IRRIGATION SOFTWARE INFORMATION

- how to find and evaluate the program you need

Report of a workshop

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FOREWORD

Rapid developments in computer application over the past decade are affecting many disciplines all over the world. Irrigation and drainage are in part rather practical arts, and many of their more scientific, planning, design, management and operation aspects lend themselves to computerization. Modelling and simulation play an increasing role in irrigation and drainage education, and electronic information exchange is also becoming increasingly important, although maybe not as quickly and as completely as in other professions.

Even though the introduction of electronic computing and information exchange in irrigation may be relatively slow, this does not mean that no software has been developed. Reviewing the literature over the past five to ten years, there is indeed a substantial increase in the number of computer programs, ranging from simple calculation tools to complex growth simulation or water-flow models. It is, however, rather difficult to obtain an overview of what is available where, and what the properties and qualities of these reported programs are.

In trying to find an appropriate irrigation program one is confronted by two major questions:

- How do I know which programs are available worldwide for the subject and problem in hand; what are their names, where can I get them, and where can I get relevant information about them?
- If I have located a program, how can I evaluate: if I can use it on my hardware, what the program can do for me, and what its typical features, characteristics, and qualities are?

These two questions are addressed in these proceedings, the first under the general heading "inventory" and the second as "evaluation criteria".

A number of people and institutions, concerned with producing, collecting and disseminating irrigation knowledge, have shown an interest during recent years in giving some guidance to potential users as to the above two questions: how to collect and evaluate existing irrigation and drainage software. Occasional contacts between interested parties took place over the last few years, and they agreed that a slightly more formal exchange of ideas and material could be useful.

A workshop on the issue was then planned, initially to be held in Cuernavaca, Mexico, in January 1996. That workshop would cover two days on irrigation software inventory and criteria, a one-day field visit to see practical application of management information systems and decision support systems, and two days on ITIS. ITIS stands for Information Techniques for Irrigation Systems, a Network Newsletter, published by IIMI (International Irrigation Management Institute), launched in December 1994. The Mexican Institute for Water Technology (IMTA) at Cuernavaca would organize the workshop, while other preparations were made jointly by IIMI-Sri Lanka, IIMI-Pakistan, CEMAGREF and ILRI.

When this failed to materialize, an alternative meeting was agreed upon between some parties in Western Europe. Although less formally organized, the participants did not want to lose the momentum that had been gained for the Mexico-meeting. Moreover, such a meeting at that moment could provide useful information for other discussion fora planned to take place later in the year 1996. Therefore, CEMAGREF (Centre d'Etude du Machinisme Agricole, du Génie Rural, des Eaux et des Forêts) gracefully agreed to receive the participants for a number of days in Montpellier, France, for a workshop from 22 to 25 January 1996.

Participants of the workshop came from CEMAGREF, the International Commission on Irrigation and Drainage (ICID), IIMI-Sri Lanka, IIMI-Pakistan, the University of Kassel, the Institute of Irrigation Studies (IIS) Southampton, and ILRI Wageningen.

The present report contains the proceedings of this workshop in an edited form. It aims at letting a wider public of interested irrigation professionals know about the current state of affairs with regard to irrigation software inventory and evaluation. Potential users, who may benefit from these proceedings, could be individual professionals, government departments, private consultancy firms, or education and training institutes.

These proceedings start with an overview article. In the following three chapters, one can easily recognize that there are various paths for disseminating information on irrigation software: there is the LOGID database on diskette, the written ILRI report, and, recently, IRRISOFT database on Internet. In the rest of the proceedings one finds a few ideas about evaluating irrigation software, and cautions for using programs, while conclusions and possible further work on the subject are mentioned at the end. Workshop details like the programme, the participants, and some review material are given in three Annexes.

Chapter 1

INVENTORIES OF IRRIGATION SOFTWARE AND CRITERIA TO USE

Rien Jurriëns (ILRI)

1.1 Software inventory: need and purpose

1. Although the application of computer programs in irrigation seems to lag behind compared with many other sectors, quite a number of computer programs on various irrigation subjects have now been developed or are nearing completion. The situation has become rather confuse and few irrigation experts have a good overview of which programs are now available where, for which purposes they can be used and what their practical relevance and qualities are. This applies to public-domain software (institutes, universities) and even more to software made by commercial companies. Marketing of the software is poor, while documentation and literature are often scarce or completely absent.

It is only logical that, in such a situation, the common irrigation student, engineer, consultant or manager only sees "*a jungle of software*" (as Martin Smith of FAO named it). My experience is that many program names are not commonly known, and that their contents are even more obscure, while addresses/prices are often difficult to obtain. If one considers how much time and effort it has taken some institutions to prepare their recent overviews, one cannot expect many people to have the time and resources available to find out for themselves.

At the same time, computer applications for various practical purposes in irrigation will certainly become more important, until they become a normal professional tool, much in the same way as pocket calculators replaced the slide rule at a certain moment.

2. A conclusion can thus be that it is needed *to establish a clear and complete inventory of irrigation software* in order to provide irrigation professionals with information on
- which programs are available where?;
- for which purposes/subjects can they be used?; and
- what are their main characteristics?.

This could be a first objective of the present workshop: seeing how best such an inventory can be made.

Such an overview, made by researchers as a service to the common user, would effectively enhance the dissemination and wider practical application of existing programs. It would also perhaps reduce the all-too-common practice of putting much effort in developing new programs for a specific purpose, where they already exist and could much more easily be modified or upgraded.

3. For this inventory, a *classification/categorization* of subjects to be covered is needed first. This involves questions such as, e.g., how to categorize the different types of

programs dealing with canals, and: should reservoir operation or land levelling programs be included from the beginning or should we concentrate first on real direct irrigation subjects like crop water requirements, surface irrigation, canal flow simulation, etc.? A further discussion is presented in Chapters 4 and 5.

4. Subsequently, we should agree which programs on a certain subject should be included in the inventory, which ones should not, and why. There are two possible criteria: one is *availability*. For instance, should a program costing 15 000 UK£ be considered "available" ? Or, generally, should cost criteria be used and, if so, what is the accepted limit? Should in-house programs, not available to the public, be included? A second inclusion criterion could be quality or *usability*: when does a model become a program, or: how to judge the underlying theory, how to address program verification and validation, how many bugs can be accepted, what demands can be made on user-friendliness?

5. In the recent past various activities have taken place related to the establishment of preliminary inventories on different subjects. This work is summarized below (Sections 1.3 and 1.4). In further finalizing the inventory, experience and lessons from this work have to be used and hence co-ordination of activities is advocated.

1.2 Software criteria: need and purpose

6. The work done so far is summarized in Section 1.3. Some lessons from these various inventories are:

- for many programs it is not easy to get a clear picture of what they really do, certainly not quickly: purposes, possibilities and limitations, input and output are not well outlined;
- it is no exception that different programs on a same subject give different results;
- some programs do not really work (well). They show bugs or even give incorrect results;
- quite some programs have been developed for research purposes, they do not have a minimal user interface, they are constantly upgraded without making it known, and have never reached the status of a real program, with which one can work for practical purposes;
- there are many papers about models with suggestions that a program exists or can easily be made. Such programs may not exist or may not be available, however. It is therefore useful to make an explicit distinction between *models*, describing the mathematical formulation of a process, and *programs* which a common user can apply in a practical situation.

7. Against this background, a second objective of this Workshop is *to develop criteria on how a program can be described and assessed.* This concerns its properties (what can a program do?) and qualities (how does it do that?). A proposal for a general framework is presented in Chapter 5. This framework can be detailed in future during meetings and discussions on specific subjects.

8. Development of such criteria can serve various purposes; it can help to

- clearly and uniformly describe main characteristics of a program in the inventory;
- enable a user to quickly evaluate the relevance of a program for his purpose;
- facilitate comparison of programs on a same subject;
- give guidance for upgrading existing programs or for developing new ones.

9. *Property criteria* should address the purpose, limitations, conceptual model used, input and output and similar aspects, which would immediately make clear what the program is about. To give one example: for surface irrigation one would like to know for which method (basins, furrows, borders, all), for which purpose (design, operation, analysis, training), which options (cut-back, re-use, etc.), which model or concept it is based on (zero inertia, volume balance, etc.), which input variables are required and which are the important performance indicators among the many output data. This list can be modified or extended as necessary. For other subjects other lists must be made.

10. *Quality criteria* would concern two types: technical quality and user-friendliness. The technical criteria would include aspects like solution techniques, robustness, stability, accuracy, modularity, and verification, calibration and validation. The user criteria could include hardware requirements and availability and documentation, but should concentrate on simplicity of use and interface aspects. These criteria will be more generally applicable than the property criteria. Specific details are discussed in Chapter 5.

1.3 Recent work done

11. Considerable work has been done on irrigation software inventories but less on criteria. This work should be known and used. In order to avoid duplication and to make some essentials known more widely, this work is listed here. A slightly more detailed review is given in Annex 3.

a. During the 14th ICID Congress in Rio de Janeiro (1990) there was a first Workshop on Crop-Water models. Selected papers from this Workshop were published in ICID Bulletin Vol.41 No.2, 1992, giving information on about 15 models in as many articles (Pereira et al., 1992).

b. ILRI started preparing an inventory in 1991; a first draft was distributed for comments in 1992. The final version was issued in April 1993. The publication (Lenselink and Jurriëns, 1993) contained some general chapters on computer use and criteria, and a brief overview of available programs per irrigation subject. Some 150 programs were identified of which 45 were tested. Besides the publication, the collected literature was stored in a database (using Cardbox). Programs and literature collection continues (see Chapter 4).

c. An ICID working group started an inventory in 1990; work is still on-going. The recent version contains 146 programs on irrigation-related subjects. Core information on programs is put in a database (called LOGID) under various categories. The diskette is distributed informally. The inventory also includes 22 programs on drainage and 10 on flood control (ICID, 1994). See also Chapter 3.

d. A substantial part of the ASCE 1991 Hawaii conference was devoted to canal simulation programs, specially those with non-steady flow. Proceedings were issued by the ASCE (Ritter, 1991). An ASCE Task Committee presented results of an inventory/scrutiny and a discussion of model development criteria. Six selected canal-flow programs were specifically tested and reviewed.

e. The IIMI/CEMAGREF workshop in Montpellier in 1992 also concentrated on canal modelling. Pre-workshop proceedings were distributed among participants (IIMI/CEMAGREF, 1992). Although not primarily aiming at an inventory, important conclusions were formulated on availability and quality of programs. In 26 articles about half as many programs were discussed. Unfortunately, final conclusions and recommendations were never published.

f. During the 15th ICID Congress in The Hague, 1993, there were two Workshops dealing with computer software, one on irrigation and one on drainage. The first was the Second Workshop on Crop-Water models, where some 24 models and programs were presented in a Transactions Volume (ICID, 1993). The second was largely on subsurface drainage models, with 24 papers on almost as many programs in a Transactions Volume (edited by Lorre, 1993). Selected models appeared in a separate book (Pereira et al., 1995).

g. In 1994, ICID organized another Working group meeting on Crop-Water models, in Varna, Bulgaria. Various programs were discussed, among which several already included in the previous workshops. No proceedings were published.

h. In 1993, in Rome, there was a FAO-sponsored "Expert consultation on water delivery models". Proceedings were published by FAO as Water report No. 2 in October 1994 (FAO, 1994). They include some 11 programs on canal simulation, allocation and system management.

i. Recently, i.e. by the end of 1995, Thomas Stein of the University of Kassel started an irrigation site on Internet, in which space is provided for IRRISOFT, an inventory of irrigation and hydrology programs and software-related literature (see also Chapter 2 of these proceedings).

1.4 Discussion of recent work done

12. The picture is a bit chaotic. There are now four (attempts at) real inventories: ILRI, ICID (LOGID) and IRRISOFT for the entire irrigation field and ASCE for canal simulation models. The other meetings concerned some general aspects, or concentrated on one or two subjects only, or presented a limited number of programs. Some contain rather unusable programs, some include pure (non-program) research models, others only

include programs for practical use. Yet, all this knowledge can contribute to making a complete inventory.

13. The ILRI inventory is primarily on irrigation with a brief summary on drainage. ICID (LOGID) covers both irrigation and drainage with a start on flood control and some miscellaneous issues. They contain partly the same, partly different programs. LOGID includes many programs of which the actual availability and functioning has not been tested separately. ILRI virtually only included programs that were publicly available at an acceptable price, one third of them were tested.

ICID '93 concentrated on some crop-water models and on subsurface drainage. FAO (Rome) dealt with general software application and requirements and with some management and canal simulation programs. The latter was the explicit focus of ASCE and IIMI/CEMAGREF.

LOGID is only a database. ILRI, ASCE and FAO (Rome) also provide conclusions and recommendations (the Montpellier conclusions were not published). Complete lists of programs mentioned in the various meetings are presented in Annex 3.

IRRISOFT has just started. The "display-window" is there, but filling it with organized contents still requires a lot of work. The idea is very promising.

14. None of the inventories is complete and some are rather inconsistent and unsystematic. There is scope for co-ordinating efforts and coming to an exchange of knowledge in the course of further inventory activities. Overseeing the work done, a number of possible conclusions are:

- a good and complete inventory is still to be made;
- only a limited number of good practical programs are (publicly) available;
- many "programs" have not developed far beyond the model and research stage and lack the necessary clarity and user-friendliness;
- there is much duplication and overlap;
- by far, most programs are on crop water requirements;
- there are very few good available canal programs; and there is hardly any publicly available canal management program;
- the real user needs must still be assessed, to make irrigation software more relevant and effective;
- case studies on practical applications are needed;
- there is a need for training of irrigation staff and professionals;
- in all respects, much more communication and co-ordination is needed between research, education and implementation institutions, as well as between software developers, so as to reduce overlap and to make software application more effective.

15. Most of these conclusions were already listed in the ILRI publication, and were supported by the ASCE, Montpellier, FAO-Rome meetings. This Workshop is an attempt to address various of these issues. At the same time it will, hopefully, be an effective contribution to more international co-ordination and collaboration.

16. It is noted that various institutions are now working, with varying intensities, on the preparation of an inventory. This concerns ILRI, ICID and Kassel. All of them are small, with limited time, money and manpower. Judging by the way things have been going so far, it is unlikely that either of these institutions will be able to produce a consistent and complete overview in the near future. A well-organized collaboration seems to be the only logical solution to this problem.

17. The three inventories use different media: ILRI works on a printed publication, a type of dissemination in which people are likely to remain interested. ICID concentrates on a database on diskette, while IRRISOFT is on the Internet. There seems to be no reason to prefer one medium or the other; all three have their own public and can live alongside each other happily.

18. ILRI is also working on a database of literature on irrigation software. IRRISOFT has started this as well. LOGID does not cover this aspect. Further collaboration between ILRI and IRRISOFT seems appropriate.

1.5 Workshop approach and follow-up

19. The workshop should specifically concentrate on practical irrigation software, and aim at co-ordinating and improving knowledge in this field. In line with the foregoing, the workshop therefore concentrated on improving the inventory and the criteria. In addition, it did:

- scrutinize available programs on certain subjects, in order to give recommendations for use or upgrading of certain programs and for further developments;
- draw conclusions and give recommendations on further actions in the various fields of interest.

20. Over the past few years, insufficient progress has been made on completing a systematic inventory. The few groups working on this issue are small; altogether only a few people are really involved and they can devote only part of their time to it. The same, and probably even more so, applies to the development of software criteria. All this is not very time- and cost-effective. Therefore, it seems appropriate that these institutions co-ordinate efforts and collaborate on these issues. The workshop addressed this collaboration, tried to identify various options, weighed their pro's and con's, their organizational, logistic, and financial implications, and, in the end, arrived at conclusions and clear recommendations.

