Chapter 4

THE ILRI INVENTORY OF IRRIGATION SOFTWARE

Rien Jurriëns (ILRI)

4.1 The upgraded ILRI inventory

In the early eighties, the idea was born at ILRI to systematically identify and collect irrigation programs that were publicly available. Computer use was rapidly increasing and in journal articles and brochures existing computer programs were mentioned. Not many programs seemed to exist at the time, but in 1990 many more irrigation programs were available and hence this idea was given more attention. A provisional inventory was made and disseminated among interested parties.

After a tiresome job of identifying and collecting programs and test-running a number of them, a first draft of the inventory report was circulated in 1992 for comments. It was finally issued in 1993 (Lenselink & Jurriëns, 1993). Subsequently, a number of papers and articles were written on the issue of irrigation software (Jurriëns & Lenselink, 1992; Jurriëns, 1993, 1994).

As a follow-up of this work, ILRI in collaboration with IIS, started an International Course on Computer Applications in Irrigation (ICCAI) in 1994, which has been conducted annually since. In this course, selected programs on various irrigation subjects are demonstrated, explained and exercised with, interspersed with lectures summarizing irrigation subjects, modelling aspects, etc., while ample attention is given to making and using spreadsheets for irrigation purposes.

In the meantime, we tried to keep pace with new developments in the field of irrigation software. More old programs became known, new programs were made and old ones upgraded. The (provisional) result of this additional work is presented in this chapter. It consists of two parts. One is the attached listing, which gives an overview of names of programs now known to exist, per irrigation category, with the versions and names of developers. The other part concerns brief descriptions of some selected programs for five categories. These selected programs are, to our present knowledge, the best available at the moment, in terms of properties, technical quality and user-friendliness. The five categories are: evapotranspiration and crop water requirements, irrigation scheduling, surface irrigation, canal design and canal flow simulation, and irrigation system management programs. Before describing these programs, a brief discussion on classification and categorization is presented.

The list presented as Table 4.4, at the end of this chapter, is a combination of three inventories: ILRI, LOGID and IRRISOFT. The ILRI contribution also includes all programs presented or discussed in the various meetings on irrigation software held over the past years, as described in Chapter 1 and listed in Annex 3.

Intensive program testing, as reported for some 45 programs in the ILRI Special report, is not yet complete and is therefore not described here. Moreover, the list also contains programs which are too expensive for the common user, or which are not obtainable without special arrangements.

The programs in the inventory list are classified into categories, which differ somewhat from the ones used in the earlier ILRI inventory. We shall first, in the next Section, discuss this categorization.

4.2 Inventory categories

The large number of existing programs requires some classification/categorization. One possibility is to classify them according to accepted or logical irrigation subjects, although the question may remain what is "logical". One could, on the other hand, also start from the available programs. E.g., 'canal structures' would be a logical irrigation subject, getting ample attention in most textbooks, but if there would be no programs on the subject, it would not deserve a category in our irrigation software classification system. Furthermore, it remains to be seen if sub-categories are needed. Our proposed categories are a compromise between rigid thematic classification and pragmatism.

Another question is whether to include subjects (and programs) that do not directly classify as irrigation, but are nevertheless related to it (and may be useful for an irrigation practitioner). E.g.: should reservoir operation or land levelling programs be included in the inventory straightaway or should we concentrate first on more basic irrigation water subjects like crop water requirements, surface irrigation flow, canal flow simulation, etc.? Here again, a compromise had to be found, as discussed below. A few existing programs on related subjects have, for the time being, been placed in a 'miscellaneous' category. At the workshop, the few existing classifications were shown and discussed and it was decided to accept the classification presented later in this Section.

Let us first take a look at the few existing classifications of irrigation software, i.e. the one in the initial ILRI inventory, the one used by the ICID working group in LOGID, and the one present in IRRISOFT.

The categories that were used in the first ILRI inventory are shown in Table 4.1. Categories are primarily irrigation subjects. The same approach was followed in the ICID inventory (LOGID), but the subjects are somewhat different. In the LOGID inventory there are many categories (called 'Theme' there; see Chapter 4). They are given in Table 4.2, in a different sequence. At the right-hand side the corresponding ILRI category is shown. In addition to the real irrigation subjects shown in Table 4.2, the ICID inventory contains a number of subjects which are more or less related to irrigation. They include very narrow as well as very broad subjects. They are: Irrigation planning, Earth dam, Pumping station, Water hammer, Reservoir sedimentation, Sedimentation control, Hydrology, River basin management, River regulation, Water quality, Hydrometeorology, Probable rainfall, Resistivity model, and Impact assessment.

Table 4.1 Categories in the first ILRI inventory

- Games
- Water requirements and scheduling
  - — Water requirements
  - — Scheduling
- Field irrigation
  - — Surface irrigation
  - — Pressurized irrigation
- Canals and canal networks
  - — Canal design
  - — (open) Distribution networks
- Piped networks
- Structures
- Irrigation system management
- Drainage
- Miscellaneous

It can be seen that the ILRI and LOGID lists show a number of similarities and differences. The similarities concern the first group of "core" subjects which largely coincide. The differences are in the second group of more general subjects which are largely lacking in the ILRI inventory.

Table 4.2 LOGID categories and older ILRI groups

LOGID groups	*Corresponding ILRI group*
Evapotranspiration Soil water Water requirements Irrigation scheduling	Water requirements and scheduling
Surface irrigation Level basin design	Field irrigation
Gravity network Open channel flow Open channel semi-circular Regime canals	Canals and canal networks
Irrigation design	None
Overhead irrigation Sprinkler Center pivot Micro-irrigation	Field irrigation
Pressure network Pipeline	Piped networks

Among the LOGID categories there are some that are actually a sub-category of others. E.g. 'level-basin irrigation' is part of 'surface irrigation' and should not be at the same level; 'center pivot' is part of 'overhead irrigation' which is the same as 'sprinkler'; 'regime canals' are part of 'open channel flow'. Furthermore, some of the ILRI categories are missing, notably 'irrigation structures'. Apart from that, after further scrutiny, a number of programs appear to be in the wrong LOGID category. This is explained by the way in which LOGID is organized: the information is provided through the National ICID committees and they can give their own categories in the descriptive files coming with the program.

