TOWARD A CORRECT EVALUATION OF WATER ECONOMICS: EXPERIENCE FROM THE REGION OF MURCIA, SPAIN

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ABSTRACT

The Murcia Region, in Eastern Spain, has developed highly profitable irrigation agriculture that uses both surface and groundwater, complemented with reuse of municipal sewage. Groundwater resources are being used intensively and they are progressively depleted, but imported water is being and will substitute for them. Water prices are high but this encourages more efficient use of water resources. Then the amount of water used decreases and more profitable crops are grown. In this semiarid region, maximum productivity per cubic metre of water use should be sough after, and not per hectare of land. Therefore, any system of irrigation other than localized systems cannot be considered and applied to selected cash crops. All these have increased the availability of water by some 60 per cent. Groundwater irrigated areas, developed by private funds, in spite of the higher cost of water, are more than 3 times more productive than areas irrigated with surface water. Water economic analyses readily assess the impact on local economy of the form that water is used. This aspect is discussed considering factors such as the GNP, employment and family income, all this with special regard to ground water. Public Administration has to consider the main decision variables, such as water price, crop, irrigation system, water resources distribution and allocation, and environmental impact.

INTRODUCTION

Although Economics is an Science, and the methodology used for the economic evaluation of projects for the development and use of water resources would appear to be clear-cut and objective, the fact is that the final outcome of these evaluations can vary tremendously depending upon whether cost-benefit analyses are determined by individual, local, regional, national or even world-wide considerations.

The outcome varies not just because of social and political factors, as critics of this type of methodology would have it, but essentially, in the author's opinion, because decision-makers take into consideration the benefits to be obtained on a much wider scale than that which is sit especific. Such

overall considerations are vital if local government administrations are to carry out successful water resources management policies.

2 WATER RESOURCES IN MURCIA.

Murcia is an autonomously governed province in the South-East of the Iberian Peninsula, in Spain (figure 1). About 60% of the province lies within the Segura River basin. Located on the shores of the Mediterranean sea, at the opposite end of the peninsula from where rain is blown in off the Atlantic Ocean, water resources in the area are notoriously scarce (see Table 1).

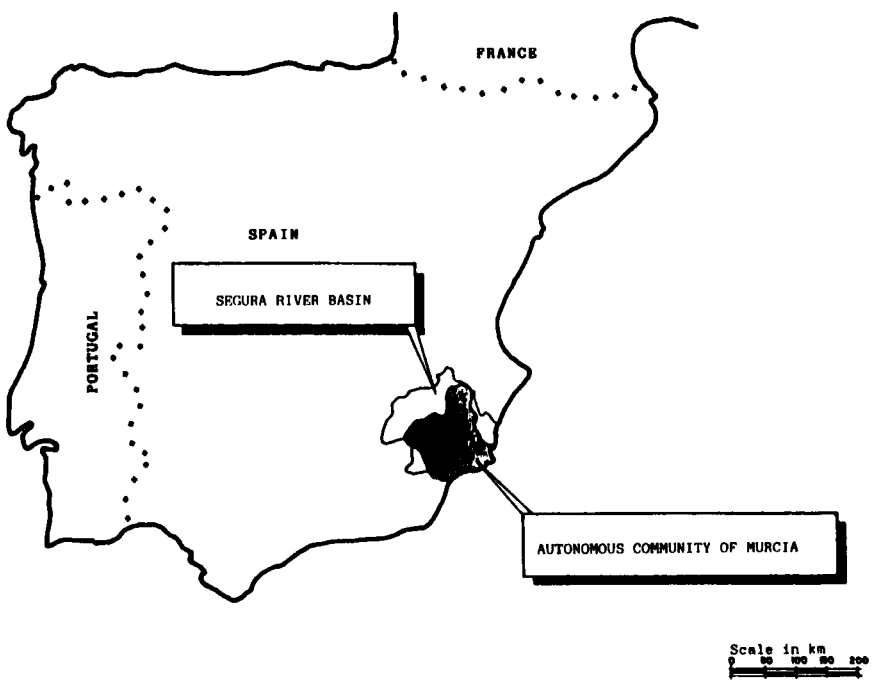

Figure 1.- Situation map

Water shortages are aggravated by the high temperatures registered in the area (18 ^{o}C annual average) and the irregularity of rainfall. Long periods of drought alternate with periods of heavy rainfall and catastrophic flooding.

