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ITIS

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Information Techniques for Irrigation Systems

The establishment of the ITIS network is of special interest to IIMI for at least two reasons. First, the subject of the network—the application of information techniques for improving the management of water in irrigation systems—is an outstanding example of the interface between technology and management. Better management of irrigation systems can undoubtedly be fostered by improvements in technology—including not only the "hardware" of physical infrastructure but also the "software" of decision-support systems. In particular, the specific decision-support technologies to be addressed by this network, including simulation models, performance measurement tools and modern communication systems, have a proven capacity to help irrigation managers make better decisions and thus manage their systems more effectively. All of this provides an excellent illustration of the way in which irrigation management and irrigation technology are closely interwoven, reinforcing the need for improvements in both if real breakthroughs in irrigation performance are to be achieved.

Second, the objective of the network—to facilitate the dissemination of knowledge in this subject area—is fully congruent with IIMI's overall mission of fostering the development, dissemination and adoption of lasting improvements in the performance of irrigated agriculture in developing countries.

But undoubtedly the network will not only contribute to the dissemination of existing knowledge; it will also indirectly contribute to the generation of new knowledge, by providing ideas and insights to the growing number of researchers and practitioners in both developed and developing countries who are working jointly on the application of decision-support systems in various irrigation settings. And surely the network will also assist the further development of generic knowledge, concepts and methodologies based on the aggregate results generated by participating network members in site-specific studies.

I am pleased that IIMI is able to play a role in the establishment and further development of the ITIS network. The editors of the ITIS newsletter and all of us at IIMI look forward to comments from readers on the articles in this inaugural issue. Your ideas will help make sure that the network's objectives are fully achieved.

Roberto Lenton
Director General
INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
NOVEMBER 1994

Inside ...

From a Research Project to Information Techniques for Irrigation Systems (ITIS) Network

In 1986, IIMI's researchers embarked on a program on irrigation canal operations in Sri Lanka.

It was decided that the first phase of the program would consist of designing a user-friendly computer model, able to simulate the hydraulic conditions in canal systems. The objective was to provide managers with a tool which could assist them in operating their canals in a more efficient, equitable and flexible manner in the context of diversified cropping.

The Kirindi Oya Irrigation and Settlement Project was selected as the pilot experimental site in 1986, after a mission during which about 10 Sri Lankan irrigation schemes were visited. The Kirindi Oya Scheme was still under development and regularly faced water-shortage conditions. The Right Bank Main Canal, of a regular shape, appeared to be adequate for initiating the modeling exercise even though the managers did not show a real enthusiasm for the project at that time. The design of the computer software was subcontracted to CEMAGREF, and the Government of France agreed to fund the project. The complete story of the work undertaken and realized since then in Sri Lanka, a country which unfortunately had to face many periods of political unrest, is interesting in many ways. A few key points are mentioned below:

PROJECT MONITORING

From the inception of the project, IIMI set up a Study Advisory Committee (SAC) comprising representatives of the donor, researchers and users. This committee worked in a very flexible and voluntary manner and played an important role.

EVOLUTION OF THE PROJECT

The first output of the project came in 1990 in the form of a hydraulic simulation software, tested by the canal managers, and immediately it proved to be useful for the improvement of some of the management rules in place. Nevertheless, it appeared at this stage that this tool alone could not answer the complete spectrum of the concerns expressed by irrigation canal managers. In 1991, the committee acknowledged the necessity to integrate it in a wider information system taking into account the need for dynamic data acquisition, transmission and storage. During a second phase of the project, the first prototype of the Irrigation Management Information System (IMIS) was designed and tested following these recommendations. Further work, enlarging on the experience gained through contacts in Pakistan and Mexico, permitted to begin a third phase of the project aiming at producing generic outcomes in terms of decision support which can be applied to a wide range of situations encountered in irrigation canal systems around the world.

PARTNERSHIP

Conducting research in partnership with collaborators who have different cultures and who live in countries at different stages of development is challenging. A good understanding of the needs is a difficult exercise. In this case, the commitment of all partners from IIMI, CEMAGREF and the Sri Lankan Irrigation Department for sustaining a continuous dialogue and deriving orientations for the research proved to be determinant. The experience shared during the first phase of the project led to a better formulation of the needs and the emergence of the present research agenda whose relevance is confirmed by the interest it has generated in different countries.

In Pakistan, Mexico, Sri Lanka or almost in any other country on the planet, the production of food through agriculture is a major challenge. To meet this challenge, irrigation is essential. A good management of irrigation systems thus becomes essential for satisfying the food requirements of our increasing world population as well as for ensuring the sustainability of essential resources such as water and land. The work undertaken is a contribution towards this objective of better management of irrigation systems.

A successful project and a continuous effort for sharing the experience gained are key ingredients for setting up a network: ITIS. This network was in gestation in 1992 when

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The Network

The Information Techniques for Irrigation Systems Network (ITIS) links the conceptual to the practical—the world of Decision Support Systems (DSS) to the world of irrigation. This newsletter is intended to serve as that bridge, to facilitate the dissemination of knowledge concerning the application of information techniques for improving the management of water in irrigation systems.

The IIMI-CEMAGREF Project in Kirindi Oya, Sri Lanka was the foundation on which ITIS was launched. Following the successful development and implementation of decision support tools in Sri Lanka, the project has entered a new phase with work being initiated in Pakistan and Mexico. Work on the IIMI-CEMAGREF Project will progress for another five years. It is hoped that ITIS would have gained a sufficient critical mass by that time to sustain itself.

CEMAGREF

CEMAGREF is the French institute of agricultural and environmental engineering research. It is a parastatal organization supported by both the French Ministry of Research and the French Ministry of Agriculture. It has a strength of more than 500 researchers and conducts research programs in the field of land and water management, environment and agricultural engineering. Its irrigation division is located in Montpellier, France.

IIMI

The International Irrigation Management Institute (IIMI) is an autonomous, nonprofit international research and training institute supported by the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of public- and private-sector donors that supports a worldwide network of 18 international agricultural research centers, including IIMI, conducting global research on agriculture, forestry and fisheries. The CGIAR is sponsored by the Food and Agriculture Organization of the United Nations (FAO), the International Bank for Reconstruction and Development (World Bank), and the United Nations Development Programme (UNDP) and comprises more than 45 donor countries, international and regional organizations, and private foundations.

IIMI's mission is to foster the development, dissemination and adoption of lasting improvements in the performance of irrigated agriculture in developing countries. With its headquarters in Colombo, Sri Lanka, IIMI conducts a worldwide program to generate knowledge to improve irrigation management and policymaking, strengthen national research capacity, and support the introduction of improved policies and management approaches.

Are Decision-Support Systems Useful in Irrigation System Operation?

Decision-Support Systems (DSS) are procedures, often computerized, to evaluate options in system operation, and, hence, they identify those that will have better results with respect to specified objectives. Though the line dividing Management Information Systems (MIS) from DSS is not always clear, the focus of the former is on the orderly presentation of data, while the aim of the latter is to interpret and evaluate alternative courses of action based on such data. The evaluative nature of DSS provides the basis for caution in their application in areas where the response being predicted or evaluated includes behavioral relationships. This note is not aimed at DSS that help managers to follow known operational rules, but rather at those (including large models of irrigation systems) which suggest "better" rules.

The argument for caution has three foundations.

First, is the evaluation function right? This point is self-evidently applicable to any modeling system, but is worthy of mention in this context if we note the extraordinary difficulty normally encountered in explaining farm-level behavior. Most of the users have seen "if not actually constructed" farm models that indicate that strawberries, or some local or exotic equivalent is the best choice of crop. Far fewer have succeeded in capturing the set of physical, market, and experience/expectation parameters which result

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IIMI and CEMAGREF organized an international workshop in Montpellier on the use of computer models for irrigation canal management. This is the first issue of its newsletter.

IIMI's mandate and its international status have made possible this evolution of the research program from the Kirindi Oya pilot study to the consideration of more generic concerns. IIMI is at the crossroads of research in the North and of operational projects in the South and is committed to promoting institution building along with technology transfers. ITIS is thus naturally integrated in IIMI's activities. The network hopes that all readers interested will join its efforts for contributing to advances in the field of irrigation management.

