MAIN SYSTEM PERFORMANCE AND MANAGEMENT CONTROL PROCESSES: TAMIRAVARUNI SYSTEM

by

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1. INTRODUCTION

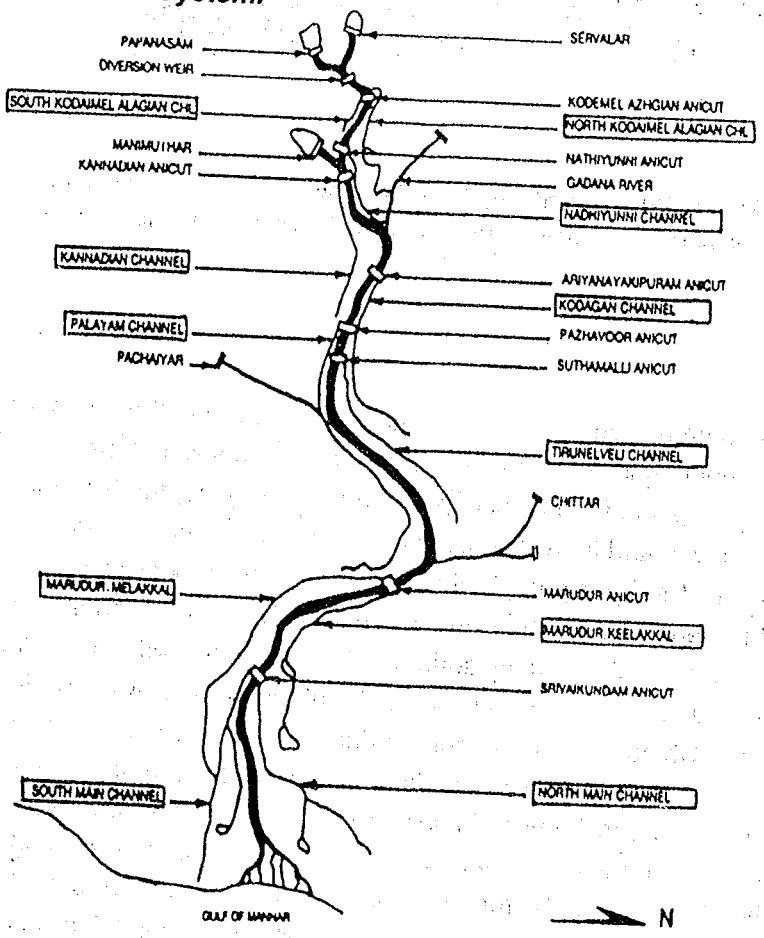
The "Tirunelveli-Kattabomman" and "Chidambaranar" districts are in the southern part of Tamilnadu. The rugged barrier of mountains covering the western side and visible from almost any part of these districts is a fascinating aspect of the landscape. Along the skyline, the hill range averages 1,525 m above MSL (mean sea level) and there are at least 20 peaks towering over that height. The Agasthiar hill or Pothigai is the most striking peak in this range. Often, for weeks together, it is wreathed in clouds as it enjoys the benefits of both northeast and southwest monsoons. This peak is the main source of the river Tamiravaruni. From its source to its confluence with the Gulf of Mannar, the river traverses a length of 120 km. Some of the bigger tributaries of the river are Servalar, Manimuthar, Gadana, Pachaiyar and Chittar. Runoff occurs during both monsoons; thus it is a perennial river.

Irrigation development in the Tamiravaruni command dates back many centuries. It is one of the five largest irrigation systems in Tamilnadu where two crops of rice are cultivated. It is based on anicuts and system tanks to balance variations in river flow. From the existing eight anicuts, water is conveyed to fields either directly by means of supply channels or via tanks through 11 channels, to command 34,934 hectares (ha) (Figure 1). Five percent of the total rice production of Tamilnadu comes from this system. While in all the other systems, the water requirements of industry and of domestic consumption are met by tapping the riverbed through pumping, in Tamiravaruni, this demand of 91,000 m^3 a day (20 mgd) is met from a system tank through the existing north main channel at the tail end. The government is committed to providing drinking water to every habitat. The demand from this sector is consequently increasing day by day.

The command area experiences a semiarid tropical climate with a mean annual rainfall of 752 mm recorded in 45 rainy days. Sixty percent of the rainfall is received during the northeast monsoon (October-December), 10 percent during the southwest monsoon (June-September) and the rest in summer. The present cropping pattern and the average annual rainfall in the command area are shown in Figure 2.

