# L'irrigazione automatizzata

**Cavazza D.**

**L'eau**

**Paris : CIHEAM**
**Options Méditerranéennes; n. 14**

**1972**
pages 56-59



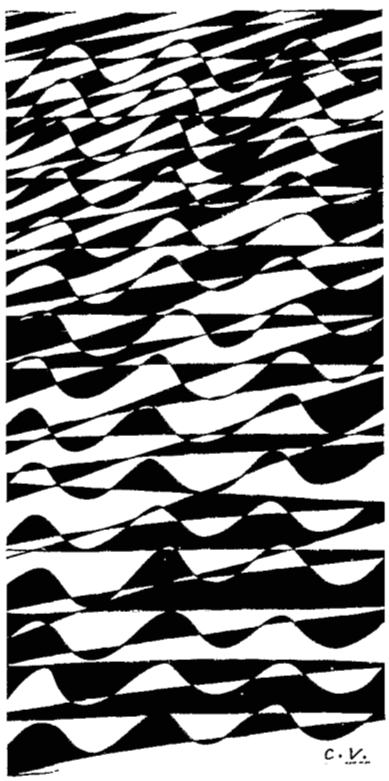
Thomas STICKLEY (2)
and
Theodoulos CHARALAMBIDES
(3)

# Criteria for pricing irrigation water in Cyprus (1)

(1) This paper is the condensation of a Master of Science thesis in Agricultural Economics by Theodoulos A. Charalambides, Faculty of Agricultural Sciences, American University of Beirut, Beirut, Lebanon, 1971, approved for publication in *Options Méditerranéennes* as AUB-FAS Journal Number 381, and Miscellaneous Publications Series Number 63.

(2) Assistant Professor of Agricultural Economics, Faculty of Agricultural Sciences, American University of Beirut, Beirut, Lebanon.

(3) Master of Science Graduate in Agricultural Economics, Faculty of Agricultural Sciences, American University of Beirut, Beirut, Lebanon, and currently in the Planning Bureau, Government of Cyprus, Nicosia, Cyprus.




Cyprus, with an average annual rainfall of 19.4 inches (493 mm), is considered to be a semi-arid region. Water is, therefore, a most critical factor in the agricultural development of the island. It is estimated that irrigated horticulture produces 8.1 times more value of product per unit of land area than dry farming and animal husbandry together (under present conditions). Thus, it is not surprising that the Republic of Cyprus, committed to economic and social development, has been involved, since its creation in August 1959, in the intensive development of the water resources of the island. As a result, a number of dams for both irrigation and the replenishment of depleted aquifers have been built and are now in operation.

One of the most crucial problems now facing the Government is the determination of the price at which farmers can buy water from the dams. An improperly determined price will lead to the wasteful use of scarce resources and will impair the success of water development projects. Proper pricing criteria are, therefore, imperative.

In order to determine proper criteria, two approaches have been used. First, relevant economic literature was reviewed. Second, a survey of Cypriot farmers from three different irrigation project areas was carried out in 1970. These areas, chosen after consultation with the Planning Bureau and the Water Development Department in Cyprus, represented mountainous, hilly and plains regions. The results of this research are summarized here.

## PRICING ALTERNATIVES

### 1. Determination of a Single Price

The three alternative pricing policies open to the Government are: (*a*) profit maximization, (*b*) average cost pricing, and (*c*) marginal cost pricing.

Profit maximization is followed by the private sector and also by some public sector enterprises. For example, this pricing policy is followed by the government steel mills in India (4).

(4) ENKE (S.). — *Economics for Development*, p. 285, Prentice Hall, Inc., Neff Jersey, U.S.A., 1963.

Average cost pricing is based on the principle that the charge should be the lowest possible price which generate enough revenue to meet all variable and fixed costs. The objection to this pricing policy is that fixed costs are included in the calculation. Their inclusion prevents optimum welfare conditions which call for additional costs involved in providing for that consumption.

This objection is removed by marginal cost. It is greatly favoured by development oriented economists but has little appeal to the economically conservative.