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in the cropping pattern observed in the field. Until we have sound models that embody farmer perceptions of constraints and opportunities, our ability to evaluate operational alternatives will necessarily be limited.

Second, whose objectives? Real-world decisions involve tradeoffs between competing interest groups, for example:

* Maximizing the gross value of production (scheme manager's objective);

* Minimizing area suffering from complete crop loss (insurance company's objective, also shared by agency receiving water charges, where these depend on the area of crop matured);

* Maximizing net revenue at farm level (farmer's objective);

* Minimizing total diversions (farmers in low-lying areas prone to waterlogging);

* Maximizing total diversions (negotiators in interstate water rights disputes); and

* Maximizing carry-over storage into the dry season (hydropower objective).

The complex set of possible objectives and conflicts point to the need for careful specification and identification of benefits and costs of each objective.

The two foundations noted above, though complex, are at least obvious and transparent. The third foundation is more difficult to define, and more difficult still to incorporate into DSS. It is, feedback instability: farmers behave rationally within an uncertain world—they do not grow only strawberries, as linear programs would have us believe; they do not always put the full amount of fertilizer and pesticide that extension agents recommend and they do not grow only those crops that give the best return to the limiting input, be it water, labor, credit or land. Farmers make choices in response to long experience, and can often be observed following cropping practices that reflect the distribution of uncertainties they have experienced.

Irrigation is a means of reducing uncertainty, and its availability has two quite distinct impacts on agricultural production:

* a static impact (better soil-moisture availability automatically results in higher yields in economic terms—a shifting up of the production function); and

* a dynamic impact (farmers plant higher-value, more moisture-sensitive crops if water is assured—a shift to a new production function).

Advocates of DSS would argue that better analysis of operational options should result in better allocation of water, and improve both the static and dynamic effects of irrigation.

But what impact will "rational" DSS have on farmer behavior? If DSS save a higher proportion of the crop in a time of shortage than an alternative simple allocation, this must also be seen as a learning experience for the farmer. And here the fact that the experience of the individual differs from the project-level experience is critical. In the short run, noting perhaps that high-value crops were favored in the DSS solution to shortage, farmers may "learn" that high-value crops receive a more secure water supply. Shifts in that direction will simply increase the extent of losses when the next shortage arrives, and then undermine farmer confidence in the future.

A transparent allocation system that divides the available water over the irrigated area provides each farmer with a reliable supply, in the important sense that he understands exactly how his entitlement is defined. More complex allocation rules are likely to undermine that understanding, and while our ability as modelers to incorporate the impact of farmers' reactions to such perceived uncertainties is limited, the role of DSS as practical guides to operational decisions will similarly be limited. The contrast between neural networks and artificial intelligence is relevant—neural networks seem to be "discovering" that humans utilize subconscious knowledge in making judgements: we do not even know what we know! This has serious implications for modelers of rational behavior.

Some readers will have mentally rejected each of the above points, noting quite rightly that the topic is Decision-Support Systems, indicating that human judgement is being assisted rather than replaced in this process. The point is valid and appropriate. But note that computerized models have two common characteristics—they do well in "normal" times, much worse when we really need their expected contribution; and second, they can incorporate and evaluate almost endless rules and factors. As time goes on, and new users exploit existing models, some rules may become both forgotten and obsolete, rendering advice invalid, though still delivered with the precision and assurance that our computers provide.

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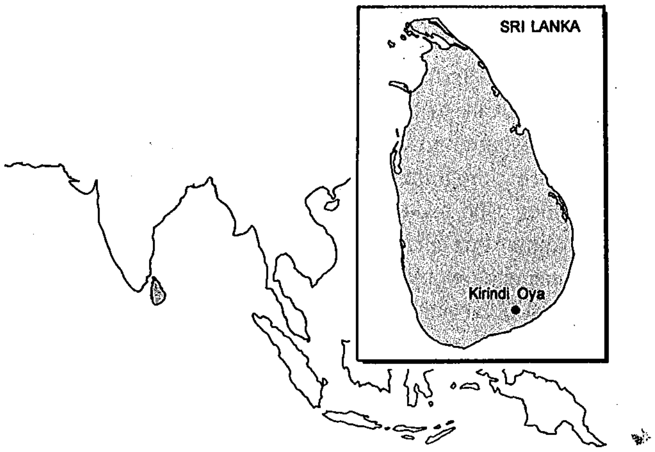
ITIS in the Field

In this issue, ITIS in the Field focuses on field projects in Sri Lanka, Pakistan, Malaysia, India and Mexico. As ITIS extends its contacts to field laboratories in other countries, future issues of ITIS will include reports from those irrigation schemes as well. Other irrigation schemes while joining ITIS, will find room in this regular column to describe their own decision- support systems, environments and experiments.

Data Collection Network in Kirindi Oya Project



INTRODUCTION

Kirindi Oya Right Bank Main Canal (RBMC) located in southern Sri Lanka is a 22-mile (35-km) long canal which starts from the right bank sluice of Lunugamwehera Reservoir and ends at Bandagiriya Tank. It has 19 gated cross regulators and 42 takeoff canals. The canal can carry a 350 cusec (10m^{3}s) discharge and the capacities of takeoff canals vary from 1 cusec to 50 cusec (0.03 to 1.40m^3/s). The last regulator and takeoff point is about 17 miles (27 km) from the sluice and after that the canal flows to a small intermediate tank called Karambagaswewa. Further to Karambagaswewa the canal continues as a feeder canal to augment Bandagiriya Tank or its main canal whenever necessary. The direct command area under the RBMC is about 8,400 acres (3,400 ha) [without the Bandagiriya Scheme which has a command area of 2,100 acres (800 ha)].

The command area has been divided into four administrative units (tracts) with an approximate area about 2,000 acres (800 ha) managed by one Technical Assistant with a Work Supervisor. There are 17 Gate Operators in the four tracts whose services are extended up to the field channel head level. There is a unit office at the mid of each tract and the Work Supervisor of each tract is expected to be stationed in the unit office.

All the main canal offtakes are gated (all with galvanized cast iron gates) and meter gauges are fixed upstream and downstream of each offtake turnout. All the cross regulators are fixed with wooden lifting gates and a check wall to guide the normal water level of the main canal. Meter gauges are fixed to read the upstream and downstream pond levels at all the offtakes as well as at all the cross regulators. The opening of the gate may be determined by measuring the height of the spindle.

All the meter gauges are made of ceramic wall tiles, each 20 cm by 10 cm, embedded in the wall of the structure. The gauges are factory printed and well readable up to 1 cm accuracy with a distance of 100 feet (30 m). The gauge does not need much maintenance except for just being wiped with a piece of cloth. Damaged pieces, if any, may be replaced with minimum effort and time. The cost of the gauge is about US$2.00 per meter.

The management of the whole RB irrigation system is under the responsibility of the Resident Engineer (Right Bank) whose office is centrally located at the 11th mile (18th km) along the RBMC. The head sluice operations are under the responsibility of the Chief Resident Engineer (CRE) who is the Superintendent Manager of the whole irrigation system of the Kirindi Oya Project. There is an engineer stationed at the headwork for all the headwork operations and he carries out only the instructions given by the CRE.

MANAGEMENT OF THE MAIN CANAL SYSTEM

The responsibility for the main canal management is to ensure target discharges at each offtake and at the end, with the correct time, considering the variation of requirements, the cropping area, cropping stage and climatic conditions.

This involves the management of proper pond levels at each cross regulator (Gated Regulator [GR]), by setting the GR gates and controlling the offtake gate settings to discharge the correct target.