The mean maximum monthly temperature ranges from 30°C to 36.4°C, the maximum being during May. The minimum temperature varies from 22.3°C to 27°C, the minimum being in January. The RH (relative humidity) varies from 45 percent to 88 percent. Wind speed is around 6 kmph in most months except from the middle of May to September when the wind speed is around 15 kmph. Number of sunshine hours per day is more than 6 in all the months except October and November. Evaporation is more than 10 mm per day during the windy period and lower during November and December.

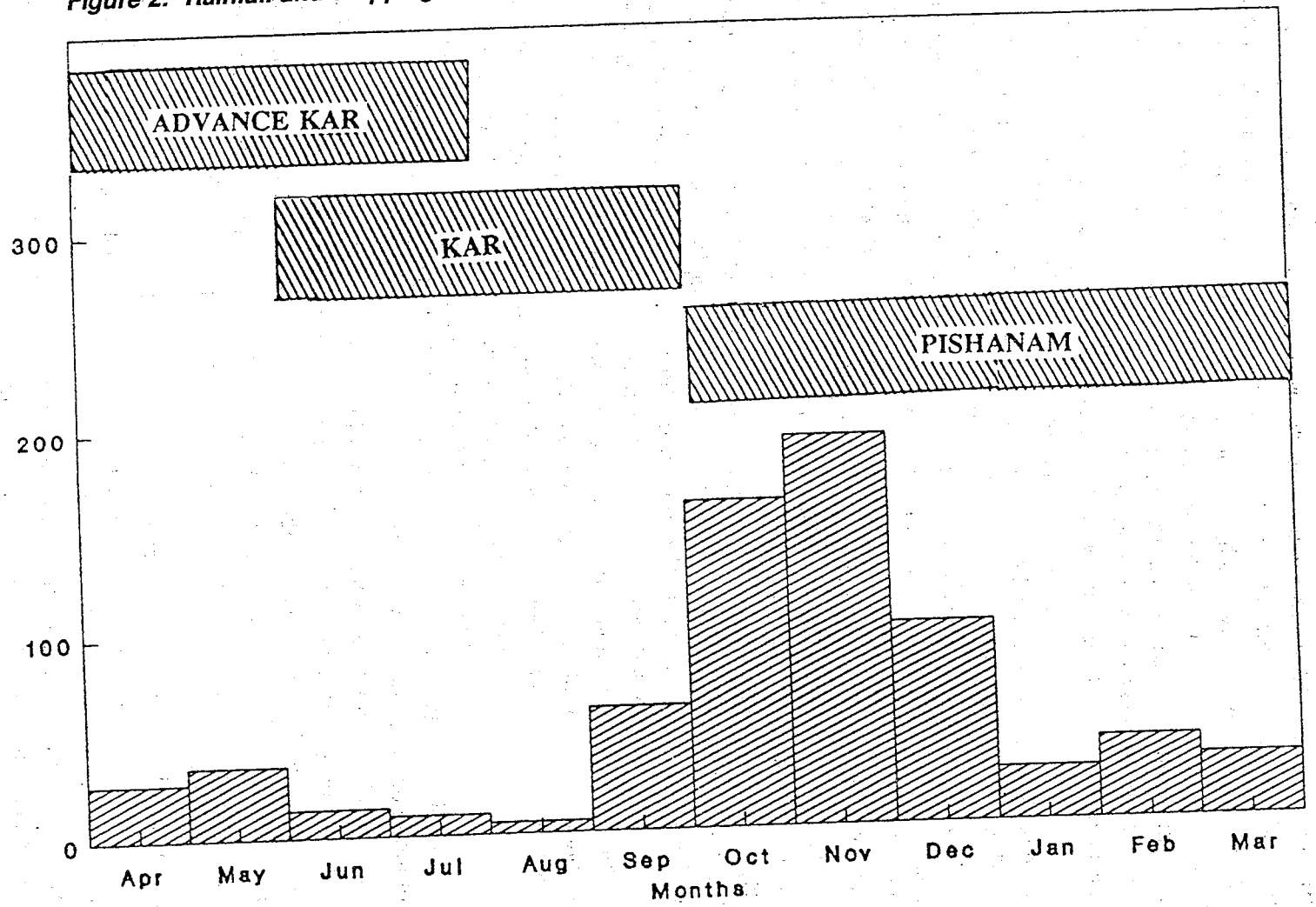
Figure 1. The Tamiravaruni System.