For longer-term objectives and prospective it may be useful to refer to the groundwater circles, where there is an International Groundwater Modelling Center, which started making inventories and developing criteria. It now acts as a "evaluation, testing and clearing house" for groundwater models and programs.

21. Summarizing the above-mentioned points, in my opinion, the following subjects are to be addressed (see Annex 1 for the actual Workshop programme):

- Introduction - workshop scope and activities;
- Discussion of work done;
- Review of broad inventory; further approach:
  * categories and criteria for inclusion;
  * identify programs to include in various categories;
- Demonstration of IRRISOFT;
- Demonstration of LOGID;
- Presentation of upgraded ILRI inventory;
- Review of inventories per subject;
- Discussion on property and quality criteria:
  * general approach;
  * elaboration per subject;
- Demonstration of some programs;
  * BASDEV-FISDEV (basin-furrow irrigation);
  * FLUME (measurement structure);
  * CROPWAT-VisualBasic (old and new version);
  * SIC (old and new version);
- Discussion of possible further collaboration:
  * activities;
  * options;
  * implications;
  * recommendations;
- Summary, conclusions, recommendations, and arrangements.

1.6 Final remarks

22. We observed above that not much progress has been made in the development of irrigation software over the past years. It may be useful to discuss the reasons for this formulate recommendations to improve this situation.

23. In the discussions we should realize that the workshop participants may have different views on various subjects, as related to different interests and backgrounds. To name a few possible differences:

a. Model science or practical application? The workshop is not meant to contribute to further theoretical aspects of model development. We should not discuss theoretical model aspects. Its primary aim is the collection and dissemination of existing knowledge.
b. Who are our clients? In my view this would be the irrigation practitioners or program users: students, engineers, consultants, managers, and not the scientists or program developers.
c. Public service or commercial platform? Related to the foregoing: the inventory is meant to be a public service - making available our knowledge to a wider public - rather than a platform to promote the sale of some programs.

d. Professional objectivity or commercial subjectivity? Some texts about certain programs resemble washing-powder advertisements. Naturally we prefer the provision of objective and relevant professional information;
e. Specific interests of own institute. Of course, every institution has its own interests in contributing to the subject. This is perfectly understandable and should be taken into account, if possible without violating the previous points.
f. Irrigation experts or computer freaks? (an important source of confusion). There seems to be a tendency with some people to be more interested in aspects of advanced computer techniques rather than in practical applications to solve irrigation problems. The marriage of the two would be nice, but the irrigation expert should be the head of the family.

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Chapter 2

IRRISOFT - A WorldWide Web Database on Irrigation and Hydrology Software [1])

Th.-M. Stein (University of Kassel)

2.1 Introduction

The "information world" is dramatically changing as electronic means of accessing information are rapidly gaining importance. Not only has the desktop PC revolutionised information processing and handling, but the enormous growth of the Internet has increased the speed of international and intercontinental information exchange.

The Internet, often called the Network of the networks, is growing exponentially. According to Logan (1995), it is estimated to reach 100 million users by the year 1998. The WorldWide Web especially, with its user-friendly interface, forms an important base of information in the Internet. According to Lycos (1996), approximately 18 million unique URLs (URL stands for "Uniform Resource Locator") have been registered and indexed according to their type and context (January 5, 1996 catalogue). Lycos holds the largest Internet catalogue and is claimed to include 91 % of the WorldWide Web sources.

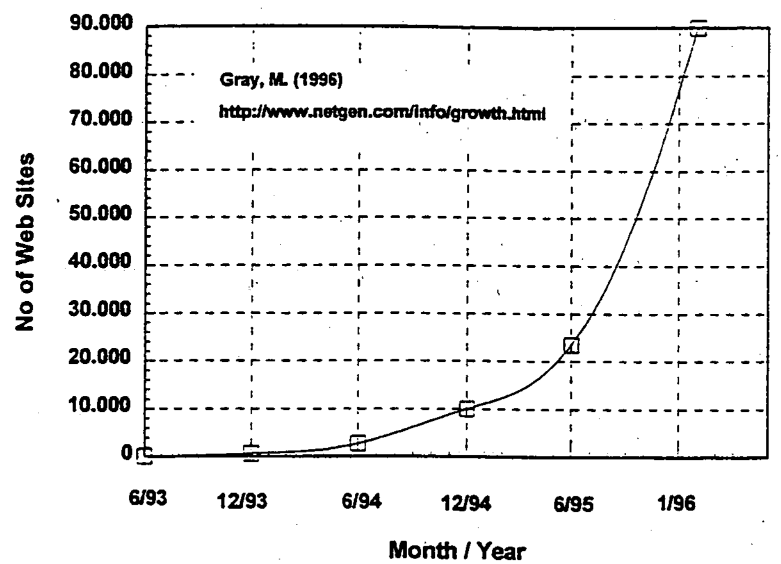

Figure 2.1: The worldwide growth of web sites form June 1993 till January 1996. Graph created with data published by Gray (1996)

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1 Article has been submitted also for publication in "Zeitschrift für Bewässerungswirtschaft"

The latest figures published by Gray (1995) demonstrate the exponential growth of the number of web sites in the world. As shown in Figure 2.1, the number of WorldWide Web servers has nearly quadrupled form 23 500 to 90 000 during in seven months.

The Internet and its powerful tools cannot be ignored anymore. Especially during the last two years, the WorldWide Web has established itself as a widely accepted means of information provision. Together with the other Internet services (E-mail, ftp, gopher and telnet), they form an important base for scientific and practical discussions and exchanges.

These modern technologies for bringing information on irrigation and hydrology software to the end-user and their potential as discussion platform are discussed below.

2.2 The IRRISOFT database

IRRISOFT is a database which provides information on irrigation and hydrology software. In addition, metalinks to servers containing the software packages and further information are included (Stein, 1996). As a WorldWide Web Database, it adds to the traditional sources of information by incorporating other Internet services, so that a broad base for efficient information exchange and discussions is formed.

The objectives of IRRISOFT are to give an overview of irrigation and hydrology programs available and to facilitate the retrieval and distribution of the software. The latter is done by establishing download or E-mail order facilities via the WorldWide Web. Numerous irrigation and hydrology programs have been written by individuals, groups or companies and are available as public domain, shareware or commercial software. However, there is still a lack of easy and efficient information exchange about products and new developments. This situation will be improved by the IRRISOFT system. Beside information and software retrieval, IRRISOFT goes beyond the traditional forms of information exchange and aims at the incorporation of discussion and feedback mechanisms. Besides this maintenance and support service, IRRISOFT allows the inclusion of knowledge and experience of a broad group of practitioners and scientists working in the area of irrigation and hydrology. This may be achieved through E-mail postings on WorldWide Web bulletin boards and discussion lists like IRRIGATION-L.

2.3 The development of IRRISOFT

IRRISOFT was launched on the web in summer 1995. It was announced in the major technical Internet discussion lists like IRRIGATION-L, TRICKLE-L and AGRIC-L. Since then, links have been included in several technically-related servers like AGRIGATOR, DAINet, the Virtual Library IRRIGATION, and other government and commercial servers. Also the information on IRRISOFT is included in several general world Internet catalogues like YAHOO or Lycos.

The IRRISOFT System is located at the University of Kassel and is maintained by the

Department of Rural Engineering and Natural Resource Protection. It started with a few Software Description Pages (SDP). Since then it has been steadily growing, reaching more than 75 software or model descriptions at the end of 1995. The service has been extended to include download facilities by the addition of the IRRISOFT aFTP-server (aFTP). A news section, an irrigation and hydrology software bibliography and a section on other related servers have been created and opened to the public.

IRRISOFT is frequently being accessed, reaching more than 100 different external servers (clients) per day. Every server accessing IRRISOFT generally reads between four and eight pages, which means that the information from approximately 400 to 800 pages is being transferred per day.

2.4 Structure of IRRISOFT

2.4.1 IRRISOFT servers and services

The IRRISOFT system is basically structured into three main servers or services which are shown graphically in Figure 2.2.

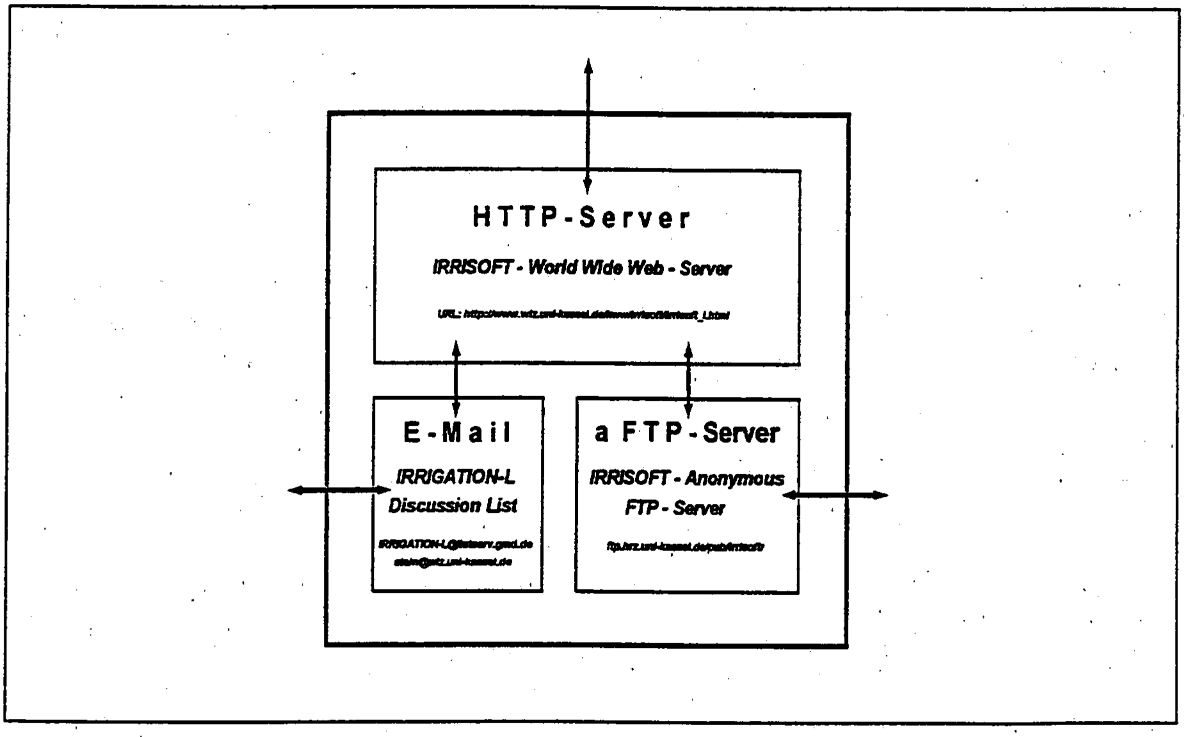

Figure 2.2: IRRISOFT structure in relation to the server and services provided. Main directions of access and information flow into, out of and inside IRRISOFT.

The http-server or WorldWide Web server forms the base of IRRISOFT holding the main database information and interconnecting the three systems via a single user interface. It also forms the main gateway between IRRISOFT and the external world. The IRRISOFT server may be reached through the following URL:

http://www.wiz.uni-kassel.de/kww/irrisoft/irrisoft_i.html

or also via http://ilri.nl/irrisoft.html

The IRRISOFT - aFTP - server is used to store software packages and demonstration programs, which have been released to the public by the authors of the programs. Additional information, like documentation, stored in a non-html-format may be grouped with the corresponding software packages. All entries are directly accessible through the main IRRISOFT-WWW server. In addition, the aFTP-server may be reached by regular ftp (file transmission protocol). This is the only way of uploading software. Downloading known programs may be done by ftp or by using a WorldWide Web browser through the IRRISOFT pages. The address of the aFTP-server is: ftp.hrz.uni-kassel.de/pub/irrisoft/

The third IRRISOFT component is the information exchange and discussion component based on E-mail facilities (named "E-Mail" in Figure 2.2). This has been implemented by adding "mailing buttons" to every information source, which allows a user to contact the responsible person or support service of the corresponding software package. Furthermore, direct links are provided to contact the IRRISOFT administration from every page in IRRISOFT. A special bulletin section has been implemented to allow the posting of questions or information on the WorldWide Web page via the IRRISOFT administration. A direct automatic posting in the WorldWide Web, similar to that implemented in "news groups", will be implemented in the future. This will supplement the already existing E-mail discussion list IRRIGATION-L on irrigation and hydrology topics. Links for direct subscription to IRRIGATION-L have already been implemented.

2.4.2 Database structure and information flow

IRRISOFT is a WorldWide Web hypertext and hypermedia-based database, which allows the combination and linking of different types of information (like documents, graphics, demos etc.) from different sources into one document. Since it is permanently linked to the Internet and its different resources, the information provided does not necessarily have to be physically stored on the same server and type of server (http, gopher, ftp, etc.). This has the great advantage of allowing diverse types of information to be accessed; it also allows the major part of the information to be stored where it is produced and maintained. Information can be updated as and when necessary. This ensures a high degree of actuality and minimum time delay in the presentation of new results and updates in the database. The database structure, therefore, is dynamic: it is steadily changing and modifying its sources and appearance according to the actual needs and developments.

The main source of information of IRRISOFT are the Software Description Pages (SDP), which exist for every software package and include INFORMATION and LINKS to the corresponding local or external servers (where available). These SDP have been elaborated to give the maximum information in a concise format, which allows a good overview and supports purchasing decisions. SDP's are designed to be an open system allowing the inclusion of additional information and links. This extra information may be stored locally on the IRRISOFT servers (www, ftp) and/or externally on other providers' servers (www, gopher, ftp).

Storing information and programs locally on the IRRISOFT Servers as well as on external servers may seem to be a duplicate effort. But experience has shown that it is useful to keep information both stored locally as well as available from external sources. External servers may be down and inaccessible or the information transfer across continents may take a long time during busy hours. Splitting and partly doubling (mirroring) information and software download facilities improve the accessibility of information.

Having "dialled" into IRRISOFT, the user may stay on that server getting all the basic information he needs and he may then switch to the corresponding external server for extra or more detailed information or contacts. Even in the case of an external server failure, IRRISOFT should still hold enough information to allow informed decisions to be made by users and to provide traditional contact information (mail, fax, phone) as well as E-mail addresses and facilities.

Besides the pure information retrieval software, download facilities play a major role in the IRRISOFT concept. Establishing download facilities has the great advantage of supplying irrigation and hydrology software in a convenient, fast and cost-effective way. Not only the time saved by directly downloading software should be taken into account, but also the possible difficulties of transferring software on floppy disks across continents (e.g. to some developing countries). Offering downloadable software may well turn out to be more cost-effective, because packing, copying and handling costs are reduced to a minimum. Time saved may be invested in support and updates.

The IRRISOFT database is generally accessed through the IRRISOFT Main Page which contains all relevant starting information and links to different information and services provided. The general IRRISOFT structure, including the main information sources and directions of information flow, is shown in Figure 2.3. Only the most important sources and links have been listed. The hypertext-based structure of the WorldWide Web server allows numerous external and internal cross-links to any particular document. Less important links and information have been omitted in Figure 2.3 in order to emphasize the main structure.

The Main Page is divided into six sections, according to the type of information stored:

- The 'General Information' Section
  containing all relevant information on IRRISOFT, its administration, objectives and descriptions of how the information sources have been collected and compiled.

