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# USE OF SIMULATION IN IRRIGATION MANAGEMENT IN TAMIRAVARUNI - A CASE STUDY

*Dr. N. V. Pundarikanthan*[1], *P. Gomathinayagam*[2], *R. Mohandoss*[3], *C. Gunasundari*[4], *K. Jayachandran*[5], *S. Saravanababu*[6]

## INTRODUCTION

It is generally felt that the performance of Irrigation Systems has been deteriorating over the past few decades due to various facts. One such fact is that the reservoir operation is being handled more as an art based on past experiences and intuitions than as a management. Decision making in operations of reservoir is difficult considering the stochastic nature of inflows and rainfall.

The Reservoir Operation is the main process in Irrigation Management. In order to meet the objective of the Project, a system manager has to make vital decisions on various aspects before the start of operating the reservoir. For this decision making, he has to rely upon the past operational data, physical condition of the system, hydrological information, rules, policies, human resources and a wide range of other factors.

The System Manager has to examine various plans, to choose the best alternative. To take such decision, optimisation techniques will be of great use. However, they can be really useful only at the stage of planning. When we are to deal with a centuries old irrigation system, wide variety of crops in the command, those techniques may not be useful. They may give an optimal solution, which in most cases will not be a practical solution. Hence it has been proved beyond doubt that SIMULATION is the best tool for Modelling Irrigation System Operation and its Management. The simulation model was first attempted for NILE RIVER in the early fifties and we have come a long way. With the advent of Personal Computers and User Friendly software, every System Manager can simulate his system to examine various alternatives and choose the best.

This paper presents a case study of Thamiravaruni river system in South India. The "Lotus 1-2-3" and its use in simulating the system is highlighted. The present decision making process and how simulation can be used to arrive at a more accurate decision are explained.

[1] Director — Center for Water Resources, Anna University, Madras - India 600 025
[2] Associate Professor
[3] Project Manager
[4] Systems Programmer — Irrigation Management Training Institute, Trichy
[5] Research Associate
[6] Graduate Student

# THAMIRAVARUNI SYSTEM

THAMIRAVARUNI irrigation system is one of the oldest in Tamilnadu, India, lying between 8° 25' N and 8° 50' N latitudes and 77° 20' E and 78° 15' E longitudes. The river has its origin in the "Agasthiar Peak" or "Pothigai" of the western ghats. Often weeks together, the Peak is wreathed in clouds as it enjoys the benefit of both south-west monsoon (June-September) and north east monsoon (October-December). From its source to its confluence in Gulf of Mannar, the river traverses a length of 120 km. Some of the bigger tributories of the river are Servalar, Manimuthar, Gadana, Pachaiyar and Chittar. Irrigation development in the Thamiravaruni command dates back to many centuries. It is one of the largest irrigation system in Tamilnadu where two crops of rice are cultivated. The then rulers had planned a good system of anicuts and tanks so that the available water were utilised fully. There are eight anicuts in the system with 11 supply channels. The command area of 34,934 ha gets water either directly from these supply channels and from 187 system tanks spread over the command which get water through the 11 channels. The system with 187 tanks worked well as long as the irrigated area was limited and rice was the only crop. The agricultural operations usually commenced on June 1 and till the closure of all the channels on 31 March, farmers were happy to receive water on all days. All the channels remained closed for maintenance during April an May. The system continued as a "RUN OF THE RIVER" system till a reservoir was built at PAPANASAM in 1943.

The Papanasam reservoir is a multipurpose reservoir to stabilise irrigation for 34934 ha and to generate 28 MW power. The reservoir has a gross storage of 150 $Mm^3$. Manimuthar reservoir was constructed (1955) across the tributary Manimuthar to store 156 $Mm^3$. It provides irrigation to its original ayacut of 1100 ha and stabilises the Thamiravaruni command. A high level canal was also excavated to supplement the storage in 347 tanks to irrigate 9248 ha. It can draw water only when the storage is above 24 m from river bed and storage exceeding 62 $Mm^3$. Another reservoir across Servalar was constructed in 1986 and it is interconnected to Papanasam reservoir by a tunnel. It has a storage capacity of 41 $Mm^3$ and generates 20 MW of power. From 1986 onwards all the releases for Thamiravaruni command from Papanasam is routed only through Servalar reservoir.