DETAILS OF ANICUTS, CHANNELS, COMMAND AREAS AND TANK

SL No.	Anicut	Channel	Channel length (km)	Command area (ha)			Number of tanks
				Direct	Indirect	Total	
1.	Kodamel Alagian	South Kodamel-Alagian	8.64	357	-	357	-
		North Kodamel-Alagian	18.51	532	393	925	20
2.	Nadhiyunni	Nadhiyunni	11.55	1053	-	1053	-
3.	Kannadian	Kannadian	33.95	4182	876	5058	16
4.	Ariyanayaka-puram	Kodagan	29.04	1295	1133	2428	17
5.	Pazhavoor	Palayan	42.66	1862	1983	3845	59
6.	Suthamalli	Tirunelveli	29.14	1022	1572	2594	23
7.	Marudur	Melakkal	19.84	1843	3330	5173	16
		Keelakkal	17.92	1202	1952	3154	15
8.	Srivaikuntam	South Main	33.87	1090	4076	5166	15
		North Main	36.32	1331	3850	5181	6
			Total	15769	19165	34934	187

Figure 2. Rainfall and cropping seasons.



Extremes of weather are not prevalent in this area. The climate is suitable for growing rice throughout the year. It is also an ideal climate for growing banana and sugarcane.

The soils of the head reach are deep, stratified, dark grey, medium to heavy textured, non-calcarious, and colluvial and mostly formed by the deposition of solids from the waters of the Tamiravaruni River. In the middle reach, the soils are very deep, dark greyish brown, medium to heavy textured and calcarious with moderate permeability. In the tail-end areas, the soils are deep, light to medium textured and calcarious. The texture of the and sub- range from loamy sand to sand. Moderate saline and sodic soils are also present in this area.

When this study was formulated at the end of 1990, its purpose was to understand the way in which the system performs and to examine how its management assesses its performance. It was also the intention to investigate ways in which the management, and consequently the performance, could be improved. These objectives are unchanged. However, the work that has been done in this project study during the last few months has enabled these objectives to be viewed in a more comprehensive and perspective manner. It is clear now, that the process of management has many dimensions. In theory, the Irrigation Department takes certain decisions and performs particular tasks. The Tamiravaruni communities then orient their agricultural activities to the flow of water that is indicated and made available by these decisions. The outcome of this response is of course an agricultural product and the income that it provides.

The reality, as it is becoming abundantly clear, is far more complex. The decisions regarding water delivery taken by the Irrigation Department are guided by principles and standards which were formulated decades ago. The physical condition of the system has undergone changes. The economic circumstances of village agricultural production have also altered. These factors have led to the situation where the community response is by no means one of passive acceptance of the Irrigation Department's way of managing the system. This response is fashioned by a variety of circumstances. The physical conditions of agricultural production are clearly important. So too is the economic framework within which the community operates. Its final response, therefore, is a reaction to a mix of all these factors. It may be passive or aggressive. It may be organized or it may be diffused; and it will vary according to the extent to which it challenges and seeks to modify the decisions of the Irrigation Department.

Therefore, the final adjustment between the plans of the Irrigation Department and the interests of the community could, in some instances, be a complex and long drawn-out process. It is this complexity which this study has come to recognize as one of its major concerns. The study perceives that the understanding of the process is, in fact, the study of the management of the system and of its level of performance. Such an understanding is clearly the pre-requisite for any suggestions regarding improvement.

Such an approach implies that this study has to have an interdisciplinary character. In fact, the study team is composed of engineers, a management specialist, sociologist, an economist and an agronomist.

Hydraulic and hydrologic data have been collected from past records dating back to 1960. The delivery performance ratio of each channel has been computed.

On the agronomic side, a series of preliminary investigations have been undertaken as the background against which the more specific empirical enquiries will be conducted. The data now available on the Tamiravaruni system in terms of soil, climate and other factors, have been brought together. The impact of climatic factors on irrigated rice have been set out. The significance of water as the main input in the management of irrigated agriculture has been assessed. Crop water requirements have been calculated in considerable detail. The Advance Kar season has been evaluated in agronomic terms. The agronomic conditions of banana have been analyzed, as well as its impact on water use. These background studies now provide a corpus of data and analyses on the basis of which the next part of the work will be designed.

The economic data now being gathered, parallels the agronomic investigation described above. Background data relates, in particular, to the courses followed by the two crops, viz., banana and rice. The development of these two crops in the Tamiravaruni has been examined and the probable reason for the particular pattern, by no means identical in all areas, is being investigated. This part of the work also requires the examination of the rural economy and its wider context in Tamilnadu, in some depth. This work is also in hand.

The sociologist and his team have been engaged in the identification and initial classification of all farmers' organization in the Tamiravaruni system; nearly 150 in all. This survey, which is preliminary to an intensive study of selected cases, has revealed a wide variety of circumstances. Farmers' organization are not found in all communities and they do not exhibit the same strength and effectiveness where they do exist. Overall, however, the organizations appear to be more widespread in the Tamiravaruni system than elsewhere in Tamilnadu.

