Irrigation Advisory Services and Participatory Extension in Irrigation Management

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IRRIGATION ADVISORY SERVICES FOR EFFECTIVE WATER USE: A REVIEW OF EXPERIENCES

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Irrigation Advisory Services for Effective Water Use

A Review of Experiences

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1 Introduction

The great challenge for the coming decades will be to increase food production with less water, particularly in countries with limited water and land resources. The effective and sustainable use of water for agriculture has become a global priority of vital importance, requiring urgent and immediate solutions in view of intensifying competition.

The problem is not new and much research and investments have been made to develop more refined techniques and practices to apply water accurately to the crop according their requirements. There still exists a large gap between the availability of technologies for effective water use and the adoption of these technologies. One of the reasons is that relatively little attention is paid to establish an effective support system to assist farmers in the adoption and properly operation of new techniques and technologies. As a result the impact of the investments in many irrigation projects is considerable lower in terms of production, water savings and sustainability both economically and environmentally.

Irrigation advisory services can play an importantly role in assisting users to adopt new techniques and technologies for more efficient water use and increased production. Such services can be provided by private, public or co-operative agencies. Increasingly commercial agencies can take over the traditional role of the public agencies, although often restricted to the more lucrative parts of irrigation sector. Critical in the promotion of irrigation advisory services is the financial sustainability of such institutes, as in particular in many developing countries inadequate funding is available to finance public services.

Already in the seventies the potential importance of irrigation advisory services in achieving more effective water management has been realized and special services and campaigns have been launched mostly with public money to promote more rational water use. Results have been rather mixed. Despite the importance attributed to the introduction to more effective irrigation management and the large amount of techniques available and research and resources devoted to it, the adoption and impact of the technologies have been well below expectations. One of the reasons is that little attention is paid to the process of introduction and adaptation of the method into the farmers' field. Many of the techniques are insufficiently known or if introduced inadequately handled or used.

The importance of advisory services to advise users on the type, the design, operation and maintenance of irrigation techniques is insufficiently recognized by policymakers. The potential is quite considerable but requires a consistent and sustained funding, for which often no resources are made available

2 Classification of Irrigation Services

To review the different irrigation advisory services a classification can be made according to the different objectives and type of advice as well as according the target groups and service provider. Furthermore a distinction can be made between the different tools and communication means used to

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reach the water users.

2.1 Irrigation Technology advisory services

2.1.1 Crop Water management and Scheduling Services

Advise farmers on **when** and **how** to irrigate. Different devices and tools are promoted to provide farmers with guidelines and instructions on how to determine the correct time and application depth of the irrigation. This is the type of advisory service most widely introduced in many developed countries.

Normally farmers will use their own experience and indicators (wilting characteristics, soil dryness) to determine when to irrigate. This has proved not very accurate and a "scientific" advice to farmers on when to irrigate can lead to considerable water savings and to a more rational planning of water distribution.

Devices such as tensiometers, gypsum blocks and infra-red thermometers have been introduced to assist farmers to determine when to irrigate. Despite many efforts their use has been limited to some of the larger commercial estates. Taking regular readings and the cumbersome installation and maintenance requirements have proved a major bottleneck. In horticultural production systems the use of automatic sensors linked to micro-irrigation systems seems promising as they can be fully automated. The use of remote sensed infra-red radiation has further potential to estimate soil-moisture and stress conditions in the field and has found some experimental applications in the larger scale irrigation schemes.

A practical device successfully used in a number of countries is the evaporation pan, which can be a useful predictor of crop evapotranspiration provided appropriate calibration has been carried out to link meaningful pan evaporation to crop evapotranspiration.

More commonly applied these days is the water budget method. The large amount of studies and research on crop water requirements has lead to more accurate ETcrop estimation from weather data and has made the ETo based water balance method the most convenient and reliable way to predict when to irrigate. Simulation of the soil moisture conditions by estimates on incoming (rain and irrigation) and outgoing water fluxes (Evapotranspiration, run-off, deep percolation) through water balance calculations allows to estimate when and how much to irrigate. Information on the weather either real-time or average values, combined with basic information on crop development and soil conditions are sufficient to estimate when and how to estimate.

Many universities and research institutes have been involved in the development of several computer models and offering services in the use and introduction of the models for advisory services to farmers. Private consultants are often using such computer models in their package of crop advisory services. Below a number of such examples are provided. The models are used increasingly by private farmers in particular in developed countries, where farmers have the means to pay and absorb the technology. In developing countries these has proved less suitable as for individual small-holders no separate water balance calculations can be carried out. In such case the simple calendar method can used, using computer programmes such as CROPWAT (See para 4.6).

