Use of Computer-Operated Models as Decision-Support Tools in Operation and Management of Irrigation Systems

Use of Computer-Operated Models as Decision-Support Tools in Operation and Management of Irrigation Systems: Sri Lankan Experience

Proceedings of the Workshop
on the Use of Computer-Operated Models
as Decision-Support Tools
in Operation and Management of Irrigation Systems
held in Galgamuwa. Sri Lanka
from 15 to 16 July 1993

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Contents

Acronyms

BC	-	Branch Canal
DC	-	Distributary Canal
DSS	-	Decision-Support Systems
ECL	-	Engineering Consultants Limited
ESI	-	Essential Structural Improvements
ET	-	Evapotranspiration
FC	-	Field Canal
HQ	-	Headquarters
HR	-	Hydraulics Research
ID	-	Irrigation Department
IE	-	Irrigation Engineer
IIMI	-	International Irrigation Management Institute
IMIS	-	Irrigation Management Information Systems
INCA	-	Irrigation Network Control and Analysis
IRMU	-	Irrigation Research Management Unit
ISMP	-	Irrigation Systems Management Project
ITI	-	Irrigation Training Institute
KOISP	-	Kirindi Oya Irrigation and Settlement Project
LB	-	Left Bank
MC	-	Main Canal
MCM	-	Million Cubic Meters
MEA	-	Mahaweli Economic Agency
NIRP	-	National Irrigation Rehabilitation Project
NWP	-	North Western Province
O&M	-	Operation and Maintenance
OMIS	-	Operation and Management of Irrigation Systems
PD&SS	-	Planning and Design and Specialized Services
RB	-	Right Bank
SIC	-	Simulation of Irrigation Canals
SLFO	-	Sri Lanka Field Operations
SLITI	-	Sri Lanka Irrigation Training Institute
TA	-	Technical Assistant
USAID	-	United States Agency for International Development
WATMAN	-	Water Management Model
WS		Work Supervisor

Preface

THE USE OF computer models as decision-support tools has become popular in almost all sectors of the economy. Nevertheless, the use of computer technology in irrigation is yet to reach its full potential and research is still ongoing to identify the potential areas for the possible application of computer technology in this field. During the last decade, a number of computer-based decision-support tools were developed and are currently used in different irrigation schemes in Sri Lanka. The first model was developed in 1984 and is used in Gal Oya Left Bank and the latest was developed in 1990 for major schemes in Polonnaruwa.

This workshop was organized with the objective of reviewing and comparing experiences in the application of computerized decision-support tools to improve the performance of water management in irrigation systems of Sri Lanka. The performance of seven computer models, currently in use, was presented during the course of the workshop to a selected group of irrigation engineers, working in the field. The constraints and the potential of these models were evaluated at the end of the two-day workshop and recommendations were made for the future advancement of computer usage in irrigation water management, in Sri Lanka.

Acknowledgements

THE WORKSHOP ON the Use of Computer-Operated Models as Decision-Support Tools in Operation and Management of Irrigation Systems held from 15 to 16 July 1993 was an instant success due to the close interaction between the resource persons and the participants.

We are thankful to Mr. L.U. Weerakoon, the chief guest of the workshop and State Secretary to the Ministry of Irrigation and Mr. Nanda Abeywickrema, Director International Cooperation and Dr. Jacob Kijne, Director for Research, both special guests from IIMI for attending the inaugural session of this workshop despite their heavy official engagements in Colombo.

The workshop immensely benefited from the participation of Messrs. K. Thurairajaratnam, L.T. Wijesuriya and D.W.R.M. Weerakoon, all Senior Deputy Directors of the Irrigation Department, Mr. K.S.R. de Silva, Project Director/National Irrigation Rehabilitation Project and Dr. R. Sakthivadivel, Senior Irrigation Specialist, International Irrigation Management Institute. We thank them sincerely.

We like to thank Mr. N. Madusudanan, retired Senior Deputy Director of the Irrigation Department, for accepting the invitation to be the guest lecturer and delivering an inspiring lecture on computer applications. All the resource persons presented meticulously prepared papers which were very informative and useful. They deserve special acknowledgement and thanks.

We should particularly commend the support provided by Mr. H.M. Jayatilleke. Deputy Director, Sri Lanka Irrigation Training Institute and his staff for providing excellent logistic support for the successful holding of the workshop.

We also wish to thank the technical assistance team of the Irrigation Research Management Unit of the Irrigation Department who were instrumental in making this workshop a success and Mrs. D.K. Jayasinghe who skillfully typed this manuscript.

The European Union deserves special acknowledgement without whose generous funding this workshop would not have materialized.

Editors

WORKSHOP OBJECTIVES
AND PRINCIPAL OUTCOMES

Workshop Objectives and Principal Outcomes

IT HAS BEEN recognized that performance of most of the irrigation systems in the country is well below their potential which has raised serious concerns among the planners and administrators. It has, therefore, become imperative to find ways to optimize benefits from investments in irrigation.

In the recent past, various computer-based decision-support tools have been developed and introduced to help irrigation project managers in the operation and management of the systems. A number of such tools are currently being used in different irrigation schemes in Sri Lanka to address mainly the problems of low rainfall effectiveness and consequent overreliance in stored water, high degree of inequity of water distribution within the systems and inadequate irrigation water in the yala season. The studies generally include the establishment of reliable flow monitoring networks, the development of computerized decision-support tools for assisting water scheduling and other system operation activities, and the development of indicators to evaluate the effect of changes in management practices.

Objectives

The main objective of the workshop was to discuss the experiences gained through such studies and to formulate a strategy for future works. The specific objective of the workshop was to:

> ***review and compare experiences, successful or otherwise, in the application of computerized decision-suppon tools to help improve practical management of water in Sri Lankan irrigation systems.***

Principal Outcomes

Based on the deliberations, the workshop recognized that the introduction of computer models along with a proper data collection system for implementation of irrigation schedules will improve the performance of irrigation systems, as was observed in the Galoya and Hakwatuna schemes. However, for wider applicability and institutionalization of the systems, the participants recommended that (1) institutional problems associated with data collection. processing and conversion of data into information shall have to be solved, and (2) a study has to be initiated to pilot-test promising models in a few selected schemes.