So far, IRRISOFT has only a few, somewhat different categories, as listed below. Currently, it contains 70 programs (a rapidly changing number), including some on drainage and hydrology. The categories are:
- Irrigation systems;
- Surface irrigation;
- Sprinkler irrigation;
- Drip/Trickle;
- Canals and canal network;
- Pipes, pipe network and pumping;
- Hydraulic structure;
- Irrigation management;
- Computerized irrigation games;
- Drainage;
- Hydrology.

Differences with the categories in the other inventories are partly due to the its recent establishment and the relatively few programs it contains. When information on more programs will come in, the structure may gradually be adapted. It was recognized during the workshop that also the nature of the medium may affect the categorization. Because one can surf and jump through the information on Internet, a hierarchical structure as with the ILRI list on paper may not be necessary.

Taking these categories into account, we now distinguish the (sub)categories presented in Table 4.3. The listing of programs in Table 4.4 (at the end of the chapter) is based on this classification. It is noteworthy that about half of the 211 listed programs fall in category A on 'Water requirements and scheduling'. Apparently, the cumbersome formula-based evapotranspiration calculations have, in many places, inspired programmers. The first three sub-categories of this group are increasingly comprehensive, i.e. evapotranspiration (A1) can also be computed in the next two (A2, A3), and crop water requirements can also be found in irrigation scheduling programs (A3). In a similar way, individual canals (category D1) can also be designed in canal network design programs (D2). The irrigation system management category (F) is even more comprehensive: irrigation requirements (A2) and scheduling (A3) are often included, while crop production (A5) and canal network flow simulation (E) could also be present in the management program. Still, it is useful to distinguish programs that can only do a limited task by not including them under a more general heading.

Table 4.3 Categories for the current ILRI inventory + number of programs

A.	**Water requirements and scheduling**			106	
	A.1	Evapotranspiration	12		
	A.2	Crop water requirements	19		
	A.3	Irrigation scheduling	36		
	A.4	Crop production	24		
	A.5	Soil-water models	15		
B.	**Surface irrigation**			11	
	B.1	Basin irrigation	2		
	B.2	Border irrigation	3		
	B.3	Furrow irrigation	2		
	B.4	All methods	4		
C.	**Pressurized irrigation**			30	
	C.1	Pressurized field irrigation	14		
	C.2	Pressurized distribution systems	16		
D.	**Canals and structures design**			16	
	D.1	Single canal design	11		
	D.2	Canal network design	1		
	D.3	Structures	4		
E.	**Canal network flow simulation**			7	
	E.1	Steady flow	1		
	E.2	Non-steady flow (+mixed)	6		
F.	**Irrigation system management**			15	
G.	**Computerized irrigation games**			7	
	G.1	Management games	5		
	G.2	Training games	2		
H.	**Miscellaneous**			19	
	H.1	Toolkits	2		
	H.2	Sedimentation	2		
	H.3	Levelling	2		
	H.4	Rivers	3		
	H.5	Reservoirs/dams	10		
			Total:		211

4.3 Programs on evapotranspiration and crop water requirements

In this Section, a number of programs in the first three categories (A1, A2, A3) are briefly discussed. Programs in categories A4 and A5 are less uniform, do not always have a clear purpose or application, and are more difficult to assess. Most of them have not been tested and are not available to us yet.

Group A1 concerns programs that only calculate some form of reference evapotranspiration (ET_{ref}). Programs may use one formula or may have options to choose between various formulae. Input data are the relevant climatic data, output is hourly, daily, 10-daily, or monthly ET_{ref}. Under this sub-group 12 programs have been identified. More local versions may exist in many places.

- *Evapotranspiration*

The three CIE programs (ETREF, ETCROP and ETSPLIT) are batch programs, not very friendly and a bit outdated. ETSPLIT calculates evaporation and transpiration separately. A very simple but nice and handy small program is DAILY-ET (Silsoe-Cranfield). It works under Windows, and input is simple. One can select one of three formulae (Penman, modified FAO-Penman and Penman-Monteith) and the daily or monthly ET_{ref} output is immediately shown after input data or the selected formula are changed. Radiation can be given as a value or be calculated by the program from other input data. Humidity can be given as relative humidity or be calculated from wet/dry bulb psychrometer values. There is no further help or information with the program. Some rather similar Silsoe programs, like AWSET and HOURLY-ET can accommodate data transmission from automated weather stations.

The charm of REF-ET (USU) is that it gives the possibility to choose from eight formulae (i.e. 1963 Penman, FAO-24 corrected Penman, 1982 Kimberley-Penman, Penman-Monteith, 1985 Hargreaves, FAO-24 radiation, FAO-24 Blaney/Criddle, FAO-24 pan evaporation). Depending on the method, alfalfa or grass ET_{ref} can be calculated and it can handle monthly, daily or hourly (or shorter) values. Also, it has options for anemometer height, etc. This DOS program is not very user-friendly, but this can be overcome easily if one is really interested and takes some familiarization time, for which the extensive manual (supplied with the program) provides ample help.

Calculation of an ET_{ref} is also a basic element of most of the more comprehensive programs discussed below, which determine crop - or irrigation water requirements.

- *Crop water requirements*

These programs calculate water requirements for crops in the form of a potential crop evapotranspiration, ET_p, based on a computed reference ET_{ref} and crop factors, mostly for specified crop growth stages or crop calendars. They may subtract effective rainfall, using one fixed method or giving options to select from various methods.

Input data are ET_{ref} values and crop factors for specified periods, and for one crop or for more crops. Most programs allow to specify areas for the selected crops. The output gives (i) potential crop or irrigation water requirements, either per time span or for a cropping season; (ii) total requirements for a certain crop or for a certain area with different crops and cropping patterns.

Programs in this group do not give crop production or yields based on actual evapotranspiration, ET_a, as output. They calculate how much water is needed for optimum crop growth.