2.1.2 Irrigation Performance analysis Services

A relatively new concept in service provision, but increasingly important is the irrigation system analysis, mostly carried out by a specialized field survey team that measures in the field a number of key indicators to assess the efficiency and performance of the irrigation system and provides detailed recommendations to the farmers how to improve his irrigation

practices and the equipment used. In the first place a tool to improve farmers practices, it may involve an upgrade or modernization of the irrigation equipment and infra-structure used on the farm. The advise may concern an individual farmer, but can include also a group of farmers or water users associations or irrigation agency.

Field irrigation performance

The performance analysis typically relates to an analysis of the irrigation method. The uniformity efficiency is measured in the field. For sprinkler and micro irrigation through a grid of water cans, uniformity of pressure, and discharge rates, etc; for surface systems an evaluation of water infiltration depth and leveling conditions. Extension services and private consultants have established **Mobile Irrigation Laboratories**, which are increasingly used in developed countries.

Farm Irrigation Performance

In addition to a performance analysis of the field irrigation system, performance evaluations can be carried out on farm irrigation systems, related to the water distribution and pipe conveyance system.

Scheme Irrigation Performance

A specific application is found increasing application is the performance analysis of the irrigation system. Here an assessment of the effectiveness and efficiency of the water delivery services is evaluated at the hand of a number of key indicators, as recommended by IPTRID/IWMI.

- System indicators (Annual water supply, Main system water delivery efficiency, Security of entitlement supply)
- Financial indicators (Cost recovery ratio, Total MOM cost per unit area (US$/ha), Revenue collection performance, Staffing numbers per unit area (persons/ha))
- Production efficiency (annual agricultural production (tonnes), total value in US$, Output per unit irrigated area (US$/ha))
- Environmental control (Water quality: Salinity and biological, watertable depth, saltbalance)

The scheme performance analysis are often carried out by independent consultants in the framework of an overall irrigation rehabilitation and irrigation reform programme.
The performance analysis services will become increasingly important as they are effective in increasing effective water use.

2.1.3 Advisory services on design and installation of irrigation equipment

Advice on the investment and installation of irrigation equipment is of direct interest to the provider and a range of services are available from the private sector to provide information and advise on design, installation as well use and maintenance of the irrigation equipment. Two basic services may be distinguished irrigation equipment providers and irrigation system designers.

Irrigation Equipment Provider

The irrigation equipment provider typically include:

- Micro irrigation systems
- Sprinkler irrigation system
- Farm machinery (land leveling, furrowers, landplanes)
- Pumps
- Scheduling (tensiometers) and water measurement devices.

Most providers offer assistance also in the design and installation of the equipment.

Consultancy Services

For the development, rehabilitation and modernization of irrigation, the private sector offers a range of consultancy services, advising mostly on the design and installation, in some cases also on the management aspects of irrigation systems. Such consultancy services, which may have a team of experts and survey teams, are often commissioned by the Government, development agencies or large commercial firms. For many farmers in developing countries such consultancy firms would be well beyond their financial means.

2.1.4 Environment and water quality advisory services

Concern on the environmental degradation linked to irrigated agriculture has put up increasingly strict regulations and legislation. To advise farmers on environmental hazards and to have them to comply with the regulations, advisory services are set up.

The advise can concern general information and sensitization campaigns against the use of chemicals in irrigated agriculture as well as regular monitoring surveys to assess conditions of key indicators in the field related to :

- Chemical and biological water composition
- Ground water depth and water quality
- Waterlogging and salinity conditions
- Health hazards related to water borne deseases

2.1.5 Irrigation management support services

Many governments have adopted policies to transfer the management of irrigation systems to the beneficiaries and farmers, as government agencies have proved unable to maintain in a sustainable manner the irrigation system. A process of management transfer (IMT) has been initiated in many countries with the formation of Water Users association as the local organization to take over responsibility for operation and maintenance of the irrigation system. Participatory irrigation management (PIM) is the guiding principle with in appropriate legislation put in place to facilitate the transfer process.

Financial and managerial capabilities of the water users associations is however often poor resulting in low-performance and failures.

Irrigation advisory services offering the water users association support in the management of the irrigation system is most appropriate. Such advisory services typically include:

- Advise and support in financial and administrative management of the system and may include calculation procedures for water fees, rules and regulations, bookkeeping and auditing procedures, credit and loan formalities with local credit institutes;
- Technical advise on the operation and maintenance of the hydraulic system, including irrigation scheduling, pump maintenance; maintenance and repair of infra-structure;

The irrigation agency is often the most appropriate institute to provide such irrigation management advisory services. In several cases NGO’s have played an important role in the formation and strengthening of the water users association and in establishing the administrative and financial system.