The management of this system has been seen largely in terms of the powers and duties of the Irrigation Department and the decisions taken by it. Related to this are the promises and regulations on which these powers are based and the apparatus through which these decisions are implemented. However, the decisions and their implementation are influenced and modified, directly or otherwise, through the operations of farmers' organizations. The management of the system is the product of interaction between these two institutions: Irrigation Department and farmers' organization. Apart from these two institutions, the municipal and industrial demands also play the major role in the decisions taken by the officials. The political representation plays a major role during periods of scarcity.

The main focus so far has been on the identification of cases in which the decisions of the Irrigation Department have been challenged by the beneficiaries acting in various ways -- sometimes through their organizations, at other times in less direct ways.

In the next section of this paper, we give a brief account of how the system is managed. This is followed by descriptions of four episodes which seek to illustrate how this works out in practice. The concluding comment of this section draws attention to the play of forces which characterizes the decisions and implementations. In the third section, we identify a set of problems to which our preliminary work has now led us. This constitutes the current focus of the study. We conclude by indicating the work that will be done from this point onwards.

2. MANAGEMENT OF THE SYSTEM

Irrigation under the Tamiravaruni River, as already noted, is several centuries old. The two monsoons ensured that it is perennial. The then rulers had planned a good system of anicuts and tanks so that the available water was fully utilized. The topography of the land changes from moderate slopes to flat slopes from the head to tail reaches. 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 larger channels and a large number of small tanks. These channels and tanks are located in such a way that they receive the drainage water from the upper channels. As all the drainage water will flow to the river, the tail-end anicuts have bigger tanks which when filled once can support a full crop season for its *ayacut*. The main channels have to run continuously when there are no tanks or when the size of the tanks is small. Large tanks, wherever located, which can store water for a month or more, facilitate intermittent operation of the main channel.

This 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. This enabled them to have two good harvests. All the channels remained closed for annual maintenance during April and May. The system continued as a run-of-the-river system till a reservoir was built at Papanasam.

The Papanasam Reservoir was built in 1944 across the Tamiravaruni River. Another weir was constructed below the reservoir at the confluence with the Servalar River. From this weir, water is drawn through penstock pipes for power generation and then let into the river for irrigation.

Before the construction of the Papanasam Reservoir, the farmers of big tanks under the Srivaikundam anicut used to raise a crop called *Palantholi* or Advance Kar during April to August. They used residual storages in these big tanks and the summer flows in the river. The area was confined to about 3,200 ha. After the construction of Papanasam Reservoir, there were dependable releases due to power generation during April and May. This quantity together with already available water, enabled more farmers at the last anicut to go for Advance Kar. The area so cultivated steadily increased to 9,000 ha in good years. This was substantial enough for the formalization of this arrangement by a Government Order in 1949. Under this order, the Advance Kar area was to be decided and set up under channels of Marudur and Srivaikundam anicuts alternately.

This did not work out as planned as the farmers of Srivaikundam anicut claimed sole rights to Advance Kar as they were raising this crop even before the construction of the reservoir. Hence, the government again came up with another order in 1969, categorizing the areas to be given priority. If water is sufficient to irrigate 3,000 ha only, the Category I lands under the tanks in the south main channel and north main channel, will get Advance Kar. If water is sufficient for 3,700 ha, Category II lands under south main channel and north main channel also will get water for cultivation. If it is sufficient for 7,300 ha, Category III lands under south main channel and north main channel will also be included. If the water available is more than that, then the area under Marudur Keelakkal or Marudur Melakkal will get water alternately, in addition to the three categories mentioned above. This order is still in force and is followed with occasional deviations as decided by the government. The

farmers' organizations are powerful in the last anicut area and they are able to force the government to make these exceptions.

The Irrigation Department, soon after independence, decided to construct a reservoir across Manimuthar with two objectives in mind:

1. To stabilize the irrigation under the Tamiravaruni system from the third anicut.

2. To provide water to 349 rain-fed tanks through a high-level contour canal.

Of course, the old command area under the Manimuthar was to have priority in water rights. The reservoir was completed in 1958. The rules for this reservoir stipulate that up to 34Mm^3 (1200 Mcft) of water can be drawn for Tamiravaruni in June-September, and 17Mm^3 (600 Mcft) in January-February, subject to availability. But the quantity of water drawn from Manimuthar had always been more than these.