FAO's CROPWAT program is the best known and most frequently used for this subject. It calculates ET_{ref} and ET_p, for each of which supplied data files can be used or new data can be given. Many crops are possible and for effective rainfall, a choice can be made out of four methods. Scheme requirements can be determined for different areas under different crops. The latest published version 5.7 (Smith, 1992), containing the Penman-Monteith method, still showed some problems, however. The menu was not very clearly structured, file management was problematic, errors and bugs could still occur with some scheduling options. Therefore, the program was upgraded. This version 7.0 is now circulating informally for comments and will be published shortly. CLIMWAT is a set of five disks with climatic data from all over the world, to be used as input in CROPWAT.

In 1995, another CROPWAT version was made at IIS, with a very easy and friendly menu under Windows using VisualBasic (CWR-VB). At present, some small errors are being removed from this program, and the program is being finalized by IIS in collaboration with FAO; the most recent version (March 1996) is 3.0.

After years of frequently-interrupted work, ILRI's CRIWAR program was published (Bos et al., 1996). It basically does the same jobs as CROPWAT, but uses either the modified Penman or the Penman-Monteith method. The advantage is that it has better options for file management and can produce graph outputs of all kinds of data. It can also handle 10-day values, in addition to (CROPWAT's) monthly data. A disadvantage is that it includes only one fixed formula for effective rainfall. Like CROPWAT, the program calculates crop requirements for specified areas under different specified crops.

IRSIS (CIE) is a simple program for calculation of ET_{ref} and ET_{crop}, with the advantage that it provides options for using different ET formulae (Modified Penman, Makkink, Hargreaves, pan evaporation and Blaney/Criddle). Also, one can get intermediate results such as the values of the various coefficients used in the calculations. There are two ways of calculating effective rain and various crops can be given. The program menu is slightly complicated, but easy to handle once one is familiar with it. DEFICIT, coming together with ETREF, ETCROP and ETSPLIT, calculates ET_a in case of water shortage and corresponding yield reductions, similar to the scheduling options in CROPWAT.

Some of the other programs in the listing in Table 4.4 are not readily available or are in fact part of a bigger program package (mainly concerning scheduling).

4.4 Programs on irrigation scheduling

This Section discusses programs for scheduling of irrigations at field level. Scheduling of main system water distribution is included in some of the system management programs or a few special programs on this issue. Some programs, like CMIS, are typically made for assistance of (large) farmers in the USA and are not discussed here. Almost no programs, as far as we know (except BIGSIM), take groundwater contributions into account. For this aspect, one generally has to resort to soil-water models. Most programs in this category also give ET_a when water availability is in deficit, together with approximated seasonal yield reductions.

There are many programs in the list which we have not tested, so that we may easily have overlooked some good ones. More information on some of the scheduling programs can also be found in the literature cited in Chapter 1 and Annex 3.

The best programs dealing with scheduling first need data on irrigation requirements, which in turn have to be calculated from ET_{ref}, crop data and effective rainfall. Most programs have options to either give new input for one or more of these parameters, or take them from ready-made files. Additionally, soil data then have to be given, concerning soil type, initial and available moisture and rooting depth. Programs have various options for scheduling as discussed below.

The new version of CROPWAT (not yet officially issued, but nearly ready) is not basically different from previous versions, but its structure, menus, etc., have so much improved that virtually all earlier drawbacks have been remedied. The addition of graphical outputs, especially with the scheduling options is a major improvement. Scheduling options are divided into timing options and application options. The first concern user defined timings, at critical depletion or some percentage of that, at a fixed interval or fixed depletion, and for a reduction in ET_{crop} and yield. Application depth options are refill to field capacity or a value below that, fixed depth or user-defined depth. As mentioned above, CRW-VB follows the same approach and options as CROPWAT.

In a similar way, the scheduling part of IRSIS allows you to give all required input anew, or use existing files made earlier for the calculation of ET_{ref} and ET_{crop}. Apart from user-defined irrigations, other options are: fixed interval, depletion as an amount or as a fraction of readily available water, and allowable stress as a (daily) water shortage or yield reduction. The output can also be viewed in graphs.

4.5 Programs on surface irrigation

There are two programs specifically on level-basin irrigation: BASCAD and BASIN. BASCAD (ILRI) is a fool-proof, user-friendly program with a clear menu, offering options for design or evaluation. Used in its first mode, flow rate (or dimensions) and cutoff time are output for given dimensions (or flow rate), while realizing a minimum target infiltration depth. In the opposite mode, flow rate, dimensions and cutoff time are all given and the output is the minimum depth actually realized. In all cases there are three options to give soil infiltration parameters (SCS intake families, time-rated intake families, or Kostiakov's k and A parameters); flow resistance and required depth have to be given as basic input. Application efficiency (and storage efficiency in the evaluation case), applied and infiltrated depths, advance and recession times are given as output. The BASCAD user interface is now being upgraded, which gives the program a completely different appearance. The simulation core has remained the same, however. It will be issued later in 1996 renamed as BASDEV, together with a publication on surface irrigation and two programs on borders (BORDEV) and furrows (FURDEV).

BASIN (Clemmens et al., 1995) basically covers the same input and output options as BASCAD/BASDEV. The difference is that where BASDEV simulates the surface flow and infiltration, BASIN takes the results from graphs (based on the earlier BRDRFLW model (Strelkoff, 1985) and thus can offers more direct calculation options. E.g., in BASIN, a target efficiency can be given or a maximum length can be calculated, whereas in BASDEV this can only be achieved by trial and error (though this can be done in a few seconds). Also, BASIN includes options for different advance ratios, which are not available in BASDEV. BASDEV shows graphs, BASIN does not.

Good programs specifically for furrows or for borders are not available currently. FISDEV (CIE) on furrows is being upgraded to become FURDEV (along the lines of BASDEV), in which ILRI and CIE collaborate. The same applies to BISDEV becoming BORDEV.

There are a few packages, containing options for all three irrigation methods. One is SURFACE, made by USU, but also coming with FAO Irrigation and Drainage Paper 45 (Walker, 1989). Calculations are based on the volume balance model, using the Kostiakov-Lewis infiltration equation. Options are: fixed flow, cut-back and re-use (where appropriate). Input is a bit cumbersome without assistance and one really has to know how to get the output produced on the screen.