### 2. Benefit Pricing

This method pricing is based upon the benefits received, as these are valued by the recipients. Benefit pricing opens the way to price discrimination. If a seller can divide his market into two or more markets and keep them separate, he may charge a different price in each of the markets and maximize his profits.

But price discrimination is also possible even if there is only one market which cannot be divided into separate submarkets. This is usually referred to as second-degree discrimination and depends on the principle of diminishing marginal utility. If the policy is to increase demand, after a certain quantity has been bought, the price is lowered so that it is lower than marginal utility. This should induce additional demand. Public utilities, such as electricity authorities, pursue this policy.

### 3. Penalty Discrimination

In the case of irrigation water in Cyprus the problem is not to induce the farmers to buy more, but rather, to keep farmers from wasting the water, a scarce resource. This can be done by what has been defined as "penalty discrimination." It consists of charging one price per unit for the use of small amounts of water and raising the price per unit for the use of larger amounts of water. This encourages efficient use of water and discourages waste.

DAMS CONSTRUCTED UP TO 1960

| No | DAM | TYPE | HT | 1000m³ | YEAR |
|---|---|---|---|---|---|
| 1 | Kouklia | Earth | 6.1 | 4545 | 900 |
| 2 | Lymbia | Masonry | 5.2 | 18 | 1945 |
| 3 | Lythrodhonta | Masonry | 10.7 | 32 | 1945 |
| 4 | Kalochorio (Kl) | Masonry | 9.1 | 82 | 1947 |
| 5 | Akraounda | Masonry | 6.7 | 23 | 1947 |
| 6 | Galini | Masonry | 11 | 23 | 1947 |
| 7 | Petra | Masonry | 9.1 | 32 | 1948 |
| 8 | Petra | Masonry | 9.1 | 23 | 1951 |
| 9 | Lythrodhonta | Masonry | 10.4 | 32 | 1952 |
| 10 | Kafizes | Masonry | 23.5 | 115 | 1953 |
| 11 | Ayios Loucas | Earth | 3.4 | 455 | 1955 |
| 12 | Gypsos | Earth | 3.4 | 10.5 | 1955 |
| 13 | Kandou | Masonry | 14 | 35 | 1956 |
| 14 | Perapedhi | Gravity | 21.6 | 55 | 1956 |
| 15 | Pyrgos | Gravity | 22.3 | 280 | 1957 |
| 16 | Trimiklini | Gravity | 33.2 | 340 | 1958 |

Total Storage Capacity 6190 $m^3 \times 10^6$

MINOR RECHARGE DAMS FROM 1960-70

| No | DAM | TYPE | HT | 1000 m³ | YEAR |
|---|---|---|---|---|---|
| 47 | Sotira | Earth | 7.6 | 45 | 1962 |
| 48 | Panayia (F) | Earth | 7 | 45 | 1962 |
| 49 | Paralimni (45) | Earth | 4.6 | 115 | 1963 |
| 50 | Ayia Napa (17) | Earth | 8.2 | 55 | 1963 |
| 51 | F sta Recharge | Earth | 4.9 | 50 | 1963 |
| 52 | Phrenaros (6) | Earth | 5.5 | 115 | 1964 |
| 53 | Dherynia | Earth | 6.1 | 23 | 1964 |
| 54 | Phrenaros (3) | Earth | 6.7 | 45 | 1966 |
| 55 | Avgorou (7) | Earth | 3 | 68 | 1966 |
| 56 | Konteas (2) | Earth | 5.5 | 82 | 1966 |
| 57 | Xyluphagou (4) | Earth | 6.7 | 86 | 1966 |
| 58 | Sotira (4) | Earth | 4.6 | 32 | 1966 |
| 59 | Lysi | Earth | 6.7 | 77 | 1967 |
| 60 | Ay Yeorgios (9) | Earth | 3 | 68 | 1967 |
| 61 | Ay Epiktitos (6) | Earth | 6.1 | 34 | 1968 |
| 62 | Akanthou (6) | Earth | 6.1 | 45 | 1968 |
| 63 | Akhna (3) | Earth | 4.3 | 40 | 1968 |
| 64 | Xylotymbou (5) | Earth | 5.5 | 50 | 1969 |