- The 'Irrigation and Hydrology Software NEWS' Section
  which holds information and links on subject related events like congresses, conferences or workshops or other important news like software updates, new developments, etc.

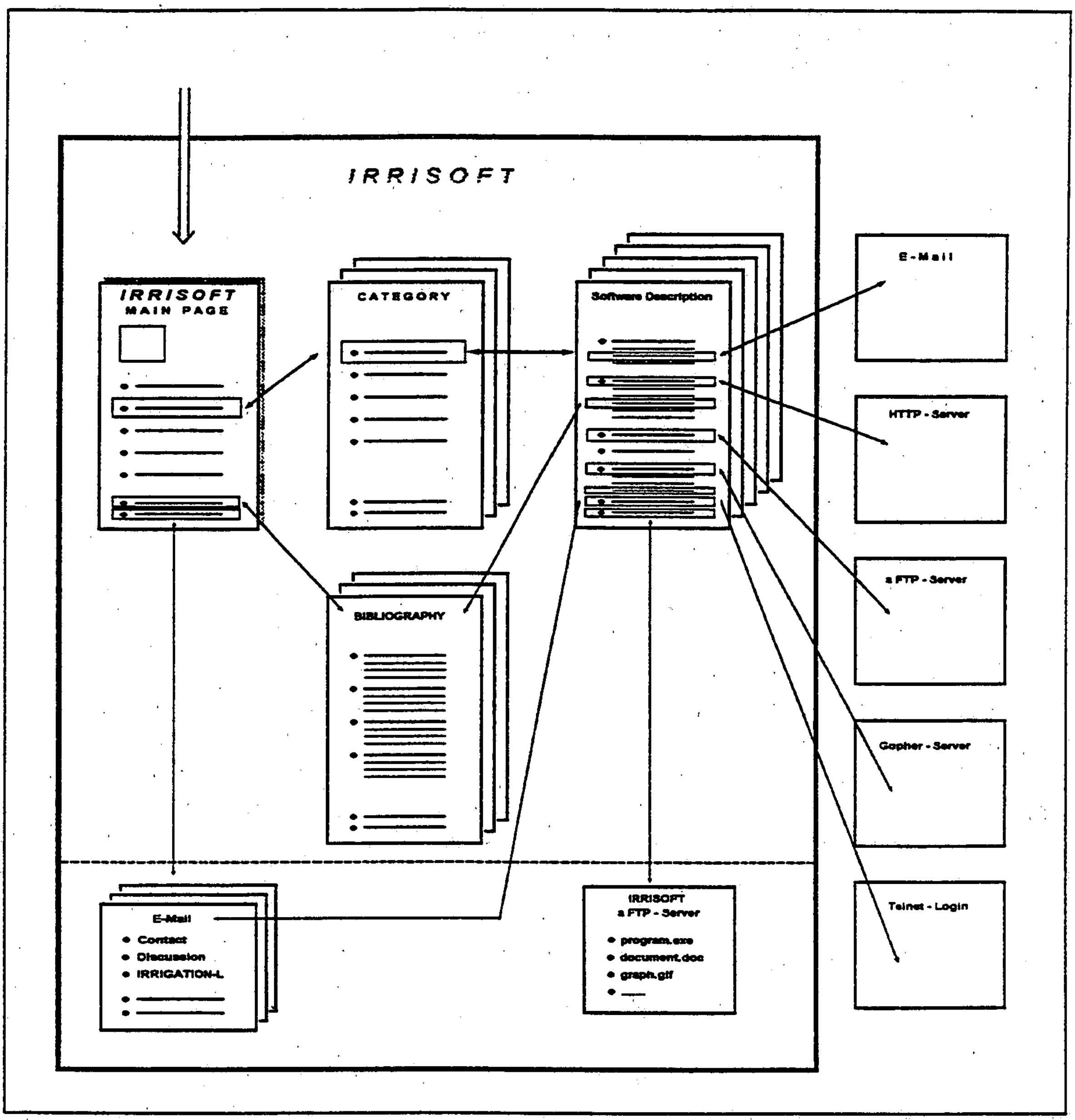

Figure 2.3: IRRISOFT information structure including primary links and interactions to internal and external sources and services.

- <u>The 'Software Index' Section</u>
  contains a thematic index of the main data sources stored in IRRISOFT. The index presently leads to eleven different pages which contain alphabetical lists of programs stored under their respective categories. Every software name is included with a brief description to allow a better pre-selection. The main categories of IRRISOFT are:

- Irrigation Systems Programs
- Surface Irrigation Programs
- Sprinkler Irrigation Programs
- Drip / Trickle Irrigation Programs
- Canals and Canal Network Programs
- Pipes, Pipe Network and Pumping Programs
- Hydraulic Structure Programs
- Irrigation Management Programs
- Drainage Programs
- Other Irrigation Programs
- Hydrology Programs

These categories are dynamic as they may be supplemented and modified in response to future developments and needs.

- The 'Additional Software Information' Section
  leads to information and links related to the database development. It allows a user to read lists of programs under development and to get information on submission of new programs to IRRISOFT. Furthermore, it leads to a locally stored Irrigation and Hydrology Software Bibliography.

- The 'Other Servers with related information' Section
  allows users to contact other servers holding thematic information or to access the IRRISOFT aFTP server.

- The 'Discussion' Section
  forms the IRRISOFT discussion platform allowing the direct exchange of information between users. Questions, problems and experiences related to irrigation and hydrology software may be posted and discussed on the IRRISOFT pages or through linked mail discussion services. This section has been partly implemented already, allowing the subscription to the discussion list IRRIGATION-L and the posting of messages on the web through E-mail directed to the IRRISOFT administration.

2.4.3 Software categories

The software has been classified according to its purpose into eleven categories, listed above. Taking into account the structure of the WorldWide Web and expected user preferences, the categories have not been implemented strictly hierarchically. A "flatter" structure has been favoured by putting categories on the same level rather than adding deep-structured trees. Additional sub-classifications have thus been omitted deliberately, thereby preventing the users from getting lost in the links, back-links and cross-links of a WorldWide Web server. This allows a reduced number of pages to be loaded before reaching the final Software Description Page.

Different structural systems may have to be implemented with growing numbers of software packages listed. Reference is made to Benz and Voight (1995a, 1995b), who have shown effective ways of indexing file systems for the implementation of search interfaces on WorldWide Web databases.

2.4.4 Structure of the Software Description Pages (SDP)

The IRRISOFT software information is based on Software Description Pages (SDP) which have been compiled for every listed program. They have been designed to give the maximum information in the concise form of one page. Besides traditional types of printable information, additional meta-information like links to local and external server, mailing "buttons", download facilities have been included. A graphical overview of possible and implemented links is shown in Figure 2.2.

The structure of the Software Description Pages has been undergoing gradual modification in order to improve the presentation of information. The information structure allows the supply of large amounts of information, while still making local and external extensions possible. The chosen structure with a short description of every topic is shown in Table 1 below.

2.5 Conclusions and outlook

There is a considerable interest all over the world in sharing information on irrigation and hydrology software through the WorldWide Web. IRRISOFT has shown the potential of offering this service by combining traditional types of information with web-specific meta-information. It may, therefore, become a gateway for information and software exchange by bringing together software providers and end-users in an expected time- and cost-efficient way.

Looking at possible future developments, IRRISOFT will surely undergo structural, management and information changes brought about by the rapid changes on the Internet scene. This probably means that IRRISOFT will have to adopt other retrieval systems based on searchable indices. Generally speaking, the work-load will increase with the growing acceptance of the new database. Other management and co-operation strategies will have to be introduced.

From the software developers' point of view, changes will be necessary in the way products are marketed and distributed. The software development industry has to adapt to new methods of software distribution and management, which are already quite common in other parts of the software scene. This may be done, e.g., by implementing software keys, which allow a free distribution of "locked" software packages over the net. After free testing of restricted versions, users can register with the software producer and the program may be unlocked to its full functionality by purchasing its key.

Table 2.1: Structure of the Software Description Page for programs listed in IRRISOFT

	Topic	Topic Description
1	**Name**	SOFTWARE NAME
2	**Keywords**	Keywords describing the software package like: *Irrigation, design, management, etc.*
3	**Categories**	Main- and Sub-Categories *for the classification of the software packages. This section is mainly for future developments in the implementation of searchable indices.*
4	**Contact**	Contact Person: *Name, Mail Address, Telephone, Facsimile, Telex, E-Mail and URL.*
5	**Abstract**	Abstract: *A clear and precise description of the software functions and abilities. This section may contain further information by incorporating linked pages for explanatory notes.* Author of the Abstract: *Name, Institute or Company, E-mail*
6	**On-line Information, Purchase, Download**	All additional available on-line information including internal and external links: *Features, Functions, Screen shots.* *Software price list* *Software purchase.* *Software download facilities.*
7	**Model Description**	A model description verification.
8	**Application Criteria**	Target Group: *For whom this program is designed.* User Application Level / Knowledge: *Background information needed to run this program.* Program / Application Limitations: *This program is not meant to be used for / by ...*
9	**System Requirements**	Software Hardware
10	**Source-code**	Source code used: *Programming language used.* *Availability of source code.*
11	**Price**	Price and Maintenance
12	**Other**	Other types of information: *Time scale.* *Software use.* *Software environment.* *Unit system.* *Date of current version.* *Working language.* *The program contains...* *On-line help and functions.*
13	**Documentation/ Literature**	Documentation accompanying the program and references describing the software package or its model sources.

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Chapter 3

LOGID, A DATABASE DISKETTE FOR IRRIGATION, DRAINAGE, AND FLOOD CONTROL SOFTWARE

Gilles Bonnet (CEMAGREF/ICID)

3.1 Introduction

The International Commission on Irrigation and Drainage (ICID) recognized the importance of computer assistance in irrigation, drainage, and flood control a long time ago. They also saw it as one of their tasks to provide member countries with as much relevant information as possible on the subject, and therefore installed a Working Group on Systems Analysis. One of the tasks of this working group was to collect and disseminate information on the use of systems analysis, and more in particular the use of computer-based technology, in irrigation and drainage among member countries.

This is the short background of the existence of a database on diskette of a wide range of computer models and programs (178 in the latest update of November 1994). The information about the programs was initially collected from ICID member countries using a questionnaire in a specific format. The current shape of the form is treated in Section 3.3 below. The forms were returned to CEMAGREF (Centre d'Etude du Machinisme Agricole, du Génie Rural, des Eaux et des Forêts), where the Secretary of the working group resides. The data were then entered in a database (using dBase III), while a standard list of qualifications and terminology was adhered to as much as possible. The initially limited database was extended over the last few years with information from other sources, such as institutions and private persons, so as to be able to make the database as complete as possible.

The current policy is to distribute the LOGID disk as widely as possible and request users to append as much information as possible, and return the updated disk to CEMAGREF, for the attention of the present author (see address in Annex 2).

3.2 Running LOGID

The LOGID database (dated November 1994) is supplied on a 3.5" 720 kB diskette and takes a total of 581 kB in 16 files. There are four *.bat files, including an install.bat file for installation to the C:-drive and a logid.bat file for starting the program. There are eight *.dbf or *.dbt files, which form the core database, together with two index files (*.ndx). The running of the program is done through the logiciel.exe file. Note that LOGID is an abbreviation of the French word LOGiciel, combined with the I for Irrigation and the D for Drainage. The program will run on an IBM PC XT/AT or PS/2 compatible microcomputer under the MS-DOS operating system.

Installation is simply done by putting the diskette in an appropriate floppy disk drive, and typing A:install at the C:-prompt and [Enter]. This action will create a C:\LOGID directory and copy all files thereto. So, next you go to directory C:\LOGID and type logid to start the program. The database management system's Main menu will now be displayed, which looks as shown in Figure 3.1.

```
=====================Possible choices=====================
Exit from LOGID to MS-DOS ----------------------------------> X
Introducing a new file into the data base -----------------> I
Read files from the data base -----------------------------> R
Change data in a file -------------------------------------> C
Keyword list ----------------------------------------------> K
Erase a file from the data base ---------------------------> E
Affichage des écrans, messages et aide en français --------> A
===Only one screen===
To select press the 1st letter of a line or the arrow keys and RETURN
```

Figure 3.1 The Main menu of the LOGID program

If you have a colour monitor, the selected item is shown in green characters on a red background. Other possible choices are in white letters on a light-grey background. Non-usable choices are in dark-grey against a light-grey background. On a black-and-white monitor these colours will be in different shades of grey only. Note that the 7th choice allows you to switch from English to French and vice-versa.

The Main menu allows you primarily to choose between entering a new record (or file; i.e. describing a new program), reading, or editing, or erasing existing entries or going to the keyword list.

In case you want to read from the database, you will get another menu with six choices, as shown in Figure 3.2.

```
=====================Possible choices=====================
End of consultation/Return to previous menu----------------> E
Name: Select a software knowing its name ------------------> N
Field: Select a software from a field ---------------------> F
Topic: Select from a topic within a field -----------------> T
Complete programs list ------------------------------------> C
Affichage des écrans, messages et aide en français --------> A
===Only one screen===
```

Figure 3.2 The Read sub-menu of LOGID

The complete list of programs can be shown on screen (see also Table 3.1).

Table 3.1 The software list in LOGID as per November 1994

Software name	Country	I/D/F	Theme
AAD MODELING SYSTEM	NETHERLANDS	I	Irrigation management
ADIMO	NETHERLANDS	I	Water requirements
AGNPS	USA	D	Simulation
AGREGA	PORTUGAL	I	Irrigation management
AGWAT	NETHERLANDS	I	Water requirements
AQUIFER MODEL	UNITED KINGDOM	D	Simulation
ASTRHYD	FRANCE	I	Irrigation management
BACKWAT	UNITED KINGDOM	F	Open channel flow
BAHIA	FRANCE	I	Open channel flow
BAHIDIA	ARGENTINA	I	Irrigation management
BALANCE	BULGARIA	I	Irrigation scheduling
BALLISTIC TRAJECTORY	BRAZIL	I	Sprinkler irrigation
BASCAD 2.0	NETHERLANDS	I	Reservoir management
BCW	USA	I	Open channel flow
BEL	FRANCE	I	Water hammer
BICADM	AUSTRALIA	I	Border irrigation
BIDRICO	ITALY	I	Soil-water model
BILAN HYDRIQUE PRAIR	BELGIQUE	I	Irrigation management
BILANREG	FRANCE	I	Water requirements
BUCKL	JAPAN	I	Water requirements
BYM	FRANCE	I	Soil-water model
CALDERIN	ESPAGNE	I	Pumping station
CALPIV	FRANCE	I	Sprinkler irrigation
CALSITE	UNITED KINGDOM	I	Reservoir sedimentation
CANAL9	FRANCE	I	Open channel flow
CANAL_D	USA	I	Open channel flow
CATCH-3D	USA	I	Sprinkler irrigation
CEBELMAIL	FRANCE	I	Pressurized network
CERES	FRANCE	F	Flood routing
CERES-MILLET	USA	I	Soil-water model
CIRCHAN	ESPAGNE	I	Semi-circular canal
CLIMWAT	ITALY	I	Water requirements
CMMSWICG	PAKISTAN	I	Irrigation scheduling
COUP	UNITED KINGDOM	I	Water hammer
CRIWAR 2.0	NETHERLANDS	I	Water balance
CROPWAT	ITALY	I	Irrigation scheduling
CRPSM	USA	I	Irrigation management
CRUE	FRANCE	I	Peak flood modelling
DACCORD	FRANCE	D	Drainage network
DACSE	UNITED KINGDOM	I	Sediment control
DAMBRK UK	UNITED KINGDOM	F	Dam break
DELPAR	NETHERLANDS	I	Hydrology
DELTA2	PAKISTAN	I	Water requirements
DELWAQ	NETHERLANDS	I	Water quality
DEMAND	MOROCCO	I	Irrigation management
DEMGEN	NETHERLANDS	D	Simulation
DEVER	FRANCE	F	Open channel flow
DIGIT	UNITED KINGDOM	I	Hydrology
DORC	UNITED KINGDOM	I	Regime canals
DOSSBAS	UNITED KINGDOM	I	Sediment control
DRAINAGE	FRANCE	D	Drainage network
DRAINET_C	GERMANY	D	Simulation
DRAINSAL	INDIA	D	Simulation
ECOSYS	CANADA	I	Irrigation management
EVAPOTRANSPIRATION	BRAZIL	I	Hydrology
FASTQUOTE	NEW ZEALAND	I	Irrigation design
FLD_BOX	CANADA	D	Passe mare
FLUME 3.0	NETHERLANDS	I	Hydrology
FRQSIM	UNITED KINGDOM	F	Urban hydrology

Table 3.1 (Ctd.)