SURMOD (USU), with similar "illegal" versions circulating as SIRMOD, has input screens much similar to SURFACE. A considerable difference is that SURMOD has options for full hydrodynamic computations, zero-inertia or kinematic wave calculations. These three options are an attractive feature of SURMOD. Besides, one can simulate cut-back flow and blocked-end borders and can handle slopes varying over the field length. Another nice feature is that one sees the surface flow, infiltration and runoff simulated on screen. The previous version has been upgraded recently, with a new user interface and options for surge flow. Unfortunately, the program is still showing problems in usability. File handling is poor, there is little assistance for input questions, no ranges are indicated for the input variables, there is no screen help, and screen output information is limited. More output information can be seen in a separate file. One is easily thrown out of the program, without any message or further guidance.

SRFR (USWCL) is doing much the same as SURMOD. The older version was problematic to work with. An upgraded version is working under Windows and has a nice interface. It offers different calculation and operation modes and there are additional options for non-uniform soils and slopes. The program is being finalized to be published later in 1996.

4.6 Programs on canal design and flow simulation

- *Canal design*

Many spreadsheets and simple small programs have been made all around the world to calculate canal sections, mostly using the Gauckler-Manning-Strickler formula. Some of the Dutch programs (which are best known to us) are e.g. PROFILE (TUD), CID (ACL) and LUCANAL (WAU). Programs offer one or more different options: to calculate the discharge for a given section or to design the section for a given discharge and, sometimes, a given depth/width ratio. CID and LUCANAL can also make longitudinal profiles and do earthwork calculations.

DORC (HRW) is specifically for the design of regime canals, for which, under a simple and clear menu, various options are provided. Strangely enough, we have not come across a specific single backwater calculation program, apart from BACKWAT (ILRI) and a small program in the TOOLKIT (EC), although the function is included in more complex canal programs like STEADY.

MIDAS (HR Wallingford) is a very nice Windows package, including IDRISI mapping, for full design of irrigation and drainage canal systems at tertiary unit scale. It is a comprehensive program with many possibilities. It is expensive to purchase without special arrangements, and its use needs at least some days of training.

There are only a few programs for structures. Actually, three of them are on the broad-crested weir, all based on the same theory. FLUME (Clemmens et al., 1993) is the most comprehensive (original) design program, BCWEIR does the same in a more old-fashioned and limited way, and BCW (USU) only calculates rating curves.

- *Canal network flow simulation*

This category includes more complicated programs, which are capable of simulating the flow in canal networks, mostly for branched systems. Input and output can differ, but in all cases the minimum output is water depths and discharges in the various canal reaches. One program, STEADY (USU), only does steady flow calculations, all others deal with non-steady flow (sometimes with a steady flow option as well). Nowadays, all non-steady flow programs use the full Saint-Venant equations, numerically solved with the Preissmann scheme. Most programs only deal with sub-critical and non-spatially varied flow.

Some programs can accommodate very large systems, others are limited, but in all programs the system can be made/modified by the user. Virtually all programs only deal with single prismatic cross-sections. Types and numbers of structures that can be included vary. In the programs we have seen, flow through/on structures is not hydraulically modelled, but represented by (simple) equations.

The ASCE task committee (now dissolved) on canal models, selected six programs which were discussed at the Hawaii conference (Ritter, 1991; see also Annex 3). Three of them were considered outdated. The other three were DUFLOW, MODIS and CANAL.

DUFLOW originates from a river flow background and is problematic to handle, particularly in its menu structure, its formulation of the system, and its description of the structures and operations. The program is no longer officially distributed and will be replaced by a new one (SOBEC, now being completed). MODIS is very apt to irrigation systems, with a lot of possibilities. However, it lacks some user-friendliness and is not publicly available. Approximately the same applies to ICSS, which is distributed commercially and not publicly available.

CANAL (Merkley, 1987) is a friendly and cheap program. It can accommodate only four branches each with nine reaches, each with four turnouts. A new or modified canal system must be run once under a separate menu first, to fill it and to set convenient boundary conditions. Outlet demands and inflow are inputs. Inflow can be specified for 12 hours in 5-minute periods. There are three options: pre-set gate settings, manual operation or automatic gate scheduling. The program calculates the required settings of the control structures (cross-regulators) and the actual flows through the outlets (and of course canal discharges and levels). All output can be seen in tabular or graphical form. The peculiar aspect is that control structures (cross regulators) are operated and not the outlets. There now is a new version under Windows (CanalMan) which we have not seen yet .

STEADY (Merkley, 1991) also has the merits of being cheap and user-friendly. It can accommodate much bigger systems than CANAL, which are relatively easy to specify. Its working is largely the opposite of CANAL, however. Input are the specified outlet demands, and the program calculates gate settings and required flow rates to realize that. Both CANAL and STEADY can also be used to check if a system indeed works as it was designed. If not, the design can be modified (by changing the system canals or structures) so as to get the required functioning. Finally, both programs include two small utility programs, one to calculate the flow resistance from given (observed) canal data, the other to determine pump characteristics (which can be inserted in the system).

SIC is a program that has been written about extensively. It has been developed by CEMAGREF, in collaboration with IIMI, to be applied in practice in the IIMI research programme. The program accepts quite extensive systems and has a variety of operational options. System inflow is given and can be varied. It can work e.g. with settings or target outflows (for both outlets and cross-regulators) as input and then calculate levels, or it works with levels as input and calculates settings. The program has a steady flow mode, which first has to be run to get appropriate boundary conditions. The latest DOS version looks nice and has clear input screens, but the structure is not always logical and needs quite some familiarization time. The program has been calibrated and validated in the field and is indeed being used for various practical purposes, especially in Sri Lanka, Pakistan and Mexico (Kosuth, 1994). A new Windows versions will be ready shortly, particularly making system definition easier. The program is very expensive to purchase when no special arrangements for training and guidance are made.