Unfortunately, the importance of advisory services to support of irrigation reform and IMT programmes has been insufficiently recognized resulting in the poor performance of many IMT programs. Financial resources are often inadequate to sustain viable IMT advisory services.

2.1.6 Agricultural advisory services

Although not directly to be classified under irrigation advisory services, such agricultural services are nevertheless closely linked and need to be integrated in the package of advisory services to be provided to irrigation farmers.
The importance of an effective agricultural advisory service will have a direct impact on the performance and profitability of the irrigation system, as effective water management can only result in high production if combined with effective agricultural production techniques, adequate credit facilities and marketing.

To ensure high income production levels agricultural advisory services will include

- Certified seed
- Fertilizers
- Integrated pest management
- Farm mechanization
- Credit and marketing

2.2 Target group

The target group aimed for in the irrigation advisory services will determine to a large extent the way the process of technology adoption and transfer is taking place and the communication means selected. The following target groups can be distinguished:

2.2.1 Large scale commercial farmers

Predominant in developed countries. Individual approach possible as their resources and technical know-how are well advanced. Moreover they will be able to pay for services offered, which provides opportunities for the private sector and makes the financial sustainability of such services much more achievable.
Information can be distributed though traditional extension campaigns, but increasingly they are able to profit from the modern IT techniques and have access to the ww web.

2.2.2 Small-holder farmers.

Predominant in developing countries. The individual farmer is more difficult to reach and often unable to pay for such services. The agricultural extension service is in most case the appropriate agency which can effectively provide advise to farmers. However knowledge and experience of the extension service in irrigation is very limited and technical messages need to be simple and adapted to knowledge level. In addition farmers can be reached through radio, televsion and local meetings. Extension leaflets and posters are common tools for information dissemination,

2.2.3 Farmers groups and Water Users Associations

Farmers groups and water users associations managing a common water resource for irrigation require support and advise in the management of the irrigation system. Although their financial resources may initially be weak, they may be able to pay for advisory and consultancy services through water fee collection.

Groups of individual farmers interested in advise on irrigation practices may be easier and more effectively reached as groups rather than as individuals. Farmers field schools and farmers field days are typical opportunities to introduce irrigation advise to individual farmers. Reference is made in this to the FAO Participatory training and extension approach which is oriented towards groups approaches.

2.2.4 Commercial Estates

Commercial estates will have a strong financial management and are best able to appreciate

and willing to pay for advisory services. In some cases they will establish within their own organization a dedicated unit for irrigation management.

2.2.5 Individual Home Owners

Many home owners are involved in irrigation for their gardens and properties and may use substantial volumes of precious drinking water resources. To promote more efficient water use, municipalities in cooperation with the competent research agencies are trying to reach through modern communication and IT techniques the individual home owner. In popular messages, increasingly available through the internet, homeowners in mostly developed countries are offered irrigation services (see Wateright website of ITC in Fresno, para 4.2)

2.3 Support Service Providers

Irrigation advisory services can be provided by a number of different agencies and institutes each with their specific capabilities, resources and mandate. A brief review of the different agencies involved may include the following categories of services providers..

2.3.1 Irrigation agencies

The irrigation agency will typically have the national mandate for the development, management and monitoring of water resources for irrigation and drainage. In many countries emphasis has been traditionally on the planning and design of irrigation development and the responsibility for the management of the larger state operated irrigation systems. With the IMT devolution process initiated in many countries and resources for new development strongly limited, the role of the irrigation agency is changing into a more service oriented agency in particular to support the water users association in managing their irrigation systems.

Many agencies are not yet well prepared for their new role, not motivated and have little capacity and means for this new role. There is a need to strengthen their ability as services providers through a process of training and capacity building.

2.3.2 Regional Irrigation development Agencies

Through public investment for infra-structure development, regional irrigation development agencies have been established in many countries with the specific task of planning, development and valorization (“mise en valeur”) of the irrigation system in all its aspects. Although their main task is new irrigation development and/or rehabilitation, such agencies often taken up an important advisory extension role in order to ensure that the equipment and water are properly used. Because of the separate financing resources and the long-term involvement of such projects there is a good financial basis to establish effective irrigation advisory services, which can have an important impact on irrigation performance. A good example of such regional development agency in Spain is given in para 4.4

2.3.3 Agricultural agency

Although the agricultural agency provides by tradition an extensive extension service reaching through the extension service all farmers even the small farmers, their knowledge and skills in irrigation techniques are very limited.

