CHAPTER 2

REVIEW OF LITERATURE

2.0 INTRODUCTION

Historically, the focus of irrigation development in India has been on the design and construction of civil works for storage, conveyance and distribution of water. In the colonial days, extensive irrigation is preferred than intensive irrigation to insure against droughts and famine, to ensure continuous and stable revenue collection. These systems are essentially supply oriented and lacked operational flexibility to deliver water at the right time and at the right quantity, essential prerequisite for any irrigation system for modern agriculture (Gopinath 1991).

The progress made in India in developing new irrigation potential is tremendous. From 22.6 M.ha in the year 1950, the total irrigation potential created reached an astronomical figure of 80 M.ha in 1990 (CWC 1992).

Non-availability of suitable sites and increase in cost of exploiting new water resources systems made it difficult to justify for new investment in a number of Asian countries including India since late 1970s. Management improvement and or rehabilitation of existing systems are less capital intensive options than creation of new capacity to increase the productivity (Easter 1986, Sakthivadivel 1991). Further efforts to create new potentials are also bogged down due to environment protection concerns, e.g. Silent Valley project, Sardar Sarovar project etc.
The gap between the irrigation potential created and potential utilised is widening. It created a concern for the National Governments and aid agencies alike, which were striving hard to increase the food production to meet the growing demand. Poor water management is the major impediment towards realisation of full potential of irrigation projects (Ian Carruthers 1981, David Steinberg 1983). Major cause of poor performance of large irrigation systems in many parts of the world has been deficient management, particularly in the operation of main canal (Bottrall 1981). Lack of proper setting of objectives, deficient programming, non-existence of operation plan, inadequacies to direct and control water distribution and inadequate performance monitoring are the various deficiencies found in the irrigation system management (Rabi 1986).

2.1 MAIN SYSTEM MANAGEMENT (MSM)

According to Chambers (1988), the Main System Management refers to management or software aspects of capture, allocation, scheduling and delivery of water from reservoir to and including outlet and disposal of drainage water. It includes planning, decision making, the operational controls and communication flow. It is exceptionally complex with physical, bio economical and human domains. Their linkages varies over space and time. Therefore the main system managers should find ways and means to match the supply and demand under prevailing agro economic and policy constraints. Their tasks are not only collection and distribution but also maintenance and conflict resolution (Coward 1990). A study in Pakistan reveals that by improving management alone a saving of more than 20 percent of available water for production use is achieved (PSASIR 1976). There are immense opportunities for improvements in the performance through management reforms. In South and Southeast Asia at least the key to overall improvement in management lies in better distribution (Bottrall, 1981).
Innovative management is needed for finding ways to overcome the bureaucratic inertia and vested interest that affect main system operation. The technical deficiencies can be corrected by existing technologies (Sakthivadivel 1991). Improving irrigation management at the system level requires in addition to physical control facilities, knowledge, analytical tool, resources and the ability to establish appropriate goals and acts to achieve them (Svendson 1991).

2.2 ALLOCATION

Allocation is matching the supply with demand. If the allocation and decisions are made at higher level i.e., water supply is determined by those who manage the higher level control, it is known as upstream control. If higher level responds to request/demand from downstream, it is known as downstream control.

2.2.1 Method of Allocation

Charles Nijman (1990) suggests four methods of water allocation and the managerial input required for each one of them:

1. Fixed Discharge, Variable Duration: It requires more managerial input from the manager but allows the water users to standardise the rotation within distributary and field channels to a certain extent.

2. Variable Discharge, Fixed Duration: It is easier for managers but requires much more management input and internal organisation from water users to managing the variable duration to different farm plots if supply is tight compared to demand.
3. Variable Discharge, Variable Duration: It requires most management input from agency staff but relatively less from water users.

4. Fixed Discharge, Fixed Duration: It is the least management intensive for agency but does not allow for tight water supply over the whole season.

When the total availability of canal water fluctuates significantly and has to cater to larger demand, trade off between maximising usable flow and minimising the variability of supply over time and space can be achieved by developing rotational and scientific water allocation policy.

2.2.2 Allocation Strategy

Basu (1991) enumerates three broad strategies for water allocation policies:

i) Higher average use with higher variability in supply: Usually supply based irrigation system achieves higher mean average use than demand based system. Projects with high variable inflow and less storage or for run-of-the-river system, this is more appropriate.

ii) Lower average use with lower variability: The system planned with higher dependable supply with higher variability of inflow and small storage reservoirs leads to lower mean use. This leads to reliable supply and hence leads to stabilisation.

iii) Demand control: When the command area has a combination of both water intensive and irrigated dry crops and the available inflow and storage are inadequate to meet the total
demand during the year, the water demand is reduced by reducing the cropped area.

For equity criteria the second and third strategies are suitable.

2.2.3 K-Factor

In Indonesia, if the demand is more than supply, an adjustment factor called "K-Factor" - the ratio between demand and supply - is used to modify all target discharges (Tom Kelly 1989). When the K-Factor lies between 1.00 and 0.60 all target discharges are multiplied by this factor. If it is less than 0.60 rotational water supply is adopted between secondary canals. But Government records do not reflect the additional sources developed by farmers themselves, say, wells or tube wells; return flow, and actual area irrigated by the canal. This affects the equity in distribution. In some cases tail end receives more water due to return flow (Rust 1991).

2.2.4 Water Distribution

Major water distribution methods adopted in India are i) rotation ii) on demand iii) continuous (Pai 1979). The distribution can be done based on supply and based on demand.

2.2.4.1 Supply Based

Supply based distribution distributes water according to pre-determined procedures and requires the farmers to arrange their activities in response to the pattern of water supply e.g. Warabandi adopted in N.W India, Osrabandi in North India.
2.2.4.2 Demand Based

Demand based distribution attempts to meet specified crop needs. e.g. Shejpali or agreement system of Western India, the localisation of South India, continuous supply in South India & SE India.

In North America, the water distribution is combination of types of frequencies (unlimited, arranged, fixed or varied as fixed), rate (unlimited, limited, constant or varied as fixed) and duration (unlimited, constant, fixed by policy or fixed) (Replogle 1981).

2.2.4.3 Warabandi

Warabandi is defined as a system of equitable water distribution by turns according to a predetermined schedule specifying the day, time and duration of supply to have irrigation in proportion to land holding. Spills, seepage, and location contribute variable flows. Being rigid schedule a particular farm must take water in its turn even though water is not needed which results in excess irrigation. Warabandi starts at 6.00 a.m on Monday and rotation period is seven days. Duration is fixed in terms of minutes. Distributary or minors are to be run for eight days and the water course for seven days. Breaching of warabandi by any person is dealt very seriously and the water supply to him will be stopped.