The maintenance of pond levels at GRs is done by the trial-and-error method, i.e., by operating GR gates until the main canal water level is at the check wall, allowing any excess discharge to escape by opening gates, if the water level rises or refilling by closing gates, if the water level drops. If the main canal water level is maintained up to the check wall, the offtake gates are operated so that the required water level is achieved at the Broad Crested Weir (BCW) built at the head of each offtake, for which calibration tables are available

DATA COLLECTION, TRANSMISSION, PROCESSING AND FEEDBACK SYSTEM

IIMI with the cooperation of the Irrigation Department designed a data collection and transmission network. This was implemented for the first time during the 1991/1992 *maha* (wet) season. IIMI provided computer facilities at the RB office. The first trial of the data management program was done by Lotus Spread Sheet. Later, IIMI and CEMAGREF developed the IMIS data management software which enabled the manager to enter data with more interest, process data into discharges, and to see the past performance of the canal.

The data collection network was designed jointly by IIMI and the Irrigation Department. But the whole program was implemented solely by the Irrigation Department staff as a part of their job. Thanks to this approach, the program will continue even in future with least effort.

Comprehensive data collection forms have been formulated for Gate Operators as well as for Work Supervisors. Each Gate Operator has been given a booklet of forms to collect and record data in the field. Data are collected and recorded twice a day for each gate under his jurisdiction (upstream and downstream water levels and spindle height). Gate Operators report water levels and spindle heights to the Work Supervisor (WS) who prepares a summary of water levels and gate settings in a message form to be delivered to the manager. This message form which includes the previous evening's positions and the day's morning position is daily hand-delivered to the manager by a messenger before noon.

Display boards have been provided to the unit offices and to the Resident Engineer's office.

The unit office disphay board displays the last seven days' d/s water levels for each turnout in the tract with the target levels. The Resident Engineer's office has a white board displaying the last eight days' discharges at each offtake along the Main Canal with the target discharges.

BENEFIT OF THE RESEARCH WORK

There are many direct and indirect benefits to the project by the research work implemented.

1. The manager of the system can visualize the water levels of the main canal as well as the discharges through the offtakes being informed of the status of all the structures at least once a day. This is a great help to him in managing his canal since he is able to pinpoint trouble areas which require more attention, take better decisions having a holistic view of the canal behavior and can, hence, maintain reasonable equity in water distribution. If there is a shortage of water in one section, a decision may be made to extract water from sections which have drawn enough or more water in the previous few days.
2. There is a better control over the field staff who have to be more aware of their work, and hence ad hoc operations are minimized. Since there is a daily monitoring program, field staff also have to improve their operations and make more accurate readings. Simply recording of an imaginary reading is not possible because the mismatch would be revealed when compared with information at other adjacent structures.
3. Since there is a proper maintenance of past records, field personnel are able to handle similar situations confidently and, with less effort, this will create more interest toward their work. If there is any illegal operation by an outsider, quick detection and quick readjustment are possible. When there is a change of work site or a new recruitment takes place, a guidance may be provided by the past records.
4. The same messengers may be used to send operational instructions or feedback to the field at least once per day.
5. Due to the upstream and downstream information flow, more collective responsibility will be felt and a better working environment created. The tract-level coordination will also be improved.

PROBLEMS OF IMPLEMENTATION

The following problems may be expected when this program is implemented in future.

1. Paying of the allowance to the Work Supervisors who transmit field data to the RE's office.

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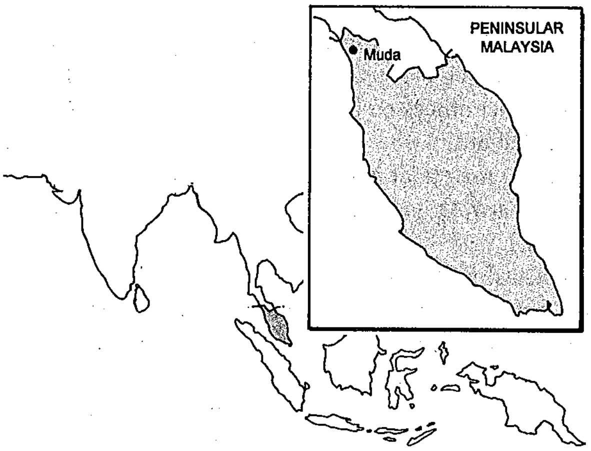
The Decision-Support System in the Muda Scheme



INTRODUCTION

The Muda Irrigation Scheme located in northern Malaysia and designed for double cropping of rice encompasses an area of 98,000 ha consisting of 110 irrigation blocks irrigated through an internal reticulation system with the primary and secondary canals being provided with discharge measurement offtake structures. The scheme is dependent on rainfall for supplying about 51 percent of the irrigation requirement. The two dams contribute about 29 percent while uncontrolled river flow and recycling supply 15 percent and 5 percent, respectively, of the irrigation requirement.

Being heavily dependent on rainfall due to limitations in dam supply, the management of the Muda Scheme hinges on maximizing the use of rainfall and minimizing the release from the dam.

WATER MANAGEMENT MODEL

The establishment of the Water Management and Control Scheme (WMCS) in 1988 based on the concept of field water depth ensures that the available water resources are utilized efficiently.

The daily computation of the water demand in the WMCS is guided by the principle that rainfall and uncontrolled flow must be fully utilized before water is released from the dam.

In each irrigation block, three depths are specified (as shown in Figure 1) for the computation of effective rainfall and rate of water supply.

1. A **Minimum Water Depth (MWD)** of 50 mm which has to be maintained throughout the planting season. Shortfalls must be met from uncontrolled flow or dam release to raise water depth above MWD.

2. **Lower Control Depth (LCD)** of 100 mm above which only uncontrolled flow is to be supplied.

3. **Upper Control Depth (UCD),** which is dependent on the height of the field levees is the maximum depth that can be maintained.

The effective rainfall (Re) is the amount of rainfall which can be stored in the field and is available for consumptive use by the plant. Re is dependent on the existing water depth (D), amount of rainfall (R) and height of field levees. Re is computed as follows:

i. When $D + R < LCD$, $Re=R$
ii. When $LCD<D+R<UCD$ and $D<LCD$, $Re=(LCD-D)+re(R+D-LCD)$
iii. When $LCD<D+R<UCD$ and $D>LCD$, $Re=reR$
iv. When $UCD<D+R$ and $D<LCD$, $Re=(LCD-D)+(UCD-LCD)re$
When $UCD<D+R$ and $LCD<D<UCD$, $Re=(UCD-D)re$
When $UCD<D+R$ and $D>UCD$, $Re=0$

where $re = 0.6 - 0.7$.

The evapotranspiration (ET) is computed from the formula $ET = kEP$ where EP is the measured pan-evaporation and k is a constant dependent on the growth stage of the rice plant.

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2. Entering of data will take about one hour if the data are coming from all the four tracts. If a trained person, preferably a draughtsman is not available, data entering will be a problem.
3. The availability of a computer at the manager's office has to be ensured.
4. If the funds allocated to employ turnout attendants are limited, especially after the handing over process of distributary channels to the farmers, field-data collection might be a problem.

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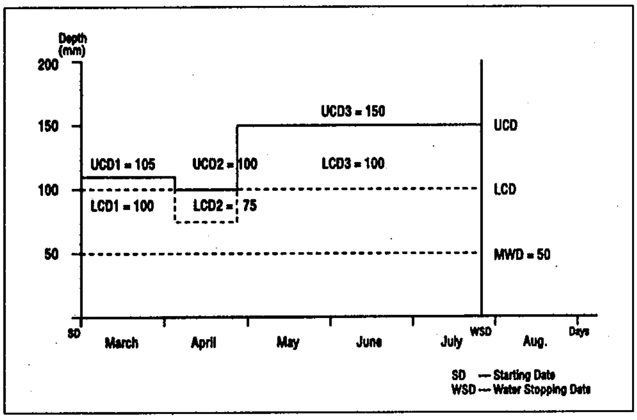
Figure 1. MWD, LCD, UCD with reference to time after commencement of irrigation.



The seepage loss (S) is largely being accounted for by the effective rainfall. Percolation loss (P) is very small in the Muda Scheme. The seepage and percolation loss (SP) is about 1 mm/day.

The daily water demand can be computed by the water balance equation:

$$D_{t+1} = D_t + I_t - ET_t - SP_t + Re_t$$

where I is the irrigation supply and subscript t is the time in days.