Their out-reach to the small-holder farmer is attractive and if the agricultural agency is to be given a greater role in irrigation advisory services, the extension staff need to be trained and supported in such activities, while adequate training and extension material need to be made available. The FAO Participatory Training and Extension in Farmers water management may serve as an example of this,.

2.3.4 Irrigation Extension service

In a limited number of countries a dedicated services has been established for irrigation advisory services in order to advise farmers in all aspects of irrigation, including the formation of water users associations. The financial resources to establish and maintain such services may however be not always available, and they may not be financially sustainable without external financial support.

2.3.5 Agricultural research services

Universities and research agencies have been in the foreground of development of new techniques. In particular the extensive research work in soil-water plant relationships and testing of various new irrigation technologies have given a favorable position as irrigation advisory service providers.

In the USA several Universities have established irrigation extension services as an outreach to growers with financial support from the local authorities and the farmers associations. Their activities concern in particular the irrigation scheduling services, as well as a range of training activities. See paragraph 4.1 and 4.2 with several examples from the USA.

In developing countries the situation of many research institutes is less suitable as dwindling resources and facilities have in many cases restricted their out-reach to farmers.

2.3.6 Irrigation equipment suppliers

The growth in modern irrigation equipment such as sprinkler and drip irrigation systems have resulted in a quite extensive and growing irrigation industry, which is interested in a effective information stream to the potential client. Their role in promoting relevant information often in close cooperation with regional irrigation agencies and irrigation research and extension services has become increasingly important in particular in developed countries.

Also in developing countries there is potential to strengthen the role of the private sector and cooperating in extending their support to the individual farmers. An example is the ITWC in California (paragraph 4.2) and EWRU in Queensland Australia (paragraph 4.3 , where close cooperation is established in the promotion of irrigation advisory services.

2.3.7 NGO's

Several non-profit organizations with special aims directed to social development or environmental concerns, can play a role in providing relevant advice to individual farmers and farmers groups.

The introduction of the treadle pump for irrigation In Asia and Africa is a good example of the role of the international NGO's in demonstrating the technique and in establishing the local manufacturing and service capacity.

Several NGO's play an important role in rural and social development and are effective at farm and household level in developing countries. They are replacing in several countries the role of the extension service.

Although NGO's are non-profit organizations, they depend on external and local funds, which are no guarantee for sustainability. Moreover their staff is in many cases recruited on a temporary basis and will depend on further training to be effective as irrigation advisory service providers.

2.3.8 Private Consultants

Where farmers or private farmers are able to pay for advisory services, private consultants can play an highly successful role in irrigation advisory services in various aspects as outlined in 2.1.

They have proved in particular successful in providing irrigation scheduling services and field evaluation assessments. Several examples are given below

3 Communications and Technology transfer

A critical element of the irrigation advisory services are the way the process of information and technology transfer are set-up and the type of communication established.

The process will be determined in the first place the target group; their level of education, their knowledge and skills in irrigation and their access to modern communication means. Furthermore the type and complexity of information to be conveyed will be a factor to be considered in what format and pedagogic process the information need to be introduced

Each service provider need to make its own assessment on how to reach farmers and irrigators and which materials to be developed based on the available resources.

3.1 Communication Means

The different communication means include:

- Dissemination of relevant materials and guidelines
- Field surveys and field studies
- Farm contacts and field visits
- Training courses
- Extension visits
- Farmers field days
- Farmers Meetings
- Web-based information
- Fax and Telephone
- Radio and Television

3.2 Communication materials

- Manuals and guidelines
- Extension leaflets
- Folders and posters
- Newsletters
- Newspaper articles
- Audio visual materials: video films, slide shows
- Web page

3.3 Participatory approaches

Participatory approaches and putting in place an intensive dialogue with farmers over time evaluating present practices and constraints to water management have proved a more effective approach to convince farmers and adopt more water use effective practices and technologies.

The FAO programme in *Participatory Training And Extension In Farmers Water Management* may be considered an example of such approach.

3.4 Conditions and Constraints

Irrigation advisory services have been promoted since the seventies in several forms and in different countries. Experiences have been mixed although farmers have been profiting of the services and adopting actively new technologies and practices.

A number of constraints can be identified in that respect:

3.4.1 Complexity of the messages and data required

Many of the proposed and recommended irrigation scheduling procedures were developed by research institutes and demanded a good knowledge of basic concepts and the collection of a considerable number of data on a daily or weekly basis. For normal this has proved often a major constraint.

However several of the private consultants have been able to adopt the water budget scheduling methods and have been converting the information in practical irrigation scheduling advises. See paragraph 4.5 and 4.6 with examples of simple irrigation calendars.