Total Storage Capacity 1075 $m^3 \times 10^6$

MAJOR DAM PROJECTS FROM 1960-70

| No | DAM | TYPE | HT | 1000m³ | YEAR |
|---|---|---|---|---|---|
| 17 | Prodhromos | Earth | 10.4 | 115 | 1962 |
| 18 | Morphou | Earth | 15.5 | 7045 | 1962 |
| 19 | Lefka | Gravity | 34.4 | 365 | 1962 |
| 20 | Geunyeli | Earth | 18 | 1050 | 1962 |
| 21 | Athalassa | Earth | 18.3 | 790 | 1962 |
| 22 | Kanli Keyu | Earth | 19.8 | 1,100 | 1963 |
| 23 | Argaka | Rockfill | 41.1 | 1,150 | 1964 |
| 24 | Mia Milea | Earth | 21.6 | 340 | 1964 |
| 25 | Ovgos | Earth | 15.8 | 850 | 1964 |
| 26 | Tremithos | Earth | 22.6 | 1,615 | 1964 |
| 27 | Agros | Earth | 26.2 | 100 | 1964 |
| 28 | Liopetri | Earth | 18.3 | 340 | 1964 |
| 29 | Polemidhia | Earth | 44.8 | 3,850 | 1965 |
| 30 | Ayia Marina | Rockfill | 32.9 | 310 | 1965 |
| 31 | Kalopanayiotis | Earth | 39.3 | 395 | 1966 |
| 32 | Mavrokolymbos | Earth | 46.6 | 2,180 | 1966 |
| 33 | Pomos | Earth Rock | 38.4 | 850 | 1966 |
| 34 | Yermasoyia | Earth | 49.4 | 13600 | 1968 |
| 35 | Syngrasis | Earth | 7.3 | 1,115 | 1968 |

Total Storage Capacity 32160 $m^3 \times 10^6$

MAJOR RECHARGE DAMS FROM 1960-70

| No | DAM | TYPE | HT | 1000m³ | YEAR |
|---|---|---|---|---|---|
| 36 | Ay Yeorghios | Earth | 6.1 | 90 | 1962 |
| 37 | F sta Antiflood | Earth | 7.6 | 165 | 1963 |
| 38 | Ay Nicolaos | Earth | 1.8 | 1,365 | 1964 |
| 39 | Paralimni Lake | Earth | 0.9 | 1,365 | 1964 |
| 40 | Fresh Water Lake | Earth | 3 | 4,545 | 1964 |
| 41 | Makrasyka | Earth | 7.9 | 195 | 1966 |
| 42 | Akhna (Mesana) | Earth | 3.7 | 90 | 1967 |
| 43 | Morphou spreading grounds | Earth | 4.6 | 130 | 1968 |
| 44 | Ormidhia | Earth | 5.5 | 100 | 1968 |
| 45 | Vrysoules | Earth | 6.7 | 140 | 1969 |
| 46 | Protopapas | Earth | 5.9 | 90 | 1970 |