TABLE 1

Comparitive study of potential water resources (Gutierrez, 1984)

	WORLD	SPAIN	SEGURA RIVER BASIN	MURCIA
Average annual rainfall, mm	740	630	375	325
Total average run-off	0.37	0.35	0.16	0.10
Usable rainfall (annual average), mm.	270	220	60	32

These circumstances have traditionally hindered the economic development of the region. Over the past few years, however, and particularly since 1976, the region's climatic conditions and traditional agricultural practices have been the key to the resurgence of a highly competitive agricultural economy that specialises in the exportation of agricultural goods (flowers, tomatoes, red cayenne peppers, citrus fruits, apricots, grapes, etc.).

TABLE 2

Comparative study of socio-economic variables in Murcia and Spain in 1986 (C.A.A.M. 1987)

	MURCIA	SPAIN	COMMENTS ON FIGURES FOR MURCIA
Population in 1986. (millions)	1.0	38.5	2.6% of Spain
Surface area. (10^3 km^2)	11,313	504,750	2.25% of Spain
Average density of population (inhab/Km2)	89.0	76.2	
Variation in population % (1981-86)	7.04	42,4	Migration balance positive since 1976
Birth-rate %	15	12	
Active working population in 1986 (Active working population/population over 16 yrs of age)	46.9	47.9	49.5 in 1987 (49.2 in Spain)
Registered unemployed 31.12.86 unemployed/active working population)	20.6	21.2	17.1 in 1987 (20.0 in Spain). 3.0 in agriculture
Population actively employed in Agriculture	19.1	15.6	25.2% in 1976. 16.6 in 1987
Contribution of farm sector to GNP 1983	10.74	5.81	Agriculture = 3.84% of national sector. Contribution to national GNP = 2.08%
Cumulative percentage of increase in farm income in constant currency, 1955-84, (Bel Adell, 1987).	1.22	0.46	Murcia's net contribution to total national agricultural production doubled. Period of max. growth from 1985 on.
1979-85 (Banco Bilbao)	6.2	1.8	
Irrigated land (10^3 ha)	170	2800	6% of total irrigated area in Spain.

Table 2 (particularly when it is compared with Table 1 which shows the limited natural water resources available in the region) shows how agriculture

has become an increasingly important part of the economy both at regional and national levels and in relation to EEC countries (Bel Adell, 1987). Moreover, as a result of this increase in agricultural production, an important food-service industry has developed (canned food, juices, etc.).

Water from the Segura River, an estimated total of about 1000 Mm^3/yr, is regulated by 12 dams with a capacity of 847 Mm^3 and 10,000 wells, which provide a total of 570 Mm^3/yr of surface water and 250 Mm^3/yr of groundwater for supply purposes. This means that 82% of the water in the river basin is regulated. Groundwater extractions have, however, meant that another 350 Mm^3/yr of water has been made available for use in addition to the figure of 250 Mm3 mentioned above, taken from aquifer reserves. It can be explained by the fact that groundwater exploitation has a number of advantages for users, such as fewer bureaucratic regulations, on-site availability of water, direct control of exploitations, cheap cost of installation, etc.

The economic development of the area, which was stifled by the scarcity of water resources, was given a new lease of life in the 70's when water was transported to the area from the Tajo River. Transfer capacity is about 6000 Mm^3/yr, although the maximum amount of water transported up to the present has been 350 Mm^3 /yr. This measure has proved to be a vital step forward in the development of the region. It has not, however, stopped the overexploitation of aquifers, which continues at the rate of about 300 Mm^3/yr. This is causing a marked decline in water table levels in the area. Table 3 shows the water resources available at present in the region with the existing hydraulic framework. In fact there was less water available over the past few years- about 80% of mean value - because of the drought suffered, but the reduction has been beared only by lands irrigated with surface water.

