COST AND PRICE OF WATER FOR IRRIGATION IN SPAIN

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ABSTRACT

A map showing the geographical distribution of irrigated land in Spain is given. Distinctions are made between areas using groundwater and those using surface water for irrigation purposes. Information is given on the total cost of exploiting groundwater for irrigation. This can vary from between 35,000 to 90,000 pts/ha (320 to 820 U.S. $/ha) - 4% interest rate, 1985 prices - depending upon hydrological conditions and the size of the works. Details are also given of the different tariffs paid by users of surface water for irrigation in the different river basins. Criteria established and used up to 1986 in determining these tariffs, particularly those related to the amortitzation of capital investment, show that, as a general rule, it is in fact the government that pays the total cost of amortization. The cost of water for irrigation purposes in the Duero Basin is calculated using different economic criteria. Costs worked out with different economic criteria give an an average of 16,000 pts/hectare (145 U.S. $/ha), more than three times the tariff paid in the year under study (1985). Finally, changes made in criteria used to calculate water tariffs introduced in the new Spanish Water Law are discussed.

INTRODUCTION

Mendizabal , a well-known Liberal politician of the last century, is reputed to have said "Spain will never be rich while her rivers run into the sea" (ORTI,A.1984). This surprising statement highlights the fact that as much land as possible should be put under irrigation to overcome the effects our largely arid or semi-arid climate has on agricultural production.

At present, three million hectares of land are under irrigation. Although this only represents 16% of the total surface area under cultivation, it accounts for half the total agricultural production. In macroeconomic terms, agricultural production in irrigated areas accounts for 1.8% of the GNP although its relative importance is much greater given its primary or basic nature and the fact that foreign trade figures for agricultural goods are balanced-(MAPA,1984).

This situation comes as the result of managing water resources, a large part

of which "continues to run into the sea". Further increases in the acreage put under irrigation are expected in the Ebro and Guadalquivir basins and the inland mesetas. Funds to carrying out these projects are currently shared and supported by autonomous governments, though it is the Spanish government that decides whether or not to include them in the national plans (Plan Hidrológico Nacional or Plan de Cuenca). Before doing this, a study should be carried out into the economic aspects of supplying water for irrigation purposes as part of a production process in different parts of the country. The cost of water should be calculated and its dependence on factors such as the area's natural hydrology, water sources, scale of works, previous degree of resource development, systems of irrigation used etc., be analysed.

The following article proposes to give a general idea of the cost of supplying water to different agricultural areas in Spain. More emphasis has been placed on the use of surface water for irrigation purposes for the following reasons:

a) It is quite common to find that regional hydrogeological studies carried out by government bodies include details of the real or estimated cost of groundwater use. This kind of information is also the subject of papers presented in symposiums , seminars and courses on hydrogeology. Besides, the cost of groundwater can easily be determined given a number of physical variables that are almost always already known and a few commercial catalogues.

b) Surface water is used to irrigate approximately 75% of the total surface area in Spain. However, a study of the cost of using surface water for irrigation purposes has not been carried out as has been done in the case of groundwater.

c) It is commonly believed that farmers using water from rivers pay only a small percentage of the cost of the water due thanks to the grants and credit facilities made available by the government. As far as we know, no attempt has yet been made to determine to what extent this is true. We therefore propose to do so ourselves.

SURFACE AREA UNDER IRRIGATION.

Table 1 - Distribution of land under irrigation according to river basins.

River Basin	Area under Irrigation in 10^3 ha	Area irrigated using groundwater in 10^3 ha
Norte	70	---
Duero	396	120
Tajo	214	45
Guadiana	270	120
Guadalquivir	485	30
Sur	152	75
Segura	244	105
Júcar	350	180
Ebro	685	20
Pirineo Oriental	65	35
I. Baleares	25	25
I. Canarias	44	35
TOTAL	3000	780

Figure 1.- Main irrigated areas in Spain.