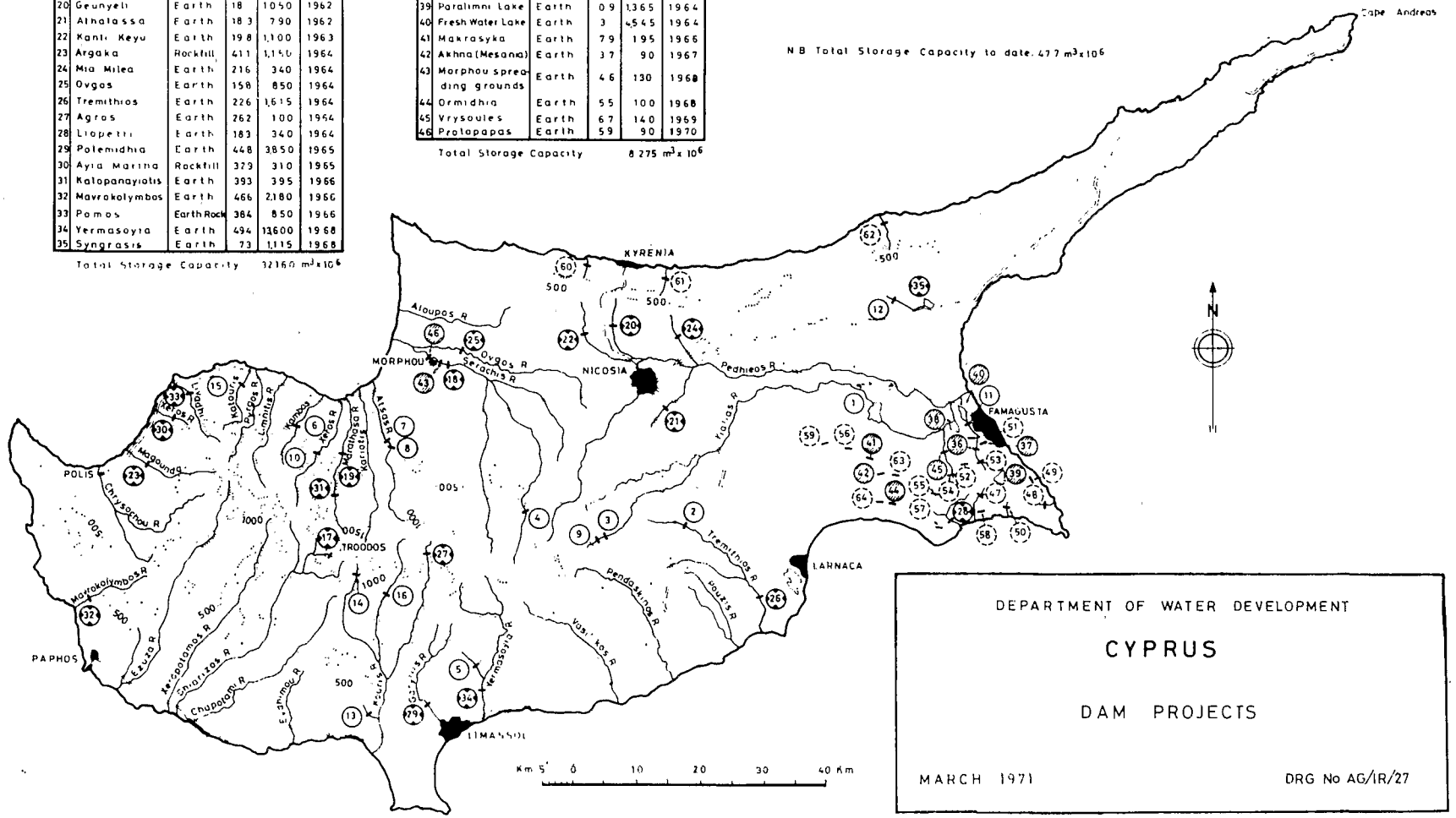
Total Storage Capacity 8 275 $m^3 \times 10^6$

HT refers to height in meters from foundation

YEAR is the year of completion

Phrenaros (6) means six small dams in Phrenaros area

N B Total Storage Capacity to date: 47.7 $m^3 \times 10^6$




(1) Dams constructed up to 1960

(17) Major dam projects from 1960-70

(36) Major recharge dams from 1960-70

(47) Minor recharge dams from 1960-70

FIG. 1. — *Dam projects in Cyprus trough 1971.*

FIG. 2. — *Aerial view of Kalopanayiotis Dam (Number 31 in Figure 1).*

## DEMAND FOR IRRIGATION WATER

The demand for irrigation water was studied in the three project areas which have been surveyed. These areas are:

Zakaki (29, figure 1), representing a plains region,

Kalopanayiotis (31, figure 1 and figure 2), representing a mountainous region, and

Paphos (23, 30 and 33, figure 1), representing a hilly region.