A Committee was formed to follow up on the recommendations of the workshop to achieve improved system operation, and to make specific proposals to the Irrigation Directorate. The Committee made the following recommendations:

1. Accept and declare the use of computer-operated models for improved operation as a policy.

2. Identify sufficient resources for investing in this activity and provide a computer to each IE in charge of a division together with a standard software package or scheme-specific application.

3. Carry out a cost-benefit analysis based on past experience and performance of computer-aided tools, to justify the investments for software against heavy investments for physical rehabilitation.

4. Initiate training sessions for field-level staff on data collection, data processing and conversion of data to information.

5. Provide incentives to ID engineers to develop software (NIRP/IRMU assistance would be a useful source for incentives).

6. Motivate field-level staff/IEs by redefining their duties, roles and functions in water management.

7. Promote the development of maintenance management models to implement maintenance hand in hand with operation and management with a view to improve system performance.

Another outcome of the workshop recommendations was the constitution of a committee to develop a proposal for pilot-testing the promising models in a number of selected schemes. The Committee has developed the proposal which is being submitted to the NIRP for approval. The Irrigation Research Management Unit (IRMU) has included the study in its 1994 Workplan.

SUMMARIES OF WORKSHOP PAPERS

Sri Lanka
Hakwatuna Oya

Computer Applications in Water Scheduling and System Operations in Hakwatuna Oya Tank Project, Hiriyala Division, North Western Province

W.G. Wimalaratna[1]

A RESEARCH SUDY was undertaken in the Hakwatuna Oya Project by Hydraulic Research of Wallingford. England in collaboration with the Irrigation Department from the beginning of 1988/89 maha cultivation season to the end of maha 199 1/92. The objective of the study was to develop and test a microcomputer-based management information system-cum-water delivery scheduling model including the establishment of a monitoring and control network.

The Hakwatuna Oya Reservoir Scheme in the North Western Province (NWP) lying within the hydrological intermediate zone has a storage tank of 19.7 MCM capacity to irrigate 1,750 ha. The average annual rainfall in the project area is in the range of 850 mm.

The irrigable area is served by two main canals, followed by a set of canal networks intercepted by several village tanks or ponds. Rice is the main crop grown in the command.

The computer model was developed and implemented in two phases. The monitoring phase included the analysis of historical data. the setting up of a measurement network, the development of the management computer software and database including the staff training on the use of computers.

The data required for the model were collected through a network of 28 gauging stations in the main and branch canals, and 17 in the field canal network. Existing facilities were utilized as far as practicable. Five nonautomatic rain gauges and a number of field wetness stakes were also installed and measurements taken. Gauge readings were obtained thrice a day during the period by deploying special labor.

The data collected were fed into the installed computer with a hard disk capacity of 20 megabytes. An irrigation water schedule on a weekly basis was ultimately obtained from the computer, specifying the depth of water to be maintained at the given gauging site with relevant time schedules.

The original schedules were developed through "Lotus 1-2-3" which were later obtained through SQL. The more flexible software developed ultimately for this purpose is termed INCA-V2 which utilizes a hard disk capacity of 200 megabytes.

The INCA-V2 was implemented in maha 1992/93. The overall duty obtained for rice cultivation was 2.12 ac.ft/acre (0.65 ha.m/ha) which compares favorably with duties obtained previously. While applying this model, it was found that where complaints of insufficiency of water were reported, the causes were disruptions made by a few errant farmers from within and outside the scheme.

[1]Irrigation Engineer, Irrigation Department, Hiriyala Division, Sri Lanka.

The use of INCA-V2 has minimized friction with user farmers and has resulted in a more effective management of the available water resources.

Sri Lanka
Kirindi Oya

irrigation water scheduling

Computer Model on Irrigation Water Issue Scheduling in Kirindi Oya Project

B.K. Jayasundara[2]

AT THE INITIAL stages of operation of the Kirindi Oya Project, a water-short system in Southern Sri Lanka, irrigation water issue scheduling was done manually. In preparing the schedule, the continuous irrigation method was adopted for the land preparation period while a 7-day rotation was practiced at FCC levels for rice crop growing period.

For a team of **5** technical assistants it took about 2 weeks to prepare water issue schedules for about 20,000 acres (8,000 ha). It was a tedious job.

Later, a computer program package was developed using "Lotus 1-2-3" for rotational water issue scheduling. The use of the computer program has reduced the time consumed for preparation of schedules to about 10 minutes from 10 days.

The program package consists of three main programs. The first program calculates weekly crop-water requirements using evapotranspiration (ET), expected rainfall, percolation, land preparation progress and the starting date of cultivation, etc. When the starting date of cultivation is entered into the program. the latter automatically calculates the weekly crop-water requirements based on the stored historical data and retrieves the second program which computes scheduling.

When the required tract number is specified, the second program automatically calculates the rotational water issue schedules from FC, DC, BC levels to tract level. The canal data (acreage, soil type, efficiencies) are stored in separate files for easy amendments whenever necessary. This program automatically uses the required data stored in the data files and the results of the first program.

Finally, when the scheduling is completed for the required area of cultivation the third program can be retrieved to combine **all** the schedules to obtain the water issues at the main sluice level.

Macro programming was used to make the program package user-friendly and automatic. Fine-tuning of the assumed data (**i.e.**, efficiencies of the canals, acreage, percolation losses in the field, etc.) was done in the program using field experiments and the feedback from the field during the past cultivation seasons.

Although this program was prepared specifically for the Kirindi Oya Project, it can he easily adapted to other projects with minor adjustments.

[2]Chief Irrigation Engineer. Irrigation Department, Galle, Sri Lanka.