The Papanasam Reservoir was operated and maintained by the Tamilnadu Electricity Board (TNEB). The maximum water that could be drawn for power generation was, and still is 39.5 cumecs (1,400 cusecs). Though this quantity was not sufficient to meet peak demands, the Manimuthar provided the needed water. The other tributaries like Gadana, Pachaiar and Chittar also provided additional supplies. However, the farmers of these tributaries demanded that reservoirs be built across each tributary so that irrigation could be stabilized. Hence, reservoirs were built across Ramanathi, Gundar, Mottaiar, Gadana, and Karuppanathi between 1960 and 1972. After these reservoirs were built, the contributions from tributaries like the Gadana and the Chittar got reduced drastically.

During the 1980s, the TNEB decided to construct a reservoir across Servalar Reservoir to have additional power generation capacity. The Irrigation Department concurred with this decision. The Servalar Reservoir was built and put into operation in 1986. An interesting feature is that the Papanasam and Servalar reservoirs are interlinked by a tunnel. The TNEB decided not to draw water directly from Pananasam Reservoir but only through the Servalar Reservoir via the tunnel. After the construction of the Servalar Reservoir, the flow in the river became a more controlled one. A run-of the-river system dating several centuries back was thus transformed into a mixed system with reservoirs and channels.

The Papanasam and Servalar reservoirs are under the control of the TNEB. The Manimuthar Reservoir is under the control of the Executive Engineer (EE), Tamiravaruni System. But the other reservoirs and tributaries are under the control of another Executive Engineer of the Irrigation Department.

The rules and regulations governing the operation of the 11 channels were framed in 1935 and are still effective. The rules relating to the Papanasam Reservoir were framed in 1961. For the Manimuthar Reservoir, rules were framed in 1966 and modified in 1971 and 1973. The rules and regulations for Servalar have not been framed so far.

With these rules as guidelines, the EE operates the system. The command area is divided into three subdivisions and each is looked after by an Assistant Executive Engineer (AEE). The first 3 anicuts and channels are under the Cheranmahadevi subdivision and the next three anicuts and channels are

under the Tamiravaruni subdivision at Palayamkottai. The last 2 anicuts and channels are under the Srivaikundam subdivision.

The Manimuthar Reservoir is maintained by one AEE, while the Manimuthar canal is looked after by another. Each AEE has a team of Junior Engineers (JEs) for the operation and maintenance of the channels. The water releases, closure of sluices and maintenance of canal banks are looked after by these JEs with the help of supporting field staff like Irrigation Inspectors and Irrigation Assistants (*Luscars*). Though it is an apparently well-distributed network of staff, the work load for each unit is not the same. Fifty-five percent of the command area is under the last 2 anicuts. But the head reaches have longer canals and more sluices to be operated with a lesser number of field staff.

Until 1988, the entire Tamiravaruni command area was under a single administrative unit -- Tirunelveli District. But during 1988, the district was bifurcated and the command area under the last two anicuts fell into the newly formed Chidambaranar District. The District Collectors who have to answer to the public directly vie with each other to get more water for their respective districts.

2.1. Operating Plan

A flow chart indicating the process of decision making is shown in Figure 3. The EE, using data on past operations available to him and guided by his experience, prepares an operation plan for a season. He formulates this plan in consultation with his AEEs and JEs. The plan is discussed at a meeting (convened by the District Collector) with officials of the Agriculture department and with farmers' representatives. An agreed plan is finalized and sent to the government. The government issues orders on two points. They are:

1. The date of opening.

2. The canals and the area to be provided with water for the season (in the beginning).

The Collector announces this through the press and the radio. The EE starts implementing his plan of operations on the agreed date and depending upon the inflow and the storage in the reservoirs, he tries to meet the demands of the farmers.

The TNEB, which is in charge of the Papanasam Reservoir, receives a request from the EE for the quantum of water to be released. The rules and regulations for the Papanasam Reservoir state that inflows in excess of certain limits are accounted to the credit of the TNEB. They can use this water for power generation even when there is no irrigation demand. After the construction of Servalar Power House, the TNEB is releasing a maximum of 39.84 cumecs (1,400 cusecs). Though irrigation has priority, the Divisional Engineer/TNEB on his own cannot release more than 39.6 cumecs for the specified period (a few days). He has to get the prior approval of the Chairman/TNEB. This has led to a situation where the EE preferred to draw from Manimuthar, which is under his control, rather than from Papanasam to meet the additional requirements.