TABLE 3

Water resources available at present (Mm^3/yr)

Resources		Segura Basin	Murcia	Comments
Surface Water	Local	570	385	Net (losses discounted)
	Transferred	495	340	
Groundwater	Replenishable	250	230	Cannot be maintained in the future
	Reserves	350	300	
	TOTAL	1665	1255	

Despite the problem of the availability of water resources in the area, the

agricultural economy has steadily improved since 1982, both in absolute and relative terms, in comparison with the rest of the country. Growth was spectacular in 1985 (see Figure 2) and also, in 1986 and 1987, although final figures are not yet available. Agricultural production in Murcia increased by 6.77% between 1980-1986 and farm income rose by 9.04% . Although separate figures for agricultural production and farm income are not available, figures for agricultural production is thought to be similar to - or higher than - the average figures for farm income. Similarly, the incidence of dry farming on these figures is thought to be negligible.

It would seem paradoxical that, at a time when there is a drought and the country is undergoing a process of modernization as a result of entering the European Common Market, the agricultural sector had increased its contribution to the GNP (see figures in table 2 compared with figure 2). It would appear that this resurgence in irrigated agriculture is attributable to a process of modernisation that has come about as a result of using groundwater resources for irrigation. This process will be analysed later on.

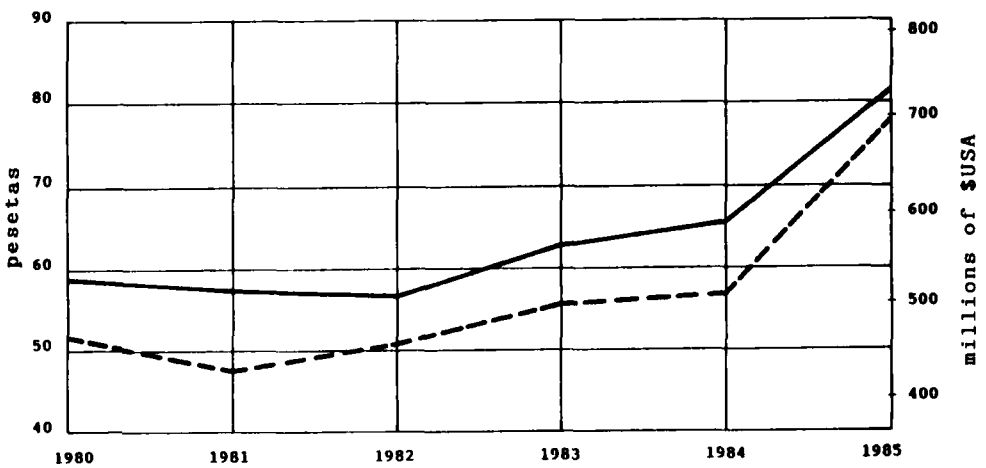

Figure 2.- Evolution of agricultural economics production (A) and agrarian income (B), Murcia region, in constant money (1985). Deflation index used: A.- prices obtained by farmers for their goods in Spain; B.- consumer price index in Murcia. Source: CAAM (1987).

3 STRUCTURE OF WATER DEMAND

At present, Murcia consumes some 1,000 Mm3/yr of water (Dirección Regional, 1987) distributed as follows:

WATER SUPPLY: 135 Mm3/year

WATER FOR IRRIGATION: 865 Mm3/year

It should be pointed out, first, that under the heading water supply, figures for water supplied for industrial purposes is included since, given the limited water resources available in the region, the majority of the large industries in the region

are supplied by water from the water supply network (more than 500 km of canals). These canals, controlled by the Mancomunidad de Canales de Taibilla, supply 70 townships, 3 military bases (2 air and one navy base) and a number of vital industries. An average of 350 litres/ inhabitant/day is supplied.