CARIMA, initially made by Sogréah with involvement of Preissmann and Cunge, was one of the selected models reviewed by the ASCE task committee on canal models. It was found to be a robust and accurate model with many possibilities, but the (batch) program was lacking user-friendliness and required substantial skills and learning time. Over the recent years, technical abilities, but particularly the interface have been essentially upgraded, in collaboration between the Laboratoire d'Hydraulique de France, California Polytechnic University and the Iowa Institute of Hydraulic Research. The latest version, now called CanalCAD, indeed looks good. The demo version (freely obtainable) suggests that the program is easy to handle, with ample error messages and guidance. It can handle systems with up to 50 canal reaches and up to 50 structures per reach. A number of standard structures can be used or the user can define his own structure algorithm in a separate Fortran file. Target flows or levels can be given as input for the various structures, varying with time with specified time-increment steps and simulation duration. Output of gate settings, levels and flows per time and location can be seen in tabular or graphical forms. Yet, as for the other canal programs, it will take some time and training effort to get acquainted with the program. CanalCAD is rather expensive to purchase. The program has been used in practice, e.g. in France and by the Imperial Irrigation District of California.

Some consultancy firms have in-house programs on canal simulation, which are not publicly available. Some examples are RUBICON (Haskoning, The Netherlands) and ONDA (Halcrow, UK). These are large programs with a wealth of possibilities, in principle only usable by experts being very familiar with the program. ONDA (part of the larger HYDRA package) is now being converted, in collaboration with Hydraulics Wallingford, to a more user-friendly and public program.

4.7 Programs on irrigation system management

We mention three programs which can deal with two or more of the various system management tasks: pre-season planning or allocation, in-season monitoring and feed-back and post-season performance assessment. Hydraulic flow simulation is not included. Because the programs deal with a number of aspects, they are quite complicated (though good-looking) and need considerable training to really understand and use them in practice.

The first module of OMIS (Delft Hydraulics, 1994) is for crop planning. For the entire scheme, as well as per tertiary unit, crop calendars and other and areas can be given (only rice and non-rice as a group), together with basic data and the resulting total requirements can be compared with available water. Easy modification of some input variables will lead to an acceptable cropping plan. Also, crop plans can be evaluated against historic hydrological years. Other information obtained are for instance allocation flows in various canals and drought stress for desired periods, crops and locations. Another module then generates operation schedules and this module can next be used for the operation period. Based on input of monitoring data from the field, the program revises the schedules and can give operation instructions. A final module can be used for either pre-evaluation of a crop plan or schedule or post-evaluation after input of all seasonal operational data. Output concerns for instance a water balance, efficiencies, drought stress and delivery ratios. All results can be seen in direct screen values, graphs, tables or on GIS screens. Finally, OMIS has a management information component, with management and operation details.

The disadvantage of the program is that the user cannot insert his own system. Also because of the GIS component, the consultant has to be hired for that. The program has now been used for schemes in Indonesia, India, Egypt and Nepal, for which the systems are included.

INCA (Makin & Skutsch, 1994) does very much the same as OMIS, though with a completely different screen appearance and menu structure. It also includes a MIS part.

There is no GIS component and the user can define his own system. The planning/allocation part can accommodate many crops and also gives pre-evaluations of alternative cropping patterns. The monitoring module includes operational schedules, structure settings and feed-back options from the field, to revise the operation. The evaluation component can be used in all phases to see various performance indicators. The program has ow been used in schemes in Sri Lanka, Bangladesh, Philippines, Jamaica, Thailand and Turkey.

WASAM finally, working under Windows (Kamphuis, 1994), also calculates allocations, but primarily does this for short periods, because it concentrates on the seasonal operation. Feed back data from the field, concerning field-wetness, canal flows and rainfall can be inserted and operational schedules can be revised accordingly. Tables, diagrams and graphs can at any moment show the actual situation or the past performance. The program has been used in various countries but particularly for a long time in Thailand, where it was initially developed and where it has now been adopted by Royal Irrigation Department as standard tool for large schemes.

These program are all rather expensive. In all cases, however, special arrangements with the suppliers may be possible; such arrangements usually include training.

4.8 Concluding remarks

The inventory and the program descriptions presented in this Chapter are only provisional. Due to time restrictions it was not possible, at this stage, to check the above remarks on some programs with the program developers. We therefore make the proviso that the discussions are limited to our own experience with the programs, supported by program documentation and other literature.

Of many programs, we only know the names as yet, and full information has still to be collected, and programs must be tested, evaluated and compared. On some of the programs listed in Table 4.4, there is more information in IRRISOFT or in the proceedings of the mentioned meetings (Annex 3). It was agreed during the workshop that ILRI, ICID and IRRISOFT will further exchange information, to make the inventories identical as much as possible.

Table 4.4 also shows that only a few institutions have produced more than a few programs. A list with addresses of these organizations was given in the first ILRI inventory (Lenselink & Jurriëns, 1993) and has not really changed much. Further information can be obtained there.

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Table 4.4 ILRI INVENTORY LIST 1996

Abbreviations in column 'Info#':

ILRI	=	ILRI inventory 1993
LOG	=	LOGID database
IRS	=	IRRISOFT
IC1	=	ICID Rio de Janeiro 1990
ASCE	=	ASCE Honolulu Conference 1991
Mont	=	IIMI/CEMAGREF workshop Montpellier 1992
IC2	=	ICID The Hague 1993
FAO	=	FAO Expert consultation 1993

CLASS/NAME	Made by	Version	Info#	Remarks
A. WATER REQUIREMENTS AND SCHEDULING				
A1 Evapotranspiration				
AWSET	CU		IRS	for automated weather stations
DAILYET	CU	95	IRS	3 methods; Windows
ETCROP	CIE	86	ILRI	batch program
ETREF	CIE	86	ILRI	batch program
ETSPLIT	CIE	86	ILRI	batch program
ETPOT	DAR	1.0	IRS	
HOURLYET	CU		IRS	for automated weather stations
REF-ET	USU	91/92	ILRI	8 methods
MOD PENMAN	FAO		LOG	
PENMET-3	OEC	88	LOG	
PET	IFAS		IRS	
POTEVAPO	IFAS		IRS	
A2. Crop water requirements				
ADIMO	DH		LOG	part of Ribasim
AGREGA	ISAP		LOG	
AGWAT	DH		LOG	
BALANCE	CU		IRS	
BILANREG	CMG	89/92	LOG	French/regional
CRIWAR	ILRI	2.0/96	ILRI	2 methods
CROPWAT	FAO	5.3/5.7	ILRI	also scheduling
CRWAT BUDGET	LI		IC1	France
CWR-VB	IIS	95	ILRI	Windows
DEFICIT	CIE	86	ILRI	
DELTA2	WH		LOG	for command areas
ENWATBAL	CPRL		IRS	
Evapotranspiration	OEC	88	LOG	ETa neutron probe method
IRSIS	CIE	4.01	ILRI	also scheduling/4 formulas
MACRA	HIMAT		LOG	
MICROWEATH.94	DTPE	94	IRS	simulation of crop canopy microclimate
NORMA	RIID		LOG	
ORIG PENMAN	M&P		LOG	
WATER-USE MOD	KSU	89	LOG	
A3. Irrigation scheduling				
AADMOD	DH	90/93	LOG	
AGWATER	CaPo	95	ILRI	for sprinklers, borders and furrows
ASRTHYD	CACG	93	LOG	telecom, France
BAHIDIA	CRA		IC2	
BALANCE	RIID		LOG	
BIDRICO2	UdU	92/93	IC2	field level