In Northwest India and Pakistan being run-of-the-river diversion systems rotations are on routine schedules, monitoring simplified and canals and outlets are designed to provide constant discharge since the second half of 19th century (Singh 1981, Malhotra 1982). Maintenance of these canals was largely a question of maintaining physical work and avoiding siltation (Chambers 1988). Under the command area development programme warabandi is introduced in Sri Ram Sagar, Nagarjuna Sagar, etc. commands. In Andhra Pradesh, though many display boards are erected
and inspected by many inspecting officials, warabandi as such is largely a myth (Pant 1983, Chambers 1988). Such unsuccessful attempts did not guide the Government of India to take any mid course corrections. But every year millions of rupees are being spent for introducing warabandi in South Indian commands. Under the National Water Management Project (NWMP) ungated proportional distributors are introduced in Sathanur command. Due to wide variations in the flows in the channels due to poor storage condition in the reservoir, such structures are not acceptable to farmers and they get damaged. Unmindful of this, it is proposed to extend such structures to all commands of Tamilnadu in the Water Resources Consolidation Project (WRCP).

2.2.4.4 Shej Pali System

In the Shej Pali System, the farmer has to give details of his proposed area of cultivation and the type of crop. The Executive Engineer sums up all demands and try to match the supply with demand. If the demand is more than the supply, then he places restrictions on the area to be cropped and issue authorisation accordingly. This type of water distribution system is adopted in the states of Maharashtra and Gujarat.

2.2.4.5 Localisation

In this, as soon as the irrigation system is developed, the area that it could command is surveyed and assessed as wet or dry accordingly. During the beginning of each season depending on the availability of water, area under different reaches are authorised to start cultivation. Once the area is authorised, then it is obligatory on the part of the department to supply water until harvest of the crop is over. This leads to very conservative estimation of area for authorisation. This system is adopted in Andhra Pradesh and Tamilnadu.
2.2.5 Night Irrigation

Both Second Irrigation Commission (GOI 1972), and the National Committee on the Agriculture (GOI 1976) saw warabandi with fixed times, but taking water through 24 hours as a means of tackling waste of water at night. But the Central Water Commission (CWC) team which visited 24 irrigation projects between 1975 - 80 found that water in the head reach is often allowed to flow freely at night either through fields or straight into drains (CWC 1980). Though it is scheduled to have night irrigation in many command area it is not practiced.

Wastage of water during night irrigation is reported in Gambhiri Project in Rajasthan (Katariza 1983), Morna Project in Maharashtra (Joshi 1983), and Galoya Project in Sri Lanka (Rust 1983). In Elfayyum project, the supply of irrigation during nights is welcomed or valued high by the farmers due to hot sunny days (Chambers 1988).

Beni Amir Project in Morocco night irrigation is unpopular during winter. As the evapotranspiration is less during the period the scheduling may be done in day time itself as the canal has sufficient capacity. But this results in additional managerial input to arrange for filling and emptying time of the canal (El Antaki 1984). As the evapotranspiration during night is low, where there is scarcity of water and farmers are resourceful to arrange labour and lights, night irrigation may be even more efficient than day (Pai 1979).

The farmers in the upstream normally prefer to irrigate their lands during the day time. This reduces the flow at the tail end. So the farmers at the tail end have to irrigate their fields during night only. In Lower Bhavani project (Tamil Nadu) the farmers at tail end prefer night irrigation because water supply is adequate and reliable (Sivanappan 1982). In Pakistan also the irrigation at night is valued socially (Chambers 1988). In
Sukho Majri most farmers do outside work during day time and prefer to
have night irrigation as they can be present in the field during irrigation
(Groenfeldt 1983). In Padianallur tank command Tamil Nadu, farmers
decided to operate the sluice opening during the day time (6.00 am to 6.00
pm) only to avoid wastage and able to save about 35 percent to 40 percent
of full tank capacity (Sakthivadivel 1991).

2.2.6 Complaints

Complaints about irrigation distribution are unsatisfactory canal
opening and closing time, inadequate and untimely supply, unreliable and
unpredictable flow in the canal, poor canal maintenance and poor water
conflict resolution. These complaints can be effectively addressed if the
farmers- the users- are consulted or involved in the decision making
processes.

2.3 COMMAND AREA DEVELOPMENT AUTHORITY (CADA)

The Second Irrigation Commission appointed by Government Of
India has recommended (1972) for a special administrative agency for
co-ordinated and expeditious development of irrigation command area under
major and medium projects. Based on this, CAD authorities were created
with the overall objective of undertaking a series of co-ordinated measures
to reduce the time lag between creation and utilization of irrigation
potential, to integrate the functioning of irrigation and agriculture
departments to improve water use efficiency and try to maximize production
by optimising the use of land and water (GOI 1972).

Under CAD, it is assumed erroneously that all is well in the main
system and the gap between the potential created and utilised is due to lack
of field channels and development of lands by farmers. But from two to
three years experience, it was found that there are many problems in the
main system categorised as duty, design discharge, distribution, development and discipline (Hashim Ali 1981).

2.3.1 Systematic Canal Operation

To overcome these deficiencies systematic canal operation (SCO) was implemented in the Nagarjunasagar command with the following components:

- Carry over reservoir storage to ensure an early and guaranteed start of the main crop.
- Water budgeting to provide equitable allocation to individual commands.
- Staggering completion of transplantation and systematic closure of canals for one/two days a week, once transplantation is over, to save water and to push to the tail end.
- Intermittent operation of canals for non paddy crop after paddy cultivation is over.
- Associated institutional movement and public relation measures.

Keeping in view the hydraulic factors and enforcing rationing of water in distributaries and minors, scheduling (SCO) are planned based on average demand of group of farmers and they are allowed to distribute themselves depending on crop needs (Hassan 1987). SCO provided less inequity between head and tail reaches than continuous flow (Seethapathi Rao 1984).

Not withstanding the impact of these activities over the past two decades, the gap between irrigation potential created and utilised now stands higher than before. The CADA approach as being practiced now lacks clear focus and its ability to influence and manage with departmental
interaction are very limited. CAD authorities do not have able multidepartment staff and which can exercise their authority. In many cases they become purely an executive committee. It should be transformed into really effective command area management entity empowered with power. They should be reorganised if they have to fulfill the basic objectives for which they were created (CWC 1992).

2.4 DECISION PROCESS

Major decision making processes in irrigation management are supply and demand assessment.

2.4.1 Supply Assessment

The supply to any system depends on the extent of catchment area, rainfall and its distribution over the area, intensity and duration, soil type, depth, infiltration capacity, moisture holding capacity and antecedent moisture content. In India a number of empirical formulae derived by Ryves, Dickens, Englis, and Strange are used to assess the peak runoff and the yield from the catchment.