Software name	Country	I/D/F	Theme
GEOCUP	JAPAN	I	Earthen dams
GESREG	PORTUGAL	I	Irrigation management
GESTIO	FRANCE	I	River training
GLYCIM	USA	I	Soil-climate-crop model
GRASPER	MOROCCO	I	Irrigation management
HSPF	USA	D	Simulation
HYDRA	FRANCE	D	Drainage network
HYDRAN	UNITED KINGDOM	I	Pressurized network
HYDRO_ID	UNITED KINGDOM	I	Open channel flow
HYDSYS FOR DRAINAGE	CANADA	D	Drainage network
HYMOS	NETHERLANDS	I	Hydrometeorology
IBMR	PAKISTAN	I	Irrigation planning
ICARE	FRANCE	I	Pressurized network
IMPACT	UNITED KINGDOM	I	Impact study
IMS	UNITED KINGDOM	I	Irrigation management
INCA	UNITED KINGDOM	I	Irrigation management
IRR-TIME	NETHERLANDS	I	Irrigation management
IRRICAD	ITALY	I	Pressurized network
IRRICAD5	NEW ZEALAND	I	Irrigation design
IRRICANE III	LA REUNION	I	Irrigation management
IRRICEP	PORTUGAL	I	Gravity network
IRRIGATION SCHEDULIN	UNITED KINGDOM	I	Irrigation management
IRRIGATION WATER REQ	BRASIL	I	Evapotranspiration
IRRIMOD	INDIA	I	Evapotranspiration
IRRISKED	USA	I	Irrigation scheduling
IRRITEL	FRANCE	I	Irrigation management
ISAREG	PORTUGAL	I	Irrigation management
L&W TOOLKIT	NETHERLANDS	I	Irrigation management
LIDO	FRANCE	I	Open channel flow
LINMOD	NETHERLANDS	D	Simulation
LOGDOS	NETHERLANDS	I	Hydrometeorology
LOGIDRAIN	FRANCE	D	Drainage system
MACRA	COLOMBIE	I	Evapotranspiration
MBAL	UNITED KINGDOM	I	Soil-climate-crop model
MECENE	FRANCE	I	Economy
MICRO DRAINAGE	UNITED KINGDOM	D	Drainage system
MICROFLUCOMP	UNITED KINGDOM	F	Open channel flow
MIDAS	UNITED KINGDOM	I	Gravity irrigation
MIKE11	DENMARK	I	Gravity network
MIS	USA	I	Irrigation management
MODFLOW+MODGRID	NETHERLANDS	D	Groundwater flow
MONFLOW	CANADA	I	Hydrology
MRI	PAKISTAN	I	Irrigation scheduling
MUST	NETHERLANDS	I	Soil-climate-crop model
NORMA	BULGARIA	I	Water requirements
OMIS	NETHERLANDS	I	Irrigation management
ONDA	UNITED KINGDOM	I	Open channel flow
OPUS	USA	I	Soil-water model
ORIGINAL PENMAN MODE	UNITED KINGDOM	I	Irrigation management
PARADIGM	UNITED KINGDOM	I	Probable rainfall
PB2DIAM	FRANCE	I	Micro-irrigation
PC-CANDES	NETHERLANDS	I	Open channel flow
PCET	USA	I	Irrigation management
PECARI	FRANCE	I	Pressurized network
PENMET 3	BRAZIL	I	Irrigation management
PIMAG	MORROCO	I	Irrigation management
POETICS	JAPAN	I	Earthen dams
POLICORO	ITALY	I	Soil-water model
PROCANAL	BRASIL	I	Gravity irrigation
PROFILE	NETHERLANDS	I	Open channel flow

Table 3.1 (Ctd.)

Software name	Country	I/D/F	Theme
QEST	CANADA	I	Hydrology
RAHYSMOD	NETHERLANDS	I	Soil-water model
RAIEOPT	FRANCE	I	Gravity irrigation
RAMI	FRANCE	I	Pressurized network
RAMIF1	MOROCCO	I	Pressurized network
RBM_DOGGS	UNITED KINGDOM	F	Flood routing
REF-ET	USA	I	Evapotranspiration
RELREG	PORTUGAL	I	Irrigation management
RESOP	CANADA	I	Irrigation management
RESPONSE FUNCTIONS	BRASIL	I	Irrigation management
RG	ESPAGNE	I	Pressurized network
RIBASIM	NETHERLANDS	I	River basin hydrology
RM4S	JAPAN	I	Resistance modelling
SALCON	NETHERLANDS	D	Groundwater flow
SALMON-F	UNITED KINGDOM	F	Open channel flow
SALTMOD	NETHERLANDS	I	Soil-water model
SATEM 1.4	NETHERLANDS	D	Simulation
SCAL	ESPAGNE	I	Micro-irrigation
SGMP 2.1	NETHERLANDS	D	Simulation
SIC	FRANCE	I	Open channel flow
SIDRA	FRANCE	D	Simulation
SIMIS	ITALY	I	Irrigation scheduling
SIMTHEO	BRASIL	I	Soil-climate-crop model
SIRFRU	ITALY	I	Irrigation management
SIRMOD	USA	I	Surface irrigation
SOILWAT	HUNGARY	I	Irrigation management
SOILWAT-I	HUNGARY	I	Hydrology
SOWABAMO	ITALY	I	Soil-water model
SPRINKPAC	NEW ZEALAND	I	Irrigation design
SPRINKSIM	USA	I	Pressurized network
STAB	FRANCE	I	Earthen dams
STC25	UNITED KINGDOM	D	Drainage network
STEADY	USA	I	Open channel flow
STORMPAC	UNITED KINGDOM	D	Simulation
SURVEY	FRANCE	F	Flood mitigation
SWACROP	PAKISTAN	I	Soil-water model
SWATRE/SWACROP	NETHERLANDS	I	Soil-water model
SWATRER-SUCROS	BELGIQUE	I	Soil-climate-crop model
SWATRES/SWACROP	NETHERLANDS	I	Soil-climate-crop model
SWIMM	UNITED KINGDOM	I	Reservoir sedimentation
TALWEG-FLUVIA	FRANCE	F	Open channel flow
TARCOMP	NETHERLANDS	I	River basin management
THALIE	FRANCE	I	Hydrometric network
TURGAP	GERMANY	I	Irrigation planning
USUPIVOT	USA	I	Center pivot
UTAHET	USA	I	Irrigation management
VERIP	FRANCE	I	Sprinkler irrigation
VERITAS	FRANCE	I	Sprinkler irrigation
VIDEOTEL IRR. MODEL	ITALY	I	Irrigation scheduling
WALLING.SYS.FOR DRAI	UNITED KINGDOM	D	Simulation
WASAM	NETHERLANDS	I	Irrigation management
WATER BALANCE MODEL	BRASIL	I	Soil-climate-crop model
WATER DISTRIBUTION	BRASIL	I	Irrigation management
WATER USE MOD	USA	I	Evapotranspiration
WBT	USA	I	Irrigation management
WIS	UNITED KINGDOM	I	Hydrology
WRMM	CANADA	I	Irrigation scheduling
XERXES-RENFORS	FRANCE	I	Pressurized network
YIELD	BULGARIA	I	Soil-water model

You can view information about any program in the database by selecting its name from any of three lists:
(i) by program name, from an alphabetical list (see Table 3.1);
(ii) by field of interest (Irrigation, Drainage, or Flood control);
(iii) by subject/keyword within a field, an example of which is shown in Figure 3.3.

```
══════Keyword══════
End of consultation
Network  (gravity)
Network (under pressure)
Irrigation planning
Dam (earth)
Pumping station
Micro-irrigation
Overhead irrigation
Water hammer
Water requirements
Hydrology
Irrigation scheduling
Sprinkler
Soil-water model
Evapotranspiration
Open channel flow
Surface irrigation
Resistivity modeling
═══Many screens═══
```

Figure 3.3 LOGID's keyword list for irrigation

If you choose to change data in a file, you may do so for your own use. To communicate the changes to us, it would be better to to create a new entry, mentioning that this is a new version of the program, and send us the complete disk (including the changes).

To enter a new program into the database, follow the menu and answer the questions from four screens. These screens correspond with the forms which were sent to the member countries, which are mentioned below. The most important item to fill in is your short description (on screen 3) of the aims and methodology of the program you are entering (a maximum of 20 lines of text). You can also, if necessary, enter new keywords for any of the three fields (I/D/F), provided you know the French translation.

3.3 Forms for LOGID entries

As mentioned above, the basic information for the LOGID database was collected via four structured forms. These forms are reproduced on the next few pages as Figure 3.3. It can be seen that the requested information falls into a number of classes or categories. After specifying the name and the purpose of the program, hardware requirements, software aspects, user aspects, keywords, functional description, and software marketing appear.

Figure 3.4 Basic forms for the LOGID database

Formulaire pour la base de données LOGID / Form for Data Base LOGID

Remplir les cases larges, cochez les cases étroites/Fill in wide squares, check off narrow squares

Nom du logiciel [ ] **Title of the software**

Fonction [ ] Purpose

Français	English
Matériel	**Hardware needed**
Grand système	Main frame
Mini ordinateur	Mini computer
Micro-ordinateur compatible IBM-PC	IBM-PC compatible micro-computer
Autre micro-ordinateur	Other micro-computer
Système d'exploitation	**Operating system**
Système d'exploitation spécial	Specific Operating system
MS/DOS 2.xx et suiv	MS/DOS 2.xx and seq.
MS/DOS 3.xx et suiv	MS/DOS 3.xx and seq
OS/2 et P.M	OS/2 and P.M
Système UNIX	UNIX system
Mémoire centrale	**Main storage**
256 kilo-octets	256 kilo-bytes
512 kilo-octets	512 kilo-bytes
640 kilo-octets	640 kilo-bytes
1 méga-octets	1 mega-bytes
2 méga-octets	2 méga-bytes
+ de 2 méga-octets	+ 2 mega-bytes
Disque dur	**Hard disk**
<=20 Mo	<=20 Mo
<= 100 Mo	<= 100 Mo
> 100 Mo	> 100 Mo
Disquette	**Floppy disk**
Inutile	Useless
5,25' 360 Ko	5.25'360 Ko
5,25' 1,2 Mo	5.25' 1.2 Mo
3,5' 720 Ko	3.5' 720 Ko
3,5' 1,44 Mo	3.5' 1.44 Mo
Format spécial	Special format
Bande magnétique	**Magnetic tape**
Inutile	useless
Format spécial	Special format
1600 bpi	1600 bpi
6250 bpi	6250 bpi
Contrôleur d'écran	**Display Controller**
Standard	Standard
Spéciale	Specific
EGA	EGA
VGA	VGA
HERCULES	HERCULES
Moniteur	**Display unit**
Monochrome	Monochrom
Couleur	Color
Haute résolution	High resolution
Multi-fréquence	Multi-synchronism
Imprimante	**Printer**
Standard	Standard
Laser	Laser
Graphique	Graphic
Graphique large	Wide graphic
Numériseur	**Scanner**
Inutile	Useless

Figure 3.4 (Ctd.)

Formulaire pour la base de données LOGID / Form for Data Base LOGID

Remplir les cases larges, cochez les cases étroites/Fill in wide squares, check off narrow squares

Français		English
Numériseur couleur	[ ]	Color scanner
Numériseur monochrome (grisés)	[ ]	Monochrom scanner (grey scale)
Traceur		**Plotter**
Inutile	[ ]	Useless
Traceur de table	[ ]	Flat bed plotter
Traceur à rouleau	[ ]	Roller plotter
Traceur électrostatique	[ ]	Electrostatic plotter
Digitaliseur		**Digitiser**
Sans objet ou inutile	[ ]	Groundless or useless
Utilisé si présent (optionnel)	[ ]	Used if present (optional)
Indispensable	[ ]	Required(absolutely necessary)
Processeur arithmétique		**Mathematical processor**
Sans objet ou inutile	[ ]	Groundless or useless
Utilisé si présent (optionnel)	[ ]	Used if present (optional)
Indispensable	[ ]	Required(absolutely necessary)
Souris		**Mouse**
Sans objet ou inutile	[ ]	Groundless or useless
Utilisé si présent (optionnel)	[ ]	Used if present (optional)
Indispensable	[ ]	Required(absolutely necessary)
Dispositif de protection		**Copy protection**
Le logiciel n'est pas protégé	[ ]	The software isn't protected
Protection par clef ou bouchon	[ ]	Protection by key
Protection par un mot de passe	[ ]	Protection by keyword
Autre dispositif de protection	[ ]	Other means of protection
Langage(s) de programmation		**Programming language(s)**
FORTRAN	[ ]	FORTRAN
BASIC	[ ]	BASIC
PASCAL	[ ]	PASCAL
DBASE III	[ ]	DBASE III
C	[ ]	C
Plusieurs langages de programmation	[ ]	Several programming languages
La fourniture du logiciel comprend		**Provided software includes**
Uniquement un code exécutable	[ ]	Only an executable code
Uniquement le code source	[ ]	Only the source language
A la fois code source et exécutable	[ ]	Both source and executable code
L'échelle de temps est		**Time scale is**
Sans objet	[ ]	Groundless
Années	[ ]	Years
Saison	[ ]	Season
Mois	[ ]	Months
Jours	[ ]	Days
Heures	[ ]	Hours
Minutes	[ ]	Minutes
Validation du modèle vis à vis de		**Model has been verified against**
Solutions analytiques	[ ]	Analytical solutions
Autres programmes	[ ]	Other programs
Mesures et/ou observations	[ ]	Measurements
Autres formes de vérification	[ ]	Other forms of verification
Utilisation		**Software use**
Traitement par lot	[ ]	Batch mode
Logiciel conversationnel	[ ]	Interactive mode
Environnement logiciel		**Software environment**
Programme fonctionnant seul	[ ]	Stand-alone program
Besoins d'autres logiciels	[ ]	Other softwares needed
Langue de travail		**Working language**

C.I.I.D. — page 2 / 4 — I.C.I.D.

Groupe de travail "Analyse des Systèmes" — Working group on systems analysis

Figure 3.4 (Ctd.)