Allocation of irrigation water to each block depends on the value of D_{t+1} with reference to MWD, LCD and UCD.

OPERATIONALIZATION OF THE WATER MANAGEMENT MODEL

The volume of water supplied to each irrigation block, rainfall and pan-evaporation data for the previous day are conveyed by the field staff to the district offices by the VHF set or telephone every morning. The data are then checked and transmitted to the Control Center at the MADA headquarters via the district computer terminals for processing. The status of irrigation and supply for the day for each irrigation block is made available to the field staff via the district offices on the same day for new gate settings to be carried out.

Data on progress of planting activity of each block are taken once a week and input into the model to determine the value of ET.

The actual field water depth of each block is also taken once a week and input into the model to correct the computed water depth. This is necessary because the computed water depth gives the theoretical water requirement of each block. The hydraulic conditions of the delivery canals are not taken into account.

The operation of the model is subjected to manual override. Decision making by the management is assisted by access to real time information provided by the telemetry system consisting of 65 automatic rainfall stations and 4 rainfall-cum-water level stations.

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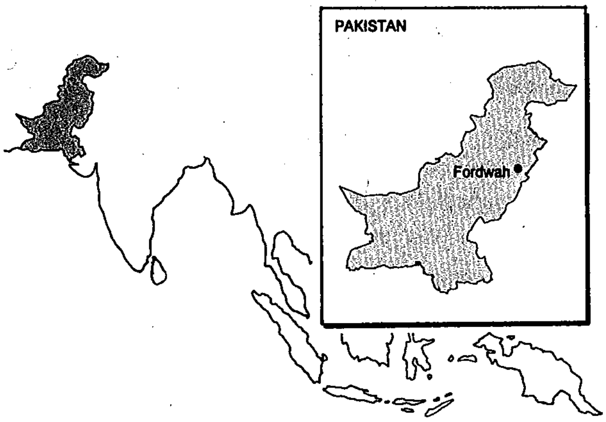
The Introduction of an Irrigation Management Information System in the Punjab, Pakistan: A Pilot Study in the Fordwah Branch Canal



The Indus Basin Irrigation System in Pakistan is one of the largest contiguous irrigation systems in the world. Annually, some 130 billion m^3 of surface water is diverted to 44 canal commands, covering an irrigated area of more than 14 million ha. In addition to that, groundwater, which has increasingly become an important source for irrigation, contributes presently an estimated 46 billion m^3 (or 35% of the canal diversions) to the irrigation supplies in the Indus Basin, through private and public tubewells.

Despite the spiraling contribution of groundwater to irrigation, water remains a scarce commodity in rural

Pakistan, where cropping intensities are estimated to be around 125 percent, as opposed to the originally envisaged 50-75 percent of design values. The demand for canal water is tremendous, particularly in the hot kharif (summer) season, as farmers favor canal water because of its low price and good quality. The irrigation agency has to increasingly deal with localized demands from farmers to satisfy actual crop water requirements, infringing on the (still valid) system objective of distributing water equitably. The effect of this on actual water distribution patterns in the Punjab has been described by various authors (see, for instance, Bhutta and Vander Velde 1992).

It is argued here that in a situation where the demand for canal water is as high as it is and where an equitable water distribution is evermore difficult to achieve, there is a need to have accurate, easily accessible information available to managers on actual water deliveries. This information can be used to evaluate past water deliveries (vis-à-vis targets), to support decisions for future operations and to detect possible physical or other constraints to water distribution.

In recent years, a number of computer-based management information systems have been developed in the field of irrigation. These tools aim to help irrigation managers process and analyze large numbers of data, that are often otherwise not used, and to convert them into meaningful indicators. However, few of these information systems have been adopted by irrigation agencies and are now routinely used by managers.

In 1993, the International Irrigation Management Institute (IIMI) in Pakistan and the Punjab Irrigation and Power Department (PID) have launched a pilot study in the Fordwah Branch Canal (Punjab), to test the feasibility of the real-time implementation of an Irrigation Management Information System (IMIS). Managers and researchers have jointly improved the existing data collection system in an administrative irrigation unit of 67,000 ha. Moreover, the inflow into this unit has stabilized in 1994, providing local managers with a more predictable water supply.

Both partners are evaluating the utility of this tool through a Planning Group, which coordinates irrigation management research in the Punjab Irrigation and Power Department. Based on the results of the pilot study, recommendations will be made to the Department regarding application of this tool to larger areas in the Punjab.

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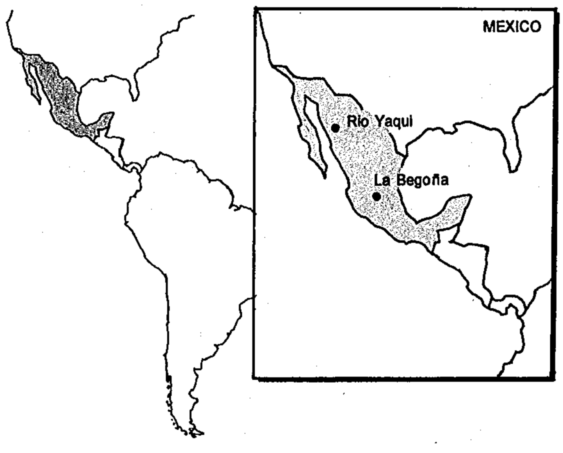
Manual Operation and Water Distribution in Two Mexican Irrigation Districts

In this article, we discuss the manual methodology used for operation and water distribution at two main irrigation canals in Mexico: the Right Bank Main Canal (RBMC) of Irrigation District No. 085 (La Begoña) and the "Canal Alto" of Irrigation District No. 041 (Rio Yaqui). Both canals are currently being studied using hydraulic simulation techniques.



In 1990, the Government of Mexico, began an irrigation district transfer project through the National Water Commission (CNA). At present, almost all economically sound irrigation districts have been transferred to user associations. To consolidate the transfer project, the CNA, in collaboration with Mexican and international research institutes and universities, is developing research and technological projects.

THE RIGHT BANK MAIN CANAL OF IRRIGATION DISTRICT "LA BEGOÑA"

The Begoña District is in central Mexico at 1,754 msl. The Right Bank Main Canal is a concrete-lined canal, 20 km long with 28 reaches, which supplies water to 7,800 ha. The reaches vary in length from 300 m to 1.6 km. The canal has 70 turnouts to secondary canals and farm outlets, with a capacity of 0.1 m^3/s to 4.7 m^3/s. The maximum inflow capacity of the canal is 10.15 m^3/s. The turnout structures are located at the downstream end of the reaches. The flow rate through the turnout structures is governed by the orifice flow law. The structures located in the turnouts are slide, Miller and constant head orifice (CHO) gates. Each of the four operational sections of the RBMC is operated by a ditch rider who modifies the flow regulation structures to distribute the water according to the delivery schedule. The superintendent of the ditch riders supervises the overall operation of the canal.

During the week, the ditch riders receive the users' water requirements for the following week. On Friday, all the water requirements (four sections) are added and the operation manager requests the inlet volume for the canal from the CNA. The CNA, which is in charge of reservoir operations, sets the water allotment for the following week, based on the water available in the reservoir. Later, the operation manager distributes the water allotment to each section. With his water allotment, the ditch rider determines the water delivery schedule considering crop requirements, the date the user asked for water, the physical distribution of the land in the district and the unsatisfied water demand from the previous week. Each ditch rider establishes his own schedule policy.

An operation method in which there is a constant water level at the downstream end of the reaches is used. This is achieved by changing the flow rate control structure at the downstream end of the reaches (upstream control). The ditch riders maintain the level constant at some set points on the canal bank, though there are no scales. This level is verified twice daily. The flow rates in the structures are estimated as a function of the gate opening, as there are no flow rate measurement devices either.

