



Irrigation Advisory Services and Participatory Extension in Irrigation Management

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FAO – ICID

AN ADVISORY SERVICE FOR
IRRIGATION IN THE PLAINS OF LA
MANCHA, SPAIN

by

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AN ADVISORY SERVICE FOR IRRIGATION IN THE PLAINS OF LA MANCHA, SPAIN

The Advisory Service for Irrigation in
Albacete

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Background

Water in Spain and East La-Mancha

According to the Spanish Ministry of the Environment white paper on water, agriculture in this country uses 83% of all the water used by man, 9% being used for the supply of towns and 8% for industrial usage. (figure 1.)

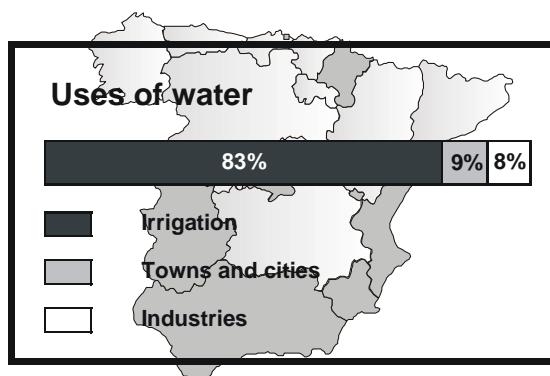


Figure 1. Use of water in Spain.
(From: White paper on water, M of E)

These figures alone would be enough to justify the creation of an advisory Service for Irrigation policy (Servicio de Asesoramiento de Riegos, referred to as SAR from now on), it is also true that the rising demand of the other priority uses will demand greater efficiency and more technological advances from the agricultural sector. We shouldn't forget that when talking about the availability of domestic water for mankind, we are dealing with one of the public commodities par excellence, to use the expression by Sunkel et al. (1985), with "heritage or social asset". But we think that it is necessary to carry on analysing more figures to be able to better justify the suitability of our SAR, which carries out most of its work in the East of La-Mancha.

In fact, if we analyse the proportions of the origin of irrigation water in our country and in our area, we will find that in the Peninsula 68% of irrigation water comes from rivers or springs (surface water) whereas only 28% comes from subterranean water, in the East of La-Mancha, figures are inverted since 92% of the water destined to meet the needs of the crops comes from the subterranean water of the aquifer, and only 6% from surface run-offs of rivers and streams (fig. 2).

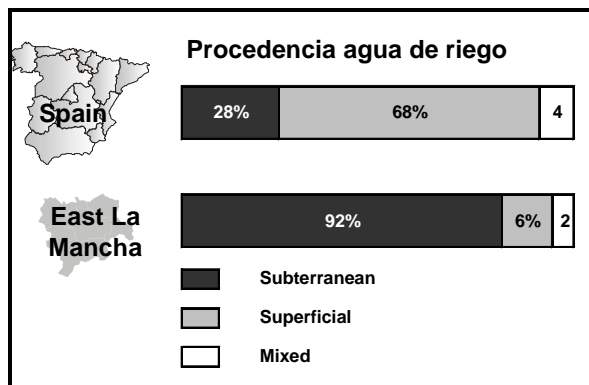


Figure 2. Comparison of the origin of irrigation water in Spain and in the East of La-Mancha. (From: White paper on water. MMA e inventario de regadíos de la JCRMO)

Regarding the sustainability of water in The Unit.

It is well known that in many areas, the sources of surface water have been exploited beyond the natural reload capacity of aquifers. The overexploitation of aquifers has obliged many villages to resort to lower quality water, making access to this more expensive and difficult (Sumpsi et al.;1998) without forgetting that the falling of the level of the water table can reduce the flow available for the users of surface water (FAO,1993). According to Llamas (1996), it seems clear that nowadays the systems of water exploitation are less vulnerable when we can use both, subterranean and surface resources. In the East of La Mancha water for irrigation and the supplying of villages is still nearly exclusively subterranean, although the implementation of the new state Water Plans provide for the substitution of some of this pumping by regulated surface water, which will allow a more rational and sustainable exploitation of the system.

Secker et al. (1998) analysed the total irrigation demand for the year 2025, and one of the conclusions of this study is that approximately half of the projected increases in demand from 1990 to 2025 could be due to the increase in the efficiency of irrigation via the conservation of the resource. Fereres (2001), points out that knowing that improvements in the biological efficiency of the use of water for crops are not possible in a short period of time, and given the increase in the demand for water around the world by other users with higher priority than irrigated agriculture, it seems that the conservation of this, by means of efficient management, should be the new and most important source of supply for irrigation agriculture now and in the future.