Formulaire pour la base de données LOGID / Form for Data Base LOGID

Remplir les cases larges, cochez les cases étroites/Fill in wide squares, check off narrow squares

Français	[ ]	French
Anglais	[ ]	English
Plusieurs langues	[ ]	Several languages
Langue du pays d'origine	[ ]	Original country language

Système d'unités utilisé — Used unit system

Système International	[ ]	SI system
Unités anglaises	[ ]	English units
Autre système d'unité cohérent	[ ]	Any consistent unit system

Le domaine d'application choisi — The chosen application field is

IRRIGATION	[ ]	IRRIGATION
DRAINAGE	[ ]	DRAINAGE
MAITRISE DES CRUES	[ ]	FLOOD CONTROL

Choisissez ou ajoutez un mot clef — *Choose or add a keyword*

Le thème spécifique choisi est — The chosen specific theme is

Si thème=IRRIGATION,mot clef : — If theme=IRRIGATION keyword :

Réseau (sous pression)	[ ]	Network (under pressure)
Réseau (gravitaire)	[ ]	Network (gravity)
Economie	[ ]	Economy
Barrage (en terre)	[ ]	Dam (earth)
Station de pompage	[ ]	Pumping station
Micro-irrigation	[ ]	Micro-irrigation
Irrigation par aspersion	[ ]	Overhead irrigation
Coup de bélier	[ ]	Water hammer
Besoins en eau	[ ]	Irrigation needed
Hydrologie	[ ]	Hydrology
Gestion des irrigations	[ ]	Irrigation management
Asperseur	[ ]	Sprinkler
Modèle sol-climat-plante	[ ]	Soil-climate-crop model
Evapotranspiration	[ ]	Evapotranspiration
Hydraulique à surf. libre	[ ]	Open chanel flow
Irrigation gravitaire	[ ]	Surface irrigation
Mot clef à ajouter	[ ]	added keyword

Si thème=DRAINAGE, mot clef: — If theme=DRAINAGE, keyword:

Réseau	[ ]	Network
Simulation	[ ]	Simulation
Mot clef à ajouter	[ ]	added keyword

Si thème=MAITRISE DES CRUES, mot clef : — If theme = FLOOD CONTROL, keyword:

Hydraulique à surf. libre	[ ]	Open channel hydraulic
Mot clef à ajouter	[ ]	added keyword

Description des fonctions du logiciel: — *Description of the functions of the software:*

Figure 3.4 (Ctd.)

Formulaire pour la base de données **LOGID** / Form for Data Base **LOGID**

Remplir les cases larges, cochez les cases étroites/Fill in wide squares, check off narrow squares

Commercialisation	*Software marketing*
Société	Company
Service de conception	Design division
Personne à contacter	Contact person
Adresse	Address
Boite Postale	P.O. box
Code Postal	Postal code
Ville	City
Pays	Country
Téléphone	Phone number
Télex	Telex
Télécopie	Fax
Prix de vente au détail hors taxes	Software retail price without taxes
Devise	Currency
Date de la première version / /	Date of first version
Date de la version actuelle / /	Date of current version
Date de ces informations / /	Date information entered
Conditions de maintenance	Maintenance conditions
Disponible gratuitement	Available free of charge
Disponible avec paiement	Available against payment
Non disponible	Not available

Note that about 1½ pages are concerned with hardware requirements, and another half page with software building aspects, almost one page with specifying the appropriate subject, half a page with a free-format description, and half a page with addresses. The hardware is relatively easy to specify (and detail in a form) and gets quite some attention. One might want more information on some user aspects, like the intended use or target group, the availability of a manual or on-screen help, and more specific and more distinctive keywords. Nevertheless, it shows a rather comprehensive approach to obtaining information on available irrigation (146 programs) and drainage (22 programs) software (and relatively few -10- flood control programs). The merits of this type of information, in comparison with other attempts at an inventory (like the ILRI inventory and IRRISOFT) will be discussed in Chapters 4 and 5. Moreover, LOGID is easily accessible and thus may grow in future, as more member-countries, institutions, and individuals discover its usefulness and submit more forms.

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

Chapter 5

PRACTICAL INFORMATION AND EVALUATION CRITERIA FOR IRRIGATION PROGRAMS

M. Jurriëns (ILRI) & P.O. Malaterre (CEMAGREF)

5.1 The need for practical evaluation criteria

As we have seen in Chapters 3 and 4, there are many programs, of many types, for many purposes, varying in quality. Several classification systems or categories of available irrigation programs, mainly according to their subject or theme, were mentioned in the previous chapters (IRRISOFT, LOGID, ILRI). Making useful groups is not so easy, but evaluating and comparing them systematically (say, per group) in terms of properties and qualities, is even more difficult.

Computer programs have many facets, which actually have been addressed and should have been documented during the process of model building (or software engineering). During the various stages of model building (from conceptualisation to validation), many questions were answered and decisions made by the developers. However, assumptions, limitations, or specific solution techniques are not only of interest to the program developer, but may also affect the usefulness of the program for a practising irrigation engineer. This information tends to disappear in the marketing stage of the program, especially the limitations. Of course, one can buy or drive a car without being a car manufacturer or a mechanic, but essential information to make a choice between various models and types of cars must be available to the potential buyer/user. Such essential information is not standard available with irrigation programs, which makes it very difficult to compare and evaluate them, and make the right choice.

It would, therefore, be useful to develop a framework for evaluating programs, e.g. in the form of a systematic checklist of criteria. In the future, such criteria might be used by an international body to give irrigation software a rating and encourage the wider use of vetted programs. Compare, e.g., the International Groundwater Modelling Center, which started making inventories and developing criteria, and which now acts as an "evaluation, testing and clearing" house.

In this context, we may refer to Rogers et al. (1991), who presented evaluation and comparison criteria, especially for canal hydraulic models, at the ASCE Hawaii Conference. They stated that "model evaluation is intended to describe each program's capabilities, application, and usefulness." The established criteria were applied to six models. The task committee was originally set up to examine existing computer programs for their suitability and to foster communication among developers and users (Clemmens et al., 1991).

Another illustration of the need for irrigation software criteria is found in the Opening session of a recent FAO expert consultation (FAO, 1994), the objective of which was said to be "to establish criteria to guide model development for the improvement of irrigation water delivery (...), taking into account the considerable development of irrigation and drainage software which has taken place over the last few years".

Therefore, we conclude that there is scope for further developing such criteria for irrigation software. We do this in the following Sections by first looking at existing forms of general program information. We then proceed to look at what has been done in terms of validation and evaluation. After that we propose a general information and evaluation format for irrigation software.

5.2 Existing work on general program information

- *The FAO expert meeting*

The aforementioned Expert consultation in Rome in October 1993 (FAO, 1994) suggested to address issues like:
- how flexible is the software?;
- how easy to learn?;
- how secure against the inexperienced user?

Other questions raised were: "Is there a need for development of new types of models?" and "How should dissemination be managed?". Furthermore, sustainability aspects were emphasized, addressing aspects such as staff training, staff motivation, software support and maintenance, improved communications and keeping farmers informed. Aspects of cost and organizational management required to collect the necessary field data were also mentioned. Although conclusions are not well-outlined in the proceedings, the forms that were used for describing the computer software presented at the consultation (contained in their Annex III) are useful. An example is shown in Table 5.1. The information is of a general type and is comparable to the brief ILRI inventory pages (Lenselink & Jurriëns, 1993). The pages are notably shorter than e.g. the Software Description Pages of IRRISOFT (see Chapter 2). Mainly containing general information, they definitely assist in making a first classification or selection, but they do not contain sufficient information for a thorough evaluation and comparison.

- *IRRISOFT*

The most recent attempt at presenting a format for describing irrigation software is found in Chapter 2, where an IRRISOFT structure for the Software Descriptive Pages is mentioned (see Table 2.1). There is no need to repeat that structure here, but it shows a rather comprehensive approach at describing the most important general software information, so that potential users can make a first selection from the many existing programs. In a further development stage of IRRISOFT, the format may change to include more details, e.g. also on assessment, comparison and evaluation of properties and qualities.

Table 5.1 Example of a 1993 FAO software descriptive form

Software name:	SIC
Software type:	Hydraulic simulation
Functions:	Simulates system behaviour to identify appppropriate operational strategies. Evaluates effects of changes to system parameters
Suited to:	Steady and unsteady flow conditions Branched and networked systems
Brief description:	Three principal programs carry out topographic generation, steady flow computation and unsteady flow calculations respectively. Model calibration assisted by a module which calculates discharge coefficients and roughnesses from field data. Steady flow calculation can be performed on an type of network. Unsteady flow conditions at present only possible on non-looped networks. Versions in English, French, Spanish
Use:	Menu-driven
Input:	User-friendly interface for: topographical data and network definition; seepage rates, flows, gate openings Structure regulation rules need to be written in special modules (in FORTRAN) which can be linked with the program.
Output:	Graphical or numerical interfaces or results files. Water levels, flow velocities, discharges at points throughout system. Comparisons between actual and predicted situations.
On screen help:	Yes
Language:	FORTRAN, TURBO PASCAL
Graphics:	Yes
Other reqs: (software)	No
Hardware:	IBM-PC/PS2 or compatible. Minimum 1 Mb RAM, 20 Mb HD. Maths coprocessor
Ref paper:	P Kosuth. Application of a Simulation Model (SIC) to Improve Irrigation Canals Operation: examples in Pakistan and Mexico
Contact:	P. Kosuth, Head, Irrigation Division, CEMAGREF, 361, rue J.F.Breton (BP 5095), 34033 Montpelier Cedex 1, France
Tel:	
Fax:	33-67635795

- *The previous ILRI inventory*

The ILRI inventory of 1993 mentions some practical usability criteria, particularly concentrating on four aspects, i.e. hardware requirements, user-friendliness, the manual, and availability. Hardware requirements do not often pose a real problem these days, although some programs may require extra memory, a digitizing tablet, a flat-bed scanner

or a special plotter. Under user-friendliness the following points were raised:
- program should be self-explanatory on screen;
- screen lay-out should be logical and clear;
- basic actions must be under commonly-used keys;
- program should be fool-proof;
- interactive data input is preferred above batch processing;
- file handling should be straightforward;
- graphical output should be included whenever possible.

Despite the requirement that a program should be self-explanatory and contain on-screen help, a good manual should accompany the program. Such a manual should at least include a clear introduction, background theory, the program structure, a user instruction, an example case, a common error listing, and a clear index.

The availability of a program was discussed in terms of being adequately advertised, being quickly sent when ordered, being reasonably priced, and having a fixed contact point.

5.2 Irrigation software validation

- *Software development*

As already mentioned in Section 5.1, there is a definite link between software users and software developers on the topic of software quality. It may, therefore, be useful to take a brief look at some relevant issues that are mentioned in a few software engineering literature. Deutsch and Willis (1988) mentioned fifteen required software qualities, mainly from the developer's point of view, but also with interesting points for the end user (compare Jurriëns & Lenselink, 1992). In the initial stages of program building, questions like: Who is to use the program?, What is the basic objective?, What input data are required?, Which results can be expected?, Why is the computer model necessary? clearly are questions that have a bearing on the purpose, properties, and qualities of the final product. Moreover, after the computer programming or implementation has taken place, one may expect the program to:
- use efficient code;
- have adequate error traps;
- give technically correct results;
- possess robustness;
- have been extensively tested;
- require reasonable input;
- return default values where possible;
- return useful output of reasonable detail and format.

In addition, the program should be able to run on different computers (portability), and should be written and documented in such a way that both a programmer and a user find it "friendly". Programmer friendliness has to do with maintenance and flexibility, and includes internal and external documentation, logical and modular lay-out, use descriptive variable names, have built-in debugging aids, etc. User friendliness has more to do with the ease with which a normal computer user can apply the program. More than a decade ago, Ingels (1985) already mentioned that a program must:

- be interactive;
- be menu-driven;
- have a reasonable response time;
- have a reasonable amount of input and output;
- let the user always know what to do next (+ help);
- have an adequate user manual;
- have a reasonable price;
- not require excessive learning time.

Such requirement lists, especially the earlier ones, are not always adequately structured, but they assist in forming an opinion of aspects to include in a more comprehensive framework for evaluation of irrigation software. We shall consider such a framework in the Section 5.5.

- *Software validation*

In fact, if we are trying to find software criteria, we are busy with the last stages of software development, for which we can distinguish the following seven stages: conceptualisation, (mathematical) model building, programming, verification, calibration, validation, and evaluation. We have already referred to some of these stages above. Our quest for criteria covers the validation and evaluation stages. In some instances, these two stages are lumped together under "validation". In that case, program validation is understood to be the process of testing and documenting the quality of a computer program, in relation to its intended applications and the physical system it represents. Others make a distinction between validation, i.e. testing the program results against some independently measured data, and a subsequent evaluation, in which one wants to assess a program's applicability and usefulness. This evaluation is exactly what we want to achieve, and for which we are trying to find a suitable, structured format.

In other sectors of industry it is not uncommon to require a validation document as part of an industrial product, which could also be applied to the software industry (for major packages). Some hydraulic institutions, who produce software in-house, have been considering such a validation document (which may ultimately lead to certification). Standardization of such a document has been advocated, and a possible format has been laid down. It may be useful to illustrate our discussion with the contents of a validation document as produced by Hydraulics Research Wallingford for their MIDAS program version 1.1 in March 1992. The contents page of this document is reproduced below in Table 5.2.

It can be seen that some general information about the model is given first, after which the aims of the validation are described in detail, before the validation in test cases is reported. However, this standardized approach to a validation document shows that our search for an evaluation framework is not a loose idea, but that it has roots in the more

Table 5.2 Sample contents page of a validation document

1. INTRODUCTION
   - 1.1 Model Description
     - 1.1.1 Purpose
     - 1.1.2 Features
     - 1.1.3 Version Information
   - 1.2 Model Validation
     - 1.2.1 Priority quality issues
       - 1.2.1.1 Survey data input and reduction
       - 1.2.1.2 Construction of the ground model
       - 1.2.1.3 Export of X, Y, Z to MIDAS
       - 1.2.1.4 MIDAS functions
     - 1.2.2 Approaches

2. VALIDATION OBJECTIVES
   - 2.1 Model Functioning
     - 2.1.1 Physical System
     - 2.1.2 Processes
       - 2.1.2.1 Terrain
       - 2.1.2.2 Lay-out
       - 2.1.2.3 Land levelling
     - 2.1.3 Applications
     - 2.1.4 Computational Aspects
   - 2.2 Basic Elements
     - 2.2.1 Conceptual model
       - 2.2.1.1 Description
       - 2.2.1.2 Applicability
     - 2.2.2 Algorithms
       - 2.2.2.1 Description
       - 2.2.2.2 Applicability
     - 2.2.3 Software
       - 2.2.3.1 Description
       - 2.2.3.2 Applicability
   - 2.3 Data Requirements and Model Performance
     - 2.3.1 Physical Parameters
     - 2.3.2 Algorithmic Parameters
     - 2.3.3 Software Parameters

3. VALIDATION RESULTS
   - 3.1 Misty Vale
   - 3.2 Murara
   - 3.3 Photogrammetric Input

4. SELF-TESTING
   - 4.1 Built-in Tests
   - 4.2 Guidelines for Self-Testing

general process of software development. Merging ideas from other from such areas with our own can lead to a better evaluation system for irrigation programs.

5.4 Existing work on evaluation criteria

- *ASCE assessment and evaluation*

Let us take a closer look at the ASCE task committee's criteria, mentioned above. For their canal simulation programs, Rogers et al. (1991) distinguished between three main types of criteria:

- those dealing with the technical merits;
- those related to the modelling capabilities;
- those qualifying user considerations.

For each of them, further details were discussed as shown in Table 5.3.