CLASS/NAME	Made by	Version	Info#	Remarks
A3. Irrigation scheduling (continued)				
BIGSIM	WMRL		IRS	with groundwater contribution
CITRUS IRR SCH	IFAS		IRS	
CMIS	UoC	91	ILRI	also CMIS1 and CMIS2
CMMSWIG	PCWR		LOG	with salt
CROPWAT	FAO	5.3/5.7	FAO	
DEMAND	IAVH		LOG	system level
EXPERDI	IMTA		FAO	
GRESREG	ISA		LOG	Portugese/for irrigation blocks
GRASPER	IAVH	85/89	IC1	from field to system level
HYDRA	UST		IRS	
IMS	CU	93	LOG	
IRRICANE 3	CTRA	93	LOG	
IRRICE	ISA		IC2	Portugese menu
IRRIG SCHED	HTS	87	LOG	
IRRISKED	USU	88/93	LOG	field and farm level
IRRITEL	MF	94	LOG	
IRR WAT REQ	FCA	89	LOG	
ISAREG	ISA	93	IC1	Portugese menu
IRSIS	CIE	4.01	ILRI	
PCET	USU	88	LOG	
PROREG	ISA		IC2	Portugese menu
RELREG	ISA		IC2	Portugese menu
RENANA	CDBR	-84	IC2	videotel Italy
RIWAP	AIT		FAO	scheduling tertiary units
SOILWAT-I	RIIH		LOG	
SOILWAT	RIIH	88	LOG	
SOWABAMO	UoP	92	IC2	
UTAHET	USU	88	LOG	
VIDEOTEL	CDBR	90	LOG	
WCAMOD	USU	-87	IC2	watercourse command
A4. Crop production				
BYM	INRA		LOG	French menu
CERES-MILLET	MSU		IC2	
GLYCIM	ARSB		LOG	
CRPSM	USU	86	LOG	
ECOSYS	UoA		LOG	
IRRIGATE	IFAS		IRS	simulation of corn and soybean
IRRIMOD	AIMC	91	LOG	
MILP	FAO		FAO	linear programming
OPUS	ARSC		IC2	
PIMAG	IAVH		LOG	
RESP FUNCTION	ESAL		LOG	
RICEYIELD	WBI	88	ILRI	
SIMTHEO	CCI		LOG	
SIMYIELD	WBI	88	ILRI	
SIRFRU	ISAI	86	IC1	wheat
SOYAMET	SBF		IC1	
SOYGRO	ISA/UoH	5.42	IC2	
SWACROP	LWSC	91	IC1	
SWATRE/SWACROP	LWSC		LOG	
SWATRER/SUCROS	CIE	92	IC1	
SWATRES/SWACROP	IGWC	93	LOG	
SWARD	ADAS		IC2	
WBT	CSU	89	LOG	
YIELD	RIID		LOG	

CLASS/NAME	Made by	Version	Info#	Remarks
A5. Soil-water models				
BILANHP	FdSA		LOG	
BIWASA	UoCE		IC2	simulating salt and water movement
MBAL	M&P	89	LOG	
MUST	IHE	89/93	IC1	unsaturated zone
POLICORD	UoN		LOG	soil/plant/water/atmosphere
RAHYSMOD	ILRI		ILRI	combination of SGMP and SALTMOD
SALTMOD	ILRI		ILRI	salt
SCHEDM	CSU		IC1	generating water balance tables
SDSMBM	RJFU		IC1	simplified version Versatile Soil Moisture Budget
SPAW	UoL		IC1	
SWATRE	WSC		IC2	application in Pakistan
SWBM	VPIU		IC2	with GIS database management
SPACTEACH	UoR		IRS	
Water Balance Model	PFU	78	LOG	output: ET, soil moisture, drought index
Water distr	ESAL		LOG	water distribution in soil
B. SURFACE IRRIGATION				
B1. Basin irrigation				
BASCAD	ILRI	2.2	ILRI	being upgraded
BASIN	USWCL	2.0	USWCL	
B2. Border irrigation				
BICAD	UoM	1.0	ILRI	
BISDEV	CIE	94	ILRI	being upgraded
BRDRFLW	USWCL	7.2	ILRI	outdated
B3. Furrow irrigation				
FISDEV	CIE	94	ILRI	being upgraded
RAIEOPT	CMG	89/91	LOG	French menu
B4. All methods				
DISEVAL	NUC		IC2	design and evaluation border, furrow
SURMOD	USU	86/94	ILRI	
SRFR	USWCL	2.0 (91)	ASCE	being upgraded
SURFACE	FAO/USU	89	ILRI	FAO I&D paper 45
C. PRESSURIZED IRRIGATION				
C1. Pressurized field irrigation				
BAL.TRAJECTORY	DUU	86	LOG	precipitation simulation model
Calpiv	CMG	91	LOG	sprinkler systems
CAMS/SCHED	VI/ARSFC		IC2	for center pivot systems
CATCH3D	USU	4.60	ILRI	
IEM	OSU		IC1	irrigation efficiency model sprinklers
PB2DIAM	CMG	84/86	LOG	micro-irrigation
RIEGOLOC II	IRYDA	94	ILRI	micro-irrigation; in Spanish
SCAL	UPV	92	LOG	micro-irrigation
SPRIK-D			ILRI	
SprinkPac	LV		LOG	design sprinkler systems
SprinkSim	USU	87	LOG	hydraulic simulation sprinkler systems
USUPIVOT	USU		LOG	soil water infiltration under center pivots
VERIP	CMG	88	LOG	simulation sprinklers
Xerxes-Renfors	CMG	87-92	LOG	economic optimum sprinklers (French)