3.4.2 Supply and Demand oriented advisory services

In many cases the demand for irrigation advice is based on the desire of planners, water resources developers and irrigation experts who wish to see the use of water for irrigation reduced and more effectively used. Irrigation management advice is subsequently defined by irrigation experts and water use scientists, which often are not responding to actual interests and priorities of farmers, leading to low acceptance rates.

Participatory approaches and putting in place an intensive dialogue with farmers over time evaluating present practices and constraints to water management have proved a more effective approach to convince farmers and change to a demand oriented advisory service.

Economic motives and rules and regulations are main factors in determining the demand for irrigation advisory services.

In many cases more strict rules and legislation related to water use and conservation of water resources and water quality have proved effective in recent years and has increased the demand for irrigation advisory services.

3.4.3 Socio-Economic and Educational background and Knowledge level.

Good irrigation management involves a range of technical, agricultural and institutional aspects to be taken into account. This has proved not always easy to be translated into simple operational guidelines to farmers as underlying concepts are often complex. This has been a bottle-neck in the introduction of irrigation scheduling advice, but also in introducing more efficient field irrigation practices, water delivery schedules and financial and administrative management of water users associations.

The resources of farmers are often a bottleneck, as farmers are unwilling and unable to pay for the services, undermining the sustainability of such services, in particular in cases where governments are unable to sustain public services at field level.

3.4.4 Sustainability and duration of advisory services

Adoption of new technologies and more efficient practices have proved to take time. Only after an extended period of time and sustained levels of support are more efficient practices adopted. Many of

the irrigation advisory services established are linked to specific grants and development projects with limited time duration. This has had a negative effect on the adoption and sustainability of the adopted practices.

3.4.5 Financial support and subsidies

Financial resources allocated to training and advisory services in irrigation have been limited in many cases, as most development agencies give low priority to such services, which impact is often less clear and spectacular. Nevertheless there is a growing awareness on the importance of good advisory services provided that services can prove they are effective.

Financial sustainability of advisory services can only be ensured if farmers are to some extent willing and able to pay at least part of the advisory costs. This will ensure a client-seller relationship, where a nominal cost is linked to the value of the message and the message corresponds to the needs of the farmers. This put specific demands on the quality of the advice, but also on the farmers ability to pay at least part of the costs in relation to the economic benefits such advise can bring him. For reason of general public interest related to the conservation of water resources consideration can be given to public financial support to such services.

3.4.6 Numbers of farmers to reach

Most irrigation services are able to reach only a limited number of farmers. The limited number of staff and constraints in communication are main factors to effectively reach farmers. This is particularly valid in developing countries where the pre-dominant small holder farmers are difficult to reach all effectively in all corners and cannot be expected to receive an individual advice.

Solutions need to be sought in such cases through farmers groups and water users association, which have proved to be more effective in reaching a large number of farmers.

4 Examples

In order to illustrate the review given above on the different aspects of irrigation advisory services, some examples are provided of typical advisory services, which probably best illustrates the potential and constraints of irrigation advisory services.

4.1 CIMIS California

(http://www.cimis.water.ca.gov)

The arid conditions of California combined with a highly productive agricultural sector and a densely population with outspoken environmental concerns have made California one of the states in the USA with the most stringent regulatory framework on its water resources. To respond to demands for water conservation and water quality control, a range of initiatives have been taken to promote more effective water use. Several universities in close cooperation with growers unions and the irrigation industry are offering advisory services and training courses. A extensive pool of consultants are offering irrigation advise in various aspects.

In the early eighties the California Irrigation Management Information System (CIMIS) was established with as main objective the promotion of ET-based irrigation scheduling. Through the establishment of a network of over one hundred automated weather stations (118), daily weather data are collected for Crop Evapotranspiration estimates. **(**http://www.cimis.water.ca.gov**)**

Presently a central computer is processing all weather data and the information is made daily available through the world wide web. Presently there are 4700 registered users, of which 1220 farmers and 50 consultants servicing an additional 15,000 farmers. There are 70,000 users assessing the site, or approximately 200 per day. In a recent survey on the impact of CIMIS, they have estimated that the impact of scientific scheduling results in an 8% increase in yield and a 13% decrease in water use, The annual benefit are amounting to a net benefit of $ 270/ha.

A main constraint remains however that only a fraction of the farmers uses the scheduling information. Because of a large number of corporate farms that use CIMIS information, however, the number of hectares that are managed using CIMIS information is large relative to the number of farmers using the system directly.

The CIMIS project does not provide direct irrigation advice, but refers its customers to a range of linked services provided by several institutes, agencies and private consultants and provides direct information in the form of an extensive range of relevant documents and guidelines.