Each Monday morning, adjustments are made in the canal flow rate conditions. Every morning, the ditch-rider adjusts the flow rate structures to compensate for variations in the main canal. During the day, the ditch rider makes no more than two or three gate movements in each structure. The water distribution within the sections is determined by the ditch rider's scheduling policy. The relation between the users and the ditch rider is dynamic resulting in continuous modification of the irrigation schedule and waste.

The RBMC operates with high velocity and very small volumes, making perturbations produced in the canal difficult to be compensated. There are pumping stations on the river, upstream of the canal's headworks, that produce other flow rate variations. The combination of these variations results in reduced water distribution efficiency and a lack of water at the canal tail end.

THE "CANAL ALTO" OF IRRIGATION DISTRICT "RIO YAQUI"

The "Rio Yaqui" irrigation district is in northwest Mexico at 75 MSL. The "Canal Alto" structure is divided into two parts. The first is a trapezoidal concrete-lined canal, 42 km long with 8 reaches and 2 in-line reservoirs. The second is an earth-lined canal, 62 km long with 10 reaches and 5 off-line reservoirs. The maximum inflow capacity of the canal is 80 m^3/s. The canal serves two irrigation units. The first is from 14+749 km to 81+000 km and the second, from 81+000 km to 105+000 km. The units are divided into areas and the areas into irrigation modules. The irrigation module is the basic administrative entity. The modules are associated with secondary canals.

The "Canal Alto" is operated under a scheduled delivery program. The farmers give their water requests, three to four days in advance, to the module supervisor, who transmits the total demand, with one day of anticipation to the area supervisor who, in turn, conveys the total demand to the unit supervisor. It is the unit supervisor who makes the canal flow rate modifications on Mondays and Thursdays or immediately, if necessary.

All the canal variables, levels (upstream and downstream at flos regulation structures where scales are available), gates openings (scales are available), flow rates (measured directly or by means of gate models, for which the calibration frequency is unknown), and water requirements are transmitted by radio to the unit supervisor. With this information and a mass balance, he determines the inflow to the unit and the modifications to be made at the different flow rate regulation structures. When the flow rates are specified, gate adjustments are made to maintain constant water levels in the reaches. The water levels are verified twice daily. If there is an error in the water level in the canal, the unit supervisor is advised so he can make the required corrections considering the entire canal volume.

A supervisory heuristical analysis is made by the unit supervisor and is verified at the main office of the irrigation district. Canal information transmitted by radio, efficiency indicators of gate movements and flow rate through the canal, and reach volumes (the reservoir volumes are not considered) are used in the analysis. Some form of controlled volume operation is used to supervise the overall canal.

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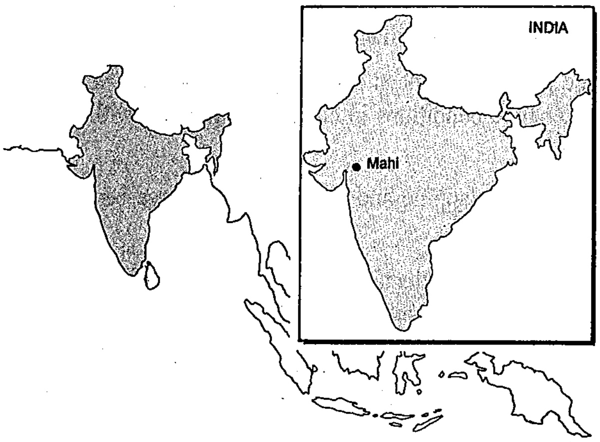
Management Information System in the Mahi-Kadana Project, Gujarat, India



The ultimate objective of irrigation management is to enhance the productivity of irrigated agriculture on a sustainable basis for the development of the community and the nation. The performance of irrigation in achieving the ultimate objective needs to be monitored and evaluated in terms of efficiency, effectiveness and equity. Management information system for monitoring and evaluation refers to the system by which information is collected, processed and presented to system managers to help in better decision making.

MAHI-KADANA PROJECT

The Mahi-Kadana Project in Gujarat is a major irrigation project where *Shejpali,* a demand-based water distribution system, is practiced. It serves 485 villages of 7 talukas of Kheda District, with a command area of 212,000 ha, and a planned annual irrigation area of 260,000 ha.

In this demand-based water distribution system, each irrigator has to apply to the irrigation agency before the start of each season stating the crop and area to be irrigated. Any irrigation availed without prior sanction is treated as 'unauthorized' irrigation for which the defaulting irrigator has to pay penal irrigation rates. The water requirement of the various canals is supposed to be assessed on the basis of the demand applications received. However, usually the water requirement assessment is made based on the past performance of each system. The irrigation management including operation and maintenance of the canal system, and preparation and collection of the irrigation revenue is the responsibility of irrigation officials.

The data to be monitored are details of water deliveries, crop area irrigated and mode of irrigation. All the activities for data collection, compilation, processing and communication are done manually, involving overlapping and repetitive efforts, excessive use of human and time resources, proneness to human error, scattered information, nonavailability of information to the system manager for decision making in time and non-suitability for computerization.

The Management Information System in the Mahi-Kadana Project has been developed to mitigate the drawbacks of the prevalent system, to standardize the irrigation information system, to minimize the time factor and to have a system appropriate for computerization.

The MIS operates on the PRIME (Performance Record of Irrigation Management and Evaluation) package, developed at WALMI, Anand by the authors. The PRIME package basically involves three basic database inventories: hydraulic, administrative and revenue sub-system inventories. The hydraulic sub-system is codified and configured into main canal, branch canal, distributary, minor, sub-minor and outlet. Similarly, the administrative sub-system is codified and configured into circle, division, sub-division, section and beat. Also, the revenue sub-system is codified and configured into district, taluka and village. The sub-system inventories are codified, configured and correlated. The package is prepared using dBase IV version 1.5, programmed in 'C' language to restrict undue database manipulation whereas the RUN TIME module facilitates free distribution and installation of the compiled program object code. Each sub-system code starts with an identifier and a subsequent trail of characters signifying its position and relation within the sub-system. Thus, hierarchical codification is done to facilitate proper reporting.

The package has been devised for the following preseason, on-season and postseason activities:

The preseason activities are:

- farmers' database.
- system configuration and database.
- query and updating.
- checking application.
- issue of irrigation pass.

The on-season activities are:

- data collection.
- feeding data to computer.
- intermediate reports for monitoring.

The postseason activities are:

- preparing seasonal progress reports.
- preparing reports for evaluation of system performance.
- preparing farmers' bills.
- archival storage of the seasonal data set.

The reports can be presented in the form of both tables and graphs. At present, they have to be generated from a spreadsheet program (LOTUS 123 Rel 3.1+) utilizing the spreadsheet files created by the package automatically; however, in due course, graphs will be generated in the routine reports through the development of additional algorithms in 'C' language.

There are three obvious advantages of having such a computer-based information approach that provides the basis for effective and rapid decision making by managers at various levels in the system.

First, it is possible to determine the performance in respect of any unit (i.e., hydraulic, administrative and revenue) at any level. This enables managers to identify performance problems being encountered, and to take necessary action.

Second, the performance reports can be generated at the end of each rotation and season quickly, so that within-season performance assessment now becomes a realistic task.

Third, faster and accurate billing of farmers, for use of irrigation water, is possible.

The unique features of the PRIME package are:

1. Data collection, compilation and processing are planned along the existing organization hierarchy.
2. The package has been incepted, developed and tested under field conditions in close co-ordination with field officials.
3. All the overlapping and repetitive tasks have been abolished.
4. Field data are collected by the Karkoons and Chowkidars, in a specially developed "outlet register."
5. The data entry task at field level has been simplified, and can be quickly done by existing system operators, with little training.

The MIS for the Mahi-Kadana Project has been developed and field-tested in one section of the project, and is under operation in one sub-division. The package has been highly acceptable to all users, and it is being planned to extend its coverage to the whole Mahi-Kadana Project.

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Workshops and Seminars (1994)

ITIS Network Meeting—to review and discuss ongoing projects in Pakistan, India, Malaysia and Mexico. (5–10 December 1994. Coordinator: Marcel Kuper, IIMI Pakistan, 1 A/B Danepur Road, GOR-1, Lahore. Fax: 92-42-6369194, Telex: 44926 IIMI PK.)