CLASS/NAME	Made by	Version	Info#	Remarks
C2. Pressurized distribution systems				
MAINL-D			ILRI	
OPTIPIPE	FAO	88	ILRI	design of branched pipe networks
UNDP	UNDP/WB	87	ILRI	drinking water pipe networks
BEL	CMG	87	LOG	pipe systems
Buckl	NRIAE		LOG	
Cebelmail	CMG	77-92	LOG	
COUP	M&P	76-93	LOG	piped network
FastQuote	LV	93-94	LOG	residential irrigation, pipes
HYDRAN	H&P	76-93	LOG	open channel + pipe network
ICARE	CMG	86-91	LOG	network under pressure
IRRICAD	L&A	85	LOG	design piped irrigation network
IRRICAD 5	LV	87-94	LOG	pressurized irrigation network
Pecari	SCP	84	LOG	French, pipe system design
RAMI	SCP		LOG	see Pecari
RAMTF1	IAVH	88	LOG	see RAMI
RG	UPdV	92	LOG	
D. CANALS AND STRUCTURES DESIGN				
D1. Single canal design				
BACKWAT	ILRI	93	ILRI	
CANALCAD	CIE	1.0	ILRI	drains
CID	IACL	1.0 (88)	ILRI	Manning/earth work
DORC	ODU/HR	1.1 (92)	ILRI	regime canals/8 methods
LUCANAL	WAU	93	ILRI	
NESTOR	IACL	1.0 (91)	ILRI	in Dutch
PROFILE	TUD	1.0 (90)	ILRI	Manning/Strickler
Canal 9	CMG	86-93	LOG	new version of CANAL
Circhan	POMPA	90-91	LOG	permanent flow
HYDRAN	H&P	76-93	LOG	open channel + pipe network
PC-Candes	EC	93	LOG	Manning
D2. Canal network design				
MIDAS	ODU/HR	95	ILRI	demo/up to 500 ha
D3. Structures				
BCW	USU	2.2 (91)	ILRI	
BCWEIR	LBer	92	ILRI	
FLUME	ILRI	3.0 (93)	ILRI	
Tidal Sluice Out	IHE		ILRI	
E. CANAL NETWORK FLOW SIMULATION				
E1. Steady flow				
STEADY	USU	2.20 ('91)	ILRI	6 branches/250 reaches
E2. Non-steady flow (+ mixed) programs				
CANAL	USU	91	ILRI/ASCE	4 branches/9 reaches
Canal_d	USU	90-92	LOG	Windows-> CANALS
CanalCad	CaPo		Mont	former CARIMA
DUFLOW	IHE	2.0/2.01	ILRI/ASCE	
HYDRO_ID	M&P	87-93	LOG	
ICSS4	UoC		FAO/Mont	
MODIS	TUD		ASCE/Mont	not available (private)
Mistral	IWASRI		FAO	

CLASS/NAME	Made by	Version	Info#	Remarks
E2. Non-steady flow (+ mixed) programs (continued)				
ONDA(HYDRA)	H&P		ILRI	not available (commercial)
Rubicon	HaKo		ILRI	not available (commercial)
SIC	CMG	91	LOG/Mont	
SIMWAT	CRA/WSC		Mont/FAO	part of package MOGROW
F. IRRIGATION SYSTEM MANAGEMENT				
F1. Irrigation system management				
CAMSIS	IIS	94	ILRI	being upgraded
CIMIS	FAO		Mont	
CG1	YRIB		FAO	
EXPERDI	IMTA		FAO	from user to system level
HYDRA-DSS			IC2	
IMIS	IIMI		FAO	
IMSOP	UoM		FAO	
INCA	HRW		ILRI/FAO	demo/Windows
MIS	CADI	90-92	LOG	planning scheduling evaluation
MRI	PDD	92	LOG	command area management
OMIS	DH	3.2 (93)	ILRI/Mont	
RIWAP	AIT		FAO	
SIMIS	FAO	93	LOG/FAO	management system
SYMO	AIT		Mont	
WASAM	EC	1.0 (94)	ILRI	student version/Windows
G. COMPUTERIZED IRRIGATION GAMES				
G1. Management games				
IRRIGAME	USU	92	ILRI	irrigation scheduling
IRR MAN GAME	IIS	95	ILRI	Windows
MAHAKALI	M&P	92	ILRI	
SUKKUR	M&P	87	ILRI	barrage
WYEGAME	WCol	1.0 (88)	ILRI	role-playing game
G2. Training games				
NILE	M&P		ILRI	
REHAB	Cornell	86	ILRI	teaches design skills
H. MISCELLANEOUS				
H1. Toolkits				
L & W Toolkit	EC	2.0 (93)	ILRI	Manning/Lacey/Penman/etc.
WAT. MAN. UTIL.	IFAS	95	ILRI	various tools
H2. Sedimentation				
DACSE	HRW	92	LOG	sediment extraction
DOSSBASS	HRW	94	LOG	sedimentation
H3. Levelling				
LEVELGRAM	USU		ILRI	
LANDLEV	USU		ILRI	

CLASS/NAME	Made by	Version	Info#	Remarks
H4. Rivers				
Bahia	CMG	92-93	LOG/Mont	river regulation and simulation
MIKE11	DHI	86-93	LOG	river hydraulics simulation
Ribasim	DH	85-93	LOG	river basin management
H5. Reservoirs/dams				
Calsite	HRW	92-93	LOG	GIS: reservoir sedimentation
GEOCUP	NRIAE		LOG	dams, Japan
MONFLOW	SWC	86-93	LOG	annual flows for water reservoirs
Poetics	NRIAE	85-88	LOG	earth dam
Qest	SWC	86-93	LOG	with Monflow
RESOP	KL	88	LOG	Lotus spreadsheet, reservoir operation
STAB	CMG	72-91	LOG	analyses stability of side slopes
SWIMM	HRW	91	LOG	calculates reservoir volumes
TARCOMP	DH	85-93	LOG	optimum reservoir releases
WRMM	AEP		LOG/IC2	water reservoir network simulation model