The Irrigation scheduling service is provided by private consultants as well as growers associations of specific cash crops such as Avocado. The consultants and growers association link the ETo information to the specific irrigation system and field conditions and growers receive information on timing and required irrigation depth based on their actual field and crop conditions.

An important part of the scheduling services include the evaluation of field irrigation practices through **Mobile Irrigation Laboratories**, that asses the performance of the irrigation system and carries out a series of field measurement on application rate and system distribution uniformity and gives recommendations on system improvements and upgrading.

In addition to the CIMIS ETo service, training on irrigation and irrigation scheduling is provided by the irrigation Training and Research Center of San Luis Obisbo and the Center for Irrigation Technology in Fresno.

The **Irrigation Training and Research Centre (ITRC)**, (http://www.itrc.org/) established in 1989 in the California Polytechnic State University San Luis Obisbo works closely with the irrigation industry for testing of new irrigation technologies. Providing short courses on irrigation management and assistance in the analysis of irrigation district efficiencies.

The **Center for Irrigation Technology (CIT),** Fresno California, (http://cati.csufresno.edu/cit/) provides similar services as the ITRC. It has establishes Wateright, an web-based irrigation scheduling tutorial for water managers directed towards agricultural users as well as home owners and commercial turf growers. The interactive web programme addresses a range of concepts and familiarizes irrigators with options to improve their irrigation (http://www.wateright.org/index.asp)

4.2 Other Examples of Advisory Services in USA

A range of agencies in different states in the USA provide various irrigation scheduling services. These include :

4.2.1 University of Florida,

(http://edis.ifas.ufl.edu/index.html)
The Cooperative Extension service promotes irrigation scheduling with evaporation pans. Installation of standardized NWS (National Weather Service) Evaporation pans and providing Pan factors and Kc factors allow to set up a simple water budget.

4.2.2 University of Georgia,

(http://www.ces.uga.edu/)
The Cooperative Extension service assists in the introduction of irrigation scheduling methods, based on water balance methods with calculations of crop water use curves, pan evaporation pans or tensiometers and electrical resistance blocks.

4.2.3 Texas Cooperative Extension

(http://texaset.tamu.edu/index.php)
The Irrigation and water management section of the Texas Cooperative Extension department provides information on various techniques related to crop irrigation and ET, salinity, water control, irrigation equipment, groundwater wells, and surface water preservation. Weather information provided and information on irrigation scheduling methods. On line site to determine irrigation water needs. Extensive information on various irrigation equipment and irrigation companies.

4.2.4 *Utah State University Extension*

(http://www.engineering.usu.edu/Departments/bie/software.html)
Provides a range of irrigation information leaflets with detailed information per county on crop water use and irrigation timing for sprinkler systems, using simple irrigation calendars.

4.2.5 *North West Energy Efficient Alliance*

(http://www.nwalliance.org/about/index.html)
The Scientific Irrigation Scheduling project of the North West Energy Efficient Alliance is a joint initiative of the cooperative extension services of Washington, Oregon, Idaho and Montana, promotes the introduction of more efficient irrigation applications based on the water budget and assist the introduction of the technology through demonstration, technical assistance, promotion of private scheduling services and maintenance of weather stations.

4.2.6 University of Minnesota

(http://www.extension.umn.edu/topics.html)
The Extension outreach of the Biosystems and Agricultural Engineering systems of University of Minnesota promote irrigation water management with the objective to enhance irrigator and crops advisor skills in soil-water management and understanding of decisions tools including real-time crop water use and to increase irrigation awareness of the potential impact of irrigation practices on degradation of water quality. Methods promoted includes the computerized Minnesota Checkbook, daily ET phone messages, web information and crop advisors. Service bulletins on irrigation scheduling methods.

4.3 Rural Water Use Efficiency Initiative, Queensland, Australia

(http://www.nrm.qld.gov.au/resourcenet/water/rwue/index.html)
The RWUE Initiative has been established as a partnership between industry and government to improve the use and management of available irrigation water, thereby improving the competitiveness, profitability, and environmental sustainability of Queensland's rural industries.

So-called Adoption programs have been established to help farmers to achieve best practice in irrigation water management on their properties. The programs are managed by rural industry organizations, which include :

- Cane growers for sugarcane;
- Cotton Australia for cotton;
- Queensland Dairy farmers Organisation for dairy and lucerne;
- Queensland Fruit & Vegetable Growers for horticulture.