IHE Delft organized a conference on Hydroinformatics—hoping to bring together users and developers of software for the support of consultancy, research and education in the area of hydraulics, hydrology and environmental engineering. (19–23 September 1994. Adri Verwey IHE, P O Box 3015, 2601 DA Delft, The Netherlands. Fax: 31 15 122 921.)

HYDROSOFT '94—5th International Conference on Hydraulic Engineering Software in Porto Carras, Greece. (21–23 September 1994. Wessex Institute of Technology, Southampton, United Kingdom.)

Tools and Techniques

Overview of Practical Irrigation Software

IRRIGATION SOFTWARE: PRESENT SITUATION

During the past decade it has become normal practice for irrigation experts around the world to develop or use computer software. Recently, some overviews have been produced on what is currently publicly available. The American Society of Civil Engineers, during their 1991 National Conference at Hawaii, devoted part of the program to software for irrigation canals (Ritter et al. 1991). An international, IIMI-cosponsored workshop was conducted at Montpellier, France, in 1992 (CEMAGREF 1992) concentrating on the same subject. Lenselink and Jurriens (1993) produced an inventory of irrigation software, covering, among others, the subjects of irrigation games, crop water requirements and scheduling, field (surface) irrigation, canals and canal networks, piped networks, structures, canals, irrigation management and drainage. A summary, largely based on the foregoing information, is presented in Jurriens (1993) and Jurriens and Lenselink (1993). Currently, an ICID (International Committee on Irrigation and Drainage, New Delhi) working party is in the process of setting up a database on irrigation and drainage software, called LOGID.

A common conclusion from all inventories is that at present, only a few good programs are (publicly) available. Of course, many models are constantly being developed and published, but only a few end up as a completed and workable program. Burt and Gartrell in Ritter et al. (1991) observed that programs for unsteady canal flow "were in no way, shape or form comparable to standard, user-friendly micro-computer software." Unfortunately, the same applies to software on other irrigation subjects. Much of the software is restricted to private use, for research purposes at institutes and universities. And most programs I have seen are far from complete, show many bugs, are very user-unfriendly and cannot be used by others than the developers or researchers themselves. Some software, developed by consultants, are running well and are very powerful, but are either not publicly available or too expensive. In this article, I will give a brief overview of some good programs available for practical use for various irrigation purposes, although most of them are still not perfect. Lenselink and Jurriens (1993) suggested a number of criteria for "good" software for practical use, dealing with the hardware requirements, program structure, user-friendliness (interface), the manual and availability. With respect to the interface, "good" means that the structure, purpose and functioning of the program are clear to someone with irrigation knowledge, even only by browsing through it on the screen, without a need to extensively study the manual first, and that input and output of the program are clear and the user is not annoyed by constantly getting stuck and facing bugs. "Available" means that it is publicly obtainable and that it is easy to learn how and where to get it at an acceptable price. Apart from that, obviously, the results should be correct and the calculation characteristics and processes should meet a number of requirements, as listed, for instance, by Rogers et al. in Ritter et al. (1991).

Evidently, the programs listed below cannot be exhaustive. I have mentioned only some programs that I like best, as far as I know them from personal experience. There may be other good programs. I hope the readers will provide us with the lacking information. The programs discussed have been, among others, mentioned in the ILRI inventory and are being demonstrated and practiced at the International Course on Computer Applications in Irrigation (ICCAI), organized by ILRI and IIS. *The acronyms used for various institutions are spelt out at the end of this article.*

AVAILABLE PROGRAMS ON VARIOUS SUBJECTS

Crop Water Requirements and Scheduling

This is one of the favorite subjects in support of which models and programs are made and many "personal" programs are being used around the world. In fact, most of the work could be done with a relatively simple spreadsheet. CROPWAT, made by the FAO, is the most well-known and most widely applied program for this purpose. It can calculate potential (Penman-Monteith) evapotranspiration and water requirements of single crops or cropping patterns, and can also provide various options for analysis of irrigation scheduling. It can solve a wide variety of problems, but it still shows bugs and errors and it takes some time to get familiar with its structure. IRSIS (CIE) is a somewhat simpler program, also needing some guidance to work through, and offering most of the CROPWAT options. CRIWAR (ILRI), to be published shortly, is a simple program for calculating crop requirements only. USU developed a variety of programs on this issue, like REF-ET on evapotranspiration and CROPWAT (different from the FAO program with the same name, for project requirements). Like IRSIS, they enable the use of various evapotranspiration formulae.

Field (Surface) Irrigation

Two programs are meant specifically for basin-level irrigation. BASCAD (ILRI) is a simple, user-friendly program with various options for analysis of design and operation. BASIN (USWCL) has been circulated in various non-final versions. The most recent version (1994) is much improved and almost completed. Both programs can, in principle, do the same things, though BASIN provides more explicit options, several of them oriented towards the design practices and conditions prevailing in the Western US. CIE, in consultation with ILRI, has developed BISDEV for (sloping) border irrigation and FISDEV for furrow irrigation, with the program structure and interface inspired by BASCAD. The present versions of both programs are, in most cases, working well, but are not yet completely finalized. They both offer possibilities for fixed or cutback inflow and tailwater reuse. SURFACE (USU) also coming with Walker (1989) and SRFR (USWCL) are packages enabling the design of basin, border and furrow systems. SIRMOD (USU) simulates irrigation under either one of the three systems, whereby different calculation models for the advance phase can be selected. It can do many things but is not so easy to work with. The present version of SRFR is less complicated and more user-friendly. It provides a wide variety of possibilities and has a good interface, but is not yet finalized.

Canals, Canal Networks and Structures

Uniform flow in single canals can easily be computed with a spreadsheet, although there are some more sophisticated programs for it, like PROFILE (TUD). DORC (HRW) offers various possibilities for the design of canals.

For steady, gradually varied flow, the program STEADY (USU) is the best I know, enabling flow analysis in a canal network with various types of control structures and outlets.

For canal networks, having the theory and powerful computers, the tendency has been to develop models for non-steady flow rather than for steady flow, although perhaps this automatism deserves some more thorough discussion. On the non-steady flow programs, the ASCE Task Committee on "Irrigation Canal System Hydraulic Modeling" (Clemmens et al. in Ritter et al. [1991]) selected six models for further testing, out of which three were regarded to be outdated. Of the remaining three, one is not available. The second, DUFLOW (IHE) is powerful but tiresome to master and the third, CANAL (USU) is the easiest. But unfortunately, it can only "operate" the control structures (cross-regulators) and not the outlets (turnouts). The SIC program, developed by CEMAGREF under the IIMI program, has been extensively tested, and is said to be recently completed, but it may be expensive. It contains three modules, one for topographical data handling, one for steady flow and the other for unsteady flow simulations.

In all four programs the user can insert his own system (canal network and structures) although with considerable limitations in size and nature. A general feature of most programs is that they seem to have been developed primarily for research purposes (flow simulation and analysis) rather than for practical purposes of design or management. Some other programs are very powerful and sophisticated, like CARIMA, ONDA and MIKE11. But they are not very user-friendly and/or they are not readily available, because they have a restricted circulation and/or they are very expensive.

From all inventories, only two programs on structures were identified, both on the broad-crested measuring weir (or flume). FLUME (ILRI) is the most comprehensive, enabling the user a complete and checked design of the structure. BCW (USU) is a small program, based on the same theory, but can only calculate rating tables.

Irrigation System Management

In line with actual practices, one could divide irrigation system management into three activities: preseason planning (strategic or operational), in-season operation and monitoring, and postseason evaluation (performance assessment). For various planning purposes the above programs on water requirements, surface irrigation or on canal simulation could be used as a tool for analysis and to compare different options, although they were not especially developed for those purposes. Programs specifically meant for practical use are scarce.

OMIS (DHL) enables the analysis of scheme water requirements for various cropping patterns and calendars, compares the results with the expected water availability during the season and analyzes the effects of changes in case the first plan results in possible water shortages. This can be done for an entire scheme and for all tertiary units as well. OMIS contains a second module for the operation phase; actual field data are compared with planned data and adaptations can be made on that basis. Finally, there is a performance module which evaluates the planned or realized results.