2.4.1.1 Dependable Yield

The rainfall received in the catchment and the consequent yield to the reservoir is stochastic in nature. Therefore yield estimated by mean value always gives a higher value. The dependable yield is the yield from the catchment which will be equal to or more than specified percentage of years. In India, 75 percent dependable yield is adopted for design purposes. That means the yield received in three out of four years is more than or equal to the dependable yield of the basin.
2.4.2 Demand Assessment

Irrigation Demands represents the major share in total demand from the system. Industrial, Drinking water, Power generation, Navigation, and Recreation are other Demands. Power, recreation and navigation demands are non-consumptive in nature. Others are consumptive demands. Normally, industrial and drinking water demands are not varying very much during the year and can be considered as fixed ones. The irrigation demands are dependent on type and stages of crop, soil, and climate. It varies from week to week. Again the rainfall received during the cropping season reduces the irrigation demand.

The irrigation demand assessment is based on the area under cultivation. The irrigation department collects figures on irrigated area through its field staff. The revenue department has the responsibility to submit the statement of cultivated area at the end of the season. They make their assessment by visual observation. The figures collected by irrigation department and revenue department are not tallied. There are variations of even 20 - 40 percent between these two figures (Wade 1968). Muralimohan (1992) attempted to assess the cropped area in Tamiravaruni system using remote sensing technique. With limited imageries, he concluded that all the channels are commanding 2.3 percent to 14.8 percent more than registered command area in both kar and pishanam seasons. He could not accomplish to identify the area under rice and banana separately as they exhibit similar tonal characteristics in the available imageries. Such variations in the cultivated area estimation results in wrong assessment of the demand.

2.5 Rainfall Contribution

The crop water requirement to meet its evapotranspiration needs is met either by irrigation or precipitation. The rainfall received during the cropping season partially or fully met the crop water requirement based on the relative quantum received. The rainfall received in a station is stochastic.
in nature. Mooley and Apparao (1968) have shown that pentad rainfall received during Southwest and Northeast monsoon over India may be described by Gamma distribution. Mooley (1973), using data from 39 well distributed and long record stations spread over India to Japan showed that Gamma distribution is the most suitable probability model.

2.5.1 Effective Rainfall

All the rainfall received is not utilised to meet the crop water requirement. A portion of it is only useful for the crop growth and that quantity is known as effective rainfall. The term effective rainfall has different meanings, depending upon the context of its usage. In the irrigation management, effective rainfall is that portion of total rainfall that contribute to meeting ET requirements of a crop. FAO - Irrigation and drainage paper 25 (Dastane 1974) presents a comprehensive review of various methods to estimate effective rainfall. These methods vary widely in complexity and sophistication.

2.5.1.1 USDA-SCS Method

USDA-SCS have developed a relationship based on soil moisture balance performed for 22 stations using 50 years data. It considers the monthly precipitation, crop water requirement and net depth of irrigation.

\[ R_e = (f) (0.8332 R_t^{0.82416} - 0.2889) 10^{0.00097U} \]  

\[ R_t = \text{Total monthly rainfall in cm} \]
\[ U = \text{mean monthly consumptive use in cm} \]
\[ f = \text{multiplication factor to relate monthly effective rainfall to net depth of irrigation application} = \]
\[ 0.53175 + 0.116210 - 0.00894 D^2 + 0.000232 D^3 \]

where \[ D = \text{net depth of irrigation application in cm} \]
2.5.1.2 Percentage Method

The second method is the percentage method

<table>
<thead>
<tr>
<th>Monthly precipitation in inches</th>
<th>Eff. rainfall in inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 &lt;= R &lt; 10</td>
<td>Re = 0</td>
</tr>
<tr>
<td>10 &lt; R &lt; 30</td>
<td>Re = 0.8 R</td>
</tr>
<tr>
<td>30 &lt; R &lt; 200</td>
<td>Re = [0.87 - R/425] R</td>
</tr>
<tr>
<td>200 &lt; R</td>
<td>Re = 0.4 R</td>
</tr>
</tbody>
</table>

Vlotman (1986) modified the above by replacing monthly rainfall in inches by weekly rainfall in mm.

2.5.1.3 Standard Irrigation Depth Method

The third method is known as Standard Irrigation Depth formula

\[
Re = 0.67 (R - 1.0) \text{ \ ...(2.2)}
\]

\(Re\) = effective rainfall in inches/ month

\(R\) = Average monthly rainfall in inches

Vlotman (1986) modified the above formula to use average weekly rainfall as follows.

\[
Re = 0.67 \left[ R - 6.0 \right] \text{ \ ...(2.3)}
\]

\(Re\) = eff. rainfall in mm /week

\(R\) = Average rainfall in mm /week

The empirical relationship and coefficient 0.67 is strongly dependent upon local condition. In these equations no provision is included
to take into account the consumptive use of the crop. In monsoonic rainfall tract, the rainfall received in a week is much more than the crop water requirement. Therefore the effective rainfall estimated for heavy rainfall week may estimate much higher value than it actually is useful for the crop.

2.5.2 Effective Rainfall in Rice Fields

Effective rainfall in the rice fields are to be dealt differently than other field crops. Rice fields can store additional rainfall upto the level of field bunds of 100 mm to 150 mm height which can be used by the crop subsequently. Dastane (1974) recommended different methods for estimating effective rainfall for the low land rice crop.

2.5.2.1 Indian Method

A number of empirical methods are adopted in India. The first one assumes that 50 to 80 percent of rainfall is effective. In the second method any rainfall more than 6.25 mm and less than 75 mm is effective. If rainfall is less than 125 mm in 10 days, it is also considered effective. Any excess over this limit is considered ineffective.

2.5.2.2 Vietnam Method

Daily rainfall below 5 mm and above 50 mm is discarded. If the daily evaporation requirement (ET) is 10 mm, a two days and three days successive rainfall upto 60 mm and 70 mm respectively is taken as effective. Any excess over this limit is considered ineffective.
2.5.2.3 E.T-Rainfall Ratio Method

Effective Rainfall depends on the evapotranspiration and other losses considering a group of days during growing season. The ratio is expressed as percentage and maximum value of the ratio cannot exceed 100.

2.5.2.4 Water Balance Method

This method dynamically employs the simple hydrological components. The concept of standing water is also incorporated in this method.

Mohan et al (1995) compared the above methods and concluded that ET-Rainfall Ratio method and Indian method which are considering the depth of rainfall in successive days can be used for determining effective rainfall in the lowland rice fields. Total seasonal effective rainfall varies from 72 percent to 83 percent of total seasonal rainfall.