An example is the **Horticulture Adoption Program** "Water for Profit",

(http://www.nrm.qld.gov.au/resourcenet/water/rwue/adoption.html) which has as goal improving water use efficiency in the Queensland horticulture industry by 11%. This goal is to be achieved through water savings, or improvements in yield and increased revenue as a result of moving from average to best practice management. The value of this water use efficiency goal is $147,518,901.

A survey of horticultural irrigators shows that:

- 62% of respondents use micro application systems
- 25% of those surveyed use monitoring technology to support irrigation scheduling
- 31% of respondents consult irrigation advisors
- Increased profit is the most likely factor that will motivate irrigators to become more efficient
- 72% of respondents are keen to work with irrigation extension officers

In support of the adoption programmes a **R & D Program**

(http://www.nrm.qld.gov.au/resourcenet/water/rwue/research.html) is being implemented as part of the RWUE Initiative Research & Development Program, addressing specific issues related to sustainable water use and conservation through studies and research.

An extensive range of **extension leaflets** with a wide range of topics and practical tips to improve water use efficiency, covering all aspects of the irrigation system.

An excellent series of **Fact sheets**

(http://www.nrm.qld.gov.au/resourcenet/water/rwue/factsheets.html) with a range of practical recommendations to improve the irrigation system: examples : Irrigation Performance *: measuring the performance of furrow irrigation / overhead irrigation* , Irrigation Scheduling: includes *What is scheduling to scheduling with mini pans and weather and climate forecasting*

4.4 Riegos de Navarro, Spain

(http://www.riegosdenavarra.com/Indice.html)
The Riegos de Navarro in Spain provides a good example of a regional irrigation development project. Initiated in 1984 the project was to extend and modernize the irrigation systems for 12,000 ha.

In 1995 the Irrigation support service (http://www.riegosdenavarra.com/sar/regante1.htm) was established with the specific objective to provide the users of the new irrigation system with relevant information for a more efficient management of the system and to provide relevant data on climate and crops on crop water requirements of the different crops.

A net work of eight automatic weather stations in each of districts
(http://www.riegosdenavarra.com/sar/regante2.htm) together with detailed crop information for over 50 crops allows to develop appropriate irrigation schedules fro each of the crops.

In addition to the website relevant information is distributed through radio and television, through relevant technical newsletters and periodicals, as well as through regular meetings with the farmers irrigation association, the water masters and the cooperatives.

Furthermore an extensive range of training programmes is provided to the different users and support personnel. (http://www.riegosdenavarra.com/sar/cursillos.htm)

4.5 Cropwat Irrigation Schedule.

http://www.fao.org/ag/AGL/aglw/cropwat.htm
The FAO Cropwat programme is an example of computerized irrigation schedule programme that allows the calculation of crop water requirements and the development of indicative irrigation schedules based on average climatic data and standardized crop data adopted to local conditions.
An example of the irrigation requirements of tomatoes planted on 15 May and corresponding irrigation schedule for treadle pump irrigation on a medium soil type is given below.

CROP EVAPOTRANSPIRATION AND IRRIGATION REQUIREMENTS

Rain climate station: Choma — Crop: TOMATO
ETo climate station: Choma — Planting date: 15 May

Month	Dec	Stage	Coeff Kc	ETcrop mm/day	ETcrop mm/dec	Eff.Rain mm/dec	IrReq. mm/day	IrReq. mm/dec
May	2	Init	0.70	1.89	11.3	0.7	1.77	10.6
May	3	Init	0.70	1.77	19.5	1.5	1.64	18.0
Jun	1	In/De	0.74	1.75	17.5	2.1	1.54	15.4
Jun	2	Deve	0.84	1.84	18.4	2.2	1.61	16.1
Jun	3	Deve	0.95	2.18	21.8	1.5	2.03	20.3
Jul	1	Deve	1.06	2.54	25.4	0.1	2.53	25.3
Jul	2	De/Mi	1.13	2.83	28.3	0.0	2.83	28.3
Jul	3	Mid	1.15	3.03	33.3	0.0	3.03	33.3
Aug	1	Mid	1.15	3.18	31.8	0.0	3.18	31.8
Aug	2	Mid	1.15	3.33	33.3	0.0	3.33	33.3
Aug	3	Mid	1.15	3.72	40.9	0.1	3.71	40.8
Sep	1	Mi/Lt	1.07	3.83	38.3	0.0	3.83	38.3
Sep	2	Late	0.92	3.57	35.8	0.0	3.57	35.8
Sep	3	Late	0.75	3.15	31.5	1.1	3.04	30.4
Oct	1	Late	0.58	2.62	2.6	0.4	2.26	2.3
Total					389.9	9.8		380.1