ACRONYMS used for 'Made by'

ADAS	ADAS Soil & Water Research Centre/Institute of Grassland and Environmental Research North Wyke, UK
AEP	Alberta Environmental Protection, Canada
AIMC	Advanced Irrigation Management Centre CSSRI, Karnal, India
AIT	Asian Institute of Technology, Bangkok, Thailand
ARSB	USDA Agricultural Research Service, Beltsville, USA
ARSC	USDA Agricultural Research Service, Fort Collins, USA
CACG	CACG, Tarbes, France
CADI	Computer Assisted Development Inc., Fort Collins, USA
CaPo	California Polytechnical State University, San Luis Obispo, USA
CCI	CEPLAC/CEPEL/INFES, Brazil
CDBR	Consorzio della Bonificia Renana, Italy
CIE	Center for Irrigation Engineering, Catholic University Leuven, Belgium
CMG	Centre d'Etude du Machinisme Agricole, du Génie Rural, des Eaux et des Forêts, Montpellier, France
CPRL	USDA-ARS Conservation and Production Research Laboratory, USA
CRA	Centro Regional Andino, Mendoza, Argentina
CSU	Colorado State University, Fort Collins, USA
CTRA	CTRAD-CA, La Réunion
CU	Cranfield University, Silsoe College, Department of Agr. Water Management, UK
DAR	Department of Agrosystems Research, DLO, Wageningen, The Netherlands
DH	Delft Hydraulics, Delft, The Netherlands
DHI	Danish Hydraulic Institute, Copenhagen, Denmark
DTPE	Department of Theoretical Production Ecology, Wageningen Agricultural University, The Netherlands.
DUU	DEA/UFV/USU, Brazil
EC	Euroconsult, Arnhem, The Netherlands
ESAL	ESALP/USP Sao Paulo, Brazil
FAO	Food and Agriculture Organization, Rome, Italy
FCA	Faculdade de Ciencias Agronomicas, Brazil
FSA	Faculté des Sciences Agronomiques, Gembloux, Belgium
HaKo	HasKoning Consultants, Nijmegen, The Netherlands
HIMA	Instituto Colombiano de Hydrología, Met. y Adecuación de Tierras
H&P	Sir W. Halcrow & Partners, Swindon, UK
HRW	Hydraulics Research Wallingford, UK
HTS	Hunting Technical Services, UK
IAVH	Institut Agronomique et Véterinaire Hassan II, Rabat, Morocco
IACL	International Agricultural College Larenstein, Velp, The Netherlands
IFAS	IFAS Software Support, University of Florida, USA
IGWC	IGWC-Europe (TNO), Delft, The Netherlands
IHE	Institute for Infrastructural, Hydraulic and Environmental Engineering
IIS	Institute of Irrigation Studies, Southampton, UK
ILRI	International Institute for Land Reclamation and Improvement, Wageningen

ACRONYMS (Continued)

IMTA	Instituto Mexicano de Tecnología del Agua, Cuernavaca, Mexico
INRA	Institut National des Recherches Agronomiques, Paris, France
IRYDA	Instituto Nacional de Reforma y Desarollo Agrario, MMadrid, Spain
ISA	Instituto Sperimentale Agronomico, Bari, Italy
ISAP	Instituto Superior de Agronomia, Lisbon, Portugal
IWAS	IWASRI, Lahore, Pakistan
KL	Klohn Leonoff, Canada
KSU	Kansas State University, USA
L&A	C. Loth & Associate, Italy
LBer	Louis Berger International
LI	Laboratoire INRA associé a la Chaire de Bioclimatologie de l'INAPG
LWSC	Agricultural University Wageningen/W. Staring Centre, The Netherlands
LV	Lincoln Ventures Ltd., New Zealand
MF	Meteo France
M&P	Sir M. MacDonald & Partners, Cambridge, UK
MSU	Michigan State University, East Lansing, USA
NRIAE	National Research Institute for Agricultural Engineering, Tsukubashi, Japan
NUC	National University of Cuyo, Argentina
OEC	OSU-EMPRABA-CNPH, Brazil
OSU	Oregon State University, Corvallis, USA
PCWR	Pakistan Council of Research in Water Resources
PDD	Planning and Development Division, Pakistan
PFU	Pelotas Federal University, Brazil
RJFU	Rio de Janeiro Federal University, Brazil
RIID	Research Institute for Irrigation and Drainage, Bulgaria
RIIH	Research Institute for Irrigation, Hungary
SBF	Station de Bioclimatologie France
SCP	Société du Canal de Provence, France
SWC	Saskatchewan Water Corporation, Canada
TU	Texas A&M University, Baton Rouge, USA
TUD	Technical University, Delft, The Netherlands
UdU	Universita de Udine, Italy
UoA	University of Alberta, Canada
UoCa	University of Calgary, Canada
UoC	University of Colorado, USA
UoCE	University of Cairo, Egypt
UoH	University of Hohenheim, Germany
UoL	Univetsity of Ljubljana, Yugoslavia
UoM	University of Melbourne, Australia
UoN	University of Naples Federico II, Italy
UoP	University of Perugia, Italy
UoR	University of Reading, UK
UNDP	United Nations Development Program
UPV	Universidad Polytécnica de Valencia, Spain
UST	Universita degli Studio di Trento, Italy
USWCL	United States Water Conservation Laboratory, Phoenix, USA
USU	Utah State University, Logan, USA
VI	Valmont Industries, USA
VPIU	Virginia Polytechnical Institute and State University, USA
WBI	World Bank, New Delhi, India
WCo	Wye College, Ashfort, UK
WSC	Winand Staring Centre, Wageningen, The Netherlands
VI/ARSFC	Valmont Industries/Agricultural Research Service Fort Collins, USA
WH	WAPDA/Harza International, Pakistan
WMRL	Water Management Research Laboratory, Fresno, USA
YRIB	Yelllow River Irrigation Bureau, China