Sri Lanka   decision making | irrigation operation | decision support tools
Gal Oya

The Use of Computer-Operated Models as Decision-Support Tools in Operation and Management of Irrigation Systems: Sri Lankan Experience, Gal Oya System

G.G.A. Godaliyadda[3]

THE LEFT BANK canal system of the Galoya Irrigation Scheme covering about 16,000 ha of irrigated land was rehabilitated in order to improve operation and water management. Canals were improved, and tlow control gates, regulators and flow measuring devices were constructed. The constructed facilities help operators **as** well **as** users to measure and achieve better regulation of irrigation water delivered. The farmers' organizations. which were formed at the beginning of the program were helpful in the implementation of smooth water distribution at the turnout level.

Computer models were developed for water scheduling, system operation and evaluation with the following facilities.

* Determination of weekly irrigation water requirement at each offtake level based on percolation, evapotranspiration. rainfall, on-farm efficiency and progress of cultivation activities of the command area. No provision has been made for scheduling at individual farms.

* Accumulating the calculated flows at offtake level throughout the system to determine flows in the main and branch canals and key diversion points for system operation. The calculation takes into account canal losses, intermediate reservoir operation criteria, catchment inflows and any changes in water delivery plan.

* Recording weekly measurements of canal flows, progress of cultivation activities and comparing them with planned values for model calibration and identifying areas for physical and operational improvements.

The computer program of the models is in ''Basic" and the models can be run on **a** microcomputer with a 20 MB harddisk. The computer models were developed to suit the Gal Oya LB System and are not general models. They were developed in close association with operating personnel and the farmer beneficiaries and, therefore, no problem was encountered when the models were put into operation.

The models have been in operation since 1984 in the Galoya LB System with a communication network for flow monitoring providing information on a daily basis. The performances on system operation and management are being evaluated seasonally and there is significant improvement in terms of water distribution, area irrigated in yala season and amount of water used in both maha and yala seasons.

[3]Deputy Director, Irrigation Department, Moneragala, Sri Lanka.

The main achievements in the use of computer models coupled with the communication system are: a smooth operation of the system throughout the cultivation season: confidence among the farmers including tail-end farmers in using the results of the model; and improved inputs such as fertilizer, weedicides and insecticides due to assured water supply.

Use of Computer Model in Irrigation Systems Management Project: Calibration of Hydraulic Structures

A.M.U.B. Alahakoon[4]

THE PARAKRAMA SAMUDRA Scheme in the Polonnaruwa Division and the Magalwewa Scheme in the Nikaweratiya Division *are* the work locations where the flow measurement exercise was carried out. Both these schemes have been recently rehabilitated according to the concept of Essential Structural Improvement (ESI) under the Irrigation Systems Management Project (ISMP), funded by the United States Agency for International Development (USAID). In addition to the rehabilitation of the physical system, a computer model was developed to improve the performance of the operation and management of the system.

The computer model developed in 1990 facilitates the operation and management of these systems. This water management model could be used to estimate required flow rates and flow volumes in irrigation channel systems and to provide evaluation reports based on actual water deliveries. It can be used as a tool by the irrigation system managers to schedule daily water deliveries according to measured losses, weather data, cropping dates and physical system configuration. It can also be used as a recordkeeping and water management evaluation tool for a week or a season.

The model can be run on IBM microcomputers and compatibles by inputting hydraulic, agronomic and climatic data. The hydraulic data and calculations are limited to water measurement ratings (calibrations) which should be given for all outflow and monitoring nodes in the canal system.

Existing structures such as drops and lined channel locations and, in certain locations, flumes constructed have been used as measuring structures. The form of the stage-discharge relation used by the model is:

$$Q = C_f H_u^{N_f}$$

where Q = discharge m^3/sec/unit width at which depth is measured,
C_f = discharge coefficient,
N_f = exponent, and
H_u = upstream flow depth in m.

[4] Irrigation Engineer. Irrigation Department, Polonnaruwa, Sri Lanka

To use this equation, the model needs discharge coefficients and exponents for different locations which are determined by flow calibration at the field sites.

A logarithmic plot of the free flow discharge against head can be obtained with four or five field measurements. From this the coefficients C, and N, can be obtained. If the field measurements are inaccurate, the expected straight line cannot be achieved and the correct values of the coefficients cannot be deduced. If the field measurements have been carried out accurately the value of the coefficients computed will be more accurate to be used in the theoretical equations than the traditional way of using the general values of these coefficients.

The two common methods of discharge measurements in irrigation channels are current metering and flow measuring in flumes such as cutthroat flumes or parshall flumes. Depending on the flow condition and the discharge rate either of the methods can be selected. Whatever the method we use, great care has to be exercised in the field to obtain accurate results.

With regard to calibration, flow measuring points have been categorized as main and secondary nodes depending on their importance. The first phase of calibration was confined to the main nodes and have been completed by now. Field calibration of secondary nodes is in progress at the moment.

Sri Lanka

System Operation Model

K.W. Nimal Rohana[5]

THE SYSTEM OPERATION Model developed under the Irrigation Systems Management Project (ISMP) implemented in the Polonnaruwa schemes is mainly to be used by the managers as a system monitoring tool for water management with a predefined intensity and an operational frequency not less than 1 day. This model, a scheme-independent one, can be configured to be used in any scheme in Sri Lanka with some exceptions. A two-way communication system was envisaged at the time of model building with a network of monitoring nodes along the flow system and a number of rain gauges scattered in the command area.

The model written in C language is a fully menu-driven program with an on-line help facility. It can be run on IBM compatible computers having a RAM of 640 KB. Hard disk configuration is preferable but not mandatory. The program makes use of the mathcoprocessor if available.

This model facilitates the decision-making process of the user by providing the following information (OUTPUT) at user selected time intervals and intensities.

1. Daily water requirements at turnout levels.

2. Performance evaluation from turnout level, subsystem level to scheme level (ratio between the actual delivery and theoretical requirement).