CROPWAT 7.0 — 18/03/99

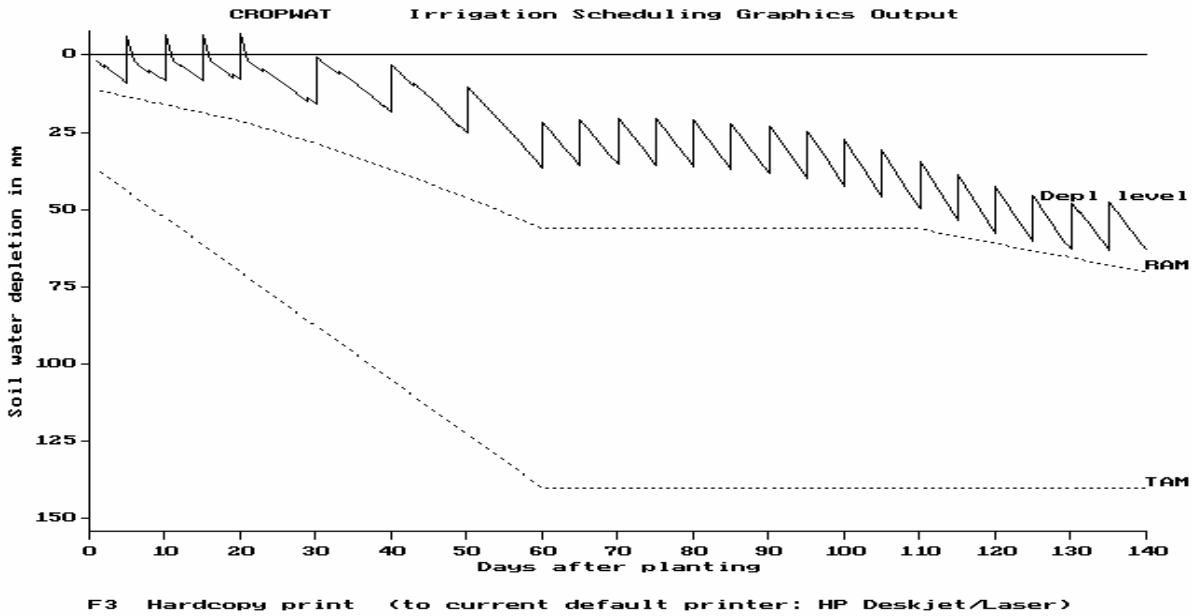
Indicative Irrigaton Schedule (planted 15 May)

Irrigation Depth 15 mm (hose pipe treadle pump)

from planting till 15 June every 5 days

from 15 June till 15 July every 10 days

from 15 July till harvest every 5 days



4.6 Irrigation Calendar, Kenya

A similar example of irrigation schedule with simple irrigation guidelines on the frequency and timing of drip irrigation of Snow peas in Naivasha, Kenya. The required adjustment to different weather conditions is elaborated in the charts given below.

Irrigation chart

Snow peas – drip irrigation

Sowing : begin (begin) July
Soil type *:* ***Sandy loam***
Region : Naivasha, Kenya
Net application depth : 57 m^3/ha

Month		July			August			September			Oct
decade		1*	2	3	1	2	3	1	2	3	1
Meteo conditions	Hot dry	2 days			1 day						
	Dry	2 days					1 day				
	Normal	3 days		2 days			1 day			2 days	
	Humid	No irrigation		3 days			2 days				

Growth Period	Establishment	Vegetative	Flowering	Yield formation	Ripe-ning
Sensitivity to water stress	sensitive	Moderate *(a,b)*	Sensitive *(b,c)*	Sensitive *(b,d)*	Mo-derate

* Initial soil wetness: Optimal soil water conditions (field irrigated the first day after sowing)

a - water deficit in the vegetative period has a relatively small effect on the yield. Unlimited water supply during the vegetative period increases vegetative growth but may not necessarily affect the pea yield.

b - when irrigation is irregular, pods are less uniform in size, more variable in colour and also the date of maturity will vary.

c - irrigation during the flowering period increases the number of marketable pods and number of seeds per pod.

d - irrigation during yield formation increases the weight of pod and seed.

Irrigation duration in hours and minutes

Discharge Per unit surface (liter/hour.m^2)	**Irrigation efficiency**	
	Good (90%)	**Medium (70%)**
2	3 h 15 min	4 h 00 min
3	2 h 00 min	2 h 45 min
4	1 h 30 min	2 h 00 min
5	1 h 15 min	1 h 45 min
6	1 h 00 min	1 h 30 min
7	0 h 55 min	1 h 15 min
8	0 h 45 min	1 h 00 min
9	0 h 40 min	0 h 55 min
10	0 h 35 min	0 h 45 min