Table 5.3 ASCE canal model evaluation and comparison criteria

- TECHNICAL MERIT
  - computational accuracy
  - numerical solution criteria
  - robustness
  - initial conditions
  - internal + external boundary conditions
  - special hydraulic conditions
- MODELLING CAPABILITIES
  - system configuration
  - frictional resistance
  - boundary condition types
  - turnouts
  - operations duplication
  - automatic control
  - miscellaneous limitations
- USER CONSIDERATIONS
  - user interface
  - documentation and support
  - direct costs
  - indirect costs

Although these criteria were specifically meant for their canal simulation programs, the approach is useful. It has yielded the inspiration for the extended and modified framework presented in Section 5.5.

- *CEMAGREF*

Also at CEMAGREF, the French ICID committee is working on further detailing, testing, validating, evaluating, and comparing irrigation software. Mainly as a consequence of the earlier comparisons of the ASCE task committee mentioned before, one is concentrating on non-steady canal flow models first. For the SIC (Simulation of Irrigation Canals) model, a list of aspects that may help to qualify the model has been prepared, and one intends to compare other French programs (like Elicsir) with them. A format that is currently in use has been translated and is reproduced in Table 5.4. This format can be used to describe the various programs in a number of sections, like: Data input, Calculations, Output, Documentation, Special features, and Hardware requirements.

Table 5.4 A CEMAGREF format for comparing non-steady canal flow models

INPUT	SIC	Elicsir	
Interactive data input	Yes		
Input from ASCII data files	Yes		
Automatic data checking	Yes		
Real geometry (point-by-point canal reaches)	Yes		
Easy modelling of trapezoidal canals	Yes		
Automatic classification of branches	Yes		
Automatic interpolation in reaches	Yes		
Names for branches	Yes		
Names for nodes	Yes		
Names for reaches	Yes		
Library of cross-regulators	Yes		
User-defined cross-regulators	Yes		
Parallel cross-regulators	Yes		
Cross-regulator manipulation	Yes		
Library of offtake structures	Yes		
User-defined offtake structures	Yes		
Parallel offtakes	Yes		
Offtake regulation	Yes		
Initial steady-state water level	Yes		
Initial transient water level	Yes		
Maximum number or branches	80		
Maximum number of reaches	600		
Maximum number of cross-regulators	200		
Maximum number of offtakes	80		
CALCULATIONS			
Steady-state	Yes		
Non-steady (transient)	Yes		
Complete Saint Venant equations	Yes		
Solution scheme	Preissmann		
Implicit solution	Yes		
Solution technique	Double sweep		

Variable time step during calculation	No		
Variable distance step	Yes		
Discharge and water elevation in all reaches	Yes		
Flooding	No		
Location of drop	No		
Dry water front	No		
Movable drop	No		
Pressurized flow	Yes		
Mesh (joints and bifurcations)	Yes		
Discharge at offtakes	Yes		
OUTPUT			
Screen: tables	Yes		
Screen: graphs	Yes		
Printer: tables	Yes		
Printer: graphs	Yes		
File: ASCII	Yes		
File: graphs	Yes		
Links with other programs: dBase	No		
Links with other programs: SIG	No		
Links with other software: CAO	Yes		
Water-distribution performance indicators	Yes		
Output for all points and times	Yes		
Water-level movement display	Yes		
DOCUMENTATION			
User manual	Yes		
Background theory manual	Yes		
Various languages	Yes		
Help screens	Yes		
Test cases	Yes		
SPECIAL FEATURES			
Library of gate settings	Yes		
User-defined gate settings	Yes		
Sediment transport	No		
Pollutant transport	No		
Salt transport	No		
HARDWARE REQUIREMENTS			
Computer type	PC		
RAM	640 kB		
Hard disk space	5 MB		
Operating system	DOS, Windows		

5.5 Proposal for a modified evaluation framework

Taking into account the results of the FAO and ASCE meetings, software engineering considerations, and other work done, as described in Sections 5.2-5.4, we propose a modified evaluation framework. Its broad set-up is largely the same as that of Rogers et al. (1991), which we have modified to agree with earlier remarks on the subject (see also Chapter 1).

We start with a category 'General information', containing the name of the program, the contact address, relevant literature, etc., combining items from the FAO software descriptive forms (Table 5.1) and the IRRISOFT software descriptive pages (Table 2.1), but excluding items that are falling in the other two categories, i.e. Properties and Qualities.

The major distinction is between 'Properties' and 'Qualities'. Properties then relate to the more factual information ("What can a program do?"). Under Properties we have added 'Scope and purpose' and the mechanical (hardware) requirements. 'Purpose and scope' includes some aspects of Rogers' modelling capabilities.

The second group (the 'Qualities', i.e. "How does a program do it?") concern the 'Program qualities' and the user-friendliness. A distinction has been made in Program qualities between 'Theoretical quality', which refers to the conceptual and model-building phases in software engineering (theories, assumptions, mathematical representation), and the 'Technical quality', which concerns the implementation or the programming of the model. 'User qualities' are a very important category, containing aspects which immediately concern the end user of the program. This framework is shown in Table 5.5. Details of this evaluation framework are discussed below.

Table 5.5 Proposed irrigation software evaluation framework

General information		- program name - made by - cost - reference person - programming language - manual availability - key refernce publication
Properties	*Scope and purpose*	- subject - purpose - capabilities/options - limitations
	Hardware requirements	
Qualities	*Program qualities*	- theoretical quality - technical quality
	User qualities	- interface - documentation - availability

- Properties: Scope and purpose

As a first item under 'Scope and purpose' one can find for which *subject* the program can be used, and *what it can do* for that subject. The indication of the subject should be sufficiently detailed and clear. "Surface irrigation" is not adequate for a specific furrow irrigation design program; the mentioning of "furrow irrigation" and "design" are essential. It should further be mentioned if it includes cut-back, blocked-end or re-use options and if the program concerns one furrow or the complete field lay-out. A brief indication of required input and expected output often makes the subject clearer.

A second item to be mentioned is the *purpose* for which the program has been made. A program can be meant explicitly for planning, design, operation, evaluation, or training. Some programs are simple calculation tools, others are simulating a process, to be used for any purpose. Of course, a design program can be an instructive training tool, but specifying the *target group* for which the program was developed assists end users in making a choice.

Under 'Options/capabilities' information can be find about *input/ouput* options of the program, if the *units* can be changed, if subject-specific *modes* can be chosen, etc. In practical terms, this is a further detailing of the subject, combined with computer-specific items. Special distinguishing *features* can be mentioned here ("... produces daily, weekly and monthly totals in tabular and graphical form..").

A clear statement on the *limitations* of the program should be included, if it were only to avoid disappointed buyers/users. Such limitations can have to do with the subject, the purpose, and the options mentioned above. They can also indicate limits of data ranges or scale, or can state underlying assumptions and boundary conditions. Examples are: "... this program is not suitable for design purposes, but returns order-of-magnitude estimates only ..."; "...the program only considers uniform soil condition...";"...the program accepts monhtly average values only...").

- Properties: Hardware requirements

Under this heading, the *operating system* must be specified (MS-DOS 6.0 and higher, Windows 95). Also the necessary and recommended *processor* (Pentium 100 MHz), the required free *memory* for installing and running the program should be stated. One also would like to know if a *hard disk* is required to unpack/install the program, whether a (special) *printer* is needed, and if a certain *graphics or sound card* is necessary. Whether or not a particular *keyboard*, *monitor*, or *mouse* is required is also useful to know. Further possible items to include are mentioned in Chapter 3 (Figure 3.4).

- Qualities: Program qualities

Under 'Theoretical quality' we expect information on the underlying *theory* of the program ("... based on a full solution of the St. Venant equations..."). Virtually all irrigation programs are based on a mathematical modelling of a part of reality, and it is important to know whether the *model approach* uses simple regression equations or more universally applicable physical laws.

Apart from this conceptualisation, one would also like to assess the chosen *modelling approach*, i.e. the mathematical approach used. Stating which (type of) algorithms and physical or statistical laws were applied is useful, so that the user can judge their acceptability.

In the implementation phase of modelling, bugs could have entered and therefore it is important to know if the program has been *de-bugged* and *verified* to give correct results for test cases. Test case results are mainly a software engineer's worry, but a user would like to know about the most recent tests.

Under the heading 'Technical quality' we mainly expect information on the chosen numerical solution technique, which affects a number of criteria, such as *correctness*, *accuracy*, *stability*, and *convergence*. Correctness is self-explanatory. Accuracy and stability deal with unavoidable rounding or truncating error in the many calculations, especially if differentiation or integration have to be done numerically. Smaller (time) steps lead to a greater accuracy, but the cumulated error may become so large that it approaches the solution, in which case the stability is lost. Convergence is another requirement is numerical iterations: we would like to know if the program will always give a solution (implicit solution schemes will, explicit ones may not).

A further technical quality relates to *input sensitivity* (are input ranges limited, or does the program also give a solution for freak values), which quality is also referred to as *robustness*.

A last technical quality that a user would like to know about is whether any *calibration* and/or *validation* has been done, and what the results thereof were. Calibration refers to the testing of the program versus measured data, after which adjustments may have been made. In the validation stage such adjustments are not made. Compare the remarks on validation made in Section 5.2.

- <u>Qualities: User qualities</u>

The user qualities are often neglected, but they form the link between the program and the user and as such are very important for its application (also see Chapter 6). One could also describe these user qualities as the degree of user-friendliness. We distinguish three groups of aspects, i.e. the *user interface* (on the computer), the *manual*, and the *availability* of the program.

For the **user interface**, we can specify the following aspects: accessibility, clarity, program handling, file handling, input and output. For each of these aspects, we have listed a number of requirements below:

* *Accessibility*
  - easy install, start, stop;

* *Apparent simplicity*
  - clear program structure;
  - clear and consistent menus;
  - easy to to browse, get back, get out;
  - set of default data (standard file);
  - clear input/output;

* *Program handling*
  - screen help (meaning/purpose);
  - common key operations + instructions;
  - clear terminology;
  - clear screens;
  - error messages;
  - time to learn/manual/training;

* *File handling*
  - retrieve and save;
  - dos/windows options;
  - import, export, convert;
  - track record;

* *Input*
  - consistent option selection - input;
  - interactive/on screen;
  - clear meaning/purpose;
  - message on ranges;

* *Output*
  - clear screen;
  - primary and secondary;
  - report, tables, graphs;
  - save/print/plot.

The **documentation** quality mainly concerns the user manual (in contrast to the programmer's manual). Although the necessity of a clear manual has often been stressed, a number of programs still do not have them. A good manual should "document the objectives, target groups, relevant current developments, the methodology and the process of program development, the background theory, the use of approximations and constants. It should also explain the use of the program step-by-step and point out any less common uses. At least one worked example should be included, the data of which should already be available on the distribution disk", as stated in the ILRI inventory of 1993. A good manual should e.g. contain an introduction, a chapter on the background theory, a summary and explanation of the program structure, a section on how to run the program (operation), one or more worked examples, data ranges and a good index.

Another user concern is the **availability** of the program. Many of the irrigation software packages are non-commercial, and therefore are not officially *marketed*. The existence of a certain program often follows from a journal article, from workshop proceedings, or from correspondence between a selected group of people. Making an inventory and adding qualities should help to overcome this problem to a certain extent. IRRISOFT (Chapter 2), LOGID (Chapter 3) and the ILRI inventory (Chapter 4) may certainly help.

Another availability aspect is the *price* of a package. Development costs of the larger packages are high (labour-intensive), and commercial institutions (consultancy firms, publishers) by nature want to sell their products at a profit. Many publicly-funded research and educational institutions do not have this urge and make programs available at nominal cost only (although privatization unfortunately leads to reversing this trend). Apart from the purchase price, there are also indirect costs which need to be invested in learning time, data collection, etc.

Under the availability heading one can also think of the **support** that is available for a software package; a name and an (e-mail) address where further information can be obtained, where queries are answered, and where updates are made (and made known).

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Chapter 6

SOFTWARE EVALUATION CRITERIA - THE USERS

Derek Clarke (IIS)

6.1 Introduction

To be able to evaluate the requirements that define a "good" computer package for irrigation calculations we have to identify the purpose of the software and how practical it is for that purpose. The practicality of the software can be defined in terms of the software's functionality, availability and cost.

- *Functionality:*

- The software should provide a useful, time-saving and acceptably accurate solution to a specified task or problem.
- The software should be tested with a wide range of data sets with several trial users and should be stable and predictable in its behaviour.
- The user interface should be effective in explaining to the user the data requirements and describing the sequence (or sequences) of calculations. At the same time the user interface should not be too complicated.

- *Availability:*

- Potential users should be able to obtain copies of the software from a well organised "sales desk" in the organisation that promotes the software.
- In-house models and packages produced for specific projects are often not suitable or relevant to other schemes unless the package is configured by the vendor.
- Many research papers describe new models and packages but these are rarely made available for use to other organisations.

- *Cost:*

- Prices for modern PC software such as databases and word-processors rarely cost more than $500.
- The cost of the software development is often very high and it is difficult to recover these costs unless many copies of the software are sold.
- The majority of individuals who require irrigation software have a restricted budget. From experience most engineers from tropical countries consider that $50/copy is a "good" price for a program, and $100/copy is "too high".
- Software costs can be a significant restraint unless it is part of a centrally funded software strategy. It is surprising that the cost-effectiveness of the software is frequently undervalued or ignored when there is always a perceived need for more or newer computer hardware.

6.2 Who uses irrigation software ?

There are four main categories of users, defined by the aims of the users, their ability to use the software and their ability to obtain the software.

- *High-technology group*

This is made up from irrigation practitioners who are involved in high-cost commercial irrigation. These users often have definite requirements and are willing to pay a lot of money for software because their business depends on it. Typical of this group are farmers in the USA who often will buy in design expertise from irrigation equipment manufacturers.

- *Researchers and scientists*

Often with a lot of theoretical knowledge, this group is able to appreciate detailed investigation and understand complex models such as finite-element simulations of unsaturated flow. This group is often tolerant of software that is more difficult to use.

- *Developing countries group*

This covers a wide range of irrigation activities including design, management and research. This group often has a restricted budget and cannot afford advanced programs usually have computers that are somewhat older. (It is interesting that in the computer industry an "old" computer is often the new one that was bought 2 years ago).

- *Trainees*

Several organisations provide training in irrigation. Most courses include some aspect of computer use. The author is involved in computer training for 1-year MSc and short courses for irrigation professionals. Such staff are often mid-career engineers who are sponsored to renew or develop their technical skills.

6.3 Problems and pitfalls with software

Users have become familiar with some large complex pieces of software (e.g. EXCEL, WORD) which are well-tested, full of useful (and not so useful) features, have a good user interface and seem easy to use. Users tend to expect all software to behave perfectly and will tend to believe the results of the calculations "because the computer says so".

A user will expect that there is a computer program that will solve all of his problems, whatever the problems may be. I once received a telephone call from an engineer who wanted a full design package for irrigation. ("All I want is a program that asks me for the numbers and then I can type them in and the program will do the design and print out the diagrams and costs.")

Many potential users see a panacea in computer software. It is clear that in many countries staff in research centres prefer to stay in their offices "working" on computer models. On one visit I was told that the office is preferable because it is air-conditioned, more reports can be produced and, anyway, there are snakes in the fields. There is a trend in many academic institutions to sit at the computer (it is cheaper than laboratory or field work).