3. Cropping progress at a given time to identify late cultivation areas.

4. Weekly crop evapotranspiration for a period based on local climatic data.

Data required (INPUT) to be processed by the computer to produce the above information can be categorized into two, namely system data and seasonal data. System data are scheme-specific and time-independent in contrast to seasonal data which are time-dependent (varies from season to season). These data consist of the following:

1. Issue tree data arranged in the order of canal level (primary, secondary, etc.) and distance from sluice and respective branching points.

2. Calibration parameters of measuring nodes

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[5]Irrigation Engineer. Irrigation Department, Designs Branch, Head Office, Colombo, Sri Lanka.

3. Evapotranspiration data of crops

4. Percolation from fields and conveyance losses.

5. Actual areas under each crop under a node.

6. Land preparation data at time intervals, until sowing.

7. Actual deliveries measured at the nodes

8. Rainfall experienced.

9. Weather data if available, not mandatory

Water requirements are calculated assuming continuous flow conditions for **24** hours.

Irrigation requirement = (crop evapotranspiration + percolation)/conveyance efficiency.

Rainfall is assumed to be zero and adjustment is made after the occurrence of the event taking carryover effect into account. The former IE Amparai suggests that a reasonable value based on judgement be adopted .instead of 75 percent probability values or zero rainfall.

Water management index is defined as the ratio of the actual delivery to the theoretical requirement which is a measure of the efficiency of management in a 100 percent calibrated system.

The model was developed in 1990 by excluding system-specific data from the source code to make it one of generalized nature. The potential users of this model have been involved from the very beginning *to* the end to make it tailor-made for the end users. The expected application area of the computer system ranges from 3,000 to 10,000 ha.

The infrastructure required for the management information system of this model was: network of measuring structures along the system at critical points; network of rain gauges covering the entire command area; number of field operation units to take care of operation and maintenance of the system and deployment of personnel for two-way communications.

The model is now being calibrated at two schemes of the Polonnaruwa systems. The problems encountered while calibrating the model are: maintaining the required accuracy of discharges at places where no critical flow exists, and the development of a methodology for field calibration in view of the large number of variables involved.

Computer programs

Application of Computer Models in Calibration of Structures for Flow Measurement

K.A.U.S. Imbulana[6]

THE INCREASED ATTENTION now being paid to irrigation management has made water measurement a very important activity in improving the performance of an irrigation system. However, it is a well-known fact that most irrigation systems have only the minimum facilities for water measurement. Lack of funds to construct new measuring structures is one of the major reasons for this situation.

On the other hand, if the existing structures of an irrigation system can be calibrated to be used for flow measurement, substantial funds could be saved. This will also eliminate the head loss, which is sometimes difficult to accommodate when rehabilitating an old irrigation system.

The field measurements include upstream and downstream heads of water above the sill of the structure and the corresponding discharges. The constants of the rating equation are obtained by a graphical method. To reduce the effect of the experimental errors, the least squares method is used.

A computer program is introduced to simplify the computational procedure and to save the time of the field staff. It is written in Quick Basic.

The computer program uses the field measurements of discharge and upstream and downstream heads as data and produces a rating curve and a rating table. It calibrates the structure under both free flow and submerged flow conditions.

This computer program is intended for the field-level staff involved in the routine operation of an irrigation system. The output of this program can be readily understood by irrigation engineers and technical assistants: with only minimal instructions, the rating curves can be interpreted by work supervisors, water issue laborers and farmer representatives.

The computer program suggested herein is applicable only to those flows which correspond to free flow over a weir with water surface at atmospheric pressure and not to orifice flow conditions that may exist in gated structures.

[6]Research Officer, Internation igation Management Institute.

Sri Lanka performance evaluation | decision support tools

Evaluation of Decision-Support Systems for Water Management in Irrigation Systems in Sri Lanka

Richard Oskam[7]

THE PAPER DESCRIBES a methodology to evaluate computerized support for water management or, Decision Support Systems (DSS), which is illustrated by the evaluation of three models presently used in Sri Lanka: the IMIS-model in Kirindi Oya, the ECL model in Kanthalai and the INCA-model in Hakwatuna Oya.

A few theoretical issues on the development and implementation process of DSS are clarified by way of introduction. A DSS consists of a user interface. a database and a model base. Prototyping is an approach commonly used in the development of information systems. It is used to determine the functional requirements of the tool and is characterized by extensive use of working models (prototypes), iterations and users' participation. The uncertainty in the information problem, due to the facts that DSS are new in irrigation management and potential users have no experience with DSS and information analysis, makes prototyping an appropriate approach in the development of DSS for water management. According to Chew[8] successful introduction of new technology in organizations needs to go hand in hand with generating knowledge about the equipment (technical knowledge) and about the organization (organizational knowledge). This is true for the implementation of DSS for water management, as well.

As far as evaluation of DSS is concerned, a subjective evaluation (user's opinion) according to Adelman[9] has been applied. In addition, a list with general issues has been made, comprising a description of the irrigation scheme where the tools are used, the development and implementation process and characteristics of the DSS (with reference to an application framework). This information is used to clarify evaluation results and to compare the tools. In the subjective evaluation, three levels of analysis are identified (individual, organizational and performance) for which a total of 42 criteria have been formulated. The users' opinion of the criteria is obtained by a short-answer questionnaire containing 140 questions.

Conclusions and recommendations have been made per DSS; they are described by their general issues and by results on the subjective evaluation, although conclusions with the questionnaires cannot be statistically justified due to too few participants (users). The IMIS-model

[7] Student in Business Administration. International Irrigation Management Institute.

[8] Chew, W.B., D. Leonard-Barton, R.E. Bohn, Murphy's Law. Sloan Management Rovicw. Spring 1991, pp.5-16

[9] Adelman, Leonard, Evaluating Decision Support Md Expert Systems, Wiley and Sons, U.S.A..1992.

is the only DSS that provides support in scheduling and operations. The ECL-model provides intensive support in scheduling. For further development of each tool prototyping is recommended. All participants assessed the influence of the DSS on related organizational factors relatively negative in the subjective evaluation, and users also expressed their concern for sustainability. The level of technical know-how must be increased (more people must he trained in fully operating the DSS).