In Spain, as Valdeyeros (1998) explains, we find the paradox that being a country with a long tradition on water policy, on institutions for the management of water and on technology for the regulation, transport, distribution and application of water in its different usages; studies on the economy of water have hardly been developed. It is really striking that the Spanish Administration has spent thousands of millions of pesetas in studies and projects about the construction of possible dams and other water infrastructures to increase the regulation and offer of water, while it has spent practically no money in studies about the efficiency of water use and management. Sharing this comment and being aware of the problem, the Provincial Technical Institute of Agriculture in Albacete (Instituto Técnico Agronómico Provincial de Albacete **ITAP**) created the SAR 15 years ago, in 1988.

Duties and activities of SAR

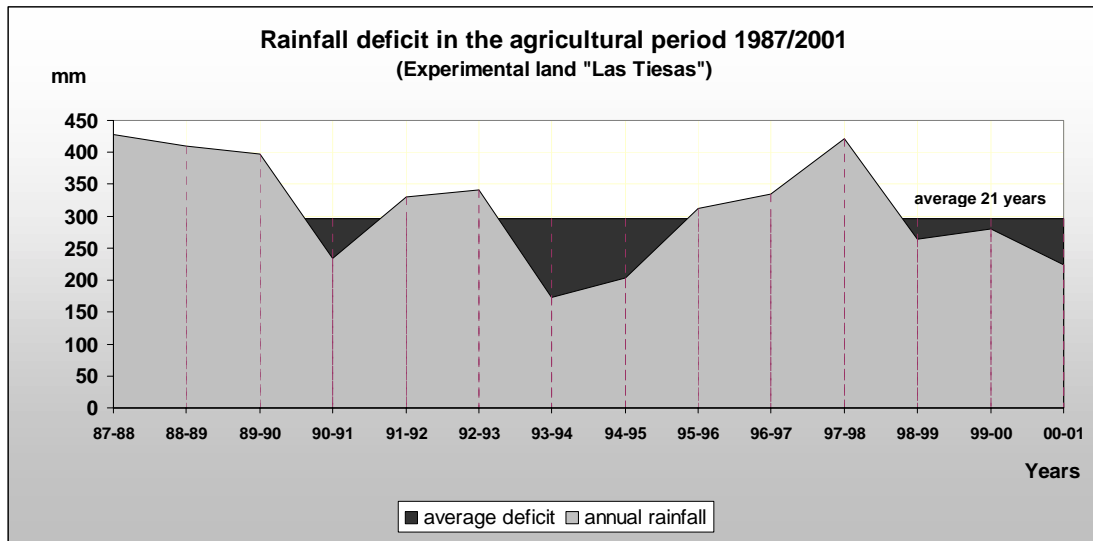
The duties of SAR in Albacete, to develop its activity as an integral part in the study of the sustainable use of water resources and, as a consequence, as support to the systematic saving of water, are the following:

- The follow-up and control of the water supply and demand in our Hydro geological Unit.
- The maintenance of the meteorological network of the Service.
- The experimental technical support station. (ITAP)
- The calculation of water needs for the different crops and the distribution of the information.
- The supply of data to the different users and the follow-up in the farmers' fields.
- The evaluation of the application of water to the ground.
- Technical support for the User Community Exploitation Plans.

It is worth going a bit deeper into each of these points.

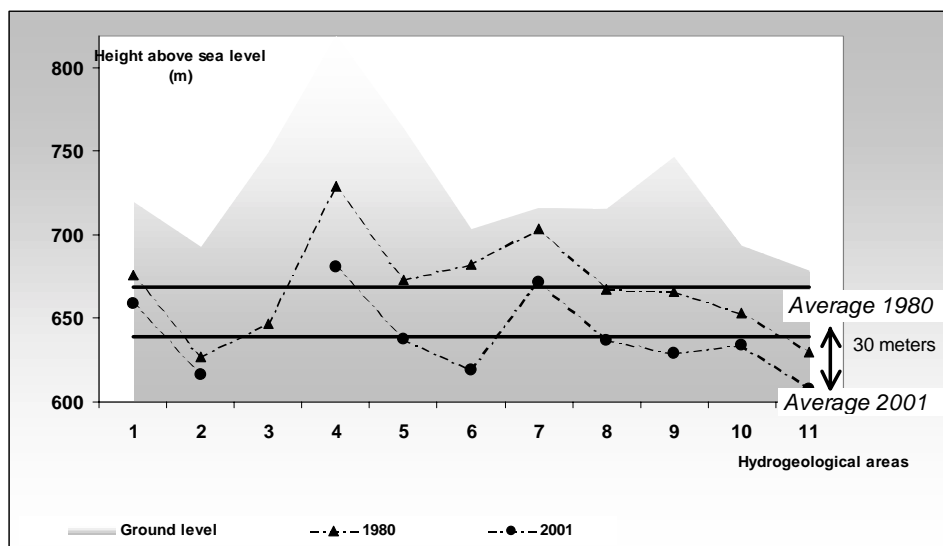
The follow-up and control of the water supply and demand in our Hydrogeological Unit.