2.6 PERCOLATION LOSSES

Deep percolation losses vary from soil to soil. For paddy crop, constant ponded level of water is required for the crop period. Therefore, percolation losses should be considered for the entire crop period based on observation in the command area (GOI 1984). In the irrigated dry cropped area deep percolation loss is limited. It is mainly due to uneven application of water and improper land development. Now the concept of alternate wetting and drying method of irrigation is prevailing in Tamilnadu, in which the percolation losses are reduced considerably.

In Walawe project in Sri Lanka the percolation losses of 23.8 mm and 26.8 mm per day were reported. It was found that percolation losses account actually only to one sixth of the above and the remaining to lateral...
seepage (IIMI 1990). The study conducted by Anna University in the Padianallur tank reports the percolation losses as 30 to 45 percent of total water applied (Shanmugham 1990). Mohan et al (1995) adopted 2 mm per day as percolation loss for the station at Annamalainagar.

In alluvial plains of North India, the losses are estimated as 17 percent in the main and branch canals, 8 percent in the distributaries and minors, 20 percent in the water course and the total losses account for 45 percent (GOI 1972). In South India, the project efficiency obtained is 25 to 30 percent as against planning assumption of 60 to 65 percent (Abbie 1982). Chenyaxin (1993) reports that losses in the unlined canal is about 57 percent of total conveyance losses. When the canal is operated on rotation the efficiency of the system is one to three percent greater than continuous operation. In Indonesia the conveyance losses vary from 11.8 percent to 43.8 percent (Rust 1993).

2.7 PERFORMANCE

Performance of a system can be assessed based on the extent it achieved its stated objectives. A number of performance indicators are developed to measure the adequacy, equity and distribution application efficiencies etc. Performance of the system can be improved by hardware improvement-improving the physical structure, and software improvement-improving operational performance, by improving management and augmenting the supply (Sakthivadivel 1991). It was thought that poor performance of the irrigation system is mainly due to the lack of distribution network below the sluice and large investments are made since seventies. If water is not delivered to watercourse outlet adequately, predictably, investment below outlet will produce disappointing results. The main system, not farm level practice is now recognised as the most important problem area. An analysis of irrigation system management first requires assessment of system performance in relation to its potential. This needs to
be followed by an analysis of reasons for performance, not all of which have to do with management. Other important factors that can influence performance include the policy environment and other physical systems design (Bottrall 1991). Assuming rehabilitation will automatically improve output is not appropriate, if current management is deficient and is not addressed as a component of rehabilitation (Rust 1993).

For improving system performance one should have commitment to manage (Sundar 1984). For any system performance, there should be a well established accountability (Nijman 1990). Though the consequence of failure in system management is serious, but the responsibility for failure is diffused. Performance oriented management requires a set of incentives and commensurate accountability (Sevendson 1991).

Improved irrigation system management has potential of increasing water and energy use by 10 - 15 percent, the production and area irrigated can be doubled (Keller 1986). Bottrall (1981) suggested for development of a systematic method for evaluating management performance. Evaluation of total system could be very useful for long term historical and comparative analysis of individual project performance (Levin 1985).

2.7.1 Main System Performance

Chambers (1988) identified five gaps or blind spots in irrigation management viz., main system management, canal irrigation at night, farmers activities above the outlet, managers and motivation, and diagnostic analysis- problems and approaches. One of the major causes of poor performance of large irrigation systems in many parts of the World has been deficient management, particularly in the operation of their main canal (Bottrall 1981). Main system manager should find ways and means to match irrigation supply and demand to the extent possible under prevailing agro economic and policy constraints (CWC 1992).
The impact of MSM on system performance are not known because the managers are reluctant to take appropriate decisions and intervene. Even if, they intervene and take decisions, the managers are not recording the circumstances under which such decisions are taken and the result of such decisions. Their apprehension is that they may be personally held responsible for any failure even if they did it with good intention. When an account of MSM is written up, normally it related to the study area with privileged water supply at the cost of other parts of the system. Water measurement and yield estimation are not done systematically (Chambers 1988). According to Rust (1993) operational targets are institutionalized and remain static even if external or system level objectives change. Such rigidity is the hallmark of bureaucratically administrated system rather than of performance - oriented management system. Number of researchers have suggested various means to improve the system performance. To improve the performance, transformation of irrigation management from administrative, centralized and allocation mode to client-responsive, flexible, efficiency oriented mode is stressed by IIMI (Kyi 1989). There should be greater accountability and transparency. Management priorities, operational targets and staff requirement should be specified. Irrigation sector has not kept pace with the changing character and complex irrigated agriculture (CWC 1992).

Therefore a close look at the main system managers is warranted to understand, how they are taking decisions, what is the basis on which their decisions are made, how the decisions are communicated and implemented and how they are monitoring and evaluating the implementation of their decisions.

2.7.2 Performance of the Managers

The degree to which the services offered by the main system manager responds to farmer's need, within the limitation imposed by
national policies and objectives and by overall resources availability and the
efficiency with which the irrigation system uses resources in providing these
services are the two complementary criteria on which overall performance
of manager depends.

Proper main system operation and adequate infrastructure
maintenance of an irrigation system, positively influence the reliability of
water supply. Officials efforts are rarely sustained due to unreliability of
water supply. They could not come up with solutions that are satisfactory
to the farmers because their authority is limited. The problems are arising
due to improper planning. Influential farmers often obtained favours
through political means or by means of intimidation. As the legal procedure
for prosecutions are cumbersome officials are helpless in prosecuting the
offenders (Gunadasa 1989). Svendson and Small (1990) suggested to assess
the performance and comparing that to deviation from prescribed procedures
or from an accepted standard. Here the performance depends on how
reliably the system managers can execute policies and programmes
determined by the implementation of distribution rules.

2.7.3 Changes in Cropping Pattern

Irrigation systems are planned assuming certain cropping patterns.
As more time is taken for the development of the system viz. main canal
distribution net work, command area development including field channel
net works, the head enders practice a different cropping pattern other than
the designed ones. When the system development is completed they find it
difficult to change to designed cropping pattern. This brings conflicts.

Water management decision including supply regulations are
influenced only by the cropping system, growth stage of crops and storage
level, but also by pressure from farmers. Reservoirs have been operated
according to the data available and guidelines established at the time of
construction. The policy makers should recognise the degree to which the stress is a consequence of fundamental changes in both supply and demand over time due to increase in command area and its cropping pattern (Rajagopalan 1991). In Tamiravaruni system the duration of rice crop is gradually changed from 150-180 days to 110-120 days due to introduction of new hybrid varieties. Changes in cropping duration warrants certain modification in crop calendar which farmers already implemented. However the system managers do not consider that these changes result in loss of water (Mohandoss et al 1993).