The Irrigation Department has set up a network of canal phones. These phones provide the vital link among the anicuts canals, subdivision offices and the EE. The water flow through anicuts and canals is observed and recorded every day at 8:00 a.m., 12:00 noon, 4:00 p.m. and 8:00 p.m. The flows are computed with reference to the water levels at these points of time. The Irrigation Department uses a "Depth Vs Discharge" relation curve and the discharge is related to the gauge readings on the rear sides of the sluices. However, as these anicuts were built centuries ago, they do not have a uniform shape or size and the discharge over an anicut is very difficult to compute. As such, the normal formulae used for calculating the discharge over a weir cannot be used in these cases without serious error. The correct data available is on the releases from the reservoirs only.

Every morning, the luscars at every anicut site inform their AEEs, over the canal phones, about the inflow at the anicut and issues to the channels and into the river in the case of the lower anicut. This information is also given, daily, to the EE before 8:00 a.m. The feedback on the crop-stage and water needs from farmers and from their supporting staff enable the AEEs to make an assessment of their water needs, daily. They make their requests for water to the EE. The EE then plans the overall allocation and if he needs more water, he contacts the Divisional Engineer/TNEB for an additional release. Then he informs the AEEs about the allocation and they regulate the water flow into canals accordingly. This exercise is repeated daily. During periods of good water- availability, the allocation will be made for a week at a time.

During periods of shortage, the farmers try their best to get water by any means that is open to them. During these periods, for most of the time, the EE resorts to **Crisis Management** to satisfy the immediate demand in any way that is possible. His entire plan becomes upset but he has to tide over the crisis.

On the cropping side, the system was supplying water for two rice crops (Kar and Pishanam), coinciding with the southwest and northeast monsoons respectively. The area under irrigation, as registered, was 27,000 ha during 1891 and now, in 1991, it is 34,934 ha. Though the registered *ayacut* is 34,934 ha, the actual area irrigated is rather more. This is mainly due to land brought into use by farmers' efforts. The irrigation planned and provided is only for two rice crops. But from 1970 onwards, there had been a phenomenal increase in the area under banana. It was 4,150 ha in 1970, and now it is 8,650 ha (Figure 4). The two-crop rice season is from June to March whereas banana is an annual crop. Banana cultivation is still increasing. The farmers demanded water for banana and the government could not ignore their demands. The problem is more pronounced in the last 2 anicuts as in these regions a third of the area is under banana.

All the 11 channels are flood carriers, i.e., they have to carry more discharge during the flood as well as carry the drainage water from upper channels during normal periods. Hence, they are larger in size. Therefore, the Irrigation Department has to supply a greater quantity of water to maintain the full supply level so that the sluices can draw their requirements. To solve this problem, the Irrigation Department built "Model Sections" (weir-like walls) below each sluice, so that for a normal discharge, the afflux caused will be sufficient to push water through the sluices.

During 1970, the Government of India and the Government of Tamilnadu planned to tap water for the heavy industries that were coming up in and around Tuticorin, headquarters of Chidambaranar district. The quantum required was fixed at 23 million gallons per day (mgd). The 20 mgd had been

proposed to be tapped from the Arumugamangalam Tank in the north main channel. This quantity is to be obtained through the savings from seepage by lining the 4 channels under the Marudur and Srivaikumdam anicuts. One of the conditions stipulated is that the Arumugamangalam tank should be kept at full level for all the 365 days of the year. This implied that the north main channel has to run throughout the year. No maintenance work could be carried out from 1970 onwards as the channel has been kept running nonstop.

Some of these channels also pass through urban habitats. The drainage and the dumping of debris into the channels have gradually hampered and reduced the flows. As a result, the time lag for water to reach the tail end became large (75-90 days). To overcome this, the Irrigation Department had to flood the channels, even to allow the normal discharges to reach tail ends. Under the National Water Management Project (NWMP), these channels are now being cleaned using bulldozers.

2.2. Role of Organization

The Kodagan Channel takes off from the 4th anicut to command 1,229 ha through 33 direct sluices, and 1,200 ha through 17 tanks and 53 sluices. The tanks are small in size and have a total capacity of 2.53 Mm^3. Almost the entire area is under rice. The length of the channel is 29.04 km and the lag period for the water to reach the last tanks was 20-30 days in the early eighties. Gradually this increased to 2 1/2 months during 1988 and the water did not reach the last tank at all during 1989. The tank communities have formal or informal organizations which patrol the channel and prevent intermediate tapping. Since the increase in the lag time is mainly due to blockages in the channel caused by the dumping of garbage by the municipality, farmers' organizations have started protesting about this.