The study of the average rainfall in each of the eleven Hydrogeological Zones into which our unit is divided, allows the calculation of useful rain and the estimation of the aquifer reloading in each one (Graph 1). We also have information about the flows of surface irrigation channels given by the stream gauges installed in them. This set of the two measurements will give us the measurement of the renewable resources at a given time.



Graphic 1. Representation of the annual rainfall and of the average rainfall deficit in the period from 1987 to 2001. SAR.

The systematic and periodic measurement of the piezometrics levels of our Hydrogeological Unit is carried out with the main objective of compiling the information needed for the creation of a model that will allow us to estimate the exploitable flow from the balance and sustainability of the resource. (Graph 2).



Graph 2. Representation of the piezometrics measurements. SAR.

The demand in the Hydrogeological Unit is estimated quite precisely, since we know the distribution of the crops during every campaign in the unit and the volume of water applied to every crop, checked by the SAR in its daily activity. To do this we have the declaration of crops and the uses of the different operators, which is checked thoroughly using tele-detection techniques, with the double objective of estimating the volume of water extracted in the unit and checking the follow-up of the agreed exploitation plans.

The maintenance of the meteorological network of the Service.

A good advisory service on the use of water for irrigation is based on the network of agrometeorologic stations available, the reliability of the data provided and also the level of attention and maintenance needed for continuous and systematic function. In our case the network is made up of two types of stations:

- A base station, where we measure all the parameters needed for the calculation of the evapotranspiration by different formulae, such as relative humidity, wind speed and air temperature at different heights; wind direction, radiation (global, reflected short wave, net short wave, incident long wave, reflected long wave, net long and diffuse wave), temperatures, thermal flow and humidity of the ground at different depths; atmospheric pressure, evaporation of the type A bulb/keg and precipitation.
- A network of support stations in all those points where diverse information is needed, where only the most common parameters are measured, such as ambient temperature, relative humidity, wind speed and direction and precipitation.

The experimental technical support station. The Provincial Institute of Technical Agriculture (ITAP)

ITAP is a public company created by the Albacete Local Authority 6th October 1986 as a model of more efficient management of its Agricultural Services. Its field of activity is the food and agriculture sector in the province of Albacete.

Together with other community objectives, ITAP was asked to act as an institute of technological transference for the development of new farming methods that were fast developing in the province and in particular new systems of irrigation (López Fuster, 2000).

In collaboration with a good number of Spanish and foreign educational institutions, and also with public research centres dedicated to activities related to water such as CEDEX from the Ministry of Public Works, and above all with the coordination and joint work with EUPA (Polytechnic University of Albacete) and ETSIA (School of Agricultural Engineers of Albacete) over the course of time. The ITAP created its own Technology to calculate the water needs of crops designed basically by professor Arturo de Juan and experimented and perfected by the technicians at ITAP at the Experimental Station of Las Tiesas (López Fuster, 2000). The culmination of this collaboration was the creation of SAR in Albacete to which this document now refers.

Since 1988 ITAP has followed a working guideline for the topics which can be summarized as follows:

- The knowledge of water needs for the main crops in the province, previously unknown.
- The measurement and follow-up of the piezometrics levels in our Hydrogeological Unit 08-29 with the objective of getting to know its behaviour and being able to identify the zones where extractions should be controlled to keep the balance and sustainability of the resource.
- The follow-up and chemical analyses of subterranean water, with the aim of studying its quality and detecting possible sources of contamination of the Hydrogeological Unit.
- The lysimetric studies that allow us to adjust more precisely the estimation of maximum evapotranspiration (E_{tm}) of crops, in our lysimetric station in Barrax.
- The systematic tests for the study of controlled deficit irrigations (RDC) in different crops and with the same aim.
- We also work on the development of functions of production versus water given to the crops, to predict the harvest depending on the water volumes used.
- The individual follow-up of a vast part of the irrigated surface of the province, with the objective of defining its characteristics perfectly with regard to the implanted crops, the average surface area of the fields, the irrigation habits, the study of water distribution equipment, etc.

The calculation of water needs for the different crops and the format of the information.

To calculate the water needs for crops we use micrometeorological methods where the reference evapotranspiration used is that calculated by the Penman-Monteith formula and the lysimetric method.

In the experimental field called Las Tiesas (Barrax) three lysimeters have been installed, one of them sowed with grass (*Festuca Arudinacea*) and kept under ideal growth conditions with the aim of getting the reference evapotranspiration values (E_{to}). Next to this lysimetre there is an agro climatic station that has the appropriate sensors to get the data needed for the estimation of evapotranspiration by traditional methods pointed out before and thereby comparing them to the results obtained by weighing.