Secondly, for the same reason, waste water and irrigation return flows are extensively recuperated and used to help satisfy the water demand, that exceeds the water resources available. Obviouously, in the long run, there is the risk of increasing water salinity.

Thus, from a practical point of view, all resources are used for irrigation. An analysis of the resources used for irrigation purposes is the subject of this paper. Industrial and domestic water supply demands will not be dealt with.

The importance that irrigation has in such a dry region is as follows:

	Percentage of total area under cultivation	Contribution to the final value of agricultural production
Dry farming	75%	10%
Irrigated land	25%	90%

The surface area available for irrigation is:

Water source	Surface area in hectares		Resources available for agriculture Mm^3/yr
	At present	On completion of work in progress	
Surface water	80,000	100,000	590
Groundwater	90,000	90,000	530
TOTAL	170,000	190,000	1,120

In a recent survey (Dirección Regional de Recursos Hidráulicos, 1987), 6,160 wells were detected in the region. The estimated cost of these wells, largely paid by private owners, is 10,000 million pesetas ($ US 90 million) in drilling costs alone. No more than 600 of these produce over 20 l/s, and 75% of the investment made in the wells has been lost due to the drawdown in water table levels, water salinization, etc..

Unfortunately, there are no figures available to show, in economic terms, the contribution made by groundwater exploitations to the overall development of the region. There is no doubt, however, that the modernization of irrigation systems in the Murcia region (drip irrigation, automatic irrigation and fertiliser application, etc.) began in areas where groundwater was used for irrigation purposes. Only now, that water is being transported from other areas, similar techniques are being used for irrigation with surface water (Gutierrez, 1986).

Water prices in the Murcia region can vary greatly.

WATER SOURCE	Pts/m3	$US\$/m^3$	
Surface water			
. Local	0.2-1.0	0.002-0.009	
. Transferred	11.70	0.10	For irrigation only
Groundwater	10-50	0.09-0.45	Varies according to areas
Drinking water	40-70	0.36-0.63	Price paid by user without water and waste treatment cost

Independent of the differences in water prices, the fact that water will become an increasingly expensive and scarce commodity in the future has done more to increase efficiency in its use than any official measures.

Although, as mentioned before, no figures are available to show the difference between the productivity of land irrigated with groundwater as opposed to surface water, just how important groundwater resources are in irrigation can be deduced from the figures available for areas where only groundwater is used for irrigation purposes, such as in the coastal areas of Mazarrón, Lorca and Aguilas, and comparing them with the regional average, even though 50% of these are irrigated using groundwater. See table 4.

Table 4

Economic evaluation of agriculture in the coastal area of Mazarrón, Lorca and Aguilas (Millan, 1987b)

	UNIT	COASTAL AREA (A)	REGION (B)	100 A/B
Irrigated Land	ha	5,600	170,000	3.3
Water consumption	Mm3/yr	30	1000	3.0
Agricultural production	10^6 pts 10^6 $	9,720 87	58,807 525	17.0
Consumption of products from other sectors	10^6 pts 10^6 $	4,698 42	40,859 365	11.0
Farm income	10^6 pts 10^6 $	4,31 39	52,486 469	8.0
Salaried employment	10^6 pts 10^6 $	3,729 33	32,126 287	12.0

It is clear, then, that in this area, 75% of which is given over to the cultivation of tomatoes, productivity per cubic metre of water used is increased 3 to 6 times. Admittedly, climatic conditions are particularly favourable, but then figures for the regional average are also favoured by the use of groundwater sources for irrigation. Generally speaking, the use of groundwater sources for irrigation purposes is 3 times more profitable than the use of surface water (although land now being brought under irrigation using water transported to the area is being equally efficiently organised). In any case, it must be pointed out that, in the area under study, there is a large potential demand for water that cannot be satisfied due to the lack of water resources available. These resources exist in other parts of the country and are used far less efficiently.

Government policy would seem to be at fault here. Moreover, the installation of irrigation systems in this area , as in almost all the areas where groundwater is used for irrigation purposes, has been paid for by private investors. This has obvious advantages for the Treasury and for the rest of the country that can see other public services being improved in exchange.