Many users can now process larger amounts of data in more and more complex models without considering the practical implications of the assumptions made in the computer programs. Finite-difference and finite-element programs can now run easily on present-day PCs, but these models are frequently built using theoretical situations and require calibration before they can be applied. In one research centre I was asked why CROPWAT did not have the crop coefficient data for a specific citrus fruit growing on a sandy soil. I suggested that the researcher try to derive the k_c data for the crop and send it to FAO to add it to their k_c files. This idea was rejected because the FAO k_c values were assumed to be correct and no other values would be accepted.

6.4 Experiences with MSc-course students

Each year a group of 20-30 students attend the 1-year MSc course in Irrigation Engineering at Southampton University. Approximately 60% of the students are from tropical countries and have several years' experience in irrigation; the remainder are usually new graduates from European countries.

At the start of the course each student completes a computer-experience questionnaire to identify his training needs. An analysis of these questionnaires between 1987 and 1995 has shown that more students are getting some experience with computers, although the experience is usually restricted to the use of one or two packages only.

Figure 6.1 shows that in 1987, 70% of students had never used a computer, but by 1993 this had dropped to only 10%. This indicates a growing availability of computers. (In the 1980's up to 50% of the students had no practical computer experience, although the author did find some students with "excellent" grades for computer courses which had been carried out entirely on paper!)

Figure 6.2 illustrates that the majority of incoming students had experience in the use of two or three packages only. The programs most frequently used were word-processors and spreadsheets. Interestingly, there has been a shift away from program "models" such as specific hydraulic packages (19% of students had used these in 1991, but none had used them in 1995).

Experience in computer programming in the main scientific languages is shown in Figure 6.3. This shows a dominance of Basic whilst FORTRAN, originally the main scientific programming language, is less common. The majority had attended a one-term university programming course. A significant trend is that the number of people with good computer

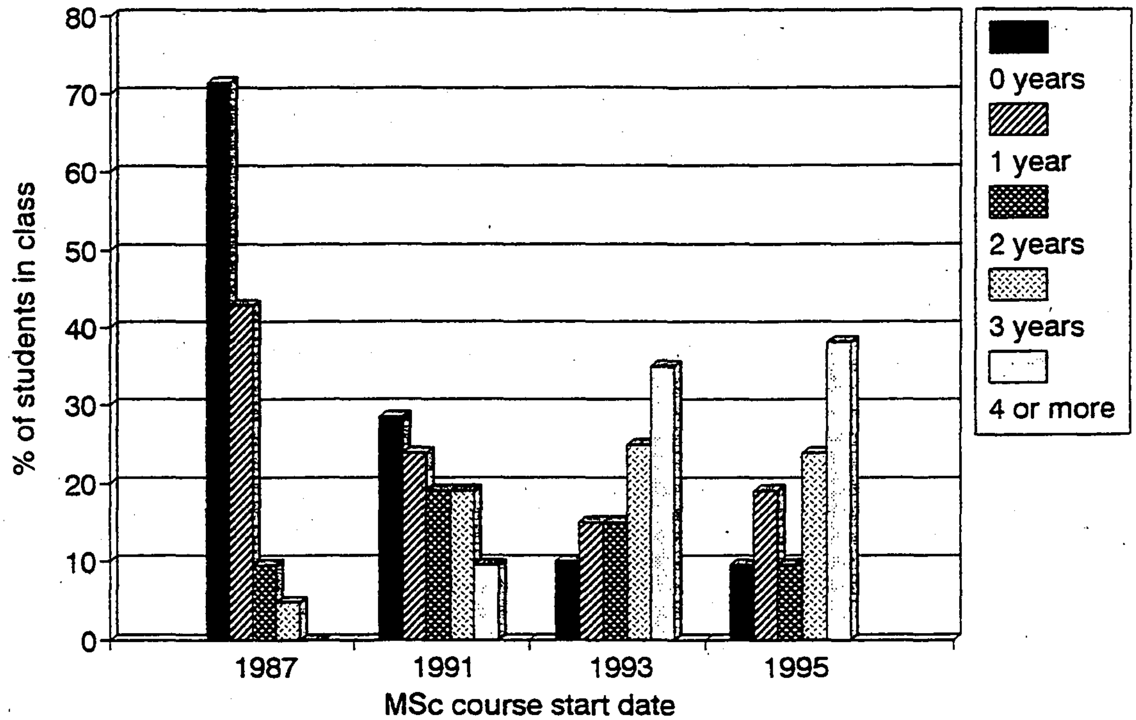

Figure 6.1 Years of computer experience before starting MSc course

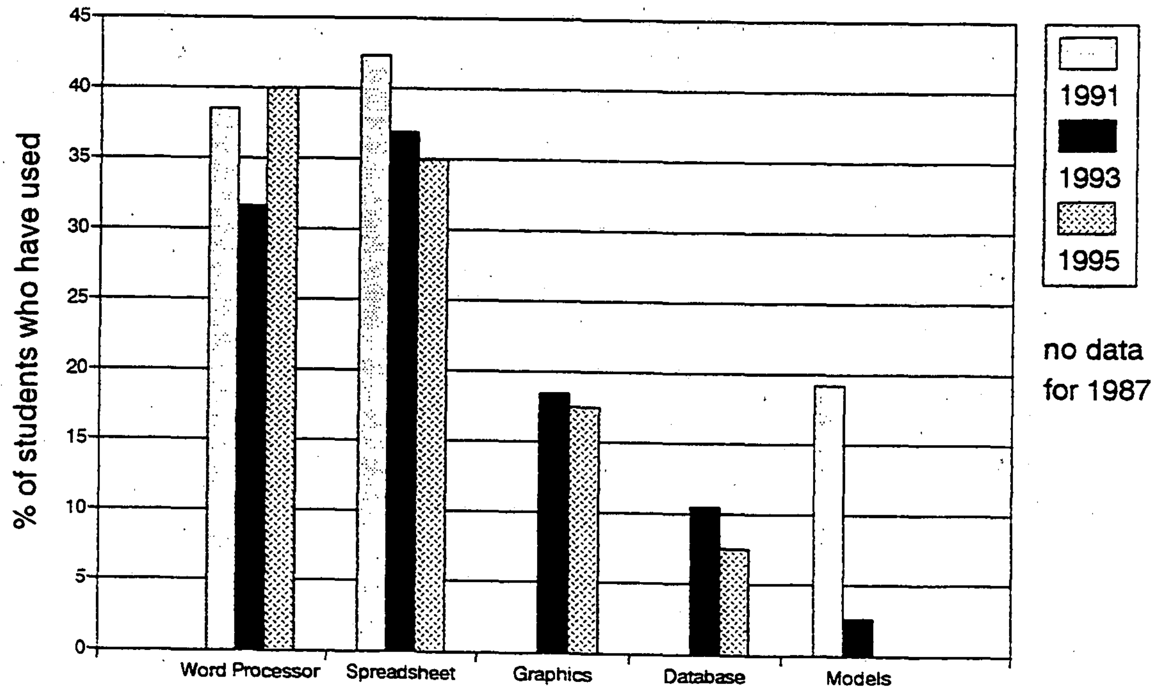

Figure 6.2 Packages used before start of the MSc course

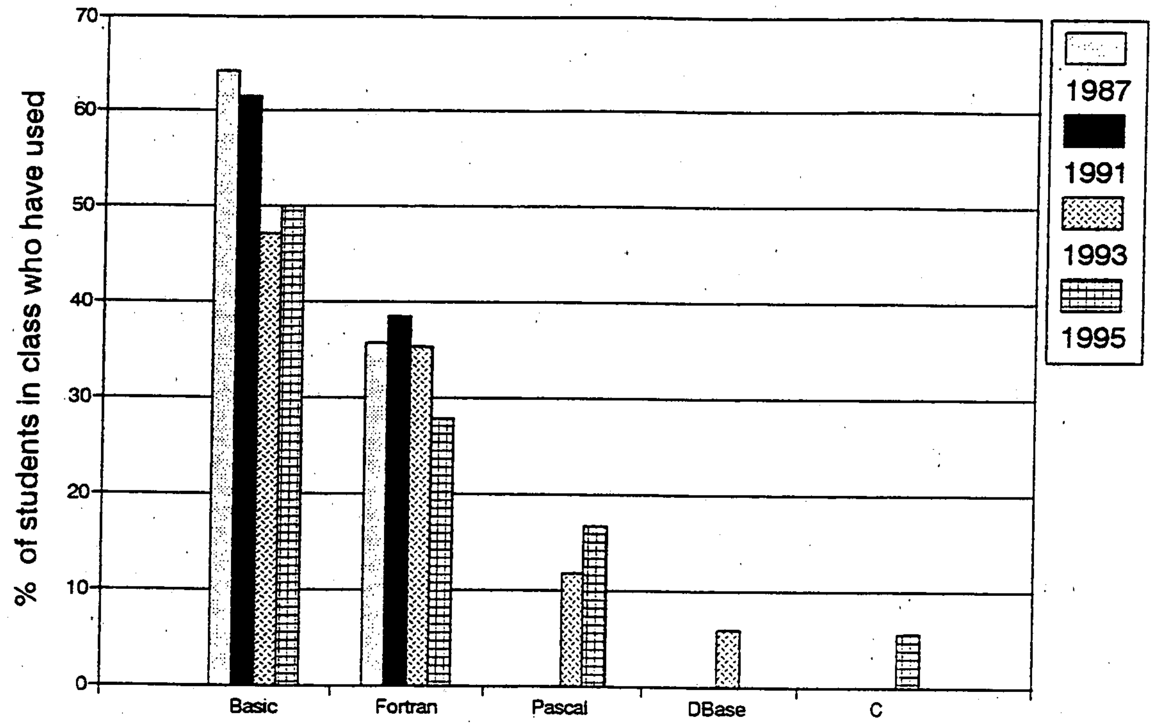

Figure 6.3 Programming experience by MSc students arriving at Southampton

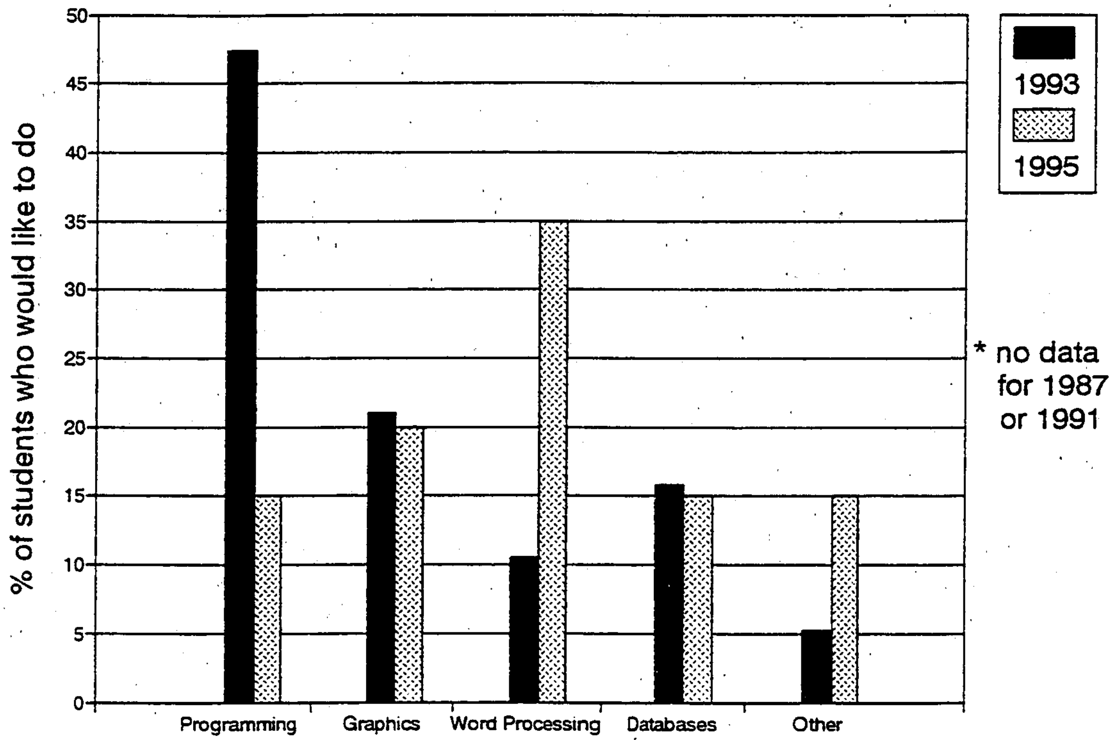

Figure 6.4 Desire for computer training of MSc students arriving at Southampton

programming experience is low and is falling each year. This is reflected by the (limited) data in Figure 6.4 which shows that the desire for training in programming is falling whilst enthusiasm for word-processing is increasing. This leaves us with the question - who is going to write the irrigation software in the future ?

6.5 Irrigation software - catering for the users in the future

It seems that there will be fewer irrigation staff with computer programming experience in the future. Writing a computer program involves having a good understanding of the theory of the method being used and the ability to interpret the results from a program in a critical manner.

Therefore, our future users will have to be taught how to identify flaws in a program rather than slavishly believing the output from a package because it was written by a well-known organisation. These people will need software that is easy to use, tested and calibrated and is well-documented. Hence I suggest that a good software package should be designed with the following points in mind:

- What is the expected technical knowledge of the user?
- Will they have the necessary hardware?
- Will the software be available at a reasonable price?
- Will it install easily (memory, EMS/XMS, ANSI.SYS etc.)?
- Can the user manage with only the manuals (no training available)?
- Will the interface trap obvious data input errors?
- Will the software be appropriate for the intended user (theory too advanced)?
- Is it feasible to collect all the data required by the program?
- Will the user have the time to collect the data and to process them?

From the author's experience with staff from many countries, we cannot expect the typical user to have a very advanced knowledge of computer systems. A common problem encountered is that "program xxxxx worked well until program yyyyy was installed and it changed the AUTOEXEC.BAT. Since then program xxxxx has never worked even though we have a powerful computer." There are many possible reasons for these problems (such as changing a DOS PATH or installing memory-hungry network drivers) but, without an experienced person being available, it is almost impossible to sort the problem out. We should be considering these potential problems when designing the software and the manuals.

Some time back, a review of MS-DOS 5 was made amongst a University Computing Department help desk support staff. They were asked what was the biggest problem with this new release of DOS. One response was

"...that the software was perfect, it is just the users who are the problem."

Chapter 7

CONCLUSIONS AND AGREEMENTS

7.1 Conclusions

1. There is need for a more intensive, more widespread and more effective use of irrigation software for practical purposes.

2. At present it seems more effective to intensify the use of existing software than to develop new programs.

3. One way to contribute to the above is to enhance the dissemination of information about available software worldwide, on various subjects, to irrigation practitioners.

4. The first step in this respect is the preparation of an inventory with basic information on which programs (names) are available on specific subjects, where and how.

5. Next, the programs should be described, outlining for what purpose they are, what they can do, how they do it and what they require.

6. Some scattered work has been done in this respect by various organizations, mostly concerning a few programs on one or two subjects only.

7. There are at present three attempts at providing a more systematic and complete overview for the entire irrigation field. One is the ILRI inventory, published as a written report in 1993. The second is the LOGID database on diskette, prepared by an ICID working group and the third, most recent one is the IRRISOFT information on Internet, operated by the University of Kassel. They do the same, but thus address and use different media.

8. The approaches as well as the contents of these inventories differ, which does not contribute to clearing the "software jungle". Attempts have to be made to come to more uniform approaches and, certainly in the end, to the same contents.

9. Having made the inventory of identified program names, the next steps are to collect the programs and test and evaluate them, in order to give a brief description of each program.