The Marudur Keelakkal takes off from the left bank of the 6th anicut -- Marudur. It has to command 1,202 ha through direct sluices, and 1,952 ha through 15 tanks and 61 sluices. Some of the tanks are big enough to hold water till the maturity of a crop in their commands. The total storage capacity of all tanks is 11.85 Mm^3. The main crop cultivated in this command is rice. Banana is also cultivated in about 30 percent of the area. In normal years, the lag period for the water to reach the last tank varies from 20 to 30 days. The water for the lower tanks will be released only after the upper tanks are filled. During scarcity years this results in an unequal supply.

The Government of Tamilnadu has started a programme to improve the system performance in the Tamiravaruni system with the assistance of the World Bank. The objective is to improve the physical system and to modify the operational rules. Since the closure period is only 2 months (April-May), it may not be possible to finish all such rehabilitation work within this short period. To discuss this issue, the respective District Collectors called a "farmers meet" with officials. In the meeting, the EE (NWMP) sought the farmers cooperation for a longer closure period so that the rehabilitation programme may be undertaken and completed. The farmers' representatives of Kodagan Channel and Marudur Keelakkal Channel agreed, at a meeting on 6th March 1990, to extend the closure period by forgoing the Kar crop during June-September, 1990.

Figure 3. Decision-making process of Tamiravaruni System.

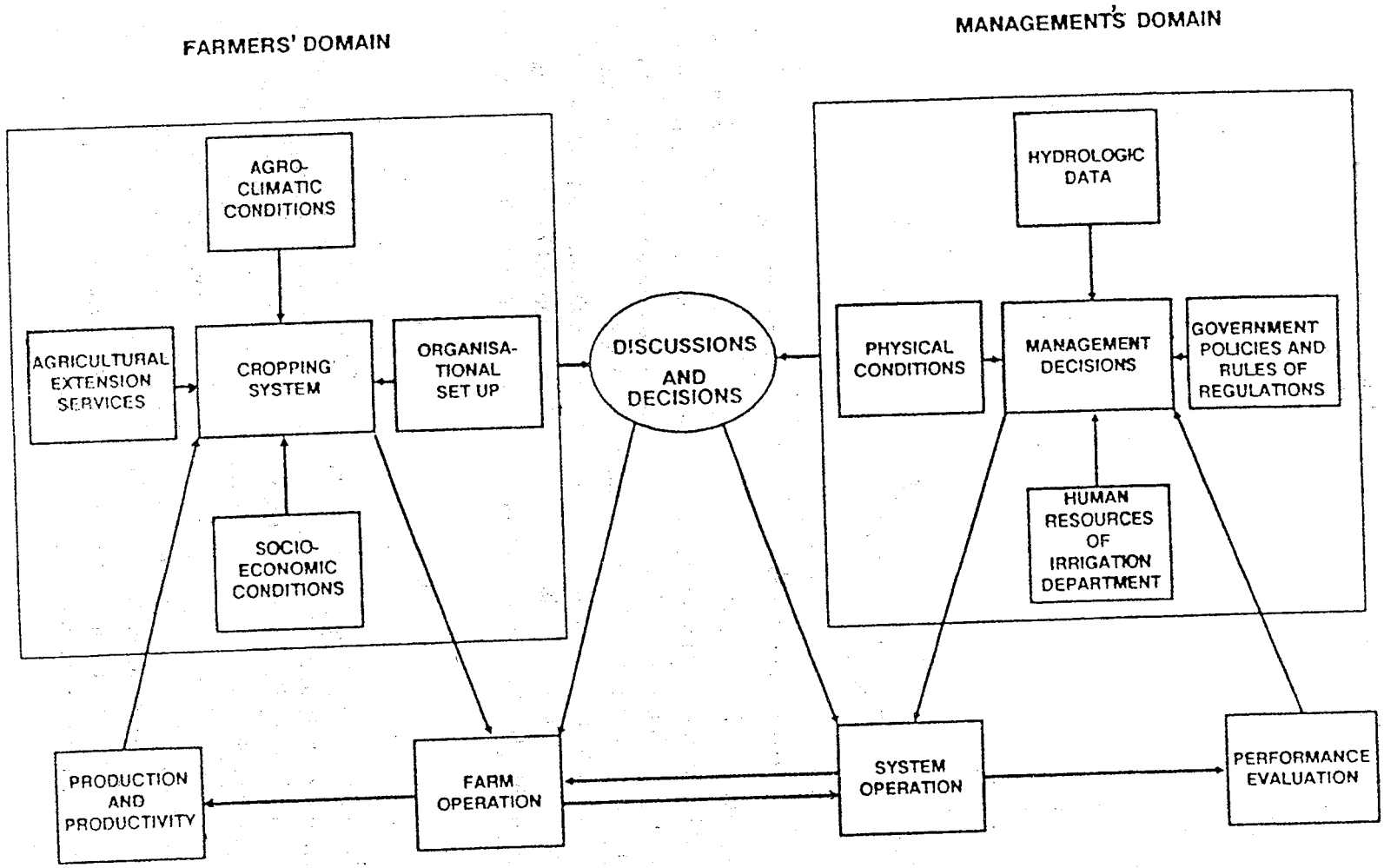
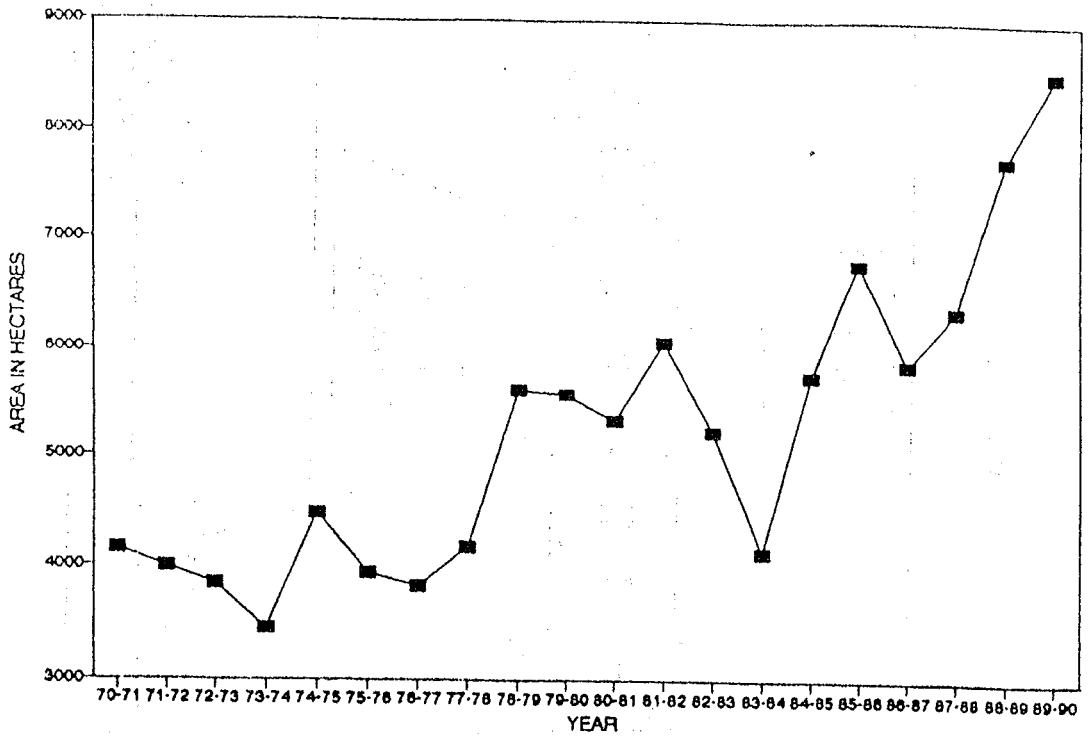