The factors influencing the demand for water were analysed (figure 3). Two graphs have been drawn for Zakaki. Zakaki (perennial) refers to high profit cultivations of citrus, and comparison is made with the high profit cultivations of apples and pears of Kalopanayiotis. Zakaki (seasonal) refers to vegetable cultivations which are of lower profitability, and comparison is made with the vegetable cultivations of Paphos.

The main factors influencing the demand for water are as follows:

1. Kind of crops grown and the growing season.
2. Profitable use of the land.
3. Area of land irrigable from the project.
4. Alternative uses of the land.
5. Alternative source of water.
6. Minimum income.

### 1. Kind of Crops Grown and the Growing Season

Irrigated crops can be divided into two categories, that is, perennial (citrus, apples) and seasonal (vegetables). Vegetables cannot be grown on the same land every year. Therefore, some kind of rotation is necessary. Since different crops need different amounts of water, enterprise selection and the growing period have an effect on the demand for water.

### 2. Profitable Use of the Land

Any decision of the farmer to increase, decrease or discontinue production of irrigated crops is made on the basis of expected total costs of production and total revenue. As the price of water increases, the less profitable crops are progressively abandoned. The vegetable growers of Zakaki would not buy water at 15 mils/m³ (Zakaki, seasonal, figure 3). Also, for an increase of 30 % in the price of water (i.e., from 10 to 13 mils/m³), they would decrease irrigated acreage by 77 %. But, in the case of citrus cultivation which is more profitable, citrus growers would still demand water at 25 mils/m³ (Zakaki, perennial, figure 3).

### 3. Area of Land Irrigable from the Project

When the price of water changes from 15 to 20 mils/m³, the slope of the curve for the Kalopanayiotis fruit growers is nearly the same as the slope of the curve for the Zakaki fruit growers (figure 3). This indicates that as price increases, the irrigated land decreases at the same rate in both cases. Therefore, the behaviour of high-profit crop growers is the same for price increases.