According to statistics in the Anuario de Estadística Agraria, 3,003,800 hectares of land were under irrigation in 1984. See table 1. These were distributed by autonomous communities (in thousands of hectares) as follows (see figure 1 for the situation):

Community	ha	Community	ha
Galicia	52,6	Castilla-León	409,6
Asturias	0,4	Madrid	31,4
Cantabria	0,4	Castilla-La Mancha	308,6
País Vasco	1,6	Valencia	351,9
Navarra	66,5	Murcia	164,3
La Rioja	48,2	Extremadura	214,7
Aragón	377,1	Andalucía	646,7
Cataluña	260,1	Canarias	44,8
Baleares	24,9		

Figure 2 shows the increase in irrigation surface over the years. Just over a million hectares were under irrigation at the beginning of the century, in the traditional zones, areas in Zaragoza, Castellón, Murcia , Valencia , Granada and Almería (many of which are as old as the arabic settlement in Spain) and others supplied by the Castilla, Esla and Imperial de Aragón canals, and a host of other smaller works located at different points along the main river courses. Over the next past 40 years, the total surface area under irrigation increased by three hundred thousand hectares. Much of this land came under irrigation under the Gasset Plan, 1902, and its later updates.

For decades before 1930, the governments encouraged private development of irrigated areas by giving grants and special credits. During the Republic , before the Civil War broke out in Spain, Joaquin Costa's ideas for economic revival took shape at the same time as it became clear that irrigation schemes could not be carried out by private initiative. In 1933 the Plan Nacional de Obras Hidráulicas was drawn up. Its objective was to bring 1,206,670 hectares of

land under irrigation and to improve irrigation in 271,665 hectares of land already irrigated.

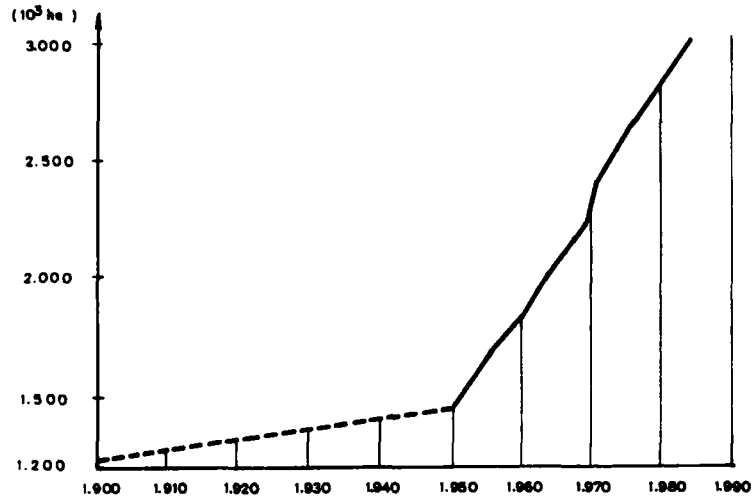

Figure 2.- Increase in the total surface area under irrigation.

Because of the precarious economic situation in Spain at the time, the 1933 Plan could not be carried out until the 50's.The overriding need to increase food production and to make electricity supplies available for industrial development made the construction of large dams and canals a priority in the government's economic policies. The Ministry of Agriculture and the Ministry of Public Works (MOPU) were responsible for carrying out the work established in the National Plan before handing over the land to local farmers and homesteaders. Land came under irrigation at a rate of about 30,000 ha/yr in the 60's and the first half of the 70's. During the transition period in Spain, with the advent of democracy , the rate dropped but picked up again later.

The total area under irrigation, then, doubled between 1950 and 1985. The government was responsible for bringing 955,000 hectares under irrigation, approximately two thirds of the increase. Private owners were responsible for the rest by tapping groundwater resources.

Private owners, however, were not the only people responsible for the development of groundwater resources. Ministry of Agriculture programmes for the development of groundwater resources , in conjunction with the IRYDA (Institute for Agricultural Reform and Development) were responsible for irrigating 100,000 of the original figure of 955,000 hectares.

Official figures for the distribution of irrigation systems in hydrgraphic basins and the use of groundwater sources are incomplete and largely inaccurate. Table 1 shows the information obtained by the author from AVANCE 80 of the different Planes Hidrológicos de Cuencas, a series of studies published by IGME (Geological and Mining Institute of Spain), the Geology Department of the MOPU (Public Works and Land Planning Ministry), and a number of autonomous communities (1984 figures)

COST OF GROUNDWATER FOR IRRIGATION PURPOSES

Detailed analyses of the factors affecting the cost of groundwater used for irrigation purposes have been the subject of numerous articles and papers presented by specialists (ANDOLZ, 1972; FERNANDEZ; 1977; TARJUELO, 1986).