In another one of the lysimeter we carry out a rotation of the crops whose E_{tm} we want to calculate. Thus, we get the evapotranspiration values for each crop studied and so the curves of crop coefficient (K_c) by comparison to the E_{to} calculated in the reference lysimeter.

The third lysimeter is a monolithic of 1,70 depth and it is dedicated to the study of grapevine irrigation.

Technicians from the SAR get data daily from the agro climatic stations, data that once ratified are the base for the calculation of E_{to} by different empiric formulas to obtain the comparisons and deviations among them. To calculate the irrigation programming we also use the Penman-

Monteith formula, since it adjusts better to our area, after comparing with the data obtained from the reference lysimeter in the experimental station of Las Tiesas and checking the minimum differences between the evapotranspired water in the lysimeter the calculation is done using the above mentioned formula.

Although the data of the quantities evapotranspired for each crop are calculated daily, the irrigation programming is done weekly since with the irrigation infrastructure we have in the area it would be impossible to follow a daily programming, because of restrictions imposed by the average rainfall, the field infiltration, the capacity of the pumps, and the planning of crops for each farming structure or Water Management Unit (WMU). As we can see in the following Graph, the basic information on the water needed for the crops is provided weekly (figure 3), this being useful for the user to program the irrigation for the following period through the advice provided based on the historical data of all the campaigns studied for that crop in that week. The difference between the quantity programmed and the real quantity of the known week is adjusted in the following programmed period.

DIPUTACION DE ALBACETE		INSTITUTO TÉCNICO AGRONÓMICO PROVINCIAL S.A.				
ITAP		AVERAGE IRRIGATION NEEDS FOR CROPS (mm)				
Irrigation Advisory Service						
Week 4 th to 10 th April 2002	WHEAT	BARLEY	GARLIC	ONION	PEA	POPPY
4 th April	2,4	2,4	2,3	1,7	1,4	1,0
5 th April	2,2	2,2	2,1	1,6	1,3	0,9
6 th April	1,4	1,4	1,3	0,9	0,7	0,6
7 th April	2,7	2,7	2,5	1,8	1,4	1,1
8 th April	2,8	2,8	2,6	1,8	1,5	1,1
9 th April	1,4	1,4	1,3	0,9	0,7	0,5
10 th April	2,1	2,1	1,9	1,3	1,0	0,8
WEEK	14,9	14,9	13,9	10,0	8,0	6,0
SEASON	26	26	25	19	15	11
Prediction for the following week						
	17	17	15	10	10	7
STATE OF AVERAGE CROP DEVELOPMENT						11 th April 02
Wheat	Tillering		Onion	2 leaves		
Barley	Tillering		Pea	2 leaves		
Purple garlic	Vegetative development		Poppy	2 leaves		
For further information 967190090				Start of season 28 th March 2002.		

Figure 3. Example for written press of the advice by SAR.

The evaluation of the application of water to the ground.

Although the main duty of SAR is to give information to farmers about the irrigation needs of their crops based on technical criteria, from there complementary activities arise that have become of much importance for the knowledge of some of the factors that affect irrigation, such as the evaluation of irrigation systems.

Irrigation equipment is, in general, high tech, and here it is worth remembering the figures of the Spanish Ministry of Environment White paper on water and of the inventory of irrigation equipment and fields by the Junta Central de Regantes de La-Mancha Oriental (JCRMO).

In Spain, 59% of the irrigation area is irrigated by gravity, 24% by sprinklers and 17% located, these figures contrast with those in east La-Mancha, where sprinkling irrigation is 83% and there is a high level of technology: pivots and buried and automatic fixed total covers. (figure 4)

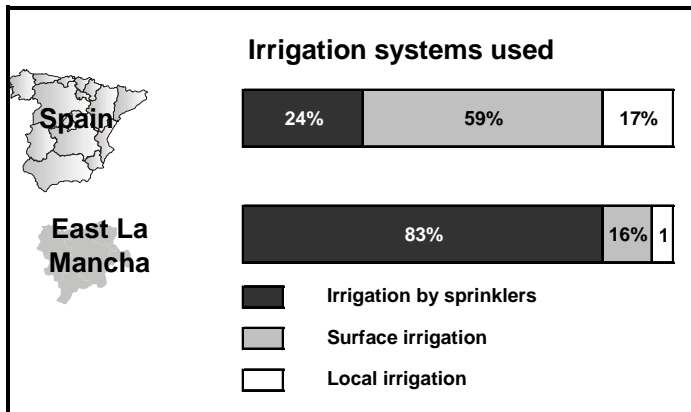


Figure 4. Comparison of the irrigation systems used in Spain and in East La-Mancha. (From: White paper on water by the Ministry of Environment and the inventory of irrigation equipment and fields by the JCRMO).