The other tributaries Gadana, Pachaiyar and Chittar also provided additional supplies to the Thamiravaruni Irrigation System. Several reservoirs across these tributories were built during 1960-72 and the contributions from these tributaries reduced considerably.

# CROPPING SEASONS

Irrigation under the Thamiravaruni river as already noted is several centuries old. The two monsoons ensured that it is perennial. The anicuts in the head reach have practically no tanks as the head reach always receives water throughout the year. The anicuts in the middle have small tanks. These channels and tanks are located in a way that they receive the drainage water from the upper channel. As all the drainage will flow back to the river, the tail end anicuts have bigger tanks which it filled once can support a full crop season for its ayacut. The farmers of these tanks used to raise a crop called "PALANTHOLI" or Advance Kar during April to July. They used the residual storages in these big tanks and summer flows in the river. The area was confined to around 3200 ha only. After the construction of Papanasam reservoir during 1943, there were dependable river releases due to power generation during April and May. The quantity together with already available water in the tanks enabled more farmers in the last anicut to go for Advance Kar.

The area so cultivated steadily increased to 9000 ha in good years. This was substantial enough for, to formalise this arrangement by a Government Order in 1949. Under this order, the Advance Kar area was to be decided and announced under channels of Marudur and Srivaikundam anicuts alternatively. This did not work out as the Farmers of Srivaikundam anicut claimed priority to raise

Advance Kar as they were doing it even before the construction of the reservoir. Hence the Government again came up with another order in 1969. The command area under Marudur and Srivaikundam anicut were grouped under 4 categories with a specified order of priority. Depending upon the availability of the area that will get water for Advance Kar will be notified.

The Advance Kar area will not get water for Kar season (June, September). The Advance kar area is confined only to the 4 channels of the tail end anicuts. The remaining area will get water during Kar season. During the north east monsoon season (Pishanam) the entire command will be getting water. However, because of the heavy rainfall over the command and the lower crop evapotranspiration values, the supply from the reservoir during Pishanam season will be less than the other seasons. A new change took place in the cropping scenario during the seventies. The farmers in the tail end channels especially in the North Main channel of Srivaikundam anicut and Marudur Melakkal opted for the Banana crop. The area under Banana increased manifold and now it is more than 30 percent of the area under the last two anicuts. As a matter of fact, a crop diversification which leads to a better economic return has evolved over a period of time. The Banana is an annual crop which needs water throughout the year. The farmers in the tail end channels who have a right to claim water for Advance Kar usually get the same. But as the Banana area increased more farmers want to include their land under Advance Kar so that they can get water for their banana crop during the otherwise closure period. As the Advance Kar area increases there will be reduction in Kar area and sometimes leading to the failure of the crops also. Now, without apparently taking note of the increased area for banana cultivation, the Irrigation Department follows a procedure to notify the area under Advance Kar.
The carry-over storage from the Pishanam season will be the initial storage for the Advance Kar. The System Manager has to take into consideration, the initial storage on 1st April and probable inflows into the Papanasam-Servalar Reservoir during April and May to arrive at the area for Advance Kar.
Let STOa be the initial storage in April
Let INFa, INFm be the inflows into the Papanasam - Servalar Reservoir during April and May.

As per the rules of operation a minimum storage of $15Mm^3$ is to be kept in the Papanasam reservoir for the start of Kar season by the end of May. Industrial and Domestic needs for two months April & May are allocated and reserved ($2 * 7\ Mm^3$ ).

Hence the available water for Advance Kar will be

$$(STO_a + INF_a + INF_m - (15 + 14)) = Q_{Advkar}$$

The area that will be notified for Advance Kar is then

$(Q_{Advkar} * 80)$ ha

This is based on the Irrigation Department norms which is coming out of past experience, that $1\ Mm^3$ of water will provide irrigation for 80 ha of rice for one season.

