Benefit / Cost ratio were based on 15 year average life of the systems and 8% interest rate. During the first decade of the project's life (1965-1974) the Gross Benefits were estimated at CY£ 13 508 000 and the Costs at CY£ 1 302 500 for an area of approx. 5 670 ha. The B/C ratio was 10,35 : 1 and the Net Present Value CY£ 12 205 500. Almost same or similar results are found until recently.

Field irrigation trials

During the reporting period the WUS in close collaboration with the AES and the District Agricultural Offices organized, established and conducted successfully more than two hundreds field irrigation trials and demonstrational plots in all districts and agricultural areas of Cyprus. The trials implemented by the farmers in their own crops and managed by the WUS staff, covered all agronomic and engineering aspects of the on-farm improved irrigation practices (testing new methods, studying performance of technologies, familiarizing with new techniques for adoption by the farmers, investigating potential options under different conditions, verification of calculated water requirements, yield potentials under various irrigation and fertigation programmes, reuse of treated effluents, etc.). These operations have been of the greatest value to the successful adaptation of improved irrigation techniques and practices in the country.

Organizational Chart of the Department of Agriculture (1960 –2001)



5.7 Irrigation scheduling

The preparation of proper irrigation schedules based on soil, crop, climatic and irrigation practices data for each individual farm has been the very first priority of the WUS since its establishment in 1960. During the last four decades the following methods, in chronological order, were applied for the estimate of the crop water requirements and the preparation of the irrigation programs (schedules).

- The Blaney-Criddle formula
- The Soil Tension (Tensiometers)
- The Class A Pan (ETc after FAO methodologies)
- Software "IRRICROP" (ETc after FAO methodologies)

THE BLANEY-CRIDDLE FORMULA

In the sixties and the early seventies, the irrigation schedules were prepared based on a) Crop Water Requirements tables calculated according to Blaney-Criddle Consumptive Use (modified) formula and b) the soil physical characteristics of the fields.

For the calculation of the water needs the consumptive use figures (seasonal, monthly and daily) were used. The Water Use Section prepared tables with figures for most of the crops. These tables were cyclostyled and circulated among the staff. The Soil moisture holding capacity, Field Capacity and Permanent Wilting Point and other characteristics, infiltration rate, permeability, structure and depth were major elements for the preparation of the irrigation schedules, i.e. the irrigation dosage and the frequency of irrigation (interval).

The Gravimetric method was mainly applied for the soil water measurement as it was very simple and the staff was extensively trained in using this method. Other methods were used as well. A large number of soil samples were taken with Veihmeyer or king tubes from the fields at the beginning of the season and in many cases before and after each irrigation. All the district agricultural offices were equipped with the necessary field instruments for soil and water sampling, water measurement, surveying and draughtsmanship equipment etc. The samples were sent to the central Water Use Section laboratory in Nicosia.

For the preparation of the irrigation schedules, relatively high depletions of soil available moisture was considered, > 60% for deep-rooted plants (trees, fodder etc.) and >45% for shallow rooted plants (vegetables). Large irrigation dosages and long intervals (15 – 25 days) were the main characteristics of these schedules resulting into percolation losses and frequent moisture stress of plants especially during the peak demand. This way of practice was in line with the farmer's mentality and the irrigation techniques applied at that time (sprinkling, gated pipe, hose-basin, pipe–basin and surface methods). A typical irrigation schedule prepared in 1969 for a citrus plantation is presented in ANNEX 1.

THE TENSIOMETER METHOD

In the early seventies the Water Use Section introduced to the farmers the use of the tensiometers. Until then these instruments were established only in field trials. One of the reasons for the promotion of this technique was the fabrication of locally made tensiometers at reasonable cost to the farmers. Unfortunately the instruments were of poor quality and because of this all the efforts to promote this method of irrigation scheduling were setback. However, the use sporadically of imported tensiometers of good quality continued especially in field trials for drip irrigation systems.

Since the early eighties the use of tensiometers in vegetables, especially those under cover (greenhouses and low-tunnels) has been applied on a large scale. Now it is a very common method for the arrangement of the frequency of irrigation and the quantity applied. The seasonal amount is taken from the ETc methods (Class A pan and the IRRICROP software). Yet, only a small percentage (18%) of the vegetable cultivators are using tensiometers in their fields all around Cyprus. In Famagusta and Larnaca coastal districts the percentage of the users is higher, 61% and 36% respectively. The rest of the farmers follow instructions from the WUS staff, apply the neighbours timing and use their experience.