Private WMU are usually large operations, perfectly organized where there is at least one drilling from which water is extracted, and as a general rule, it is kept and regulated in a reservoir and later it is driven to the irrigation equipment. A rotation of summer and winter crops takes place, where it is relatively easy to programme irrigation.

Small fields are usually grouped in some kind of association for collective irrigation making one single WMU. Irrigation usually takes place in turns or on demand according to the number of fields associated.

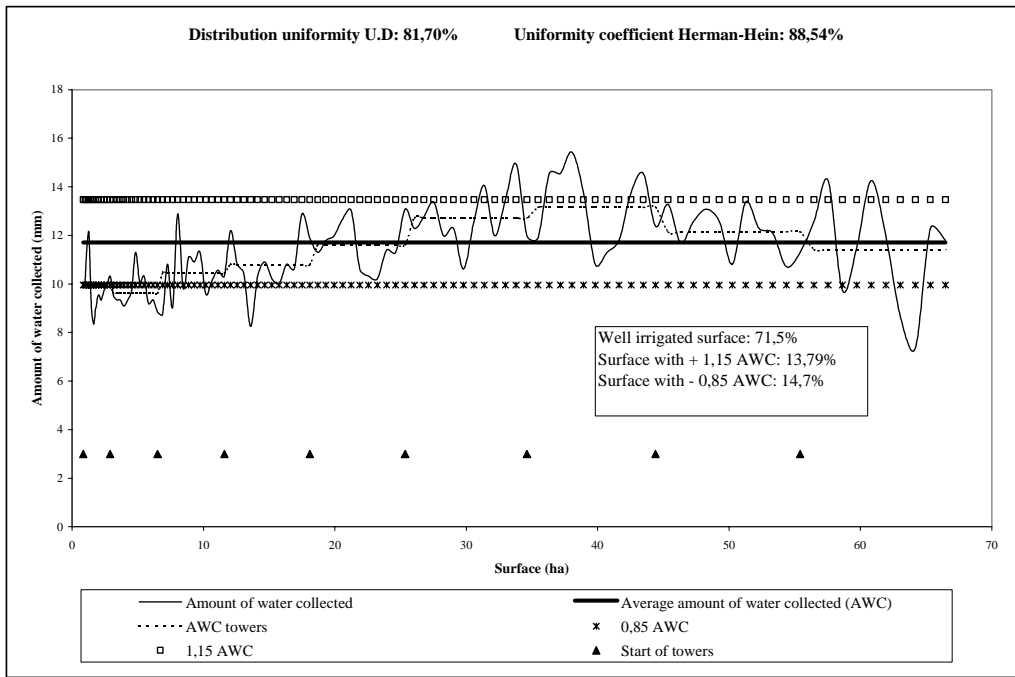
The evaluation of irrigation systems is carried out on the user's demand, following the methodology applied for central pivots and buried total covers in the international regulation:

- ISO-11545 (1994)
- ANSI/ASAE STANDARDS S 436 (1995)
- ASAE STANDARD S330.1 (1987) : "Procedure for sprinkler distribution testing for research purposes".
- ASAE STANDARD S398.1 (1985) : "Procedure for sprinkler testing and performance reporting".
- ISO 7749/1 (1986). Norme internationale. Matériel d'irrigation. Asperseurs rotatifs. Partie 1: Exigences de conception et de fonctionnement.
- ISO 7749/2 (1990). Norme internationale. Matériel d'irrigation. Asperseurs rotatifs. Partie 2: Uniformité de la distribution et méthodes d'essai.
- UNE. 68_072_86. Rotating sprinklers. General requirements and experimental methods.

It is also advisable to take into account the methodology described by Merina et al. (1978, 1980).

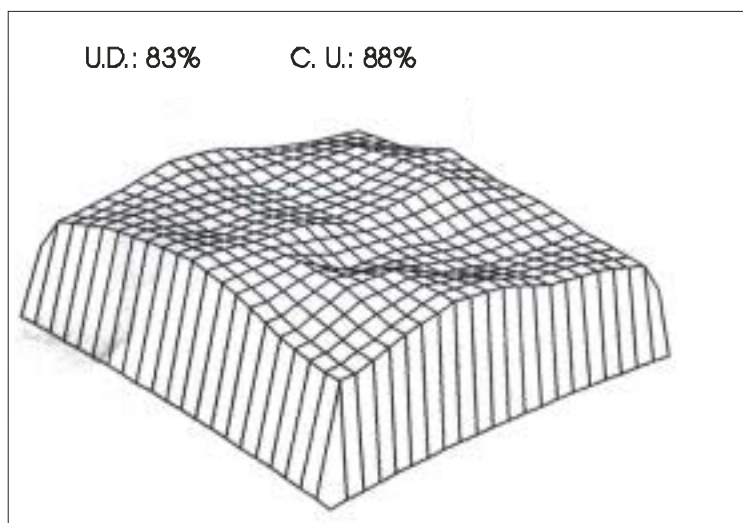
The objective of the evaluation of irrigation equipments is to keep farmers informed about the functioning of the equipment and the detection of possible failures. They are also informed about real endowments, uniformity in water distribution, well irrigated surfaces, efficiency in application, etc., that is, to give the farmer a detailed report about the functioning of his irrigation systems. It is also very important for the SAR, since it helps to know better the characteristics of the functioning of different equipment of application of irrigation water and the adaptation of these to our working area as well as the knowledge of the water that is really applied to the advised fields.

