6.1 INTRODUCTION

The performance oriented diagnostic study of the Sathanur Irrigation system has emphasised on the need for an in-built mechanism for planning, monitoring and evaluation with a feedback system. MIS is a tool providing a systematic analysis of the scheme operation and management. This chapter describes the design, development and working of the MIS for the Sathanur Irrigation System. The MIS has been developed using the concept of management information system and irrigation system performance. The components of this MIS are developed in accordance with the activities involved in the irrigation system operation, namely, planning, monitoring and evaluation.

MIS for the irrigation system establishes formalised procedures to provide managers at various levels with appropriate information from all relevant sources to enable them to take timely and effective decisions for planning, operating, controlling and subsequently upgrading the operational plans. It involves sustained analysis of information and watching the changes that take place in the components of the system. The main objective of MIS is to refine and improve the system operation plans year after year.

The main uses of the MIS are to maintain an accountability of the activities performed and to support the decision making process of the system manager.
6.2 DESIGN OF AN MIS FOR SATHANUR IRRIGATION SYSTEM

The performance diagnosis undertaken in association with the people in charge of the system was useful in developing an MIS for the Sathanur system, from information system perspective, in three ways.

* To know the technical knowledge available and required
* To know the level of organisation and coordination of information requirements, and
* To know the computations performed and database existing in the system

The MIS for this system has been designed based on the managerial activities involved in the system operation. Being a service oriented public organisation, the Irrigation Department, does not have clear demarcation of the organisational functions in its present setup. Hence, the functional approach that is generally adopted in the design of MIS for business organisation, could not be adopted here.

6.3 FUNCTIONAL MODULES OF THE MIS

The MIS for Sathanur Irrigation System (SIS) is developed with the following functional modules, based on the activities involved in the system operation and management. Figure 6.1 shows the functional modules of the MIS and the information flow between them. It includes

i. Data Entry
ii. Planning Module
iii. Monitoring Module and
iv. Evaluation Module
Figure 6.1 Functional modules of the MIS for Sathanur Irrigation System
The components of each of these modules are shown in Figure 6.2. The development and working of these components are discussed below. The logic of working of the modules are also presented in flow charts for reference. The details of the computations are provided in Appendix 4. The MIS is developed using "C" language and Foxpro. The model is run with a PC AT 386 with 4 MB RAM.

6.3.1 Data Entry

This is a data input system consisting of 10 options to input the different data required during the planning, monitoring and evaluation of the system operational plan. Some of the data like system configuration, hydraulic particulars of the reservoir and canals, design discharges and crop details are generally stored in permanent files. Some data like the flow measurements, losses, farmers' requests and rainfall during the canal operation are stored in temporary files. The format and frequency of data collection are specified. Table 6.1 gives the input and output messages of the MIS and their frequency.

6.3.2 Planning Module

The planning module deals with activities that provide information for operating the system in a planned manner.

This module supports the system manager in preparing the operational plan/schedule for the season under different requirements of the system. It also supports in modification of the plan/schedule and provide prior information on new targets, in response to field conditions. This module consists of the following components.
Figure 6.2 Components of the modules of the MIS
<table>
<thead>
<tr>
<th>Input Messages</th>
<th>Frequency</th>
<th>Output Messages</th>
</tr>
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<td>Inflow into the reservoir</td>
<td>Daily</td>
<td>Water delivery summary at canal network</td>
</tr>
<tr>
<td>Evaporation loss</td>
<td>Daily</td>
<td>New target discharges</td>
</tr>
<tr>
<td>Water level measurements at control points</td>
<td>Daily</td>
<td>Physical conditions of the canals</td>
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<tr>
<td>Rainfall in the command</td>
<td>Daily</td>
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</tr>
<tr>
<td>Tailend status of the distributary</td>
<td>Daily</td>
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</tr>
<tr>
<td>Users' request for changes in delivery pattern</td>
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<td>Seasonal Performance Report: Evaluation of water</td>
</tr>
<tr>
<td>Changes in canal system losses</td>
<td>Fortnight</td>
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<td>Canal system losses</td>
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<td>Climatic data and crop details,</td>
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<td>Area of irrigation</td>
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<td></td>
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<td>Farmers' Response Survey details</td>
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</tbody>
</table>
6.3.2.1 Allocation Option

This options helps the manager to choose the criteria for water distribution between different parts of the system during the season, according to the quantum of water available in the system. The manager can choose the following criteria for water allocation in consultation with the farmers.

(i) **Equity Considerations**: This aims at distributing the available water equitably in the entire command, irrespective of meeting the demand of the crops. It aims at achieving the equity in water sharing.

(ii) **Productivity Considerations**: It aims at meeting the demand of the crops either in the entire command or part of the command, depending on the water available during the season towards achieving the crop production.