Hydrogeological conditions at well sites - the depth of the aquifer, aquifer yield and its randomness, and depth to water level - jointly with the size of works or importance of demand are all factors that determine the cost of exploiting groundwater resources. This factors can vary greatly so that the extent to which they affect costs can also vary greatly.

Using 1985 prices, variations in the cost of groundwater for irrigation purposes in three general types of aquifer in Spain were determined (SANCHEZ, 1986). Most groundwater resources come within these categories, which include most of the existing exploitations. See table 2.

Costs include the amortization of capital investment (including 1-2 km of high tension electric wires), the cost of pumping water a height h up to the top of the well, and the conservation and maintenance costs. An interest rate of i= 0.16 was applied in the study - the prevailing rate of interest for mortgage loans at the time. Calculations were repeated using an interest rate of

i= 0.04. This rate of interest is considered to be adequate, at least in public works programmes for zero rate inflation situations.

Table 2 Cost of groundwater for irrigation purposes.

Formations	Well discharge l/s	Elevation m	Interest rate %	Water cost pts/m^2	Water cost $/$m^2$
Coastal plains and large alluvial formations	50-100	25-50	0.16	3.6-7.6	0.033-0.069
			0.04	2.5-5.0	0.023-0.045
			0.16	6.9- 16	0.063-0.145
Inland limestones	25-50	50-100			
			0.04	4.5- 10	0.041-0.090
Granular sedimentary formations in the mesetas	10-50	75-150	0.16	10 - 30	0.090-0.272
			0.04	7 - 17	0.064-0.155

Given the acreage irrigated by the three types of aquifer, and the systems of irrigation used, the cost of water per hectare in coastal plains and neighbouring limestone formations is between 50,000 pts and 35,000 pts / year (455 and 320 US $/year), in 1985 depending upon the interest rate applied. In the La Mancha Plain, this rose to 70,000-120,000 pts/ hectare (635-1090 $/ha) for the high interest rate, or 45,000 - 90,000 pts/ha (410-820 $/ha) for the lower rate. South of the Duero Basin, where the aquifer is overexploited, water costs 150,000 and 90,000 pts/ha (1360 and 820 $/ha) respectively, depending upon whether the high or low rate of interest is applied.

The cost of water in the two mesetas is high, particularly in view of the crops produced - cheap seasonal crops such as beet, maize, alfalfa, etc. Indeed, cost-efficiency criteria would not seem to be used by farmers when deciding on whether land should be irrigated or not. There are two important reasons for

this:

a) The Ministry of Agriculture encourages farmers to convert unirrigated land to irrigated land by giving non-returnable subsidies and long-term loans at very low interest rates. The size of these grants and the interest paid has varied with the agricultural policies in force at any one time and with prevailing economic conditions. Generally, however, it may be said that they have led to a reduction in the cost of amortizing capital investment of between a third and a half. Official figures show that 625,654 hectares of land were put under irrigation as a result of private initiative with the aid of IRYDA (BOSQUE, 1986), i.e. virtually all the irrigation systems using groundwater resources installed by private individuals.

b) As far as many small farmers on the mesetas are concerned irrigating their land means the consolidation of the family source of income, the equivalent to creating one or two stable jobs and this they are prepared to pay for.

COST OF SURFACE WATER FOR IRRIGATION PURPOSES.

For the purposes of water resource management, areas that use surface water for irrigation fall into three categories:

1- Areas irrigated by government-built projects that regulate and channel water to these areas (dams, canals, pumping stations, etc). These installations are also maintained and operated by Water Agencies (Confederaciones Hidrográficas) These agencies collect money every year from each area in the form of a tax or tariff in return for water supplied for irrigation. About 1 million hectares of land are subject to this tariff.

2- Areas where irrigation systems have not been built nor are maintained by the government but which benefit from the presence of dams along the rivers that have been built and paid for by the government. Since water has been made more readily available in these areas, a tax or water canon (canon de regulación) is levied. This is paid annually and the amount paid

varies according to the cost of building and maintaining the dam. In 1978, a total of about 700,000 hectares (ALVAREZ et al., 1981) was subject to this canon.

3- Other areas, half a million hectares, are not subject to either of these two taxes since they cannot be included in either of the two categories.