Length of irrigation period has a considerable impact on the amount of water used and hence the efficiency of water use. In a Malaysian irrigation scheme, when the closure dates of the canals are informed in advance, compelled the farmers to commence the cultivation operation and harvest the crop early. This one intervention is helped to bring forward the last harvest date by 32 days and hence there is a saving in turn around period (IIMI 1994).

Changes in the cropping pattern may be due to changes in market demand and agricultural prices. Introduction of dry season cropping brings a new set of requirement on the operational strategy of main system to meet the crop water requirement (Malano 1993). Panneer Selvan (1996) reports that in the Sreevaikundam South Main channel of Tamiravaruni system, there is no change in cropping pattern in the head, and middle reaches. In the tail reach the farmers are changing from rice to banana crop. The area under banana is increased from 285 ha in 1981 to 719 ha in 1994. Suitable soils, availability of water and labour, easy marketing and more profits are the reasons attributed by him for this change in crop.
2.7.3.1 Cropped Area Index

Irrigation system performance must be viewed as an integral part of entire agricultural production system. For this either micro level indicators such as net output or net area effects or gross irrigated area, crop intensity, crop diversification and crop yield can be used. Indicator gross irrigated cropped area may lead to an anomalous conclusion as the duration of crop has not been included in the parameter (Basu 1991). Performance of an irrigation system can also be evaluated by water use efficiency which compares the productivity with unit depth of water.

2.7.4 Delivery Performance Ratio (DPR)

Delivery performance ratio (DPR) compares the actual discharge to planned discharge. DPR equal to one indicates perfect management of the system. If it is more than unity, it indicates excess supply of water. If it is less than unity, it indicates deficit in the supply. DPR can be assessed at various levels of the system. It can be used to compare the performance of various systems. DPR can also be used to evaluate the performance of the system managers at various levels e.g JE/AE, AEE etc. Mohandoss et al (1993) assessed the delivery performance ratio in the middle and tail reaches of Tamiravaruni system and they are 1.75 and 0.75 respectively indicating inequity in the water delivery in between the reaches. Increase in supply rate does not necessarily bring increase in cultivated area. Increase in the DPR from 0.5 to 1.0 is accompanied by an increase in 6.5 percent of the area cultivated only (IIMI 1994).

2.7.5 Management Performance Ratio

Johnson and Vermillion (1987) adapted a parameter "Management Performance Ratio (MPR)" which compares the actual with planned discharge within an acceptable range of variation. This can be used to
evaluate the performance in spatial terms within the system. Variations in MPR indicate inequity in supply.

2.7.6 Result Index R

Seckler (1988) preferred "Result index R" which compares the actual output to planned output within an acceptable range of error.

\[
R = \frac{\text{Actual output}}{\text{Planned output}} + e \quad \ldots(2.4)
\]

When \((1-e) < R < 1+e\), the system is operating within acceptable performance limits.

2.7.7 Reliability

Reliability of water supply is measured based on the ability of the system or system manager to supply water to the users at the specified rates on the predetermined time and duration. Reliability indices can be expressed on the basis of volume, monthly and annual reliabilities (Dyck 1990). In the farmers point of view, a good irrigation water supply is adequate in quantity, hassle free, manageable, timely for convenience, cheap and profitable, predictable and timely for crops (Chambers 1988). The farmers prefer day time irrigation because they feel it more convenient than night irrigation.

2.8 MANAGEMENT DECISIONS

Decision making is the major force determining performance of irrigation system. The key decision may be classified according to their potential contribution towards delivery performance of the organisation. The decisions
and their management concerns based on Nijman (1993) is be shown in the form of a functional chart in Figure 2.1

![Diagram of Irrigation Management Concerns](image)

**Figure 2.1** IRRIGATION MANAGEMENT CONCERNS

### 2.9 OPERATION RULE

Reservoir operation policies are implemented through operation rules. A set of operating rules established for the reservoir takes into account of inflows, storage volumes and releases. Only a deterministic consideration is used. Uncertainty in hydrological variables or model
parameters are not considered. Under this assumption operating rule set around mass balance equation of the reservoir as:

\[ q = Q_i T_i - Q_o T_o - Q_{spill} T_s \text{losses} \]  

\( Q_i \) = Inflow rate into the reservoir  
\( Q_o \) = Outflow rate from the reservoir  
\( Q_{spill} \) = surplus rate from reservoir

\( T_i, T_o, T_s \) = Duration corresponding to inflow, outflow and surplus respectively  
\text{losses} = \text{Evaporation & other losses from reservoir}  
q = change in storage volume

Since the hydrological system and process are increasingly affected by human influences, information of run-off process derived from existing historic observation series on the available water resources and hydrological region cannot simply be extrapolated with planning periods to be investigated (Dyck 1990).

2.9.1 Operation Policy

Kind of operation policy to be implemented is decided based on either on engineering judgment taking into consideration the sequence of stream flows from historical run-off and demand records and or may be based on more sophisticated economic consideration (Vlotman 1983). In climate with wide variability over different years in rainfall, evapotranspiration and reservoir inflows, a fixed irrigation schedule can result in water loss and even in water shortage (Hajilal, 1993). Even in the system which follows warabandi (turn system) operational planning and control is needed because physical and organisation of the system never
remain as they were originally intended or because the demand for adjustment arise due to changes in weather, variation in cropping pattern and water storage in the upstream.

According to Nijman (1990), in Walawe project of Sri Lanka, starting of cultivation in the whole command area is allowed, only if the storage available is 60 percent of total storage. If the storage is less than that, the starting season is postponed, if rainfall is anticipated. If the anticipated supply does not materialise, the cultivation is cancelled. A cultivation as part or staggered cultivation is not practiced. It is either every body or nobody. But, due to limited availability of labourers and cattle or machineries, staggering is unavoidable. Further it helps to reduce the peak demand. Starting of cultivation in part of command is also needed where the storage capacity is small. If no area is cultivated most of the storage will go as evaporation loss.

2.9.2 Carry over Storage

It is found essential to leave some storage in the reservoir so as to enable to commence the next cropping season on the scheduled date. This left over storage is known as carry over storage. Ramamurthy (1984) simulated the effect of carry over storage with 7, 11, 15, 19 and 23 percent of contractual demand of 100, 95, and 90 percent. 75 percent dependable flow and inflows with +/- 10 percent variations are used in the LP model and found that 11 percent carry over storage gives optimum solution.

In the Tamiravaruni system's operation rule specifies that 15 M.cum of water should be stored in the reservoir as a carry over storage to commence the "kar" crop. Standing Irrigation and Water Resources Commission (SIWARC 1990) appointed by the Government of Tamilnadu, India, recommended that the carry over storage of 15 M.cum (500 M.cft)
specified for Tamiravaruni system should be adhered to avoid the delay in commencement of the next season and consequent complications.