(iii) **Priority Considerations**: This helps in the distribution of the water among the different zones of the system according to certain established priorities of the system.

(iv) **Groundwater Considerations**: The manager has provision to prepare the water delivery plan inclusive/exclusive of the groundwater available in the system, as decided in the pre-seasonal meeting.
6.3.2.2 Scheduling

The Scheduling is done at two levels.

At the first level, it computes the demand at each distributary canal head, considering the on-farm water requirements, conveyance losses, starting from the downstream outlet. Modified Penman method is used to compute the crop water requirements (Doorenbos and Pruitt 1974). It provides for results as volume of water required in each rotation in each distributary and the number of days of operation of each distributary in each rotation, considering that the distributary runs with its design discharge (Figure 6.3a). The manager has been given with an option to consider the groundwater available in each of the distributary, while scheduling. Figure 6.3b shows the procedure for estimating the groundwater contribution. Rise and Fall method is adopted to estimate the groundwater available in each distributary by taking monthly groundwater levels of the representative wells of the distributary and number wells in each distributary.

At the second level, a new computational procedure has been developed for scheduling the rotations among the distributaries. In this procedure, the distributaries are prioritised for rotation, based on the rank obtained daily, considering certain factors such as locational, managerial, equity, adequacy and timeliness involved in the rotational water distribution. The locational, managerial, equity, adequacy and timeliness factors were computed and used to rank the distributaries. The computation of these factors are explained at the end of this chapter in section 6.4. The requirements of indirect command (tank command) are also computed (Figure 6.3c). The distributaries are not ranked for operation, when there is supply to the tanks intended for indirect command.

After ranking the distributaries for daily operation, the demands of the distributaries at the main canal head are computed, considering the main canal loss. The distributaries are selected for operation according to
Figure 6.3a Flow chart for computation of the demands of the distributaries
Figure 6.3b Flow chart for estimation of the groundwater
Figure 6.3c  Flow chart for computation of the demands of the tank command
the rank, until the sum of their demand is within the capacity of the main canal (Figure 6.3d).

6.3.2.3 Reservoir

Figure 6.3e shows the daily operation of the Sathanur Reservoir. The reservoir operation takes into account the storage, inflow, sharing of the flow between the Sathanur and old ayacut, releases at the main canal head, evaporation loss and provides the Reservoir Working Table. The operational rules and regulations are incorporated in this component. This reservoir option helps in the seasonal planning as well as in the real time operation.

6.3.2.4 Modify Plan and Target

This option makes changes in the water delivery schedule and provides new target for operation within the season in response to rainfall, farmers' requests and tailend conditions with a predefined criterion established for each of the conditions, according to the performance of the distributaries, as explained in the Monitoring Module.

6.3.3 Monitoring Module

The monitoring module deals with the activities to obtain information on the present status of the system.

6.3.3.1 Discharge Computation

This option computes the delivery of water (discharge) at the head of the distributary, from the gauge readings collected by the Lascar from the field. The discharges are computed according to the type of the measuring structure in the canal head and the prevailing flow conditions, either of the free flow or of the submerged flow.
Figure 6.3d Flow chart for computation of the demands of the distributaries scheduled for operation
Figure 6.3e Flow chart for Sathanur reservoir operation
6.3.3.2 Water Delivery Summary

This option gives the quantity of water delivered at different parts of the canal network system, with their target discharges. This also indicates the tailend status of the distributaries. The manager can make a comparison between the target and actual and identify the causes for the deviation and can take corrective measures to reduce the deviation.

6.3.3.3 Rainfall Contribution

This option helps the manager to modify the schedule in response to the rainfall in the field. This option can be called daily, when there is rainfall in the system command. The manager can give the actual rainfall in the distributary as input. It computes the contribution of the rainfall (effective rainfall) in days. This is computed by finding the ratio of the depth of contribution by effective rainfall to the depth of daily requirement in the distributary in that rotation. This option subsequently provides guidelines towards making changes in the schedule / water delivery plan. In case, if the amount of rainfall is not known, the manager may input the days of contribution by personal judgement or in consultation with the Lascars or farmers. Being the post monsoon season, the contribution days may not exceed 5 days at any time from the current day (Figure 6.4a).