In Graph 3 we find the results of the evaluation of a central pivot of 9 towers that irrigates 69 hectares and that has been evaluated as turning at a speed of 100%, with 103 pluviometers placed in a sphere of equipment and at a distance of 4m. between them. The results tell us that the machine works with 81,7% of uniformity of distribution, and 88,54% coefficient of uniformity (Heermann and Hein). 71,5% of the area is well irrigated, its pluviometers being between 15% superior and inferior to the average height.



Graph 3. Distribution of water in an evaluated pivot. SAR.

Graphic 4 represents the result of the evaluation of a buried total cover, with a frame of 15x15m. which has been evaluated with 49 pluviometers evenly distributed over the surface taken in four sprinklers that irrigate with an average work pressure of 3kg. Cm². The result is shown in the three-dimensional Graph where it is indicated that the distribution uniformity is 83% and the Christiansen distribution coefficient is 88%. The average rainfall is 8.7 mm h-1.



Graph 4. Water three-dimensional distribution in an evaluated cover. SAR..

The distribution of data to the users. The follow- up in the farmer's field.

To reach this goal, the generic distribution of information regarding water needed for the crops in the area, SAR uses a series of informative media which with time have been added to, nowadays SAR makes use of local press and TV, answer phone, fax, visits to private sites, irrigation communities, and above all, INTERNET, although we sometimes also make use of bulletins and lectures or conferences to interested national and international groups.

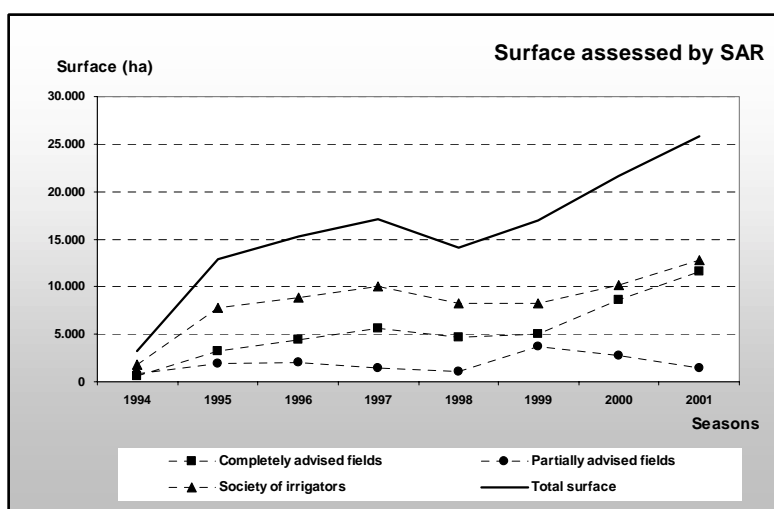
However the greatest effort is made in the follow-up of each of the private fields connected to the Service, each technician from SAR is in charge of a certain number of sites that are visited weekly. In that visit the technician writes down the growth states of the crops and farmers are given the weekly irrigation programming that they should carry out (partial advice); but there are also fields with a complete follow-up programme, those that apart from having been advised, all data is also obtained: irrigation habits, real water provided, evaluation of the irrigation equipment, effective rainfall, obtained production and efficiency, etc.

In the last campaign (2001) we reached 574 fields with complete follow-up, a surface area of 11541 hectares, 62 fields partially advised, which is a surface area of 1494 hectares, and 14 irrigation communities (12827 hectares); this means that almost 26000 hectares were advised, without taking into account the surface area which was advised via fax or answer phone calls due to the difficulty involved in gathering these statistics. (chart 1)

Season 2001	Nº	ha
Completely advised fields	574	11.541
Partially advised fields	62	1.494
Society of irrigators	14	12.827
Total	636	25.862

Chart 1. Quantification of the fields follow-up. SAR..