2.9.3 Flow Register

Effective system management requires reliable data on system operation. In this aspect water flow measurements presently available are not adequate. Water flow is measured only at the head sluice and supply at different stages is not known. Water deliveries in distributaries are not measured (Wickremasekara 1980, CWR and IMTI 1993).

Both in India and Sri Lanka system, it is common to find registers recorded flow discharges which indicates the same figure day after day apparently filled at one sitting for many days. Information needed for tight management by senior staff is not collected or does not reach them or is misleading. As the senior officers are not using these information the errors do not matter (Chambers 1988). In Tamiravaruni system, flows are to be recorded daily at 8.00, 12.00, 16.00 and 20.00 hours. In most cases readings at 20.00 hours are not observed and recorded. Any flow variation in between these periods is not accounted. Automatic water level recorders are installed to compare the actual releases and recorded releases. In the Nadhiyunni channel both readings are reasonably coinciding with each other. In the Tirunelveli channel, there are wide variations both in quantity and duration of flows. This indicates the behavioural difference between the lascars (gate operators) (Pundarikanthan et al 1992).

2.9.4 Reuse of Water

It is common that the drainage water from the upper fields supply the fields wherever there is no supply channel for each field. In many cases a channel which acts as drainage channel in the upper reach acts as irrigation channel in the lower reach. When the canals are aligned on
contour all return flows drain into the main river itself or into the canal downstream. Rajan (1993) studied the Nadhiyunni channel of Tamiravaruni system and reported that drainage from upper channel and fields, drains into this channel. On one such point, it accounts for seven percent of the total flow in the distributary head. It is found that about 12 percent of area in addition to the registered area of Kaudulla project, Sri Lanka is irrigated by drainage water from head reaches (Chambers 1988).

2.10 LEVEL OF PERFECTION

Decision making is the major force determining the performance of irrigation system. These decisions may be classified according to their potential contribution to water delivery performance of the organisation (Nijman 1993). Kamfraath (1981) introduced the concept of level of perfection/sophistication as a performance indicator for decision making process. It makes an indirect effort to provide quantitative guidelines for analysing the relation between uncertainty in the process and the management conditions. The quality of decision making will improve as the processing become more systematic, incorporates more feedback, foresees the consequence of the decision more accurately and integrate influencing decisions. He measured the level of sophistication on a scale 0-100 as given in Table 2.1.

A very low or high level of sophistication is not performance judgment in itself. A very low level of sophistication may still lead to a satisfactory performance and hence cost effective. When performance is unsatisfactory, the high level sophistication may lead to improved performance. Based on the above, Marcelis developed a questionnaire for different concerns focused on maintenance management. Charles Nijman (1993) translated related questions for irrigation management. He measured the levels of sophistication of the irrigation systems of Morocco, Sudan, Sri Lanka and the Philippines achieved in the seasonal allocation, intra
<table>
<thead>
<tr>
<th>Level of Sophistication</th>
<th>Systematics</th>
<th>Feedback</th>
<th>Foreseeing</th>
<th>Intimation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To what degree are decisions made all to a more or less fixed pattern?</td>
<td>To what degree are decisions made?</td>
<td>To what degree are decisions made?</td>
<td>To what degree are problems seen on a wider context before the decision is made?</td>
</tr>
<tr>
<td>Very low</td>
<td>No rules:</td>
<td>never:</td>
<td>hardly:</td>
<td>no:</td>
</tr>
<tr>
<td>0-20</td>
<td>a certain routine exists</td>
<td>under unconsciously</td>
<td>adhoc decision making</td>
<td>Problem are examined myopically</td>
</tr>
<tr>
<td>Low</td>
<td>Rules of Thumb: broad rule form the basis of decision making</td>
<td>Sometimes: obvious experiences are proposed</td>
<td>Somewhat: necessities are considered</td>
<td>Somewhat: convincing subsidiary influence are incorporated.</td>
</tr>
<tr>
<td>20-40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>Rules:</td>
<td>Regularly:</td>
<td>Reasonable:</td>
<td>in a broad context:</td>
</tr>
<tr>
<td>40-60</td>
<td>Imp. decision making processes are supported with rules</td>
<td>the most imp.info is considered</td>
<td>priorities are considered</td>
<td>directly related plans are considered</td>
</tr>
<tr>
<td>High</td>
<td>Procedures:</td>
<td>Often:</td>
<td>far:</td>
<td>in a broad context:</td>
</tr>
<tr>
<td>60-80</td>
<td>combination of mutually attained rules</td>
<td>most information is considered</td>
<td>foreseen development are considered</td>
<td>Imp.influencing factors are incorporated</td>
</tr>
<tr>
<td>Very high</td>
<td>System: Balanced systems of mutually attained procedures</td>
<td>Always: all relevant information from the past is considered</td>
<td>Very far: expected developments are reviewed and considered</td>
<td>in the entire context: all influencing factors are incorporated</td>
</tr>
<tr>
<td>80-100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
seasonal allocation and flow regulation. The results of his study are shown in Figure 2.2.

![Figure 2.2 LEVEL OF SOPHISTICATION IN IRRIGATION MANAGEMENT IN VARIOUS COUNTRIES](image)

The Morocco's system attained the average level of sophistication while other countries they are only in the range of low to very low.

Such a questionnaire is not used to measure the decision of capacity creation as they are mainly political decisions and hence less appropriate for quantitative analysis.

2.11 COMMUNICATION

One of the major operational difficulties experienced on any major project in efficient control and management of canal system is the lack of
efficient and dependable communication system. The communication established through canal phone system gets disrupted by inclement weather, when the need for it is usually more. Establishing communication from central system to the various units operating the project area through radio system would provide a more dependable system of communication (Pai 1979).

To do their job effectively the manager of large, centralised, manually operated canal system as are common in South and Southeast Asia need large upward flow of information about the condition of command area and conversely their response and so their overall performance is constrained by the adequacy of information they receive (Wade 1981). Though planning text books emphasise on feedback information back to planning agency, from operating schemes, but in practice this link is very weak (Ian Carruthers 1981).