The last 20 years the WUS has been provided with more than 100 pairs of tensiometers, which were established periodically in many private cultivations for one and even more seasons for observations, trials and demonstration purposes in all districts and all kind of crops and irrigation systems. The impact of the use of the tensiometers on the farmers was to convert easily from long irrigation intervals to more frequent irrigations with less amount of water, thus maintaining the soil available moisture at relatively high levels with all the positive results in increasing yield quantity and improvement of quality. The usual practice is to install the tensiometers in pairs at two different depths, one at 30% the effective root depth and one at 60%. Irrigation starts when the reading of the shallow depth tensiometer is in the range of 18 – 25cbars, depending on the type of the soil and the stage of growth. The use of tensiometers enables the introduction of the soil moisture extractors for the "in-situ" determination of the soil solution salinity, the soil moisture sensors for automation in irrigation (at a very small scale) and many other modern techniques.

The use of tensiometers in perennials (fruit trees) is very rare and it is occasionally done by the WUS staff to determine the ideal frequency of irrigations under drip irrigation systems, using the soil water deficit that maintains a relatively high percentage of available moisture in the effective root depth. In very few cases of high cash crops fully equipped with automation, the Soil Sensors are used for irrigation scheduling. These are tensiometers arranged so to transmit electronic signals to actuate electronic controller to start and stop irrigation accordingly.

CLASS A PAN AND THE ETC METHOD

Soon after the publication of the FAO Irrigation and Drainage Paper No 24 Crop Water Requirements in 1977 and the No 33 Yield Response to Water in 1999 the WUS staff was encouraged to apply the ETo / ETc method in accordance with FAO methodologies for the calculation of Crop water requirements and the preparation of irrigation programmes (schedules). The most practical way was to correlate the pan readings with ETo.

At that time, in the whole island there were around 30 Class A evaporation pans in various meteorological stations belonging to the Department of Meteorology. The WUS established another 15 pans in selected agricultural areas to meet all the requirements for evaporation data. The exact seasonal, monthly, ten days and daily crop water requirements were easily estimated using the pan readings and the FAO recommended method. WUS staff did the work, however most of them, no matter their repeated training on this simple method and the manuals available, till now find it difficult to carry out the standard calculations without assistance from the experts. Yet since that time crop water requirements for all purposes have been calculated with the use of this method.

IRRICROP SOFTWARE METHOD

In mid nineties the WUS tried to introduce the FAO CROPWAT computer programme to calculate crop water requirements from climatic and crop data, for programming the irrigation. Unfortunately this most practical tool could not be operational and useful in the hands of the WUS irrigation agronomists and technicians due to many reasons, such as the lack of computers everywhere and the limited skillfulness in using software.

In 1997 a WUS irrigation agronomist (K. Alexandrou) developed new software for this purpose the IRRICROP, which is similar with and based on the CROPWAT and FAO methodologies. It is very simple made especially for Cyprus as it uses local climatic data, i.e. readings from the nearest Class A pan, crop information and the system of irrigation. This software is on every computer of the WUS in all districts with easy access to the staff. The data needed for a complete irrigation programme are the following:

- Location of the Farm
- Size of the Field
- Type of Soil
- Kind of Crop
- Date of first irrigation, or Planting date approx.
- % Ground cover (fruit trees)

- Effective Root depth
- System of Irrigation
- % Wetted area

The results are printed out in seconds, expressed in gross irrigation requirements mm/day per 10 days period for the whole season. The irrigation agronomists and technicians find this method easy and flexible, suitable to start with the new irrigation season. So with this schedule the farmers can manage to apply the right amount of water at the right time more or less.

The differences between the old method and the new methods with FAO methodologies are obvious after the comparison of the two irrigation schedules given in ANNEXES 1 and 2. The irrigation schedule prepared with IRRICROP is an example and not a real case. Data entered to the computer program correspond to the same farm of 1969 with the old Blaney-Criddle formula.