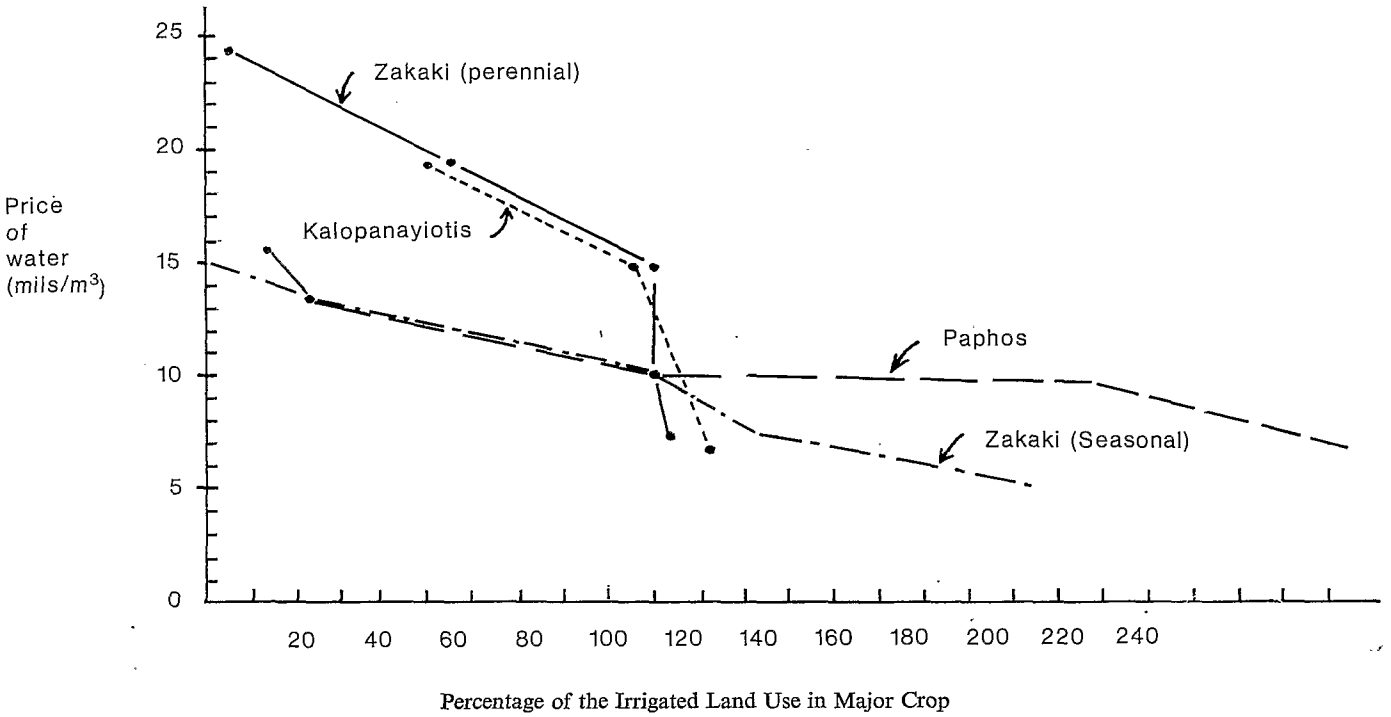



FIG. 3. — *Responsiveness of land under irrigation to changes in the price of irrigation water. With respect to the individual farmer's major crop, this shows the percent of the irrigated land that is currently used for this crop that he would use at different prices of water.*

However, there is hardly any increase in irrigated land in Zakaki for any decrease in price below 15 mils ; whereas the increase in Kalopanayiotis is very slight below 15 mils down to 10 mils, followed by a higher rate of increase below 10 mils. This indicates that in Zakaki, at 15 mils/m³, nearly all the available land for growing citrus has been developed ; whereas in Kalopanayiotis, maximum development is reached at a price of 8 mils/m³ (figure 3). Although basically the behaviour of farmers is the same in both areas, they stop expanding their irrigated crops at different price levels as a result of the differences in the relative scarcity of land.

## 4. Alternative Uses of the Land

In the case of low-profit crops, it is observed that for a price rise from 10 to 13 mils/m³, in both the Paphos and the Zakaki samples the behaviour of farmers is identical ; when the price rises to 15 mils, no land would be irrigated in Zakaki, whereas irrigated land would be reduced by 87 % in Paphos. Also, for prices below 10 mils/m³, the rate of increase of irrigated land is much higher in Paphos than in Zakaki (figure 3).

A most likely factor behind this behaviour is the fact that in Paphos there is no alternative profitable use for the land other than agriculture, whereas in Zakaki, the farmers have the alternative of using their land for residential and building purposes.

## 5. Alternative Source of Water

An important factor influencing the demand for project water is the availability of water from another source and its price. In Kalopanayiotis the land which has been developed as a result of the project can only be irrigated from the project, and there is no problem. But in Paphos many farmers pump water from shallow wells at a cost lower than the price of project water. In some cases project water is used only as a complementary source of water. In Zakaki, although many farmers own wells, the quality of the water is not very good because of sea-water intrusion into the aquifer.

## 6. Minimum Income

Farmers, like everyone else, aim at securing at least a minimum income which they regard as necessary for their standard of living. The fact that older farmers may live with their children and may not have to provide for themselves,

and the fact that many farmers supplement their agricultural income from other employment, ownership of property and gifts from relatives influence the demand for water.

## CRITERIA FOR PRICING IRRIGATION WATER

Economic theory and the results of the survey of farmers in Cyprus suggest that in developing princing policies, the following criteria should be taken into consideration :

1. Incidence of the water charge.
2. Social benefit.
3. Demand for water.
4. Solvency.
5. Efficient use of resources.
6. Capacity to pay.
7. Productivity of the land.