But information is obtained and transmitted in many imprecise and inadequate ways. Routine information about water flow in the different parts of the system is often based on inaccurate, uncalibrated measurement structures. As it is transmitted too late they could not be used. Data are recorded mechanically as a routine. Information about rainfall or emergencies is often slow to travel by foot or by cycle. The information is also conveyed through telephone or telegraph (Chambers 1988). During the unprecedented floods in Tamiravaruni in 1992 all the canal phones and telephones went out of order. The reservoirs are out of contact for the system managers and administrators for a number of days. Flood releases could not be communicated to people in advance which resulted in loss of many lives. Had the system been provided with wireless or microwave communication systems, the loss of lives could have been avoided or minimised.
2.12 ROLE OF FARMERS

Participation is a process in which share holders influence policy formulation, alternative designs, investment choices and management decisions affecting their communities and establish necessary sense of ownership. As communities increase their participation in managing water resources, project selection, service delivery, and cost recovery are likely to improve (World Bank 1993). Management objective must reflect the needs of all participants viz., policy makers, planners, and users rather than only one or two. One way of improving performance is by strengthening farmers participation in the seasonal/annual planning process and developing operational plans and targets (Rust 1991). International commission on water and the environment development issues for the 21st century held at Dublin 1992 recommends holistic approach, linking social and economic development with protection of national eco-system, including land and water linkages across catchment areas or ground water aquifers for the effective water management. Water development and management should be based on participatory approach involving users, planners and policy makers at all levels. Water has an economic value in all its competing uses and should be recognised as an economic good.

Many countries have started to recognise the role of the users in the system management. In Sri Lanka, the seasonal plan has to be authorised by the water users in the cultivation meetings. But cultivation meetings are held only to fulfill the legal requirements and no discussion or flexibility in the proposed crop calendar is allowed. Though crop calendar is determined by resident project manager, starting date of distribution channels are decided by the individual farmer.

Farmers are expected to operate an internal rotation below the sluice. Because variable delivery duration in the field channel the time that a farmer or a group of farmers irrigate their allotment will have to be
adjusted over the season with change of delivery duration in the field channels. This demands very close interaction and communication among farmers. To sustain such interaction they are required to be organised as a cohesive group working towards common interest or objectives (IIMI 1990)

When the water supply exceeds 1.5 times the demand, farmers are not motivated to make special efforts into its management. When it is less than 1.2 times the demand, they perceived it as scarcity and compete with each other which kills the co-operation. When the supply is in between 1.2 to 1.5 times the demand, the farmers’ tendency for co-operation is the best (Wade 1982).

Farmers can also create problems to get extra water to their fields by placing obstructions in the minors and field channels, making unauthorised outlets, intentional damage to minors and field channels (Singh 1990). In the Minipi, Sri Lanka, farmers individually or collectively block the channels with timber and stone and damage control structures. The Irrigation department has very little effective sanctions over farmers who damage control structures in order to obtain more water.

Irrational or non optimal behaviour of farmers only elicits corresponding behaviour from bureaucracy and vice versa. Farmers use political connections to force the irrigation engineers to supply water for larger than agreed upon. This is another cause of recurrent aggregate scarcity of water. Those farmers who shout loudest are more likely to receive more water while there is scarcity. The bureaucracy is to a large extent subordinates to short term demands of politicians responding to pressure from farmers. Local MLAs are causing more trouble to engineers. Frequently they are powerful enough to transfer the engineer who displeases them (Moore 1980, Wade 1981). Effectiveness of main system management depends on the ability of the manager to resist and control, pressure from farmers to supply more water than scheduled. Managers must
be able to improve discipline on competing pressure groups by applying rules and imposing penalties on those who break them (CWC 1992).

In Perenda scheme in the Philippines, tightened water scheduling in close collaboration with farmers increased the yield from head to tail by 20 and 150 percent respectively (Valera 1979). Tailend farmers of some command in Bihar, Andra Pradesh and Tamilnadu organise themselves to guard the channel bunds to prevent damage by upstream farmers in order to secure more dependable and adequate water supply (Wade 1979, Pant 1983, Sengupta, 1991).

Upper Pampanga River Integrated Irrigation System (UPRIS) farmers were used to take direct action to reduce supplies to other groups after careful assessment of the result of their action (Svendson 1991). In South India farmers themselves undertake maintenance of the supply channel (Wade 1979, Elumalai 1980, Singh 1984). Many instances were found where the farmers do not bother to close the pipe outlet even partially, although the water is drained off into drainage channel, while tail enders are wanting more supplies. But the farmers try to avoid action that would harm their neighbours, instead they pressurise the officials to release more (Wickramasekara 1980).

Many of the irrigation systems in India are very large which has canals running hundreds of km long, farmers participation in major management decisions would be difficult.

2.13 ORGANISATION

Indian irrigation has a long history. Several irrigation works were constructed by the then rulers and looked after by the farmers through traditional organisations viz. "yerivaram" (tank managers), "kalvai variam" (canal managers), etc. When East India Company annexed the country, the
irrigation systems become the property of the Company, which were subsequently managed by Public Works Department of the state.

The Irrigation Organisation can be classified as department, project and corporate types. For example,

1. **Departmental Type** - Irrigation Department of India, Sri Lanka etc.
2. **Project Type** - Mahaweli Authority, Demodar Valley corporation, Tennessee Valley Authority
3. **Corporate Type** - National Irrigation Administration, the Philippines; Irrigation Districts of U.S.A etc.

Organisational Assessment Instrument (OAI) was developed by Van de Ven and Ferry (1980). OAI is a generalised instrument designed for use in different type of organisation including service type and non-profit organisation. They used this instrument to assess Employment Security Agency of U.S.A. Irrigation system is also a service type organisation whose health and efficiency of its internal operation could be assessed by OAI (Kyi 1991, Personal communication).

**2.13.1 Factor Analysis**

Charles Spearman presented "Factor Theory" and the method of Factor analysis (FA) for objectively determining and measuring general intelligence in the field of psychology. In the field of psychology and social science, where the potential number of variable is very large; FA is used to determine the basic or underlying variable to account for individual difference. FA attempts to account statistically for difference in traits among individuals (Harman 1967).
2.13.1.1 Variance

Variance ($\sigma^2$) is an index of the extent to which a test or other variable discriminate individual difference. Total variance can be divided into common, specific and error variance

$$\sigma^2_j = \sigma^2_{i1} + \sigma^2_{i2} + \sigma^2_{i3} + \ldots + \sigma^2_{i_r} + \sigma^2_{e}$$

...(2.6)

when $\sigma^2_{ji} = \text{co-variance of jth variable to the ith variable.}$

Dividing throughout by $\sigma^2_j$

$$\frac{\sigma^2_j}{\sigma^2_j} = 1.00 = \frac{\sigma^2_{i1}}{(\sigma^2_j)^2} + \frac{\sigma^2_{i2}}{(\sigma^2_j)^2} + \frac{\sigma^2_{i3}}{(\sigma^2_j)^2} + \frac{\sigma^2_{i_r}}{(\sigma^2_j)^2} + \frac{\sigma^2_{e}}{(\sigma^2_j)^2}$$

$$1.00 = [a^2_{j1} + a^2_{j2} + \ldots + a^2_{jr}] + [S^2] + [e^2]$$

...(2.7)

The values of square root of common variance $\sigma a^2_{j1}$, $\sigma a^2_{jr}$ are referred as Factor loading or saturation.