The managing agency must educate (future) users in the background of the DSS to initiate further development in applications (i.e., maintenance). The level of organizational know-how must be increased to understand the impact of the DSS on organizational matters, especially with regard to the required data collection network. Finally, the management must become aware of the strategic impact of DSS and secure funds for sustainability.

Further research should be initiated to determine the objective impact of the use of DSS on performance and additional research should define all costs involved in the utilization of DSS for water management.

irrigation scheduling

Sri Lanka
Uda Walawe

Uda Walawe Irrigation Project: Use of a Computer-Operated Model for Water Scheduling

Anura Wijetunga[10]

FORM 1986, UNDER the ADB-funded Walawe Irrigation Improvement Project, the system associated with the Right Bank Main Canal has been rehabilitated to facilitate improved water management on a command area of over 12,000ha. The rehabilitation has introduced regulation and measurement structures into main and branch canals, and control and measurement structures into **all** distributary and field canals.

Operation of the Right Bank System is based on continuous flow at fixed discharge for the land preparation period followed by the rotation of field and distributary canals during the crop growth period. Most field canals are designed to receive a standard supply of **28** l/sec (1 cusec). The introduction of water rotation has been complicated by the resistance of (some) farmer groups to changing from what was effectively a demand system, to a rotational system and by physical limitations in the infrastructure caused by ongoing rehabilitation works.

In the design of the rehabilitated canal system at Uda Walawe. theoretical models were originally used to determine crop water requirements and seepage and percolation losses. However, with the availability of flow monitoring data over several years, MEA has been able to replace theoretical models by information on actual water consumption in the planning of water delivery schedules. This procedure permits the operating system to be fine-tuned to meet the needs of water users growing rice, bananas and vegetable crops on a range of soil types and topography.

Rotational planning at the beginning of the season **is** carried out for each branch canal using a purpose-developed Lotus 1-2-3 spreadsheet with the following steps:

1. Estimate the rotations at field and distributary canal level, and the intended depth of irrigation at the head of the field canal.

2. Insert the data into the spreadsheet, invoke a macro to set up a table of closures (simply because it is more convenient to work with closures — in step [3] — rather than with flows to achieve **a** balanced discharge).

3. Balance the closures over the period of a week to minimize the variations of flows with time.

4. Convert the flow closures to flows using a second macro, and print the result as the weekly delivery schedule.

[10] Civil **Engineer, Mahaweli Economic Agency. Uda Walawe Irrigation Project, Sri Lanka.**

Daily rainfall adjustments are possible by making a percentage adjustment to canal discharges to correct the total water issue to account for light rainfall. Because the schedule of deliveries is initially based on water deliveries from the previous season, it is possible to prepare a schedule well in advance of the start of the season for discussion with farmer organizations at field- and distributary-canal level. Modifications requested by the farmers can then be introduced in advance at the start of the season.

This scheduling procedure will be adopted starting from maha 1993/94 throughout the Walawe Right Bank Canal.

GS Lanka
Kantale

Application of a Computer Model for the Kantale Scheme

K. Sivapalasundaram[11]

A COMPUTER MODEL (ECL model) developed by Ms. Engineering Consultants Limited, was slightly modified and has been used to schedule water delivery in the Kantale Scheme since maha 1991.

The objectives of the model are to:

* plan irrigation delivery schedules at key control points in the project at the commencement of the season in weekly time steps;

* revise the scheduling to variations in the cultivation pattern over the whole or a part of the project area during the course of the season; and

* revise the scheduling due to rainfall in the project area

The tnodel structure consists of: a master program which controls data filing/revisions and directs computation; basic project data and crop data programs; an executive program which gets inputs from the data files and prepares water delivery schedules; and another executive program whichcould be run at any timeduring theseason to revise thedelivery scheduledue tosubstantial changes in the actual rainfall pattern from the average distribution used.

To facilitate application of the model, the entire Kantale Scheme is divided into six segments and for each a modified ECL model is developed. The printouts that can be obtained from this model are: basic segment data, basic soil data, rainfall and crop data, and weekly discharge from main canal to turnouts.

Discharge measurements in about 160 locations are continuously monitored on a daily basis throughout the season. From the above, the actual performance can be compared with the model output.

"Irrigation Engineer, Irrigation Department, Trincomalee, Sri Lanka.

Irrigation Water Management Experiences with Computer-Aided Systems

I.W. Makin, G.A. Cornish and P. Spark[12]

THIS PAPER STRESSES the need to move away from passive administration of systems towards more active management of the water distribution network.

The results of studies on the Kaudulla System in Sri Lanka are summarized which indicated poor utilization of wet-season rainfall, a lack of information available to managers regarding field-water status, limited guidance provided to field staff on system operation and limited utilization of data that were collected.

H.R. Wallingford's work to develop appropriate water management software has focused on the design of an irrigation database and scheduling software. The software makes possible the storage and processing of a wide range of data relating to system infrastructure, hydrology and climate, crops and cropping calendars. By facilitating the routine and rapid verification and processing of these data, managers are provided with effective management information to guide preseason planning and in-season operational decisions.

The paper describes the characteristics of early spreadsheet software developed in Sri Lanka and Thailand and the more generalized, Windows-based program, INCA (Irrigation Network Control and Analysis), based on this field research.

The paper highlights key issues which must be addressed if sustainable improvements in water management are to be realized. These are: the need for institutional changes at all levels to raise the profile of water management; the need for basic water measurement and control structures to be in place, to be functioning and calibrated, the need for wide-ranging training of both field and office staff and the importance of developing effective communication with water user groups and, finally, the need to adopt a realistic time frame of two or three years to effectively implement improved water managerial procedures.

The paper summarizes the impact of **INCA** on schemes in Thailand and Sri Lanka through measures of reliability, equity and adequacy of supply.

The conclusions of the paper are:

1. Computer software can contribute to improved system performance where it is part of a wider program of inputs focused on improving water management, but the adoption of any computer package in isolation is unlikely to yield benefits.