BRIEF DISCUSSION ON THE VARIOUS METHODS OF IRRIGATION SCHEDULING

The Blaney-Criddle formula for the calculation of crop water requirements (consumptive use), during the sixties, was very simple, although it was not accurate method for irrigated crops. The consumptive use figures were prepared and readily available to the staff for application. This method although not reliable helped the WUS staff to be acquainted with the crop water requirements, the soil water relationship and irrigation scheduling. On the contrary and for some strange reasons the ETc FAO methodologies have been proven more complicated to the irrigation agronomists, as these methods are using more climatic and detailed crop data, which differ from place to place. Yet there is no doubt that ETc methods give more precise figures resulting into the highest possible irrigation efficiencies. The application of the IRRICROP software solved the problem.

The use of tensiometers is very easy work for all concerned, the WUS staff and the farmers. The problem is the high cost and the farmers are reluctant to spend money for these instruments. However, it must be underlined that the farmers who have used these instruments for one or two seasons either from their own or from the WUS as field trials, they got enormous experience in irrigating their fields at the right time with the proper amount of water, without the further use of the tensiometers or any other assistance, calculations, schedules etc.

Many of the farmers strictly follow the instructions as prepared and given to them, but others use the irrigation schedules mainly for consultation. The common practice among the latter is to arrange a steady frequency of irrigation that suits them, e.g. in fruit trees 7 - 8 days interval, and apply the right amount of water (gross) needed for the next period. This amount can be calculated from the data available in the irrigation schedule already prepared for them. For seasonal cultivations some of the farmers make their own irrigation schedules that vary according to the last stages of growth of the plants, as related with the market prices, but always based on the data given to them and water availability. Sometimes they apply pulse irrigation, i.e. they give the right amount of water in two dosages, morning and evening. It is obvious that the farmers cannot afford without the advisory services provided by the WUS staff. Only those who are using the tensiometers can manage to give the amount needed at the right time. A recent study among the farmers cultivating vegetables in greenhouses on the application of irrigation schedules gave very interesting results that more or less apply to the majority of the farmers in the island (see

Table 5-4).

With the new practices in irrigation programming (short intervals and small dosages) the soil data (water holding capacity) are now of minor importance in most cases, however, measurements are always necessary and soil sampling still occupies a lot of the time of the WUS staff. The average number of irrigation schedules prepared by the WUS staff during a normal year is given in Table 5-5.

• Table 5-4 Application of Irrigation Schedules by the Farmers (Greenhouses)

	Irrigation Schedule	% of Farmers
A	Prepared by the WUS staff	27
B	Prepared by private agronomists	1
C	Use tensiometers	4
D	Farmer's Experience	39
E	A + D (Prepared by the WUS staff + Farmer's Experience)	22
F	C + D (Tensiometers + Farmer's Experience)	5
G	A + C (Prepared by the WUS staff + Tensiometers)	2
		100

Source: AES Department of Agriculture 1998

5.8 Fertigation and water quality

Closely associated to irrigation scheduling is fertigation i.e. the application of fertilizers through the system with the irrigation water directly to the plants roots. It is an integral part of the irrigation process and the water management in agriculture. This practice is indispensable to the farmers as it resulted into increase in yield, improvement in quality and uniform crop development. There are a few techniques for this process depending on the available technology (fertilizer injectors), the system of irrigation and the plantation. In Cyprus the "constant feeding" technique, with fertilizer injectors operating with system's water pressure, is the common practice in seasonal crops irrigated with drip systems. With this technique the fertilizer solution in liquid form is fed into the system through the injector at low rates repeatedly, on a continuous basis during irrigation.

Fertigation program is based on the irrigation program (schedule). In many cases the irrigation water is with medium and even high salinity content. The fertilizer concentration is added to the total salinity resulting into higher concentrations and gradual accumulation of salts in the soil. The salinity level at the soil root zone is directly related to the water quality, the amount of fertilizers and the irrigation dosage. So, it must be checked and the application of both the quantity of fertilizers and the irrigation water (for leaching control) must be adjusted according to the soil test results. The fertigation programs and the water quality evaluation for irrigation, as well as the soil solution testing in the field with the soil moisture extractors or in the laboratory with the soil saturation extract method, are WUS staff responsibilities. All the district agricultural offices are provided with portable conductivity measurement kids, soil moisture extractors, soil augers for sampling and all other relevant field equipment.