### 1. Incidence of the Water Charge

Low water prices mean that only a small proportion of the original investment expenditure may be recovered, and the tax payers bear most of the cost. High water prices mean that the proportion of the cost borne by the tax payers is reduced. But at whose expense ? The farmer's or the consumer's ? If the consumer pays most of the increase, in a country with a system of progressive taxation, income distribution problems arise.

### 2. Social Benefit

Adoption of the marginal cost pricing method leads to the maximization of the social benefit because it jsutifies an increase in output as long as the value of the additional output is not lower than the value of the resources used to produce it. However, further clarification is necessary lest two possible misunderstandings arise.

First, marginal cost pricing does not favor uneconomic projects. Projects are evaluated and selected by appropriate economic tests and other political and ethical criteria. But suppose that an uneconomic project has been completed. What marginal cost princing means is that although an uneconomic investment has taken place, the best policy to follow is to extract the maximum social benefit from it.

Second, marginal cost pricing should not be considered as a limit beyond which prices should not be allowed to rise but only as a limit below which prices should not be allowed to fall. In most cases it should be possible to make full use of the resources created by the irrigation project at a price of water much higher than the marginal cost.

### 3. Demand for Water

Knowledge of the demand for water furnishes one of the most useful criteria. In Zakaki all the area intended for perennial crops is fully developed at the present price of water of 15 mils/m³, while in Kalopanayiotis the whole area is being developed at the current price of 13 mils/m³ (figure 3).

But the lowest limits set by the marginal cost pricing method are 5 mils/m³ in Zakaki and 7 mils/m³ in Kalopanayiotis. Knowledge of the demand for water can, therefore, show the extent to which prices of water can rise above the marginal cost without any adverse effects on the social benefit. Where the price elasticity of demand for water is greater than one (figure 3), total revenues will be increased by lowering the price of water.

Another application of the demand for water as a pricing criterion is the way it can be used in " benefit " pricing and " penalty discrimination " policies.

### 4. Solvency

This criterion is a measure of the extent to which a project can pay for itself. Not only economic but also political, social and welfare implications of income distribution are associated with it. The final decision regarding these problems rests with the political system, but it is imperative to provide the political system with information relating to the consequences of alternative prices for water.

It should be pointed out that water prices developed on the basis of costs of production do not increase the solvency of a project. Benefit pricing ensures the maximum degree of solvency attainable by a project without defeating the policy objectives for which the project was constructed.

### 5. Efficient Use of Resources

Where improvement in the combination of resources is possible, appropriate irrigation policies can be used effectively. Pricing policies can be developed which would aim at influencing the farmers ; first, to select the most profitable enterprises and, second, to avoid wasting water. In the case of the latter, " penalty " discrimination may be appropriate.

In some cases, because of water rights, it is not possible to charge a high enough price for irrigation water. During some months the water may even be completely free. In these cases the possibility of imposing a land tax per unit area on the land which was intended for development could be explored. A land tax would recover some of the capital invested and would induce the farmers to choose more profitable crops. Also, charging a price for water used for all purposes and from all sources (including bore holes and run-off water as well as water from dam projects) is a possibility.

### 6. Capacity to Pay

This criterion depends on the profitability of crops per unit area. Given the production possibilities of the land and the supply and demand conditions applicable to the region, clear policies of land use and application of improved methods can be formulated.

The profitability of crops should be assessed not on the basis of the " value added " by the land but on the basis of the " value " the land is capable of " adding ". A pricing policy consciously oriented towards maximizing the capacity of the farmers to pay has more chances to meeting the objectives of an irrigation project than a pricing policy which pays little attention to this principle.

### 7. Productivity of the land.

An easy way of estimating the increase in the net productivity of the land, as a result of the change from dry farming to irrigated agriculture, is to compare market values of the land, per unit area, before and after irrigation.