"Members of the Overseas Development Unit, H.R. Wallingford, UK

2. The adoption of a small number of complementary, generalized software programs, by **the** national irrigation agency, should beencouraged. Standardizationof a package and supporting methodology **allow** staff to be transferred without vital knowledge being lost.

Setting up a Computerized Information System at the Main-Canal Level: Sri Lankan Experience, Kirindi Oya System

U.S. Wijesekera[13]

DAILY FLOW MOTORING and analysis in an irrigation system can be a very effective approach in finding solutions to water management problems. However, the complexity of irrigation systems and problems of staffing often stand as major barriers in implementing such a program. It is well recognized and accepted that at least main system level data are required on a daily basis for the proper management of water in an irrigation system. But, collecting and processing these data on a daily basis constitute a tedious task for the irrigation management which is rarely performed in the absence of appropriate support tools.

The main objective of the paper is to describe the introduction of a data collection and communication program and of a computer tool for storage and processing of daily data in the Kirindi Oya Right Bank Main Canal.

The characteristics of the scheme are first detailed followed by a complete description of the management intervention undertaken in Kirindi Oya. This intervention occurred in two steps: (1) the implementation of data collection and communication network, and **(2)** the introduction of a computerized management information system (IMIS).

The IMIS program consists of two types of tiles: database and program modules: The user interface consists of two main options and a generic option to install the program. The main options are: message entering and management options. The current configuration of IMIS-RBMC version helps entering the following input messages: sluice issues, daily measurement, daily gate operations, current metering data, structure survey, canal bed survey, schedule of water issues and rainfall data. The management activities consist of specific tasks under the processes of command, observing and evaluating functions identified in the framework. The purposes of these activities are: to display water distribution patterns along the canal for a given day; to compute hydraulic indicators such as volume issued, number of operations, level of submergence, level of fluctuations, etc., for any structure during any period of time; and to compute performance indicators such as adequacy, efficiency, reliability, etc. The generic option module is mainly to help the installation of a program in an irrigation scheme.

IMIS can be run in any IBM compatible computer (XT or AT model) with a minimum of two floppy disk drives (**720** KB) under the DOS environment.

IMIS has been put into operation starting maha **1992/93**. The main conclusions derived from this case study are as follows:

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[13]**Irrigation Engineer, Irrigation Depamnent. Kinndi Oya Irrigation and Settlement Project, Sri Lanka**

1. The introduction of a flow data collection program can be achieved with relatively affordable inputs while ensuring relatively high benefits in terms of better water management (a clear improvement in water use efficiency has been observed as a consequence of the intervention).

2. The problem caused by the necessity of handling a large amount of data can be addressed through the use of simple computer tools like **IMIS.**

3. An appropriate training of **all** levels of staff should be considered as a key component of this whole exercise on which depends its success and sustainability.

The present configuration of **IMIS** can be mainly utilized only to manage the water in simple main canal systems. Therefore, there is a need to extend this program to multichannel configuration, to incorporate water scheduling modules and to improve its graphical presentations.

WORKSHOP GROUP DISCUSSIONS

Workshop Group Discussions

THE WORKSHOP **DISCUSSIONS** were structured in two main sessions during which 6 topics were addressed by the participants. The first session (day 1 - 3 topics) was mainly intended to assess the present situation in Sri Lanka in the use of decision-support tools for irrigation systems management and to emphasize the constraints encountered while accumulating experiences in this field. The second session (day 2 - 3 topics) was expected to generate prospective discussions on what could be a sustainable strategy for the Irrigation Department on these issues during the next few years and what would be the practical steps to follow in order to implement this strategy.

Session I: **MAIN FOCUS:** REVIEW ***OF*** PRESENT EXPERIENCE

Topic 1

Question: Are the flow data collection networks of Sri Lankan irrigation agencies adequate? Why?

Classification of data required for water management

The data were classified under two broad types: the permanent or semi-permanent data and the variable data.

The set of permanent data comprised:

> ***The extent of the command area. the soil data, the descriptive parameters of the canal network of the structures and of the reservoir (if any), and the seasonal cropping pattern (agreed during the kanna meeting).***

The set of variable data which have to be collected at short-time scale intervals comprised:

> ***Measurement of rainfall. evaporation, area irrigated, information on cropping stages, values of inflows and outflows to and from the system, flow data of canals and the settings of operated structures.***

Measurement problems

* Problems were raised concerning the accurate estimation of the command areas (in many cases, old data might have to be updated with the use of rice land registers and interviews with farmers).

* Classification of soils should be pursued at least under two broad categories (well-drained and poorly drained soils) but improved methods are needed to validate the visual classifications (to better take into account important spatial variations).

* Layout details, reservoir information and canal parameters are usually available but need to be updated regularly.

* The rainfall measurements are insufficient. It was proposed to bring the density of rain gauges up to 1 for 1,000 ha.

* The available data on evaporation seem to be sufficient.

* Work has to be undertaken to monitor more accurately the cropping activities within the season in order to update the schedules. It was suggested to make use of farmers' organizations.

* The collection of canal flow data and settings of structures have been recognized as extremely weak.

Communication problems

Very little efforts seem to have been devoted to this area so far. A need for methodological guidelines in order to establish sustainable links between the field and the managers' offices has been clearly expressed.

Existence of databases

The present status in this field was mentioned as very weak. Even in cases where variable data are regularly collected the lack of a proper database system for storing and processing these data prevent any timely and useful analysis of them. The need for awareness building and practical improvements in this field has been strongly emphasized.

Topic 2

Question: How would you rank the decision support needs of irrigation system managers in Sri Lanka?

After discussion, the decision support needs of an irrigation manager were split into the following three key areas:

* seasonal planning

* water scheduling (both seasonal and in-seasonal)

* system operations (monitoring and evaluation)

(The case of decision-support tools for maintenance has been evoked by the group but not discussed at length since very little has been done in this field so far.)