# PRESENT STUDY

Due to the crop diversification the quantity available for utilisation from April to September is to be shared among ADVANCE KAR, KAR and INDUSTRIAL needs. As the industrial needs are constant, the allocation has to be made between Advance kar and Kar. If one gets a larger allocation, the other will suffer.

When we look back to the operation of the system in the past, the Advance kar had been confined to only 3,200 ha before the construction of the Papanasam Reservoir. After the reservoir, the area

was restricted to the extent of what could be irrigated with the releases made for power generation supplemented by the available storage in the tanks. Even with this rule in effect, the area has increased to 9000 ha. This results in reduction in demand for the water in Kar season when the normal availability is limited.

In certain years the area notified for Advance Kar had gone even upto 19000 Ha. This gives rise to many questions ;

1) What could be the optimum area under Advance Kar ?

2) If we have to include banana with the above, the area may become more ? Is this feasible ?

3) Can we develop an alternative way to decide on the Advance Kar area ?

To find answers to these questions a "SIMULATION" model is developed using Lotus 1-2-3. The model requires the following data :
1. Areas under rice and banana crops in different seasons.
2. Industrial and Domestic demands
3. Inflows into Papanasam-Servalar and Manimuthar

# SYSTEM DETAILS

1. Monthly inflows Into reservoirs do have 75 % probability of occurrence

2.a. Registered Ayacut = 34,934 ha
b. Cultivable area = 32,700 ha
c. Single crop area = 2000 ha (Pishanam only)
d. Double crop area = 30,700 ha
e. Area under banana = 6000 ha - 10 % in upper reaches
f. Area under Pishanam = cultivable area - area under banana
g. Area under Kar = double crop area - (banana + adv kar)
h. Max area under adv kar = area under last two anicuts (17400) - (90 % of banana area)

3. Irrigation demand excludes effective rainfall
4. Project efficiency = 60 %
5. Return flow = 40 %
6. Allocation Policy

| Demand | Source |
|---|---|
| a. Irrn. & Ind. demand Tamiravaruni command | Papanasam - Servalar Manimuthar II priority |
| b. Irrn. demand of Manimuthar old command | Manimuthar I priority |
| c. Irrn. demand of Manimuthar new command | Manimuthar III priority |

d. No water will be drawn from Manimuthar during April and May

# SIMULATION MODEL

The Lotus 1-2-3 (spreadsheet) gives a versatile tool for modelling irrigation systems in a better way. The model is prepared in the form of a working table where the following basic hydraulic calculations is specified.

(Initial Storage) + (Inflow) - (Demand) = (End storage)
(Total demand) = (Irrn. demand of Tam. + Ind. & Dom. demand)
(Net demand) = (Total demand) - (Tributory contribution below reservoir)

Release from Tamiravaruni
(Storage - min. to be maintained (15 $Mm^3$ )) > Net demand --> Release Net demand

(Storage - min. to be maintained (15 $Mm^3$ )) < Net demand --> Release (Storage - 15 $Mm^3$)

Release from Manimuthar to Tamiravaruni command = (Net demand - Tamiravaruni release)

For Papanasam and Manimuthar reservoirs the inflows into the reservoirs are considered for years from 1967-90 and 75 % probable monthly inflow figures have been taken. The industrial and domestic demand is taken as 7 $Mm^3$ per month and is constant for all the 12 months.

The irrigation demands are based on the following seasons and crops.

| Season | Period | Crops |
|---|---|---|
| Advance Kar | April - July | Paddy |
| Kar | June - Sept | Paddy |
| Pishanam | Oct - Feb | Paddy |
| Annual crop | June - May | Banana |

The current area under banana crop is 6000 ha and 90 % of this comes under last two anicuts. Hence the maximum area that could be authorised for advance kar will be 12,000 ha. Keeping the area under banana as constant at 6000 ha and varying the advance kar area, simulation runs are made and results are furnished in Table 1.