If we compare the evolution of the areas advised in the last eight years (Graph 5) we see the appreciation that the Service is getting. We can see a rising tendency in complete advice, as well as in irrigation communities which results in an increase of 10% of the total surface area compares to last season. However the surface of partial advice fields decreased last season because they changed to complete advice; these figures show the farmers' trust on our Service.



Graphic 5. Evolution of the surface advised by SAR in the last eight years. SAR.

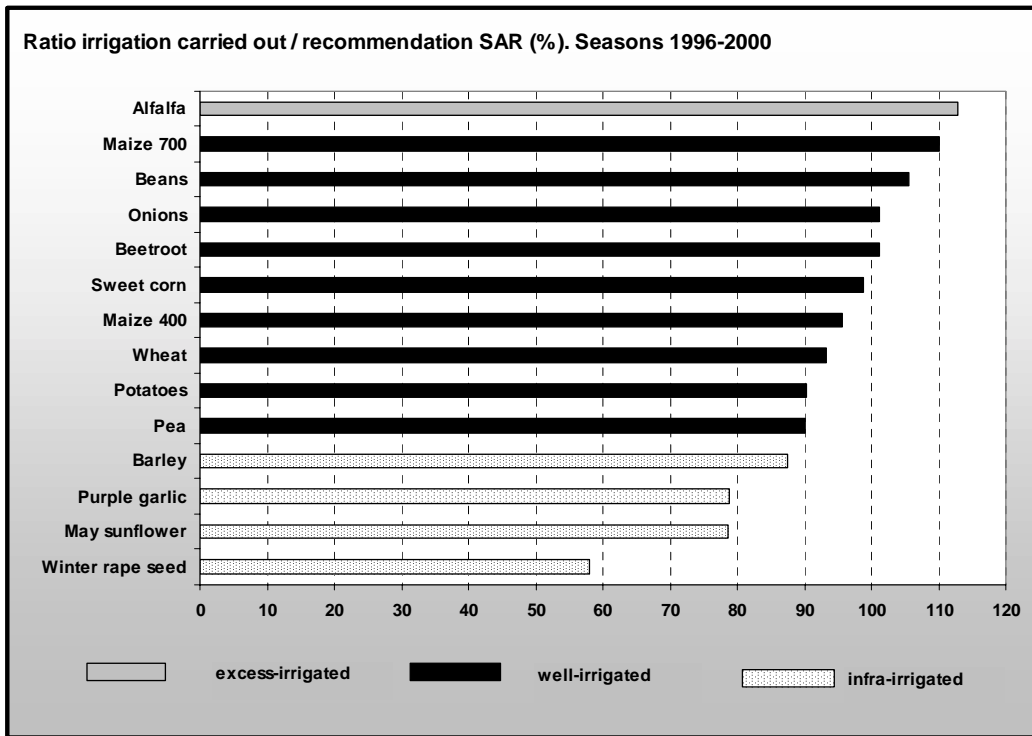
Regarding advised crops, herbaceous crops are the most important in the province of Albacete, so they are the ones we have studied, researched and experimented most (chart 2). Nowadays these are the ones that can be advised with more certainty since we know perfectly their water needs. Moreover this kind of advice is easier since there are not any big differences between the different uses of the fields, as far as the doses and sowing times are concerned, varieties and the farming techniques are practically the same.

HERBACIOUS		
CROPS:		
ALFALFA		
BARLEY	MELON	
BETROOT	OATS	
BRÓCCOLI	ONION	RAPE SEED
CHINESE GARLIC	PEA	SPINACH
GRASS	PEPPER	SUNFLOWER
GREEN BEAN	POPPY	SWEET CORN
KENAF	POTATO	VETCH OAT
MAÍZE FORAGE	PUMPKIN	WHEAT
MAIZE GRAIN	PURPLE GARLIC	WHITE GARLIC
WOODY		
CROPS:		
GRAPEVINE	OLIVE TREE	ALMOND TREE

Chart 2. Herbivorous crops advised by SAR.

In recent years the woody crops service has spread due to the current demand of two crops that are being restructured in the area: vine and olive, both with quality requirements that clearly affect irrigation techniques and the water quantities to stabilize production and get higher levels of quality. The advice on irrigation in this case is not for maximum production, as we can guess from what has been said before. Thus, for these crops in particular, but also for any woody crop, each follow-up field is different, with different planting frameworks, varieties, fruit loads, age, production, etc. and that is why in this case advice is always individual.

The true knowledge of amounts of water in many fields throughout the time SAR has been working, has allowed us to achieve a high level of follow-up through the comparison between the amount of water used to irrigate and the advice given by SAR for the different crops. In Graph 6 we find the average of this chart for the period 1996-2000. In grey we find the over-irrigated crops, that is, those that received more water than necessary (higher than 110%). In black we find well-irrigated crops, as the Graph shows these are the majority. And finally, in white we find under-irrigated crops.