INCA (HRW) is a similar integrated package and does basically the same. It has some more possibilities, but is more complicated to work with. WASAM (EC) is primarily meant for operational purposes only. Field data are fed into the program on the basis of which new operation instructions are made. In INCA and WASAM, the user can insert his own system (within limits), which is not possible with OMIS. All three programs (though not yet perfect) are working well, and can be learned quite easily, but they are rather expensive (roughly US$10,000). None of them includes canal flow simulation.

SIMIS (FAO) is composed of nine modules most of them dealing with databases and management information. One of them is the water distribution module which addresses the three phases: 1) planning, simulation and optimization, 2) daily operation, and 3) evaluation and monitoring. It is said to be operational now, but I have not yet tested it. Finally, the WCAMOD program (USU) is said to be ready in 1994. It includes options to forecast aggregate water demands and responses to specified deliveries, for commands of 40-500 ha.

CONCLUSIONS AND RECOMMENDATIONS

Many models on various irrigation issues have been developed, but there are not many good programs for practical use, certainly not for actual scheme management. There is still a lot to do in translating the existing knowledge into good user-friendly programs. Of course, I have not seen all programs used in the world. In the LOGID database there are many programs that I have not seen, from countries like Brazil, Bulgaria, Thailand, and Italy, to mention a few. It would be beneficial if people who think they have good-working, user-friendly and useful programs, would make them available for scrutiny. If they are really good they could be given a wider dissemination. A better and more complete inventory of what is available is still needed. In this respect, ILRI plans to organize a workshop on this issue, to be held at the end of 1995, possibly in collaboration with IIMI.

In this situation, the ITIS Network Newsletter starting with this issue is a good initiative. I hope that this network is used by scheme managers to exchange their experiences with the actual use of software, and to formulate their wishes for improvement. Also, a better coordination of activities on developing and improving software among various institutions is required and is gradually taking shape. At the same time, one should be careful in not trying to make sophisticated programs on subjects that could as well be treated with simple spreadsheets. Use of spreadsheets seems widely under-exploited and should be given more attention. Similarly, more attention should be given to the development of "tool kits," packages with simple small programs on various irrigation issues, which would replace the expert's diagrams, tables and calculators. The EC "Land and Water Toolkit" for instance contains various small programs on issues such as crop water requirement, flow over weirs, land leveling, dike volumes, backwater curves, etc. ILRI and EC intend to upgrade this tool kit for wider dissemination. These activities may seem less scientific, less up-to-date or less praiseworthy than working on the use of GIS, multimedia systems, dynamic models, etc. But concentrating only on the front-line of computer technology does not seem logical as long as many "older" techniques have not yet been professionally and widely applied.

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Acronyms

CEMAGREF—Centre National du Machinisme Agricole du Génie Rural des Eaux et Forêts, Montpellier

CIE—Center of Irrigation Engineering, Leuven

DHL—Delft Hydraulics Laboratory, Delft

EC—Euroconsult, Arnhem

FAO—UN Food and Agriculture Organization, Rome

HRW—Hydraulics Research, Wallingford

ICID—International Committee on Irrigation and Drainage, New Delhi

IHE—International Institute for Infrastructural, Hydraulic and Environmental Engineering, Delft

IIS—Institute of Irrigation Studies, Southampton

ILRI—International Institute for Land Reclamation and Improvement, Wageningen

IIMI—International Irrigation Management Institute, Colombo

TUD—Technical University Delft, Delft

USU—Utah State University, Logan

USWCL—US Water Conservation Laboratory, Phoenix

SIC: A Software for Simulating the Hydraulic Conditions of Irrigation Canals

SIC (Hydraulic Simulation of Irrigation Canals) software is one of the latest hydraulic models developed by CEMAGREF. The developments on hydraulic numerical modeling started at CEMAGREF in the early 1970s. Several hydraulic models exist at CEMAGREF, depending on the type of systems and events to be simulated. Various improved and updated versions have been made since. One of these models has been particularly dedicated to irrigation canals. This model, called SIC, runs on microcomputers and is specially designed for users with a minimum knowledge of computer science and hydraulics. Much effort has been devoted to develop user-friendly interfaces. It is menu-driven and an on-line help is available to assist the user. The very first version of this model was developed for IIMI to study a canal located in the south of Sri Lanka. One purpose of this model was to be easily usable by canal managers as a decision-support tool to help them in the daily operation and maintenance of their system. Since this first application was promising, CEMAGREF, with other partners, decided to develop a new standard version of this software, that could be used worldwide on most types of irrigation canals.

In 1991, the task committee of the American Society of Civil Engineers (ASCE) on "irrigation canal system hydraulic modeling" examined a number of computer programs available to simulate unsteady open-channel flow (see ASCE Journal of Irrigation and Drainage Engineering Vol 119 No 4 July/August 1993). The committee identified current limitations of these models and needs for improvements. The main issues were about computational capabilities and robustness, user-friendliness and data input, network and structure definition, user assistance in execution and calibration, definition of initial conditions, output presentation and data management. Most of these recommendations are handled by SIC, thanks to the robustness of the computational modules used for more than 20 years.

SIC is structured in 3 main units that can be run either separately or in sequence.

UNIT I

This unit is designed to handle the data gathered by a topographical survey and can generate the topographic files used by other units. Any topographical configuration of channels (including looped network) and arbitrary cross sections can be considered. The network topology is created or modified through a graphical editor with an automatic error-checking module. Node and reach numbering is automatically handled by the program without the user's intervention, unless he is willing to do so. Computational cross sections are also automatically created and handled.

UNIT II

This unit is designed to perform the *steady* flow computation. The water surface profile is simulated for any given combination of offtake discharges (or openings) and cross regulator gate openings. The canal sketch is displayed during the steady flow computation allowing to follow the calculation, and get warnings of events (overtopping, supercritical flow, etc.) or errors, if any. A summary of warnings and errors is given at the end of the computation. This unit also calculates offtake gate openings and adjustable regulator settings required to satisfy a given water distribution planning while simultaneously maintaining a set of target water levels.

This steady flow model is based on the standard step method for computing open-channel water surface profiles. Seepage and lateral inflows are considered. Specific equations are used for flows over weirs and through gates. This modelization takes into account free flow and submerged flow with automatic switching depending on flow conditions. Up to 5 weirs and 5 gates can be handled in the same cross section. Offtakes of weir or gate type are modeled according to the same hydraulic laws used for cross structures but with the possibility of handling the influence of the downstream condition without modeling the secondary canal. In addition, the user can input a rating curve to modelize any kind of offtake not described in the catalog of the unit.

For Unit II calculations discharge coefficients of cross structures and Manning's Coefficient along the reaches should be known. A calibration module automatically computes Manning's and discharge coefficients, given measured flows and water levels.

UNIT III

This unit is designed to carry out the *unsteady* flow computation. It allows the user to test various water demand schedules and operations at the headworks and control structures. The operation efficiency may be evaluated via a set of water delivery indicators computed at the offtakes. The unsteady flow model is based on an efficient numerical solution of the complete nonlinear equations of Saint Venant for the one-dimensional subcritical flows (Preissmann scheme). As in Unit II, special equations are included for cross structures and offtakes. Outputs consist in time series of water levels and discharges. Graphic facilities allow an easy review of results, including dynamic presentations. Special ASCII files are provided to be handled by a spreadsheet, so that the user can generate specific outputs. Advanced users can tailor SIC to their specific needs by creating their own modules of regulation.

SIC has been used in different countries around the world: France, Bangladesh, Burkina Faso, India, Jordan, Mauritius Island, Mexico, Pakistan, Sri Lanka, etc. It is currently being used by IIMI and CEMAGREF and by around 10 consulting companies and research centers. Unit I is protected by a *dongle* (lock key), but any user can give a free version of a model dedicated to a specific canal to a collaborating partner who can, then, freely use Unit II and III.