Existing tools and shortcomings related to these three areas were listed:

Seasonal planning

The tools available or used in Sri Lanka comprise INCA, Gal-Oya model, ECL model, Kirindi Oya model (Mr. Jayasundara), OMIS (DHV Consultants), WATMAN, etc.

However, except tentatives on spreadsheets (LOTUS) used in Kirindi Oya, the use of historical data to predict the best cropping calendar, taking into account the water availability and expected rainfall, seems to have been overlooked. A proper analysis and quantification of the risks are lacking.

Although the group was aware that proper optimized planning would imply considering other parameters like economic returns and inputs other than water, it was agreed that a simplified approach was the most suitable.

Scheduling

It was recognized that scheduling is the area where most of the work has been undertaken so far in the field of decision support. A fair amount of models is available ranging from sophisticated applications (INCA, MODIS) to elaborated spreadsheet packages (Kirindi Oya, Mr. Jayasundara) up to simple ad hoc spreadsheets developed for specific sites. The identified gaps were: better accounting for rainfall and field wetness; estimation of return flows; groundwater coupling; and link of the models with databases.

System operations

Very little attention has been paid to this area, which was nevertheless considered important by the group.

By systems operations, the group understood how the manager is actually running his system on a day to day basis in order to meet the targets worked out through the scheduling process while efficiently facing the hydraulic perturbations occurring in the system under his management. The simulation model (SIC) coupled with a database system (IMIS) tested in Kirindi Oya was mentioned as one of the few attempts in this field apart from WATMAN. the Gal Oya model and the ISMP model.

The need for efforts was advocated for undertaking some work in coupling the system operation and scheduling model, and formulating recommendations on the use of hydraulic modeling for understanding both steady and unsteady flow conditions in the irrigation canals.

As a general comment, in addition to the potentially needed investigations at the software level, the need for a proper data collection and transmission network as well as for trained operating staff has been stressed once again. Skills, attitudes and knowledge have to be enhanced or modified through training and awareness-building.

Topic 3

Question: Which are the organizational implications of the introduction of computerized decision-support tools?

The group decided to address "institutional" rather than "organizational" implications and was able to derive some preliminary recommendations in this field. The group observes that almost all the models (except Jayasundara's model) have come into existence through donor-funded projects, or in other words, on a SUPPLY-DRIVEN rather than a DEMAND-DRIVEN mode. **Mr.** Jayasundara's model was a self-driven attempt accomplished by personal interest, without direction, appreciation or support from the top management of the ID.

The above statement leads to the addressing of many policy issues:

* First, the use of computer-aided software packages for improved operation is not a declared objective of the ID.
* Second, the ID has the necessary human resources, capability and skills to develop and implement computer-aided models, provided proper direction, guidance, support and incentives are given.
* Third, the level to which the computer-supported models should **be** used for system operation is not clear.
* Fourth, the financial. institutional and other constraints are strong in the present setup.

The suggestions are therefore that the Irrigation Department:

* Declare the acceptance of computer-operated models for improved operation **as** a policy.
* Identify sufficient resources for investing in this field and provide a computer to each IE in charge of a division together with a standard software package or scheme-specific application.
* Carry out a cost-benefit analysis based on past experience and performance of computer-aided tools, to justify the investments for software against heavy investments for physical rehabilitation.

* Initiate training sessions for field-level staff on data collection, data processing and conversion of data to information.

* Provide incentives to ID engineers to develop software (NIRP/IRMU assistance would be a useful source for incentives).

* Motivate field-level staff by redefining their duties, roles and functions in water management.

* Promote the development of maintenance management models to implement maintenance hand in hand with operation and management with a view to improve system performance.

Session 2: MAIN FOCUS: PERSPECTIVES AND RECOMMENDATIONS

Topic 1

Question: What steps have to be taken by irrigation agencies (policies, institutional, human resources development, etc.) in order to ensure sustainability in the use of computerized decision-support **tools?**

The group discussed **4** issues:

Level where computer tools should be introduced

The group felt that the computer tools should provide support for water management up to the DC level and should be introduced in major and medium schemes.

Support from Irrigation Deparlment headquarters to the field sites

The group insisted on the need for a coordinated approach in this field and thought that the success in implementing decision-support activities at the field level would depend greatly on the capacity of the HQ in providing resources (computers, communication means, extra-operational costs), training facilities, clear guidelines and regular exchanges through monitoring and evaluation.

Standardized and **well-maintained databases** were understood as an important issue to trace the performances of irrigation systems at the national, range and divisional levels.

Some way would be needed within the department for identifying and rewarding of particularly motivated ofticers who would hnve undertaken pioneering work and worked out innovative tools or methods.

Topic 2

Question: What are the standards required for the next generation of decision-support tools in Sri Lanka? In-house developments or external partners?

Standards

The group's main recommendation was to move towards a higher degree of standardization of the tools within the department. The availability of similar tools requiring comparable skills in the different schemes was felt **as** a warranty of smooth transitions in case of transfer of officers.

The group did not elaborate much on what the standard should be but mentioned a few points.

* In case of seasonal planning, specific tools should be worked out for medium and major schemes in cases of water supply from a reservoir or from a diversion. Provision should be made for a database comprising historical data over a minimal period of 5 to 10 years,

* In case of water scheduling, the group recommended the use of "simple" models requiring a minimum of field data.

* In case of system operations, the discussions highlighted the key issue of maintaining standardized databases containing flow information about the canal system updated on a daily basis. The **role** of accompanying measures like standard measurements and communication procedures was again stressed.

Development

The group's main recommendation was to promote as much in-house developments as possible. It was urged to initiate a coordinated process leading to identifying existing **skills** within the department, working out first terms of references for the various tools evoked under the foregoing section, standards, and undertaking a serious training-needs assessment. The value of external inputs was not denied but the group felt that the trend should be reversed from supply-driven to demand-driven interventions.

Topic 3

Question: What are the training requirements for the irrigation managers using computerized decision-support tools?