5.9 Other advisory work

Continuous improvement of water use for crop production is essential in a water scarce country like Cyprus. To achieve this major objective the WUS staff extension activities include technology transfer programs through field demonstration, education, training, publicity and personal contacts as follows:

The establishment of irrigation field trials and demonstration plots every year in close collaboration with the farmers, is among the first priorities. All kind and types of systems and techniques in all kind of crops have been demonstrated repeatedly in every district. The farmer's respond is very positive and they participated in groups in organized by the WUS visits to these plots.

Lectures and short courses are held, at least six times per year, at the two "Farmers Educational Centers", and evening meetings are organized at various villages several times in a year on water use improvement practices.

A continuous and intensive publicity campaign is taking place through radio, TV, newspapers and magazines all around the year. This campaign is very successful and useful as it is of great interest to the farmers and contributes significantly to the irrigation extension information and training program.

The last decade the WUS has considered the treated municipal wastewater as an important source of water for use in forage crops and other cultivations. In close collaboration with the Water Development Department and the Agricultural Research Institute several demonstration farms have been established for the reuse of the re-cycled water with improved irrigation systems in agriculture. Irrigation advisory services are provided to the farmers for the proper utilization of this water

The WUS staff is responsible to advise, inform, and train the farmers who installed improved irrigation systems in the proper operation and maintenance of their installations and the implementation of the irrigation and fertigation schedules and programs. This is mainly achieved through personal contacts (see Table 5-5).

- Table 5-5 Irrigation Schedules, fertigation programs, O & M and personal contacts with farmers (Average figures during a normal year)

Irrigation schedules prepared	2 000
Tests on proper O & M	3 000
Fertigation Programs prepared	1 200
Personal Contacts	18 000

Source: WUS Annual Reports 1986-1999

6 Constraints

In Cyprus the proper on-farm irrigation management is constrained by several factors. These can be specified into institutional and technical constraints as follows:

HIGH COST OF GOVERNMENT SERVICES

The DOA employed around 50 Water Use technical officers working permanently on the improved irrigation systems supported by another 50 extension agents. The area covered around 35 00 ha is relatively small as compared with costs to the Government. In the past decades the conditions were favourable as the increase in yield that justified the costly inputs was possible through a series of development measures and activities planned together with improvement of irrigation. The present conditions with agriculture declining from being important economic sector and the farmers being familiarized with improved irrigation, cannot not justify high operation expenses for the Government irrigation advisory services. The plans of the Government to transfer these services to the private sector might create a big gap with negative results.

LACK OF NATIONAL WATER AUTHORITY

The island's water resources, development, maintenance and use, as related to the existing legislation, are responsibilities of several Ministries. The formation of Water Entity to manage the water on a national scale in an integrated and rational manner for all consumers was planned thirty years ago, but until now it has not been established. It is more than certain that this delay is a constraint to better water management in many ways but mainly in administration and coordination of activities. Unfortunately this situation provides an alibi to the reluctance of the Government in taking immediate actions to improve existing conditions in the civil service.

WATER PRICING

The price of the water from the Government major water works is given to the farmers at one fifth the actual cost. This heavy subsidy is a draw back to the national efforts in saving as much as possible water. A considerable amount of water, although not estimated, is lost due to pipe networks leakages resulted due to improper maintenance, operation and management of the farmers' systems installations. However, there is no doubt that any increase in water price will affect the cost of irrigated crop production and in general irrigated agriculture in Cyprus, which will not be competitive.

LACK OF IRRIGATION EXPERTS

There is lack of new irrigation/agronomists with experiences in dealing with latest technologies in farm irrigation practices to continue the work of the existing personnel (average age 50 years). These “veterans” are not willing to update and upgrade their knowledge to meet the increasing demand for specialized advisory work. The Government irrigation advisory services are falling into a decline, year after year. The unification of the Water Use Section with the Land Section lately might not be a wise step towards the strengthening of irrigation advisory services.

LACK OF FOLLOW UP OF IRRIGATION PROGRAMS OF WORK

The follow up of the working programs and schedules prepared for the farmers is of major importance. Unfortunately in many cases the farmers’ abilities are overestimated and left alone after the instructions given by the irrigation staff, with all the negative results. The irrigation advisory service is always blamed for any mistake did damage to the crops.