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Review of Data Loggers and Water-Level Sensors

Research and management activities on irrigation canals imply discharge and water-level measurements. Usually, these measurements are manually processed. Discharges can be evaluated from a series of flow velocities measurements usually with a propeller or an electromagnetic device. At a control section, where a rating curve Q(z) exists, discharge can be evaluated from a water-level measurement. Water levels can be easily measured through a simple visual gauge. But, when extensive measurements are required, automatic systems can be very helpful. The advantage of automatic systems is to provide data 24 hours per day, at a regular time step, with a constant precision.

In the context of a collaboration with IIMI and the Irrigation Department of Sri Lanka, CEMAGREF at Montpellier prospected the commercially available water-level measurement equipments. CEMAGREF's Antony carried out other comparative studies on the different available equipments used in drainage and river measurements. More than 30 companies located in Europe and the USA have been listed, proposing data loggers, discharges or water-level sensors.

Different companies propose comparable equipments that would fulfill the technical requirements: CR2M (SAB 600 LMU), ISMA Instruments Scientifiques (LINmP), AUTEG (Emac 85), HYDROLOGIC (DPN 7/2, LPN 8/2), and IRIS INSTRUMENTS (Mado Plus 1 or 2). The main characteristics of the proposed data logger are:

* 1 to 4 input channels (up to 32).
* autonomous power supply system (batteries or solar).
* local data recording (RAM, magnetic tape, EPROM).
* transportability.
* resistance to tropical humid conditions.

Measurement is made through a water-level sensor connected to the data logger. Most of the water-level sensors are proposed by the three main following companies: Schlumberger (FR), Druck (GB) or Transinstruments (USA). Different types of sensors exist:

* Air pressure (distance between the sensor and the logger should not exceed 10 to 50 m).
* Piezo-resistif (allow 100 to 300 m distances, less precise: around 1% total).
* Ultrasonic immersed (allow 50 to 100 m distance, very precise).
* Ultrasonic aerial (problems if temperature gradients in the air).

In conclusion, it can be stated that immersed ultrasonic sensors are among the best adapted when distance does not exceed 50 to 100 m. For longer distances, piezo-resistif sensors are adapted if a 1 to 2 percent precision is acceptable.

Unfortunately, the total price of such equipments ranges from US$3,000 to US$10,000, including the data logger, 1 to 4 water-level sensors and connection cables. This price is closer to that of a car than to that of a ceramic gauge! A collaboration program among the University of Peradeniya (Peradeniya, Sri Lanka), IIMI and CEMAGREF, aims at developing low-cost water-level data logger equipments. A prototype is currently tested in Sri Lanka.

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Development of Modular Computer Tools for Managing Environmental Systems: An Experience with the RAISON System

Microcomputers have become easily available and affordable in many parts of the world. Environmental scientists and engineers often use them for storing and retrieving data, performing analyses, displaying results on graphs and maps, and even running mathematical models or optimization procedures. There are many kinds of software available to do these tasks, such as database, spreadsheet, statistics, maps and graphics, etc. However, most of these are difficult to use for specific environmental applications. Solutions to environmental problems often require a diversity of data on air, soil, surface water and groundwater, as well as information on many scientific and socioeconomic disciplines. It is therefore necessary to develop a software package that allows easy linkage of different types of data with special functions to integrate knowledge from different backgrounds for various environmental applications.

For the past eight years, we have adopted an integrative approach and developed an environmental software package acronymed, RAISON, for Regional Analysis by Intelligent Systems on microcomputers (Lam and Swayne 1991). Its development was motivated originally to design a computer-aided support system to assess the water resources at risk caused by acid rain in Eastern Canada. Instead of developing a computer program specifically applicable to the problem, we used a generic design so that the components such as database, maps, graphics, etc., were modularized, highly integrated and easily applicable to other problems. The program was written in the "C" and "C++" languages for the DOS Operating System and is currently modified to work under the Microsoft WINDOWS System. Our experience is that it is necessary to continuously upgrade such a system to work with new advances in computer technologies, particularly those that enable easy linkages with other databases and map systems for both desktop and networking operations.

The most important aspect in the development of such a system is the direct involvement of the user. There are basically two types of users: the technical and the managerial. The technical user often requires a system that works with the software he uses and extends it to new applications. For example, some found that Geographical Information Systems (GIS) were useful for spatial analysis but could not perform complex time series analyses to compare rainfall events with long-term water-supply and water- quality data. They required a system that could connect the GIS and time series data seamlessly to environmental statistics tools. Others may like to have a data visualization capability that could link an existing hydrological model with GIS information so that the results could be presented in 2- and 3-dimensions or time evolution and animation sequences. Thus, an integrative environment system should be developed with these users in mind, by working with them through the design and testing phase. For example, in the RAISON System, each of the basic modules was designed and developed with inputs from the users: database, spreadsheet, graphics, GIS, data visualization and statistics. These components which form the basic system are tightly coupled to each other through simple pull-down menus and icons. They are designed also to import data from and export data to other existing software, e.g., database, spreadsheet and GIS. For more advanced applications, such as modeling, the system offers a programming language capability that can be used to generate simple procedures for mathematical models or to link modules in the basic system with existing computer codes of complex algorithms and models provided by the user.

The requirements of managers and decision makers are quite different from those of the technical users. Typically, they want to obtain information easily and quickly. They would be more convinced of the usefulness of a decision-support system, if it can assist them by providing the correct information, the alternatives or scenarios they can choose from, and the optimal solution with the minimal cost. An example is the irrigation design for a large region which calls for hydrological and meteorological data, soil maps, options for waterways and desalination, supply network, construction and costs, environmental impact, risk assessment as well as socioeconomic implications. It is difficult to use a single software package, be it GIS or database, for this purpose. It requires an integrative system customized for the problem and prepared with a view that it will be used by both technical and nontechnical end users. For example, with the RAISON System, decision-support systems can be constructed by first assuring that all relevant information (numeric data, descriptive text, photos, satellite image, video, etc.) is stored and easily retrievable. Then, the relevant knowledge is implemented through a hierarchy of computer programs that execute the models and algorithms and control the logical and heuristic rules to manipulate the data, text, images, etc. For more complex situations, an interface that uses expert systems or other artificial intelligence techniques may be required.

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As microcomputers become more affordable, modularized computer tools are in greater demand for solving environmental problems. Our experience shows that the integrated approach provides a viable solution to allow existing environmental and socioeconomic data and models to work with new ideas in information techniques.

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A Letter from the ITIS Network Coordinators

DEAR COLLEAGUE,

Welcome to the Information Techniques for Irrigation Systems (ITIS) Network. We hope you find this, the first issue of ITIS, to be as informative and interesting as it was intended to be. The first few issues will primarily focus on the projects conducted by IIMI and its partners, but we hope to move rapidly into a phase where the views and experiences of others are also shared and discussed. We would like ITIS to become a flexible and interactive platform for sharing information on tools, methods, and field experiences on the use of Decision-Support Systems (DSS) in irrigation. We need to know which advances are being made in the technical fields of measurements, communications and computer tools; we need to know who is making use of these tools, at what cost and with what degree of success in terms of performance improvements. Your contributions will enrich ITIS and help increase the rate of transfer of productive and cost-effective techniques from the research lab to the irrigation system.

This is the first issue of ITIS which has five sections:

- *general articles on the subject,*
- *field experiences,*
- *tools and techniques,*
- *workshop/seminar announcements, and*
- *publications list.*

The next issue will also include a section devoted to readers' feedback. Readers are urged to contribute material that might fit any of the above categories. As this first issue of ITIS goes out, we would like your feedback, critiques, and suggestions for improvement on the layout and contents of future issues.

The network is open to all those who are interested in the subject and we would like you to nominate your colleagues and friends who share the same interest.

We would also like to include your name/postal address/e-mail address in the ITIS Network database which will be distributed to all other ITIS Network members. If you have any reservations or suggestions please inform us as soon as possible.

Your contributions will help energize this network. It is also a forum to meet and communicate with colleagues. Please address your correspondence to:

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