Suppose that before irrigation the farmer could make a net profit of 25 dollats per unit area and that, after irrigation, he can make a net profit of 100 dollars (i.e., net profit increased 4 times). This is reflected in a fourfold increase in the value of the land. The process for determining price by using this hypothetical fourfold increase in productivity is as follows :

1. Since the farmer can increase, with irrigation, his net profit per unit of land four times, it is economically justifiable for his total costs of production, with irrigation, to increase four times over that of production without irrigation.
2. Since three-quarters of his net profit (75 dollars) is due to irrigation, it is economically justifiable for the costs of irrigation to be up to three-quarters of the total costs.
3. Irrigation costs can be divided into the costs of turning dry farmed land into irrigated land plus the cost of water.
4. Therefore, it is possible to estimate the annual costs of changing the land use. The difference between these costs and total irrigation costs represents the cost of water. This will supply the basis on which the price per unit of water can be calculated.

The price charged for irrigation water should be based on these criteria as well as national objectives towards which other development programs are moving.

## BROADER IMPLICATIONS

In addition to the criteria for setting price discussed above, the following re-

commendations should also be considered carefully :

1. *Interest Rate Used in Project Evaluation :* Eckstein's (5) suggestion of using an interest rate of 3 % coupled with a benefit : cost ratio of at least 1.3:1, or an interest rate of 1.5 % coupled with a benefit : cost ratio of 1.4:1 should be adopted. This suggestion does not allow the selection of uneconomic projects.

2. *Land Fragmentation :* Irrigation projects are very costly. It is therefore recommended, in order to get the maximum benefit from the use of the land, to use the land as efficiently as possible. This means that the land irrigable by a dam should not be held in many small fragments but in only one or two large holdings.

3. *Distribution Systems :* The water distribution systems should be completed so that the objectives for which the dams were constructed can be realized.

4. *Water Rights:* Proper use of water and land increases the capacity of the farmers to pay and, therefore, water charges can be raised. But water rights may lead to disputes which impede the proper use of these resources. Therefore, it is suggested that no more dams should be built in areas where these rights have not been clearly defined and no agreement has been reached.

5. *Depleted Aquifers :* It is suggested that in addition to the measures already taken to save deteriorating aquifers, a tax should also be put on water which is pumped for irrigation. The burden of such a tax should not impose an excessive social or economic cost to any income group.

6. *Government Participation and Research :* It is strongly recommended that the Ministry of Agriculture undertakes to carry out all the necessary agricultural activities on selected demonstration farms belonging to farmers in all irrigation project areas. The merits of such a policy are many.

Firstly, the research program of the Ministry would not be confined to experimental farms which are farmed under very different conditions in areas far away from the project.

Secondly, given the local conditions of the area, scientific application of the principles of agronomy, farm management and economics should facilitate the establishment of the optimum production function for the area.

Thirdly, if the produce has to be sold by the Ministry through the marketing channels used by the farmers of the locality, marketing defects would be clearly understood and evaluated.

Fourthly, after a number of years, a picture of what should be cultivated, and how, in a particular project area would emerge. The main elements composing this picture would be (*a*) size of viable farm unit, (*b*) what technology should be used in farming it, (*c*) crop rotation and intensity of land use, (*d*) expected yields, (*e*) expected prices, and (*f*) expected net returns per unit area and their allocation to labour, land, capital and enterprise.

Fifthly, all the knowledge and experience gained will be gained under realistic conditions in project areas with the participation of farmers. It will not be gained under different conditions in a " model " experimental farm away from the farmers.

Finally, the Government will have reliable information not only of the present profitability of agriculture in project areas but also of potential and attainable higher levels of profitability. On the basis of this information, realistic agricultural development plans can be worked out. Pricing of irrigation water can be used as a tool for the fulfillment of these plans. Their success would mean that (*a*) the farmers get the maximum benefit from the construction of the irrigation project ; (*b*) as a consequence, the capacity of farmers to pay is maximised and, therefore, the Government can charge the highest price possible for the water without spoiling the objectives of the project ; (*c*) as a consequence, the taxpayers benefit by having to subsidise irrigation projects less heavily ; and (*d*) the public at large benefits by the supply of cheaper food.


(5) ECKSTEIN (O.). — *Water Resource Development*, Harvard University Press, Cambridge, Massachusetts, U.S.A., 1961.