Before the present Spanish Water Law came into effect, tariffs were levied on each area under irrigation. The total amount to be paid was made up of by differenciating the involved three terms:

a) a contribution towards the amortization of capital investment made by the government in infrastructures for irrigation purposes. According to legislation regulating the payment of tariffs the users' contribution to the cost of a project was calculated according to the terms laid down in the decree authorising the construction of the works by the government. In general, this meant that users amortized half the capital employed, at historical not current prices, at an interest rate of 1.5% per annum over a period of 25 years.

b) Direct costs- these include the cost of personnel working on the site, spare parts, fuel, electricity for pumping, minor repairs, etc..

c) Overheads - these include general and administrative expenses incurred by Water Agencies in areas under irrigation. These are calculated on the basis of the Agency's annual expenditure and an established system of allocations.

The water regulation canon is made up of the same three terms, and is calculated in a similar fashion. When an area under irrigation pays a tariff and benefits from the presence of reservoirs built by the government which are not those specifically for the purpose of providing water for irrigation to that area, a second sum is levied over and above the specific tariff. (table 3).

The total surface area under irrigation in each basin is divided into irrigation zones. Details of all investments made in these zones and the date on which investments were made are available. Terms b) and c) are calculated on the basis

of the water Agency's accounts for the previous year.

Except for the Jucar Basin, the tariffs levied are not related to the amount of water farmers actually use. Table 3 gives details of the tariffs imposed in 1985 by the different Water Agencies.

TABLE 3 Average tariffs for surface water irrigation (1985)

River basin	No of areas with its own tariff	Hectares irrigated at the tariff	Max. tariff pts/ha	Min. tariff pts/ha	Weigthed mean pts/ha
NORTE	3	7.000	6.089	657	3.339
DUERO	51	168.851	13.094	1.393	4.883
TAJO	13	95.658	15.795	703	7.208
GUADIANA (1)	10	128.217	18.451	602	5.561
GUADALQUIVIR	22	169.754	18.692	738	5.836
SUR	12	22.564	27.890	183	7.981
SEGURA (1) (2)	7	62.318	6.373	240	869
JUCAR (1)	14	111.850	20.122	600	3.958
EBRO					
PIRINEO ORIENTAL	8	16.580	7.340	626	1.753

(1) Includes also areas subject only to water canon.

(2) A.T.S. (Tajo Segura Aqueduct) tariffs not included.

To convert pts to US $ divide by 110.

CONTRIBUTION TOWARDS THE AMORTIZATION OF PUBLIC WORKS

When calculating the user's contribution to the cost of public works it has already been stipulated that, as a general rule, users should amortize 50% of the capital employed,I. The amount due per annum is then calculated using the following formula:

$$A = \frac{0{,}5\ I\ .\ 0{,}015\ .\ (1{,}015)^{25}}{(1{,}015^{25} - 1)}$$

The government thus subsidizes 50% of the capital costs which, while this may be justified in the case of large reservoirs because of the benefits they afford (flood protection, increased agricultural production, dilution of waste, etc.) it is not so justifiable in the case of main canals, secondary canals, service roads, large-scale repairs, etc.

As far as the 1.5% annual interest rate is concerned, this rate was fixed by the July 1911 Law and represents a big concession in monetary terms. According to the same Law, users must satisfy payment between one and five years after the completion of the works. For various reasons it has been impossible to implement this clause. There are still many users amortizing dams built in the forties, fifties and even earlier.

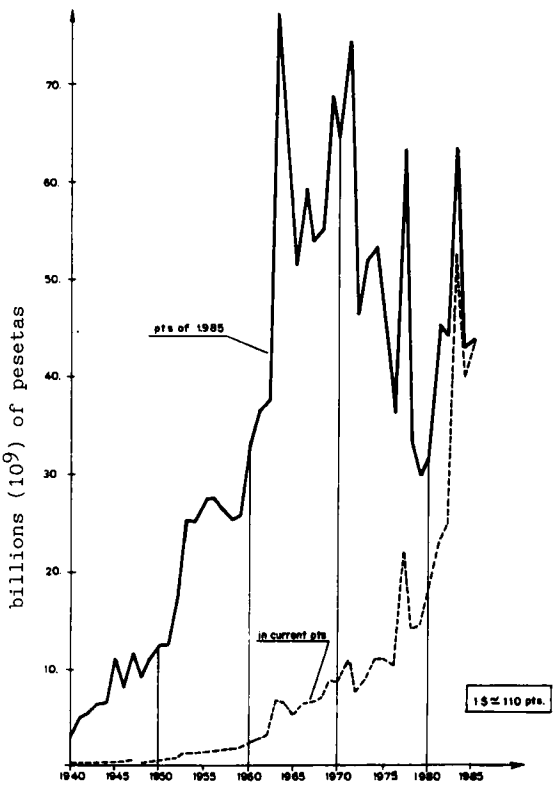

Figure 3.- Annual investments made by the M.O.P.U. in irrigation and water resources works.