Finally, since this is the area where water prices are highest - 20 to 40 pts/m^3 (0.18 to 0.36 $/m3) - the returns obtained would enable it to finance projects designed to maintain the prosperity obtained up till now and which , in view of the over-exploitation of resources in the area, cannot be guaranteed in the future.

4 MODERNIZING FACTORS

As a result of the situation described above, changes have occurred in irrigated agriculture in the region of Murcia. These changes were unexpected and may well be useful for planning and developing water resources in the area. There is no doubt that the restructuring of this sector has been a natural process. It has been slow and painless despite having been subjected to rigorous economic considerations.

Three key factors in this process will be analysed below.

4.1 DRIP IRRIGATION SYSTEMS

The prospect of being able to export agricultural products forced farmers in the Murcia region to bring larger tracts of land under irrigation. This had not been done before because of the scarcity of water, the high degree of salinity of the water available - due to the existence of evaporate rocks in the area as well as intensive water recycling and overexploitation - and the low productivity of the land.

The first land to use drip localized systems for irrigation applied groundwater resources for the purpose. The water had to be pumped from increasingly greater depths given the drop in water table levels. This system of irrigation was used in areas where the land was of poor quality but where

climatic conditions were favourable, particularly for growing crops out of season (well in advance of normal season).

The fact that adverse conditions could be overcome shows the enormous advantages that this system has for any type of land brought under irrigation and, over the past decade, it has come to be used throughout the Murcia region (see Figure 3).

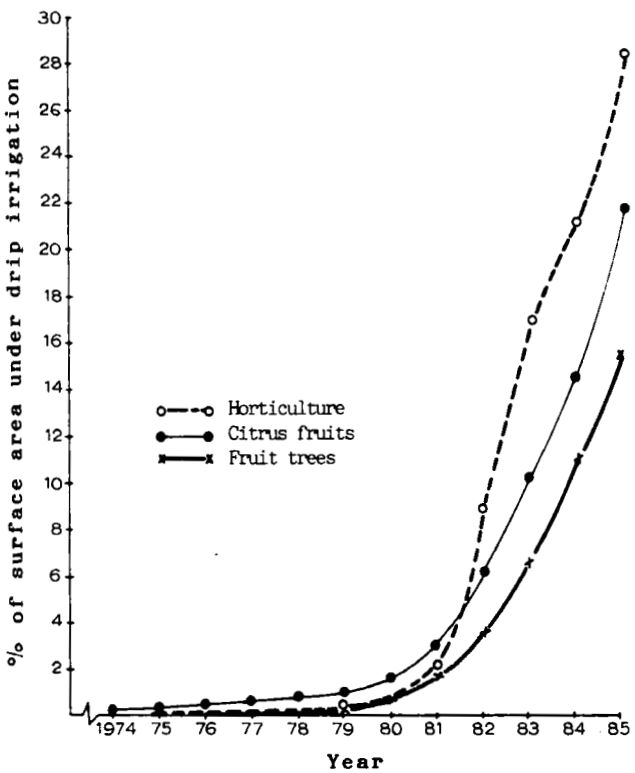

Figure 3.- Increase in drip irrigation in Murcia.

The main advantages of the system are (León, 1986):

a) Efficiency in the use of water. Despite the fact it is difficult to save water in areas like Murcia where little water is available, it is clear that drip localized systems of irrigation are efficient, i.e., they increase productivity per cubic metre of water applied to crops, and they

reduce the amount of water consumed - savings of 20-30% in horticultural products and 30-60% in the early stages of citrus and fruit tree growth can be obtained. Moreover, since excess water collected at chains from high frequency, low volume drip irrigation systems is less, salt returns is reduced and consequently water quality along the river basin is improvided when compared with low frequency, high volume traditional systems of irrigation. Programming irrigation has helped accomodate daily water requirements to the variations in climate, particularly during critical periods of plant development.