6.3.3.4 Farmers' Request

This option is provided to accommodate the farmers' request for releases on additional days in any rotation. This option prioritises the farmers' requests from the different canals, according to the performance of water delivery in the canals, till the previous rotation. Accordingly, the canals with lesser DPR get the preference. Farmers' request can be met in two ways, either from the additional storage available in the reservoir or through internal adjustments in rotations (Figure 6.4b).
Figure 6.4a Flow chart for computation of the rainfall contribution
Figure 6.4b  Flow chart for computation of the farmer's requests
6.3.3.5 Managerial Diagnosis

The structured network system in the distributaries facilitates the provision of water to the tailend on all the scheduled days so as to maintain the equity in the distribution system. Field observation has shown that the tailend has not received water on the planned days. A number of reasons could be attributed to this. However, a sequential diagnosis will help to trace the causes and take corrective measures. Hence, this option is designed to provide guidelines to make a sequential diagnosis of the distributaries or the reaches of the main canal to find the causes for the tailend not getting the water on the scheduled days of water delivery and take corrective measures (Figure 6.4c). This also makes accountability for the services provided by the Lascar or other operating personnel. Provisions are made for making changes in the losses in the canals at the beginning of each rotation, if necessary, and changes in the schedule as well. The farmers are given prior information about this.

6.3.4 Evaluation Module

The evaluation module deals with the activities to obtain information on the effectiveness of the system operation.

The purposes of this module are (a) to determine the performance of the irrigation system, (b) to evaluate whether the system has achieved its intended objectives, and (c) to find the means to achieve the objectives so as to improve the system performance.

6.3.4.1 Computation of Indicators

(i) This component computes the various water delivery system indicators such as Delivery Performance Ratio, Inter Quartile Ratio, Modified Inter Quartile Ratio, Depth of water supplied
Figure 6.4c Flow chart for managerial diagnosis of the canals
per ha (to find equity), Reliability and Predictability of the water delivery services.

(ii) In addition, it computes the socio-economic system indicators so as to have a comprehensive understanding of the irrigation system. Productivity of water and land, O & M expenses incurred against the income from water charges (percentage of self sufficiency of the system).

(iii) Farmers' Response Survey: The irrigation systems in a Tamil Nadu are jointly managed by the agency and the farmers. System managers do the business of water delivery services and farmers are the clients. Hence, it is important to get the farmers' views on the availability of irrigation water and other agricultural services. This can be obtained through a Farmers' Response Survey. The purpose of the Farmers' Response Survey is:

(a) To get an end-season synoptic view of farmers' responses to the implementation of the operation plan and to compare their views between different parts of the command, and

(b) To maintain statistics to get trends in the farmers' attitudes and crop yields and production over time.

A simple questionnaire aiming at the farmers' views on the following is being suggested as part of this module. The module has provisions to analyse the questions statistically. The manager can enhance the functioning of the system in the subsequent season in response to the information obtained.
* Farmers' perception on water delivery services provided
* Farmer - Agency interaction
* Information flow - bottom-up & top down approach
* Availability of Inputs and other services in time, and
* Farmers' income

Farmers' Response Survey was conducted by the scholar in the irrigation season of 1995 in some of the distributaries where measurements were made to get a complete picture of the water delivery and other services provided. Samples for this survey were selected as follows. Minor outlets representing head, middle and tail were selected randomly in the DY 6R, DY 10R and DY 15R of the LBC and in the BC1, BC2 and BC4 of the RBC. Six farmers were selected from each of these selected outlets, adding to a total of 108 samples. The sample size for this survey is limited to 108 for want of time and manpower on the part of the researcher. The agency can however do this survey on a large scale.

6.3.4.2 Analysis of Indicators

This component analyses the performance of each distributary using various performance indicators computed and supports in preparing the performance report and as well as taking corrective measures.

6.3.4.3 Performance Report

This option supports the preparation the Seasonal Performance Report for the irrigation system. This includes Reservoir operation - planned- actual - reasons for deviation; Water Distribution - planned-actual-major variations between different sub-commands; Agricultural production and productivity between different sub-commands; Farmers' attitudes - views on water delivery and operational plan - information flow-
provisions of agriculture and services - knowledge and satisfaction; Implications / Guidelines for the following season.

This MIS has been developed to eliminate the deficiencies in the existing system operation and management. It aims at improving the operational performance of the water delivery system through an information system. It also focuses on the performance of the irrigation system in the overall context. The general purpose of this MIS is to set up a more streamlined system of data collection, communication, processing and more rational decision making, with necessary feedback and monitoring. This will gradually lead to efficient utilisation of water and other resources.