Make the best use of ongoing experience

The experience of officers of the department who are or have been involved in developing or using decision-support tools should form the basis for identifying the needs in terms of methodology and software (see Topic **2).**

Design of training modules

A strategy has to be worked out for building awareness at **all** levels (central and field levels), and designing training modules for the staff in charge of water management activities (IE, **TA, WSS,** operators). This was identified **as** a key issue which should be addressed by ITI and IRMU **as** soon **as** possible.

APPENDIXES

APPENDIX A

Workshop on the Use of Computer-Operated Models as Decision-Support Tools in Operation and Management of Irrigation Systems

Organizing Committee

1. Mr. H.M. Jayatilleke
   Deputy Director, ITI, Galgamuwa

2. Mr. M. Bahurdeen
   Trainer (IE), ITI, Galgamuwa

3. Mr. N. Bandaranayake
   Trainer, ITI, Galgamuwa

4. Mr. S.T. Perera
   Trainer, ITI, Galgamuwa

5. Mr. P.W.C. Dayaratna
   Deputy Director, IRMU

6. Dr. K. Azharul Haq
   Technical Advisor, IRMU

7. Mr. C. Nanayakkara
   Research Associate, IRMU/IIMI

8. Mr. K. Hemakeerthi
   Research Officer, IRMU/IIMI

9. Ms. K. Maheswaran
   Research Officer. IRMU/IIMI

10. Mr. J. Rey
    Associate Irrigation Specialist,
    Research Division, IIMI

11. Mr. H.M. Hemakumar
    Research Officer,
    Research Division, IIMI

APPENDIX B

Workshop on the Use of Computer-Operated Models as Decision-Support Tools in Operation and Management of Irrigation Systems

Workshop Program

Day 1 - 15 July 1993 (Thursday)

09.00 a.m. - 09.30 a.m. Registration of Participants

09.30 a.m. - 10.30 a.m. Inaugural Session

* Welcome Address by Mr. P.W.C. Dayaratna, Deputy Director, IRMU.
* Introduction to the Workshop by Mr. K.S.R. de Silva, Project Director/NIRP
* Address of the Chief Guest, Mr. L.U. Weerakoon, Secretary, State Ministry of Irrigation.
* Address by the Special Guest, Mr. N. Abeywickrema, Director International Cooperation/IIMI.
* Address by Mr. K. Yoganathan, the Director of Irrigation,

10.30 a.m. - 11.00 a.m. Tea

Chairperson: Mr. D.W.R.M. Weerakoon,
Senior Deputy Director (O&M)/ID.

11.00 a.m. - 11.45 a.m. Use of Computer-Operated Models as Decision-Support Tools in Operation and Management of Irrigation Systems — Gal Oya Experience by Mr. G.G.A. Godaliyadda, Deputy Director, Moneragala.

11.45 a.m. - 12.30 p.m. Application of Computer Models on Water Management in the Kirindi Oya Project by Mr. B.K. layasundara. Chief Irrigation Engineer, Galle.

12.30 p.m. - 02.00 p.m.	Lunch
	Chairperson: Mr. K. Thurairajaratnam, Senior Deputy Director, (PD&SS).
02.00 p.m. - 02.45 p.m.	Use of Computer Models as Decision-Support Tools in Operation and Management of Irrigation Systems — Hakwatuna Oya Tank Project by Mr. W.G. Wimalaratna, Irrigation Engineer, Hiriyala.
02.45 p.m. - 03.30 p.m.	Application of the ECL Computer Model for Kantale Irrigation Scheme by Mr. K. Sivapalasunderam. Irrigation Engineer, Trincomalee.
03.30 p.m. - **04.30** p.m.	Tea and Group Discussions.
04.30 p.m. - 05.00 p.m.	Presentations by Group Leaders.
07.00 p.m. - 08.00 p.m.	Video Presentation of a Computer Model.
08.00 p.m. - 09.00 p.m.	Get-together and Dinner.

Day 2 - 16 July 1993 (Friday)

	Chairperson: Dr. R. Sakthivadivel, Senior Irrigation Specialist, IIMI/SLFO.
08.30 a.m. - 09.00 a.m.	Guest Lecture by Mr. N. Madusudanan. Retired Senior Deputy Director, Irrigation Department.
09.00 a.m. - 09.45 a.m.	Computer-Assisted Water Management Experiences from the Polonnaruwa Schemes by Mr. A.M.U.B. Alahakoon, Irrigation Engineer, Polonnaruwa Division and Mr. Nimal Rohana, Irrigation Engineer, Designs Branch, Head Office.
09.45 a.m. - **10.30** a.m.	Application of the Computer Model in Calibration of Structures in Flow Measurements by Mr. K.A.U.S. Imbulana, Research Officer, IIMI.
10.30 a.m. - **10.45** a.m.	Tea

10.45 a.m. - 11.30 a.m.	Setting up a Computerized Information System at the Main Canal System by Mr. J. Rey, Associate Irrigation Specialist, IIMI, Mr. U.S. Wijesekera, Resident Engineer, Right Bank, Kirindi Oya and **Mr.** H.M. Hemakumara, Research Officer, IIMI.
11.30 a.m. - 12.15 p.m.	Paper by Mr. ***G.*** Cornish, HR Wallingford.
12.15 p.m. - 01.00 p.m.	Computer Models Used in Uda Walawe Scheme by Mr. A. Wijetunga, Civil Engineer, Mahaweli Economic Agency, Walawe.
01.00 p.m. - 02.00 p.m.	Lunch.
	Chairperson: Mr. L.T. Wijesuriya, Senior Deputy Director, (Rehabilitation)/ID.
02.00 p.m. - 03.00 p.m.	Evaluation of Computer Models in Operation by Mr. R. Oskam, Student in Business Administration, Attached to IIMI.
03.00 p.m. - 03.15 p.m.	Tea.
03.15 p.m. - 04.00 p.m.	Group Discussions.
04.00 p.m. - 04.45 p.m.	Presentation by Group Leaders.
04.45 p.m. - 05.00 p.m.	Concluding Remarks by Mr. L.T. Wijesuriya.