b) Use of poor quality water. The frequent application of water to crops creates conditions of semi-permanent flow that encourage a three dimensional difusion of salts, leaving the area with the greatest root density salt-free. Continued irrigation during occasional wet spells facilitates the percolation of superficial and lateral accumulations of salt to below the root zone and there is little need for leaching in the overall evaluation of irrigation needs.

c) Combined use of fertilisers with water in irrigation systems. The management of fertilisers according to the physiologic consumption of nutrients by plants and to prevent deficiencies, is in fact a cultivation under controlled feeding. Dissolved in the water used for irrigation, these fertilisers are applied very frequently in accurate small doses, depending upon the demand required at the different stages of plant development and productivity. Savings in the use of fertilisers is a decisive factor in the rapid amortization of fixed costs incurred in the installation of irrigation systems.

d) Automation. The installation of drip systems of irrigation encourages increased automation of installations as a result of the need to save water, measure and deliver water in precise amounts. It also reduces energy and labour costs and the amount of agro-chemical products used.

e) Less environmental impact. The controlled use of chemical products to protect plants from insects and disease means that smaller amounts of these

products are used in a very precise and correct manner compared with their widespread and massive use in traditional irrigated areas. What is more, since water is applied only to selected plants, the growth of weeds is controlled thereby making the use of herbicides unnecessary. The dangers inherent in the use and handling of these products by human beings are also reduced.

f) Rise in standard of living. Modern computerised farming means that the life of farmers in these areas is much more akin to that of other ordinary citizens. Drip irrigation means that farmers, for the first time in their lives have been freed of much of the backbreaking work associated with working the land. Nowadays they work the same hours, have the same holidays, are as clean and put as much physical effort into their job as any other worker in the services sector. In many areas, young people are returning to the land because farming is no longer what it used to be in their fathers' day but is looked upon as a small business of one's own. Schools giving diplomas in farming in the Murcia area are full of students at all levels.

4.2 RETURNS ON WATER

Obviously, given its scarcity, water must be considered to be an economic good and priority should, therefore, be given to obtaining the highest possible returns on the water used. Cost-effectiveness must be maximised. This can be done on two levels:

a) Optimum amount of water applied (internal cost-efectiveness) Traditionally, farmers have sought to obtain maximum crop production per hectare of land.This premise was established on the basis of two classical principles: availability of large amounts of cheap water, and a personal or individual evaluation of what constitutes a good return on investment. Once, however, the question is considered at regional level, it becomes apparent that more land can be brought under irrigation than there is water to irrigate it. Then maximum production must be defined in terms of production per cubic metre of water used. The

optimum amount of water used in each of the two instances is different, as can be seen in Figure 4. It is clearly less when evaluated in terms of per hectare in the second case than in the first. As far as local government administrations are concerned, permission should be given for supplying smaller amounts of water than those recommended in the agronomic study of holdings. The amount would be about 75% of the theoretical figure. This policy has proved to be particularly profitable in large properties in Murcia, where water was scarce. In many places where overexploitation and the amount of water available from wells has dropped, a reduction in the amount of water supplied as opposed to a reduction in the surface area under irrigation has come about naturally. A drop of 25 % in the amount of water supplied can increase the final agricultural production in the area by a similar figure.