6.4 COMPUTATIONAL PROCEDURE FOR SCHEDULING THE ROTATIONS

A new computational procedure has been developed for scheduling the rotations among the distributaries in this system. In this procedure, the factors relevant to the rotational water distribution system such as locational, managerial, equity, adequacy, timeliness and convenience of operation are represented in terms of weights. Weights get assigned to each of the distributary based on each of these factors. The weights assigned are usually less than 1.00. They remain constant or dynamic with respect to the time of operation. Since these factors are dependent on each other, the final weight is obtained on a multiplicative basis (by multiplying the individual weights) for each distributary. The distributaries are ranked based on the final weight and then prioritised for rotational operation for each day according to the ranks. The weights of the locational, managerial, equity, adequacy and timeliness factors are computed as follows (Santhi and Pundarikanthan 1996b):

i. It is desirable to group the distributary canals based on location such that the workload or travel time of the gate operator as well
as the conveyance losses are minimised. This locational weight is represented as follows.

\[
W_{1_{kt}} = 0.9 \text{ for } k = 1, 2, 3...n/2 \text{ and } t=1, 3, 5...m
\]

\[
W_{1_{kt}} = 0.1 \text{ for } k = (n/2 + 1)...n \text{ and } t=1, 3, 5...m
\]

\[
W_{1_{kt}} = 0.1 \text{ for } k = 1, 2, 3...n/2 \text{ and } t=2, 4, 6...m-1
\]

\[
W_{1_{kt}} = 0.9 \text{ for } k = (n/2 + 1)...n \text{ and } t=2, 4, 6...m-1
\]

where \(W_{1_{kt}}\) is the weight for distributary canal \(k\) for the time period \(t\) (say a week or a fortnight), \(n\) is the number of distributary canals and \(m\) is the number of periods in the crop season. In the above case, the first \(n/2\) distributary canals are considered as one group and the remaining as another. Grouping could be done in such a way that each group is similar in size and water requirements.

ii. Once the running time of each canal is estimated based on on-farm water requirement, conveyance losses and discharge capacity, weights get assigned to each outlet in proportion to its required time of operation over the crop duration. This weight takes care of the adequacy (satisfying the requirements). This weight for the distributary canals remain constant throughout the crop season.

\[
W_{2_{k}} = \frac{d_{k}}{D} \text{ for } k = 1, 2, 3...n
\]

where \(W_{2_{k}}\) stands for the weight of the distributary \(k\), \(d_{k}\) stands for the time of operation of the distributary canal \(k\) and \(D\) stands for the crop duration.
iii. The fairest way to achieve equity is to allocate the water in proportion to the area under irrigation under the outlets with proper assessment of conveyance losses. Conveyance loss, being an influential factor of equity, has to be incorporated in the equity calculations.

\[ W_{3k} = A_k^* / \Sigma A_k^* \text{ for } k = 1,2,3...n \]

where,

\[ A_k^* = A_k / ((1 - \text{loss}_k)^{\text{length}_k}) \text{ (Hiemcke 1992)} \]

and \( W_{3k} \) is the weight representing the equity considerations indirectly, \( A_k^* \) is the virtual area of the distributary canal \( k \), \( A_k \) is the area of the distributary canal \( k \), \( \text{loss}_k \) is the percentage of loss per kilometre expressed in fraction in the distributary canal \( k \) and \( \text{length}_k \) is the actual length of the distributary \( k \). Since, the distributary canals are unlined and do not have a regular cross section, the useful way to consider the loss is as loss per kilometre.

iv. The timeliness factor (timing of water deliveries to the distributary canals) is incorporated such that water deliveries match with the crop needs over the season. Requirements of each target period (say, a week or fortnight) is satisfied within that target period.

\[ W_{4kti} = (R_{kt} - \Sigma r_{ktj}) / R_{kt} \]

where \( W_{4kti} \) is the timeliness weight of the distributary canal \( k \) for the day \( i \) in the time period \( t \), \( R_{kt} \) is the demand of the distributary canal \( k \) for the time period \( t \) and

\[ \Sigma r_{ktj} \]

\[ j=1 \]
is the net release to the distributary canal k till the previous day (i-1) in the time period t.

In this case, weights get assigned every day, based on the releases of water in the distributary canals against the requirements over a target period. The dynamic nature of this weight will give higher priority for the less considered distributary for operation in a sequential manner in that time period t.

\[ W_{ki} = W_{1ki} * W_{2k} * W_{3k} * W_{4kti} \]

where \( W_{ki} \) is the final weight of the distributary canal k for the day i in the time period t. The distributary canals are ranked for prioritising operation according to the final weight computed on each day.

The following assumptions and constraints are taken into account in the formulation of the procedure for scheduling.

i. During rotation, once the distributary canal is opened, it runs continuously with its full supply discharge. The gate operation consists of either "full open or full close" so as to simplify the managerial inputs required.

ii. Distributary canal runs a full day, even if the demand is satisfied before the end of the day. This channelises the workload of the gate operator.

iii. Distributary canals runs at the design discharge capacity and the main canal close to its design capacity depending on the requirement.

iv. On any day, the total releases in the grouped distributary canals cannot exceed the discharge capacity of the main canal.