Graphic 6. Level of efficiency (relation of the given irrigation to that advised by SAR) in the advised crops. Average in the period 1996-2000.

This data is very interesting for the feedback of the advice system, since from them we can draw very important conclusions such as these:

- The most emblematic crops in our province are being irrigated under SAR's advice which indicates an acceptable level of efficiency.
- Crops such as Alfalfa and Beetroot, where water is an extremely limiting factor in the area, are usually over-irrigated because the farmer prefers not to risk it.
- Other crops like the oleaginous ones (Sunflower and oil seed rape) that have never obtained great levels of production in the area, and despite the fact that they are subsidized by the aids of PAC, and from which the farmer does not expect big harvests, the tendency is for the investment to be minimum and they under-irrigate. We also find in this group some spring crops where the saving of water does not mean an important decrease in harvest.

The cost to the users of SAR is minimal because all the planning advice and general interest information is free, and only those services that have particular objectives, such as the evaluation of equipment, the flow measures, etc. are charged for.

Support for the utilization of Plans by the Community of Users.

In the spring and summer of 1994 due to a continuous draught that ended up frightening users (chart 1), the creation of JCRMO was made possible. This associated all the farmers using irrigation, allowing them to unite efforts to defend their concession interests and also to reach an agreement on the restriction of the use of non-renewable resources that affect the historical reserves of the system. This association groups together 100.000 hectares of irrigation, mainly with central pivot systems and buried total covers installed. (figure 4).

In 1995, JCRMO designed its first Plan of Exploitation, where for the first time in Spain an association of irrigators implemented a self-imposed restriction on the use of subterranean water, without there being a declaration of over-exploitation (López Fuster, 2000). These plans establish a maximum quantity of water per hectare per year and so every Water Management Unit is assigned a water volume that must not be surpassed. Every owner must comply with the Plan, planning his crops according to their water consumption previously fixed in the technical report that the Irrigation Management Service (SAR) of ITAP given annually to the JCRMO.

All the data that supports the Exploitation Plan every year come from the ones obtained objectively by SAR. We refer to:

- The allowances per irrigation unit that must be adhered to by the farmers in every crop that appears in his annual statement, from which it the theoretical total quantity of water that could be used in that season.
- The entry of water to the system by means of rain infiltration and run-offs and the demands for water through the calculation of the planted area of every crop in the whole work area and the average volumes used in its irrigation.
- The piezometric evolution in the different areas into which the Unit is divided.

All this information is summarized in an annual report that is the base for the design of the action plan for the subsequent year, so that we can keep the system running.

Some thoughts about 15 years of work at SAR.

The success of SAR in Albacete after 15 years of work, during which time it has been considered one of the most emblematic of this type of service in Spain, can be partly due to the geography, there is uniformity of soil, climate, landscape (la Mancha is flat) and structure which all go together to make our work a little easier. The data which we gather in our experimental field can be transferred to the fields without major errors.

However, despite this uniformity, the start of an idea such as this one is never easy in a sector reluctant to change where farmers had spent their money in transformations, most of them from private initiative and with the idea that the larger the amount of water given to the crops, the higher the production, not only following a lineal performance but also exponential in order to make maximum profit from the use of recourses and to pay back their usually high investments in the shortest time possible.

These 15 years have not only been useful to find out more and more accurately the water needs of the main crops of the area, this information being very important for farmers, but also to gather data about the total consumption of the surface irrigated with the water available in our aquifers.

As an example we are going to mention last season's data (2001), some of which is important enough as to be highlighted, such as that the total consumption for the year was calculated as 423 hm³, 50% (200hm³) of which were consumed by only two crops: corn and alfalfa. Together with this we would also like to mention that 25% of the surface area is dedicated to crops that are not subsidized by Community Agricultural Policy (PAC), usually horticultural crops, that use 25% of the water, these being all round more profitable crops especially from the social point of view.

Data speaks for itself, but how long do we have to wait until all these figures are used to carry out Agricultural Policies designed to look for solutions before new problems are created? There are enough tools and data to correct these situations. Our plea to Public Administration Organisations, who have the power to carry this out, from the European Union to our Autonomous Region and the State Government is that the necessary Policies be adopted to correct the excessive consumption of water brought about by the subsidies given for the crops which consume the most water.

We think that by making these reflections we are closing a chapter in SAR which started 15 years ago, and appearing to be a necessary and useful Service for farmers. We are now in a different phase of development where we think that saving and good management of water is not only the responsibility of the irrigator but that it is the whole of society which is involved in this problem, from the smallest of farmers to the big Administration organisations who must make the decisions regarding the sustainability of a fundamental resource for life in the future.

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