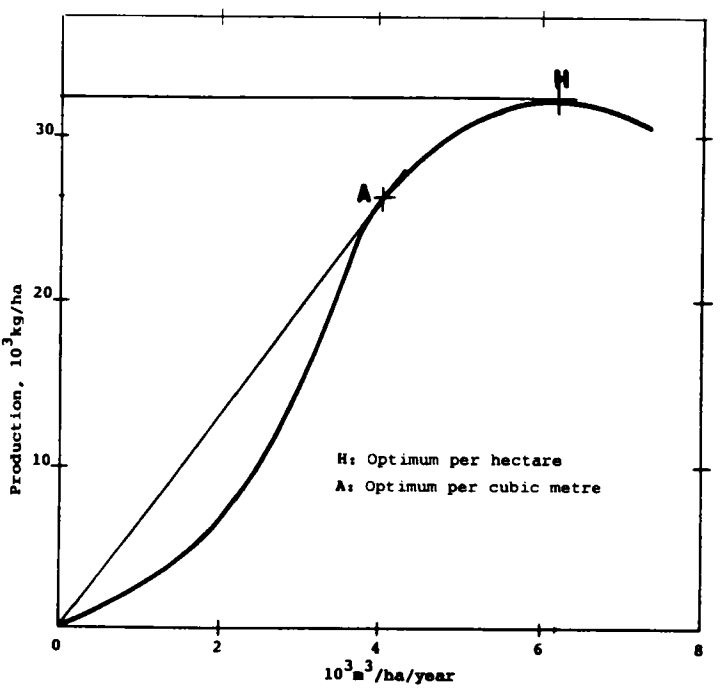

Figure 4.- Water production function in lemon trees.

b) Choice of crop (external cost-efectiveness). Decision-makers in local government administration cannot remain immune to the choice of crop to be cultivated in different areas. The final cost of the product, the input necessary to obtain it and the amount of labour, are factors that must be taken into consideration when using or developing water resources.

A recent study carried out in the Murcia Autonomous Community (Millan, 1986) analysed the cost of producing the 15 types of crops most representative of the region of Murcia. Costs were divided into 4 groups:

- Costs pertaining to the input consumptions from the agricultural sector: tilling, seeds, seedlings, etc.
- Costs pertaining to input consumption from outside the agricultural sector: installation of irrigation devices and systems, fertilisers, etc.
- Labour costs
- Cost pertaining to the income from the land

Table 5

Cost-effectiveness of water supplies in agriculture

Nº	OPTION CHOSEN	MOST PROFITABLE CROP (*)	VALUE IN RELATION TO WATER CONSUMED pts/m^3	$/m^3$	RELATION TO LEAST PROFITABLE AND TYPE OF IT
1	Final agricultural production	Tomato. Greenhouse. Drip irrigation. (Carnations)	630 (460)	5.6 (4.1)	15 Maize (11)
2	Consumption of products from other sectors	Tomato. Greenhouse. Drip irrigation.	387	3.5	39 Beans and apricots
3	Farm income	Peach. Drip irrigation (Carnations)	353 (274)	3.2 (2.4)	32 Barley and maize (24)
4	Employment	Carnations. Green-house. (Tomato, greenhouse)	232 (182)	2.1 (1.6)	747 Barley and maize (588)
5	Profit, nett surplus	Peach. Drip irrigation.	282	2.5	27 Cotton, maize and tomato

* In brackets, the next most profitable crop when this is close to the first.
NOTE: Artichokes produce negative incomes. Artichokes and cayenne pepers produce negative profits

Results are shown in Table 5 and are briefly commented upon, according to whether one or other variable is to be optimised:

- 1.- Optimized variable: Final agricultural production. This would be desirable in a policy of economic growth from an agrarian point of view.
- 2.- Optimized variable: Consumption of products from other sectors. This

considers growth as a result of farming activities (as distinct from its own contribution to the GNP). It shows the effect it has on other economic sectors.

- 3.- Optimized variable: Farm income. This measures the increase in family income for each crop. The importance of fruit trees as opposed to greenhouse products should be noted - the latter compared more favourably when other criteria were used. Negative incomes were also found (as a result of low prices, not considering real wages for work done by the family itself, etc.).

- 4.- Optimized variable: Employment. This shows the potential for creating employment should, for example, it be considered an alternative to unemployment or reversing the tendency to move to the city.

- 5.- Optimized variable: Benefits. This would be closest to a pure business consideration. Negative values appear for the same reasons as in case 3, that is to say, the benefits inherent in the sale of agricultural products, which in some cases of direct sale are more important than returns from productivity.

The following general conclusions may be established:

1 Green-house products are more profitable than any other produce.

2 Fruit production , especially peaches, is a vital factor in the increases in farm income and returns.

3 This kind of study is vital if local government administrations are to develop and use water resources correctly (e.g. grants and subsidies, employment policies, reconversion of crops).