# DISCUSSIONS

Form the simulation study the following conclusions are arrived at :

1. The minimum storage is to be maintained at 55 $Mm^3$ at Papanasam to have at least 1000 ha under Advance kar

2. The final storage of Papanasam complex is more or less constant at 71 $Mm^3$ regardless of the initial reservoir storage when maximising the area under Advance kar.

3. At the same time when the initial storage in Manimuthar is more than 70 $Mm^3$ considerable storage is built up in the reservoir which could be used to supplement the irrigation in its new command area.

4. The maximum area of 12000 ha could be authorised only if the initial storages in the Papanasam and Manimuthar reservoirs are 120 and 80 $Mm^3$ respectively.

Simulation runs are made by varying the area under banana to 7500 ha, 9000 ha and 3000 ha and the results obtained are furnished in Table 1 and 1A.

When the area under banana is increased to 7500 ha and 9000 ha and a minimum of 1000 ha to be authorised for advance kar, the minimum storage required at Papanasam works out to 60 $Mm^3$ and 70 $Mm^3$ respectively . To authorise the entire area other than banana under last two anicuts the minimum storage required at Papanasam and Manimuthar are 120 and 80 $Mm^3$ respectively.

When the area under banana is reduced to 3000 ha there will be a small deficit of 1 to 5 $Mm^3$ in kar season. This indicates the reduction in banana area below 3000 ha may adversely affect the system operation.

The existing practice of arriving at the area to be authorised for Advance kar is only based on the initial storages available and the anticipated flow during April and May. This does not consider its effect on the Kar and Pishanam seasons. But the Simulation Model developed now gives the entire scenario of the irrigation year which may be more appropriate method.

# CONCLUSION

The simulation by spreadsheet is a simple but reliable technique in which the parameters such as initial storages, inflows, area under banana, Advance kar etc., can be independently varied and their effects could be seen over the screen. This will act as a management decision support system for the system managers for taking some crucial decisions on crop area allocation.

| PAPANASAM STORAGE | | MANIMUTHAR STORAGE | | AREA CULTIVATED | | | | DEFICIT | MONTH |
|---|---|---|---|---|---|---|---|---|---|
| INITIAL M.m3 | END M.m3 | INITIAL M. m3 | END M.m3 | ADV.KAR | KAR | PISHANAM | BANANA | M.m3 | |
| 50 | 71 | 50 | 32 | 0 | 24700 | 26700 | 6000 | 14 | SEP |
| 50 | 71 | 50 | 32 | 1000 | 23700 | 26700 | 6000 | 4 | MAY |
| 55 | 71 | 60 | 32 | 0 | 24700 | 26700 | 6000 | 0 | |
| 55 | 71 | 70 | 41 | 1000 | 23700 | 26700 | 6000 | 0 | |
| 60 | 71 | 60 | 36 | 1000 | 23700 | 26700 | 6000 | 0 | |
| 70 | 71 | 60 | 44 | 3500 | 21200 | 26700 | 6000 | 0 | |
| 70 | 71 | 60 | 45 | 4000 | 20700 | 26700 | 6000 | 1 | MAY |
| 80 | 71 | 60 | 52 | 5500 | 19200 | 26700 | 6000 | 0 | |
| 80 | 71 | 60 | 56 | 6500 | 18200 | 26700 | 6000 | 5 | MAY |
| 90 | 71 | 70 | 71 | 7000 | 17700 | 26700 | 6000 | 0 | |
| 90 | 71 | 70 | 71 | 7500 | 17200 | 26700 | 6000 | 1 | MAY |
| 100 | 71 | 70 | 79 | 9000 | 15700 | 26700 | 6000 | 0 | |
| 100 | 71 | 70 | 83 | 10000 | 14700 | 26700 | 6000 | 5 | MAY |
| 110 | 71 | 80 | 97 | 11000 | 13700 | 26700 | 6000 | 1 | MAY |
| 120 | 71 | 80 | 106 | 12000 | 12700 | 26700 | 6000 | 0 | |
| 50 | 75 | 60 | 35 | 0 | 23200 | 25200 | 7500 | 4 | MAY |
| 60 | 75 | 60 | 40 | 0 | 23200 | 25200 | 7500 | 0 | |
| 60 | 75 | 60 | 39 | 1000 | 22200 | 25200 | 7500 | 0 | |
| 70 | 75 | 60 | 48 | 2000 | 21200 | 25200 | 7500 | 0 | |
| 70 | 75 | 60 | 49 | 3000 | 20200 | 25200 | 7500 | 1 | MAY |
| 80 | 75 | 60 | 56 | 4000 | 19200 | 25200 | 7500 | 0 | |
| 90 | 75 | 70 | 74 | 6000 | 17200 | 25200 | 7500 | 0 | |
| 100 | 75 | 70 | 82 | 8000 | 15200 | 25200 | 7500 | 0 | |
| 110 | 75 | 70 | 92 | 9000 | 14200 | 25200 | 7500 | 0 | |
| 120 | 75 | 80 | 111 | 10000 | 13200 | 25200 | 7500 | 0 | |
| 130 | 80 | 80 | 112 | 13000 | 10200 | 25200 | 7500 | 0 | |