For prediction and identification of fundamental traits one is interested primarily in common variance since a variable will predict only to the extent to which it correlates with some other variable. Specific variance, although it may be reliably measured is of little scientific interest since it is not related to any other thing except itself.

2.13.1.2 Communality

Communality ($h^2_j$) is obtained by summing up the squared factor loading in each row and can be interpreted as that portion of variance of each variable which is correlated with other variable.

$$h^2_j = a^2_{j1} + a^2_{j2} + a^2_{j3} + \ldots + a^2_{jr}$$

...(2.8)
2.13.1.3 Principal Component Analysis (PCA)

Principal components are the eigen vector of variance-covariance matrix. By themselves they provide significant insight into the structure of the matrix. They often are interpreted as the manner factors are interpreted. All modern factor analysis scheme employ PCA as a starting point for the analysis. In the PCA each item breaks into a number of factors. The item which has characteristic root or eigen value greater than 1.00 is considered as a factor.

Van de Ven (1980) collected data on 334 work units located in all local and administrative offices of State Employment Security Agency U.S.A. He used Unit Supervisor and Unit Member Questionnaire and collected data from 1400 respondents. He grouped the questionnaire into 39 items. Principal Component Analysis broke 39 items into 10 factors with characteristic roots greater than one and two additional factors with eigen value near one. These 12 factor accounts for 71 percent of total common variance among the 39 items. Each of the factors is considered to make a meaningful contribution. The communality for most items are in moderate range. He used 0.40 as the criterion for significant loading of an item as a factor.

2.14 DECISION MODELS

Decision making process cannot be totally formalised and modeled contrary to various technical and technological process. Mathematical programming cannot provide a unique optimal solution for water resources system. For long term planning and management methods are required, which reflect the complex interactive and objective character of decision making process, taking into account the experience of decision makers (Orlovski 1986). A desirable feature of any model is that it permits small enough decision intervals. A decision interval coinciding with irrigation
release interval is preferable to one treating the crop period in fewer intervals. Usually the irrigation decision intervals are a week or ten days (Vedula 1992).

To take into account, the stochastic character of the system inputs, the uncertainties and imprecision of natural, man made and socio economic processes, the controversy among different inter group and complex interactive and subjective character of decision making process, computer aided decision support system is needed which offers decision alternatives using multiple objective programming (Kaden 1985).

Heuristic knowledge gained from experience, conventional knowledge regarding fact and inferential knowledge obtained after study of results are three significant chunks of knowledge that can be put into expert system to help the decision making process. Inferential knowledge does encounter in most of the engineering applications and it plays an important role in water resources management (Rehak 1983).

Vlotman and Malano (1983) have developed a simulation model in modules of i) Evapotranspiration module, ii) Irrigation requirement module, and iii) System operation module. Pundarikanthan et al (1992) developed a simulation model in work sheet (Lotus 123) to allocate area for authorisation for different crops considering all demands from the command area of Tamiravaruni system lumped as a single demand. Saravana Babu (1993) and Jothyprakash (1994) modified this model by segregating the demands. Brema (1995) developed an operation plan for operating Kodagan channel and Tirunelveli channel of Tamiravaruni system. In this model, if deficit occurs, it has been distributed by adopting a suitable K-Factor.
2.15 OPERATION AND MAINTENANCE

Proper functioning of any system maintenance is essential. The main constraints in the Operation and Maintenance phase are finance and personnel. Since the financing agencies are showing more interest on new projects, thrust is given for new projects on the cost of operation and maintenance of existing projects. Insufficient staff, the transfer of skilled persons, equipment from O&M to new project areas are observed in many countries.

Salary components of the O&M is more than eighty percent of budget allocation leaving a small portion for actual maintenance which result in deferred maintenance and leads to rehabilitation (Carruthers 1981, Nijman 1993). High priority plan funds are earmarked for new construction. Maintenance expenditure are met from the non-priority non-plan scheme. Annual and special maintenance cost are 1 and 0.5 percent respectively (CWC 1992). Increased appropriation cannot be justified based on current level of output. But output cannot be improved with current level of appropriation. This is a vicious circle (Rust 1990).

Operation and maintenance (O&M) responsibilities are seen by engineers as being primarily concerned with routine maintenance function and does not call for higher degree of specialised skill and hence has a much lower status. Good system operations, matching variable water supplies with often complex pattern of water demand does involve specialist skills. Developing a new cadre equipped with computer knowledge, will enhance and boost the morale of engineers. Their desire to do a good professional job should have secondary effect on performance of lower level staff (Bottrall 1991).

Many of the problems encountered in providing water services are due to the lack of incentives both for performance by providers and for
efficient users (World Bank 1993). Motivation and incentives to the managers and farmers are the key for better performance. More numbers of staff, without motivation would not necessarily increase the performance. Performance oriented management requires a set of incentives and commensurate accountability throughout the management structure (Rust 1992).

2.16 PROPOSED STUDY

From the review of literature one could see that lot of works are done on irrigation system performance study. Everyone agrees that irrigation system performance is poor. To assess the performance the indicators used by the researchers are too many. Relative Water Supply (Levin 1982), Water Availability Index (Wijayaratna 1982), Inter Quartile Ratio (Abernethi 1986), Management Performance Ratio (Johnson 1987), Result Index "R" (Seckler 1988), Delivery Performance Ratio (Rust 1989), Reliability (Dyck 1990), and Cropped area index (Basu 1991), are some of the indicators used. Bottrall (1991) suggested that the performance has to be assessed in relation to its potential. Keller (1986) says that mere improving the water use efficiency in the irrigation system by 10 to 15 percent the irrigated area can be doubled. All the above are considering only the output of the system.

Chambers (1988) identified five blind spots in irrigation system management. Main System Management, and Managers and Motivation are among them. He stated that the impact of main system management on system performance is not known because the managers are not recording the decision processes that they are adopting. Environment under which they are working and lack of motivation are the factors for poor performance. This area needs more attention. But, so far no report is available on the assessment of any Irrigation Organisation in totality. IIMI initiated a comparative analysis of three types of Irrigation Organisation.
The results are yet to be published. To fill the gap, this study undertaken to assess the Managerial and Operational aspects of Irrigation in Tamilnadu.

Organisation Assessment Instrument developed by Van de Ven and Ferry (1980) is used to assess the managerial aspects of Irrigation Department. Questionnaire developed by Charles Nijman and developed by the author are used to assess the operational aspects. To fill the gap in the above mentioned study, participatory observation mode is used to understand the management control processes. To help the managers to overcome the deficiencies identified, simulation modules are developed.