The combination of both factors studied (amount of water supplied and selection of crops) would make enough water available to obtain maximum productivity of the crop that would give the highest returns. Thus, arid and semi-arid countries would optimise their water resources to a maximum.

4.3 REUSE OF WASTE WATER

Although water used for supply purposes is only 10% of the total amount of water used in the region, given the limited amounts of water available , this

water must be treated for the following reasons;

a) to prevent water quality from being impaired once it returns to other bodies of water into which it flows.

b) to improve the environment and in particular the water available in the Murcia region.

c) to recover this water for subsequent reuse for irrigation purposes.

Two programmes have been drawn up for treating water in the area. The "Plan de Saneamiento y Recuperación del Río Segura" (for treating water from the Segura River) and the "Plan de Saneamiento Integral del Mar Menor" (for treating water in the Mar Menor). Both aim to:

1) Construct main sewers to collect all urban waste water, thus eliminating uncontrolled disposal of wastewater.

2) Transport this waste water away from those areas that are to be protected (Segura River , Mar Menor, coastal areas), generally by pumping. This is because the above-mentioned areas are normally the lowest lying areas.

3) Treat this waste water in stabilisation ponds - cheaper and more hygenic than conventional methods of treatment

4) Control oulet points and transport water to reservoirs for use in irrigation.

5) Reuse, mixed with water from other sources (usually groundwater sources) to water fruit trees, usually citrus fruits.

Given the long hours of strong sun-light in the area, wastewater treatment in stabilisation ponds has proved to be the best method of ensuring the elimination of choliforms in treated water without having to resort to chlorination.

Moreover, all nutrients present in the water (nitrogen, phosphorous, etc.) are also retained, thereby saving on the use of fertilisers. The appearance of green algae (therefore photosynthetic) is the final proof of the efficiency of this method of treatment.

The cost of treatment is approximately 1.5 pts/m3 (0.013$/m3), although pumping the water away from the area to be protected increase the figure to 5 pts/m3 (0.045 $/$m^3$). This increase is, however, largely compensated by the fact

that once water is situated at a high level it is not necessary to pump it to users.

As a general rule, the sites chosen for the stabilization ponds are close to land irrigated using water from overexploited aquifers. Permission is obtained from local government administration for the cession of an amount of water equivalent to that taken from the wells (for the removal of machinery or cession of ownership to the administration).

A series of problems have arisen in some city councils. While some feel that farmers should pay part of the cost of treating water in the area since they benefit directly from its reuse, central and regional governments believe that those who pollute the water should be the ones to pay and therefore demand that consumers of drinking water supplies should pay the cost. At present, agreement has been reached between both parties but there is no guarantee that problems will not arise in the future.

At present , three stabilisation ponds exist for the recycling of water, two will soon be commissioned, three are under construction and five are in the planning stage. Treated water instead of groundwater will be used for irrigation purposes in an effort to reduce overexploitation of groundwater resources which are being used at a rate of 300 Mm^3/yr.

5 CONCLUSIONS

The experience in Murcia, where agricultural demand is preeminent, shows:

1) High water prices encourage more efficient use of water resources. The amount of water used decreases and more profitable cash crops are grown. Water becomes an economic good.

2) The allocation of resources should not be made in the light of the economic analysis of individual plots of land. More general considerations should be born in mind by local Government Administration.

3) In arid or semiarid areas, maximum productivity per cubic metre of water used, not per hectare of land, should be sought after. Therefore, any system of irrigation other than localized systems cannot be considered.

4) The Administration should, at the same time as it determines the real cost of water, encourage the use of water in cash crops that are the most profitable

5) Certain intangible variables should be considered: improvement of the environment, quality of life, increased employment etc., if cost efficiency in the use of water resources is to be correctly evaluated when comparing different projects.

Although no detailed figures are available as yet, it is believed that the combination of the factors described above have increased the availability of water in the Murcia region by some 60%.

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