If, moreover , we consider that I is the total cost of the works constructed, at historical not present prices, the users'contribution in real terms is

small.

Figure 3 gives an idea of the importance of inflation. Annual investments made by the Dirección General de Obras Hidráulicas in irrigation schemes and infrastructure for water resource management (essentially large dams) are shown. These do not include specific allocations in the annual budget for flood prevention, river embankment works, water supply and waste water treatment works.

Figures show the huge investment made in the 50's which continued throughout the 60's before dropping off again.

An attempt has been made in this study to compare the amortization term of irrigation tariffs and what might be considered to be their real cost. The following criteria were used:

1- The total capital cost is amortised - an extreme which does not contemplate the existence of reasons of general interest that would justify subsidising a project. However , it should be remembered that where a reservoir is used for producing electricity, the licensee pays an annuity which reduces the amount users have to pay. If it is the Water Agency itself that exploits the electricity, the value of the electricity supplied is deducted from the tariff. This practice has been continued under the new legislation. If on the other hand, the reservoir is used to provide water for industry and urban developments these users must pay the normal water canon. In short, with the exception of floodprevention, the multiple uses to which reservoirs are put are considered and those who benefit most directly from their presence must pay the total cost of the project.

2- The cost of living index, published by the Instituto Nacional de Estadística (National Statistics Institute) is used to revise the cost of different works once the date of completion is known and before calculating the tariff.

3- A 4% interest rate is used. This is usually considered to be adequate for public investment programmes when inflation is supposedly zero.

4- The period for amortization is increased from 25 to 50 years. By substi-

tuting the period of time given to finance credits by the period of time consonant with the working life of this kind of project, the amount of money paid in one year effectively represents the real cost of amortizing the project, not the cost of repaying a loan.

Calculations have been made for the 51 irrigation tariffs levied in the Duero Basin. They have been divided into 10 large groups depending on which river they are supplied by. Table 4 shows the revisions made in each of the 51 tariffs aggregated by groups according to rivers. Aggregation was made by weighting each tariff with its corresponding irrigated area.

The amount of money paid per year by the users must be multiplied by a factor of 10 to obtain the fixed cost of amortization in the Porma and Riaza rivers and 37 for the Carrion River. The mean average for the whole basin is 15.6.

On the bottom line of Table 4 the sum total of the average revised tariffs are shown. Annual figures for direct and overhead costs as given by Water Agencies have been accepted. Using these criteria, the annual cost of irrigation, which is fairly uniform, is about 16.000 pts/ha (145 US $/ha). This is a lot less than the cost of groundwater not only in this basin but in groundwater works in general.

Table 4. Tariffs applied in the Duero Basin (1985). Figures, in $/ha, weighted means of the specific tariffs applicable in each of the irrigated zones for the river in question.

	DUERO	CARRION	PISUERGA	ARLANZON	RIAZA	PORMA	ORBIGO	TUERTO	TORMES	AGUEDA	TOTAL OR MEAN
Hectares irrigated	16.498	28.884	45.854	1.378	4.553	18.752	34.663	326	16.952	99	168.851
Amortization of works	5.97	2.50	4.48	1.11	10.27	16.08	6.97	4.50	12.13	2.79	6.9
Direct costs	29.25	27.27	42.80	43.65	46.41	21.67	17.83	60.87	24.67	73.40	29.85
Overheads	7.33	6.29	7.11	7.06	8.95	6.50	6.60	6.41	13.45	13.45	7.54
Total tariff	42.56	36.06	54.40	51.83	65.64	44.25	31.50	71.84	50.26	89.64	44.39
Revised amortization	95.40	93.25	75.60	73.79	108.27	166.39	121.40	73.88	143.91	64.63	109.06
Revised tariff	128.36	126.81	125.52	124.50	163.64	194.56	145.92	141.26	182.04	151.49	145.10

IRRIGATION TARIFFS UNDER THE NEW WATER LAW.