LOW UNIFORMITY OF IRRIGATION APPLICATION

An evaluation made few years ago, showed that the biggest problem in water use in agriculture was the poor operation of the irrigation systems in potatoes and other cultivations, due to improper management, maintenance, and offhand intervention in the systems installations by the farmers without any experts’ advise. This resulted into very low uniformities of application and huge losses of water. The situation is worsening year after year and covers most of the systems and crops all around the island.

TRANSITION FROM NATIONAL TO EUROPEAN UNION AGRICULTURAL POLICY

Cyprus has signed long ago to joint EU as a full member. A harmonization program was prepared and initiated in 1997. This program, that covered agriculture, envisaged the adoption of legislative and structural measures as well as institutional relating to the Common Organization of the EU by the end of 2002. Advisory services vary between member states, however, a certain frame within which the irrigation advisory services have to work in line with EU regulations and directives should be adopted. A study of the necessary changes to the present functions and responsibilities of the MANRE is in process. The transition period will severely damage the capacity of the services to the farmers.

7 Recommendations

SYSTEM OF IRRIGATION

The basic and principal prerequisite for the successful implementation of the efficient water utilization in crop production is the use of the suitable improved irrigation technology, which enables the exercise of perfect handling and absolute control the irrigation water. The cost of the installation is not a limiting factor to the farmer as compare with the benefits derive.

IRRIGATION EXTENSION STAFF

The irrigation extension employees should upgrade their know-how by all means available, i e. Internet services, short courses abroad, in-service seminars and the development of close contacts with the manufacturers suppliers of irrigation equipment and other technology products. Their ability to suggest technological solutions to farmers’ problems, to select the appropriate technology and to identify needs for modification accordingly is of vital importance.

FIELD TRIALS AND PERSONAL CONTACTS

The crucial point in the long dynamic process of irrigation extension activities is the personal contact between the extension worker and the farmer for technology transfer. The safest way to accomplish this task is through the frequent conduct of field trials (On-Farm Trials) to verify performance and adoption potential of new techniques under farmers management conditions and with he farmers participation.

NEW MINOR IRRIGATION PROJECTS

Minor irrigation projects or programmes, short-term, should be formulated and implemented every 2 – 3 years, aiming at the proper operation and maintenance of the irrigation systems installations and in general to keep up the high level of the on-farm irrigation practices. Other objectives may included also, focusing on the improved water management for crop production.

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ANNEXES

ANNEX I Irrigation Schedule Using Blaney-Criddle formula – Year 1969

Name: M. Demetriou Irrigation system: Hose-basin Irrigation efficiency 80%		Citrus trees10 years old 6 m x 3 m 3ft root depth		Total Avail. Moisture: 5,18" Irrig Depletion 65%
Month	Daily Consumptive Use inches (mm)	Date of Irrigation	Frequency of Irrigation Days	Net depth of application 3,367" (86mm)
May	0,111" (2,8mm)	3 / 5	30	No of Irrigations: 9
June	0,136" (3,45mm)	2 / 6	24	
June	0,136" (3,45mm	26 / 6	21	Total Consumptive
July	0,168" (4,27mm)	17 / 7	19	Use: Net 30 inches depth of water
August	0,192" (4,87mm)	5 / 8	17	(774mm)
August	0,192" (4,87mm)	22 / 8	19	Gross 37,5 inches depth of water
September	0,160" (4,06mm)	10 / 9	21	(968mm)
October	0,130" (3,3mm)	1 / 10	25	
October	0,130" (3,3mm)	26 / 10	-	

Source: Pentayitis, WUS 1969

ANNEX II Irrigation Schedule with IRRICROP Computer Program (Example 2000)

Name: M. Demetriou	Citrus trees 10 years old	Type of Soil: Sandy loam
Irrigation system: Mini-sprinkler	Planting spacing 6m x 3m	Wetted area: 8 0%
Irrigation efficiency 80%	3ft (95cm) root depth	
	Vegetation coverage: 95%	