10. To that end at the same time it is necessary to establish a uniform framework with criteria for testing and describing the programs. Some attempts have been made in this respect. The experience obtained here has to be used for further upgrading of such framework and criteria.

11. Worldwide dissemination of the thus obtained information should be pursued strongly. This can be done in the form of articles, workshops and conferences, drawing attention to the issue through the three identified media.

It was further concluded that in all above activities: inventory, criteria, program evaluation and dissemination of information, only a few institutes and a few people are involved. This not only leads to slow progress, but also to inefficient work due to duplication and less effectiveness by non-consistency and non-uniformity in the information produced. The same, and even more so, applies to software development. It was agreed that programs have varying possibilities and are of very much varying qualities, with many duplications.

It was agreed that following up the above conclusions by more collaboration and unification would not only enhance the spread of program application for practical purposes, but also improve program development and avoid unnecessary duplication.

It was finally observed that all these efforts are only a first step towards more practical applications of computer programs in irrigation. A next step would be the monitoring of such actual applications, to see the actual working of the programs and of their effects, and to report on it.

7.2 Agreements and arrangements

1. It was agreed to further intensify the contacts and collaboration between the institutes involved on the above subjects (IIMI/ITIS, ICID/LOGID, Kassel University, CEMAGREF, IIS and ILRI). Work will first concentrate on the inventory and the criteria. It will be tried to meet again during the next ITIS workshop (3-5 June in Malaysia). Later this year it will be seen if and how the ICID Conference at Cairo can be used for further contacts.

2. In the next phase, different sub-groups will be formed, for which also subject experts from other institutions will be invited to continue on the program collection, testing, evaluation and description of subject programs.

3. For effective communication and collaboration the parties involved will be in close contact for information exchange via the closed E-mail circuit via Irrisoft. This contact would be (and now has been) established by Kassel University.

4. ILRI would prepare the proceedings of this workshop, which should be ready and available by the next ITIS workshop where it could be presented and discussed. The report will contain the edited papers as presented at the workshop; in the ILRI inventory brief descriptions of some programs will be added.

5. Information will be exchanged between the parties so that all inventories finally contain at least the same program names. The difference will then be in the media used. Parties will also exchange detailed information on the various programs.

6. In IRRISOFT, reference will be made to both inventories and an option will be offered to download the LOGID program. ILRI and IRRISOFT will be in further contact to make IRRISOFT a joint exercise with a joint entry page (Note that, at the time of printing the proceedings, this has already materialized). The group will continue to work on the evaluation criteria and the way in which program information should be presented.

7. Dissemination of this knowledge should be further pursued. Apart from the current Proceedings and Irrisoft, some journals will be approached to give a brief summary of the workshop and its results. ITIS will also do this in its next issue. The coming ITIS workshop and ICID Conference will also be used to further spread the message. Furthermore it will be assessed how ICID, IIMI and IPTRID can play an active role in this.

7.3 Finally

The workshop fully agreed with a conclusion from the 1993 FAO expert consultation, which was referred to by Malano in ITIS Vol.2/1: "the success of computerized operations must be measured by the overall improvement in operational performance of the system, rather than by the features of the software alone". Nevertheless, a good program can be a useful tool to that end and in that sense, underscoring the importance of computerized information, Skogerboe in the same ITIS issue observed: "getting the right information to the right person at the right time is bound to improve its productivity".

We hope that this workshop has made some useful contributions in this respect. We invite all readers of this report to provide additional information where relevant, which will be inserted in upgraded versions of the inventories.

ANNEX 1 WORKSHOP PROGRAMME

MONDAY 22 JANUARY 1996

Morning session

- Welcome
  Rémi Ponchat
  Pascal Kosuth
- Introduction to the workshop programme
  Rien Jurriëns
- Software inventories; need, past, present and future
  Rien Jurriëns
- Discussions

Afternoon session

- Demonstration of IRRISOFT
  Thomas Stein
- Presentation of LOGID
  Gilles Bonnet
- Discussions

TUESDAY 23 JANUARY 1996

Morning session

- Demonstration of programmes
  BASDEV (updated BASCAD)
  Rien Jurriëns
  CROPWAT (forthcoming version 7 and CWR-VB)
  Derek Clarke
  SIC
  Pierre-Olivier Malaterre
- Discussion on programs

- Computer use
  Derek Clarke

Afternoon session

- Classification and evaluation criteria
  Rien Jurriëns
- Discussions on classifications
- Discussions on evaluation criteria
- The upgraded ILRI inventory
  Rien Jurriëns

WEDNESDAY 24 JANUARY 1996

- Demonstration of IPTRID research network database

- Discussions
  Conclusions from presentations and discussions
  Arrangements for further work and collaboration

- Closure

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ANNEX 3 LIST OF PROGRAMS DISCUSSED AT VARIOUS OCCASIONS

INVENTORY ASCE - Irrigation and Drainage
The 1991 National Conference, Honolulu, Hawaii, July 22-26
Edited by William F. Ritter

1 SCHEDULER SCS version 1.10 [p.67] (Irrigation scheduling)

2 Large-scale scheduling in India [p.177] (Irrigation scheduling)

3 DST: Conceptual decision support tool [p.191] (Main canal operation)

4 SOYGRO and PNUTGRO [p.198] (Crop production)

5 Unsteady flow modelling [p.231,238,244,304,311,323,501] (Canal network flow simulation)

6 Crop simulation modelling [p.283,290] (Crop production)

7 CERES for maize, sorghum and winter wheat [p.297] (Crop production)

8 MODFLOW (Groundwater flow) and BRANCH (Open channel flow) [p.330,438]

9 Streamflow recession [p.337] (Hydrology)

10 MOL: Method of Lines for groundwater modelling [p.344] (Soil-water models)

11 Surface-subsurface conjunctive model [p.351] (Soil-water models)

12 Crop canopy models for row crops [p.366] (Evapotranspiration)

13 CANAL: Unsteady flow in branching canals [p.390] (Canal network simulation)

14 SNUSM: Unsteady-state model [p.397] (Canal network simulation)

15 MODIS: Modelling drainage and irrigation systems [p.407] (Canal network simulation)

16 DUFLOW (successor to IMPLIC): general open channel flow [p.418] (Canal network simulation)

17 USM: Unsteady model [p.425] (Canal network simulation)

18 CARIMA: general open channel flow [p.432] (Canal network simulation)

19 Cal Poly model canal (CARDD & CARIMA) [p.481] (Canal network simulation)

20 SIMCAR automatic upstream control modelling [p.487] (Canal network simulation)

21 CANAL: transient canal flow model [p.494] (Canal network simulation)

22 Stochastic simulation and multi-criterion decision-making [p.567] (Irrigation delivery planning)

23 Enhanced canal system scheduling (expanding STEADY) [p.576] (Short-term delivery scheduling)

24 NPUSM: Narmada model for canal flows [p.583] (Canal network simulation)

25 SRFR: surface flow in furrows, basins and borders [p.676] (Surface irrigation)

26 SWM II: furrow infiltration patterns [p.697] (Furrow irrigation)

27 Optimizing furrow infiltration parameters [p.704] (Furrow irrigation)

28 SRM: Snow-melt runoff model [p.787] (Hydrology)

29 RMA-2V: enhanced model for marshes [p.794] (Hydrology)

INVENTORY ICID - 1st Workshop on crop-water models
Rio de Janeiro, 1992
ICID Bulletin Vol 41, No 2; 1992

1 Crop Water Budget (Evapotranspiration)

2 RAINBOW (Rainfall data analysis) and ISRIS (Irrigation scheduling)

3 ISAREG (Irrigation scheduling)

4 MUST (Vertical soil-moisture flow; Drainage)

5 SWACROP (Soil-moisture flow; Crop production)

6 SWATRER (Soil-moisture flow) and SUCROS (Crop production)

7 SOYAMET (adaptation of SOYGRO; Crop production -soy bean-; Crop water requirements)

8 Management strategies for scheduling irrigation: wheat and corn (Irrigation scheduling)

9 SIRFRU (Irrigation scheduling; Crop production -wheat-)

10 A program for irrigation advice and management of irrigated areas. (Irrigation scheduling; Irrigation scheme management)

11 IEM: Irrigation Efficiency Model (Sprinkler irrigation performance)

12 SPAW (Soil-plant-air-water model)

13 SCHEDM (Soil-water balance; Irrigation scheduling)

14 SDSMBM (Soil-water balance)

15 GRASPER (Irrigation scheduling)

INVENTORY ICID - 2nd workshop on crop-water models
The Hague; 1993
Transactions, 15th Congress, 1993

1 WCAMOD (Soil-water balance and Water allocation; Irrigation scheduling)

2 BAHIDIA (Soil-water balance and Irrigation scheduling)

3 Crop growth simulation model for planning canal water delivery schedules (Large- scale irrigation scheduling)

4 RENANA (Large-scale irrigation scheduling advisory service)

5 OMIS: Operational management for irrigation systems (Irrigation system management)

6 HYDRA-DSS: Mediterranean decision support system (Irrigation system management).

7 WRMM: Water resources management model (River-basin planning tool)

8 RELREG (Irrigation scheduling at farm level)

9 PROREG (Irrigation scheduling at project level)

10 CROPWAT use for irrigating wheat in sodic soils (Irrigation scheduling)

11 BIWASA: Water and salt movement in unsaturated soils (Soil water flow)

12 CAMS: Computer Aided Management System, and SCHED: irrigation SCHEDuling (Center-pivot sprinkler systems)

13 MUST (Vertical soil-moisture flow; application for drainage design)

14 BIDRICO 2 (Irrigation scheduling at field level; Crop yield)

15 DISEVAL: Design and evaluation of surface irrigation (Border and furrow irrigation)

16 IRRICE: field level, and IRRICEP: project level water balances of paddy rice (Irrigation scheduling)

17 Soil-moisture flow simulation model (Soil-water model; Soil and water conservation)

18 SOWABAMO (soil water balance model) with sub-routines CYEM (crop production) and ADAM (drought index) (Crop water requirements; Irrigation scheduling)

19 SOYGRO V 5.42 in Portugal (Crop production -soy bean-)

20 OPUS: an ecosystem model with water-based processes (Crop water balance; Crop production)

21 SWARD: drainage effects on grass production (Drainage; Crop production)

22 SWATRE: application for drainage design in an irrigated area (Soil-water flow model)

23 CERES-Millet: Crop production under rain-fed conditions (Crop production)

24 SWBM: Soil water balance model in a GIS environment (Soil-water model; Drainage)

25 Refining soil water balance models (Irrigation scheduling)

INVENTORY ICID - Workshop on subsurface drainage simulation models
The Hague; 1993
Transactions, 15th Congress, 1993

1 Solute movement in soils; in Chinese (Salinity; Leaching; Soil-water models)

2 DRAINMOD: application to drain-spacing trial in Northern Germany (Drainage; Watertable elevation prediction)

3 SIDRA: Simulation of drainage; predicts watertable elevations and drain flow rates; in French (Drainage)

4 DRAINET: simulates saturated-unsaturated flow in drained soils; in German (Drainage; Soil-water models)

5 Flevoland watertable and drain-flow predictions per hour (Drainage; Water-balance model)

6 ADAS: predicts watertable heights (Drainage; Soil-water model)

7 Excel spreadsheets for the computation of drain spacings (Drainage)

8 Solute transport in tile-drained soils (Drainage; Salinity; Soil-water model)

9 Excel spreadsheet for boundary effect of drained areas (Drainage; Hydrology)

10 Sub-irrigation for preservation of wetlands (Ecology; Hydrology)

11 Lacul Morii groundwater regime modelling (Geohydrology; Soil-water models)

12 Flow of water and chemicals in soils with macropores (Drainage; Salinity; Soil-water models)

13 DRAINMOD-N predicts nitrate losses and DRAINMOD-CREAMS predicts sediment losses from agricultural soils (Drainage; Water quality)

14 DRAINMOD watertable height and solute concentration prediction in Finland (Drainage; Leaching)

15 Using stress day index models (SDI) to predict yield losses from poor drainage (Drainage; Crop yield)

16 ADAPT (GLEAMS + DRAINMOD) predicts drainage rates and pesticide losses (Drainage; Pollution)

17 CSUID management support system for irrigation and drainage systems -under development- (Irrigation system management; Drainage system management)

18 DRAINMOD-S: predicts soil salinity as affected by irrigation water quality and drainage design (Drainage design; Salinity; Water quality; Crop yield)

19 DRAINMOD-CREAMS predicts nitrate losses in Canadian potato fields (Drainage; Water quality; Crop yield)

20 SI-DESIGN: for the design of sub-irrigation systems (Sub-irrigation system design)

21 SIMGRO: regional hydrologic model for surface and soil water (Hydrology; Irrigation water use planning)

22 SALBAL computes salt balances and soil salinity under irrigation (Drainage; Salinity)

INVENTORY IIMI/CEMAGREF
Workshop on mathematical modelling for improved canal operation; Montpellier; 1992
Provisional proceedings

1 Management information system (Canal operation; Irrigation system management)

2 SYMO: irrigation system management and operation model (Canal system operation; Irrigation system management)

3 OMIS: operation management of irrigation systems (Irrigation water management)

4 SIMWAT: canal network and outlet flow simulation (Irrigation water management)

5 BAHIA: dam-river systems operation (Hydrology; River flow simulation)

6 RBMC for Right Bank Main Canal combines programs Talweg + Fluvia + Sirene. Developed into SIC (Canal system flow simulation for operation)

7 ICSS: irrigation conveyance systems simulation model (Canal network flow simulation for operation)

8 CIMIS: water distribution option of a computerized irrigation management information system (Irrigation scheduling)

9 SIC: simulation of irrigation canals; a Pakistan application (Canal network simulation and operation)

10 SIC; a Mexican application (Canal network simulation and operation)

11 ICSS, a research application for automatic controllers Canal network flow simulation for operation)

12 MODIS: non-steady canal flow simulation, an application in Bangladesh (Canal network flow simulation)

13 CanalCAD: dynamic flow simulation in irrigation canals with automatic gates (Canal network flow simulation)

INVENTORY FAO EXPERT CONSULTATION
on Irrigation Water Delivery Models, 4-7 October 1993.
Water Reports 2, Rome, 1994

1 ISAREG for row crops and IRRICEP for paddy rice (Irrigation scheduling)

2 Computerized irrigation monitoring system, India, with six sub-modules, including a management information system (Irrigation system management)

3 SIMIS: Introduction to its use and potential: Scheme Irrigation MIS

4 SIMIS: setting up a scheme irrigation management information system; the water distribution module is ready (Irrigation scheduling)

5 OMIS: Operational management of irrigation systems (Irrigation system management)

6 RIWAP: Real-time irrigation water allocation program, similar to WASAM (Irrigation system management)

7 IMSOP: Irrigation main system operational model, containing an evapotranspiration, an irrigation requirement and a system operation module (Irrigation system management)

8 INCA: Irrigation network, control and analysis, an integrated management program (Irrigation scheme management)

9 MISTRAL: Hydraulic simulation model of canal flows and discharges to outlet off-takes (Canal network flow simulation)

10 IMIS: irrigation management information system (Irrigation system management)

11 SIMWAT: simulation of water levels and discharges in open channels, integrating seepage and surface flows (Canal network flow simulation)

12 ICSS-4: Irrigation conveyance system simulation (Canal network flow simulation)

13 SIC: steady and non-steady flow in irrigation channels (Canal network flow simulation)

14 EXPERDI: computerized system for the distribution of water in irrigation modules (Crop water requirements; Irrigation scheduling)

15 Several programs on the use of linear programming in optimizing water allocation (Irrigation scheduling)