The example of the Duero Basin shows the difference between the tariffs charged to the farmers and the real cost of surface water for irrigation purposes. This idea can still be stressed by the following considerations:

a) the recalculated amortization costs are to be paid over a period of 50 years, instead of the 25 actually applied.

b) Intercalary interests, i.e. those that are generated during the period of project under construction, and up to the year in which users begin to pay, have not been considered. In major projects both these periods of time are long, as can be seen from the fact that data on investments include data on dams begun over forty years ago.

c) When ever the tariff is applied, the amortization of the constructed works is extended to the total number of hectares within the irrigation zone and not to those that are actually irrigated. There are many reasons why the completion of a project may be delayed or impeded (availibility of funds, difficulty in restructuring the land, urban development). Since only those areas that are under irrigation pay tariffs, tariffs cannot be collected for those areas that can not be irrigated. The ratio of hectares theoretically serviced by canals and those actually irrigated in the Duero basin is 1.30.

d) The amount of money collected from tariffs has always been lower than those legally expected. Operating costs included in the tariff are calculated in terms of the expenses incurred the previous year. The differential deficit of inflation is then carried forward. Thus, not even the total amount collected has been sufficient to satisfy operating costs in the irrigated areas. Water Agencies were authorised to retain the money paid by users towards the amortization cost of projects, which should theoretically be received by the Treasury. Even so, the Exchequer has to transfer every year money to Water Agencies in order to balance their revenues and expenditures.

There would seem to be sufficient evidence to show that, in objective

economic terms, it is the government that in fact affords the cost of irrigation projects at least as far as the Ministry of Public Works and Land Planning investments are concerned. Irrigation tariffs do not take into consideration investments made by the Ministry of Agriculture.

The situation has been modified and rationalised under the new Water Law, which introduces criteria already implemented in its by-law (Reglamento del Dominio Público Hidráulico).

These criteria affect all the most important points: canons and tariffs should cover the totality of the government's investment, the period of amortization is increased to 50 years, the capital to be amortized is revalued each year, the interest rate applied is 4% , operating costs are established on the basis of the estimated costs for the year. These conditions apply to new projects. Works undertaken before the new law came into force will have amortization annuities revalued using the appropriate formula.

The effectiveness of these new measures will be seen over the next few years. A fore-runner, Law 52/ 1980 , regulates the economic régime for the exploitation of the Tajo Segura Aqueduct. This is a huge project for the transfer of water resources from one basin to another at a rate of 30 m3/s. Water is distributed in the provinces of Murcia, Alicante, and Almeria (Postrasvase). Capital investment made by the Ministry of Public Works and Land Planning up to 1985 has been , at current prices, 44,723 and 26,998 million pesetas (407 and 246 million U.S. $) respectively for the two stages of the project. (Trasvase and Postrasvase.)

The water tariffs to be levied for the first stage of the project (Trasvase) are highly complex since a large number of items must be included in their calculation, differentiations made between the maximum capacity of the transfer works, the maximum volume transferable at different stages of operation, and the amounts of water actually transferred. The most important aspects are:

- fixed operating costs per annum (personnel, conservation, overheads) are divided by the theoretical demand in areas under irrigation and the unit price is obtained in terms of pts/m3.

- capital costs are calculated in terms of 60% of the capital invested - revalued every two years- multiplied by 0.04. This figure is then divided by the maximum volume transferable to obtain the unit value.
- an estimated unit price is established for variable operating costs (power, purchase of water).
- annual deficits in operating costs are carried forward and added to the total amount of capital invested by the government.
- the unit value of the first two addends are calculated the based on the annual volume stipulated in the contract, not the amount consumed. Variable costs are based on the latter.

The result is similar to a service provided by a public company that covers its operating costs and collects a levy for the recovery of government investment. At present, the base of the levy is about 35 % of the total capital invested, meaning that water for irrigation is subsidized. Part of this subsidy is covered through the tariff charged on the water supplied to municipalities, since in this case a coefficient of 0,08 is used instead of 0.04, plus and added amount of 2 pts/m^3.

The tariffs applied during the two year period 1985-6 were:

	Irrigation $/m^3	Supply $/m^3
a) project cost recovery	0.013	0.044
b) fixed operating costs	0.012	0.012
c) variable operating costs	0.062	0.062

Where a farmer was allotted 6,000 m3/ha and had been in fact been supplied with this amount of water in 1986, he would have paid 57,300 pts/ha (521 $/ha) an amount less than the real cost but a lot higher than other official irrigation tariffs in force.

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