TABLE 1 : ADVANCE KAR AREA SIMULATION

| PAPANASAM STORAGE | | MANIMUTHAR STORAGE | | AREA CULTIVATED | | | | DEFICIT | MONTH |
|---|---|---|---|---|---|---|---|---|---|
| INITIAL M.m3 | END M.m3 | INITIAL M.m3 | END M.m3 | ADV.KAR | KAR | PISHANAM | BANANA | M.m3 | |
| 50 | 79 | 50 | 33 | 0 | 21700 | 23700 | 9000 | 10 | MAY |
| 60 | 79 | 60 | 43 | 0 | 21700 | 23700 | 9000 | 0 | |
| 70 | 79 | 60 | 52 | 1000 | 20700 | 23700 | 9000 | 0 | |
| 80 | 79 | 60 | 61 | 2000 | 19700 | 23700 | 9000 | 0 | |
| 90 | 79 | 70 | 78 | 5000 | 16700 | 23700 | 9000 | 0 | |
| 100 | 79 | 70 | 86 | 7000 | 14700 | 23700 | 9000 | 0 | |
| 120 | 79 | 80 | 113 | 10000 | 11700 | 23700 | 9000 | 0 | |
| 50 | 63 | 60 | 32 | 0 | 27700 | 29700 | 3000 | 10 | SEP |
| 55 | 63 | 70 | 37 | 0 | 27700 | 29700 | 3000 | 0 | |
| 60 | 63 | 50 | 32 | 0 | 27700 | 29700 | 3000 | 10 | SEP |
| 60 | 63 | 60 | 32 | 1000 | 26700 | 29700 | 3000 | 1 | SEP |
| 70 | 63 | 50 | 32 | 0 | 27700 | 29700 | 3000 | 0 | |
| 70 | 63 | 50 | 32 | 2000 | 25700 | 29700 | 3000 | 2 | SEP |
| 70 | 63 | 60 | 36 | 6000 | 21700 | 29700 | 3000 | 0 | |
| 70 | 63 | 70 | 46 | 6000 | 21700 | 29700 | 3000 | 0 | |
| 70 | 63 | 70 | 51 | 7000 | 20700 | 29700 | 3000 | 6 | MAY |
| 80 | 63 | 70 | 55 | 7000 | 20700 | 29700 | 3000 | 0 | |
| 90 | 63 | 70 | 63 | 9000 | 18700 | 29700 | 3000 | 0 | |
| 90 | 63 | 70 | 65 | 10000 | 17700 | 29700 | 3000 | 3 | MAY |
| 100 | 63 | 70 | 72 | 10000 | 17700 | 29700 | 3000 | 0 | |
| 100 | 63 | 70 | 71 | 11000 | 16700 | 29700 | 3000 | 0 | |
| 110 | 63 | 80 | 89 | 13000 | 14700 | 29700 | 3000 | 0 | |
| 120 | 63 | 80 | 98 | 14000 | 13700 | 29700 | 3000 | 0 | |

TABLE 1.A ADVANCE KAR AREA SIMULATION