Month	Ten days Period	Gross Irrigation Requirements Mm / day	Date of Irrigation (recommended)	Gross Irrigation Dosage (recommended): 55mm
May	1/5 – 10/5	3,32	3/5	Total No of Irrigations: 14
» »	11/5 – 20/5	4,03	18/5	
» »	21/5 – 31/5	4,45		Total Gross application seasonal
June	1/6 – 10/6	4,59	1/6	
» »	11/6 – 20/6	4,83	13/6	770mm
» »	21/6 – 30/6	5,26	25/6	
July	1/7 – 10/7	5,39	5/7	
» »	11/7 – 20/7	5,06	15/7	
» »	21/7 – 31/7	5,23	26/7	
August	1/8 – 10/8	4,86	5/8	
» »	11/8 – 20/8	4,63	16/8	
» »	21/8 – 31/8	4,29	27/8	
September	1/9 – 10/9	4,05	8/9	
» »	10/9 – 20/9	3,78		
» »	21/9 – 30/9	3,20	24/9	
October	1/10 – 10/10	2,87		
» »	21/10 – 20/10	2,61	23/10	
» »	21/10 – 31/10	2,11		
November	1/11 – 10/11	1,60		
» »	11/11 – 20/11	1,31		

Source: Example 2001, IRRICROP

ANNEX III ETo Values in the Coastal Areas of Cyprus

(Larnaca, Famagusta, Limassol, Paphos)

Season		Month	ETo values mm/month	Effective Rainfall mm/month	
				Larnaca/ Famagusta	Limasssol/ Paphos
Rain		January	30	22	56
		February	35	24	36
		March	54	17	27
		April	81	-	-
		May	116	-	-
		June	142	-	-
	Irrigation	July	157	-	-
		August	151	-	-
		September	114	-	-
		October	81	-	10
Rain		November	45	21	26
		December	33	39	47
TOTAL mm/year			1039		

Source: Phocaides, WUS 1991

Note: The coastal areas of the island are the main agricultural areas for vegetables and other seasonal and perennial cash crops. Apart from these areas there are also the central plain area mainly for olive trees, winter salad vegetables, melons and the hilly and mountainous areas for vines deciduous fruit trees and other crops.

For the calculation of the crop water requirements the crop coefficient (kc) taken is the kc factor developed by Doorenbos, Pruit and others in No 24 FAO Irrigation and Drainage paper.

ANNEX IV: Irrigation Water Requirements* of the Main Crops in Cyprus

Crop	Length of Irrigation Season days	Seasonal Irrigation Requirements mm
Citrus trees**	220	680
Deciduous trees	150	650
Bananas	220	1200
Pecan	220	800
Olives	220	410
Table Grapes	90	290
Potatoes early	130	250
Potatoes winter/spring		360
Vegetables/greenhouse	250	650
Vegetables/ low tunnel		350
Vegetables/spring		500
Vegetables/summer		400
Melons	95 - 150	330
Groundnuts		550
Artichokes	200	550
Alfalfa	250	1200

Source: Phocaides, WUS 1996

*Gross average requirements, leaching not included

** All citrus fruit trees

ANNEX V Laboratory and Field Equipment used by the WUS Extension Staff

LABORATORY APPARATUS AND INSTRUMENTS

- Vacuum Pump complete with accessories and mounting valves
- Filter Funnel apparatus with receiving bottles
- Water Distillation apparatus
- Grinder
- Conductivity and Temperature meter
- 5 – BAR Pressure Plate Extractor with ceramic plates
- Manifold Low Pressure for the Extractor
- 15 – BAR Ceramic Plate Extractor
- Manifold Low to High Pressure for the ceramic extractor
- Rubber Soil Retaining Rings
- Air Compressors
- Drying Oven air heated
- Balance Top loading Electronic
- Aluminium Moisture Cans numbered
- Various other items (plastic beakers graduated, spatulas palette knives, brass sieves, aluminium tins, filtering papers etc.)

FIELD WORK AND METEOROLOGICAL EQUIPMENT

- Hand Augers steel for soil sampling
- Conductivity meters portable
- pH meters portable
- Tensiometers
- Soil water (solution) Extractors with Vacuum service unit
- Chronometers (stop watches)
- Pressure Gauges portable
- Parshall Flumes
- Water Meters
- Class "A" Evaporation Pans (USWB)
- Measuring Tapes

SURVEYING AND DRAWING INSTRUMENTS

- Alidades with Plain tables
- Microptic Engineers Levels
- Levelling Staves
- Drawing tables
- Drafting Chairs
- Diazo printers
- Technical pens
- Lettering Guides
- Planimeters
- Pantographs
- Compasses
- Stationary and other

COMPUTER SERVICES

- Computer hard ware, "Autocad" and other relevant software