Figure 4. Tamiravaruni System: Development of area under banana.



All the works proposed for the Kodagan Channel have been completed. At the end of June 1990, in Marudur Keelakkal, banana growing farmers, through their associations, began applying pressure on the EE and the Collector to release water, despite the earlier agreed commitment. Their claim was that the banana would perish if this was not done. A special report in the newspaper, "The Hindu" stated that the banana crop worth Rupees 2 crore was suffering from lack of water. In the above circumstances, the EE in consultation with the Collector released 7 cumecs (250 cusecs) of water for 15 days from July 16 1990. This decision hampered further rehabilitation work in the channel.

2.2.1. Comments

In both channels, farmers' organizations, whether formally constituted or not, are looking after the irrigation needs of their areas. They were able to present their cases for the early rehabilitation of their channels. They were able to convince the farmers of their area to forgo a crop so that rehabilitation work may be completed. In the area in which the problem is severe, i.e., in Kodagan Channel, the farmers cooperated with the department and the work was completed and the lag period has been reduced to 30 days. In the case of Marudur Keelakal, where the problem is not severe and restricted to certain reaches, as soon as the major bottlenecks were removed, the farmers were not willing to wait any further. It also demonstrated how the powerful associations functioning in the channel can bring pressure on the administration to alter their decisions even though the rehabilitation work was only half complete.

2.3. Advance Kar 1991

Under the NWMP, the Irrigation Department proposed to rehabilitate the Srivaikundam north and south main channels during the closure period of 1991. The District Collector convened a number of meetings of farmers and officials and the decisions made at these meetings were as given in the following table.

Serial No.	Date of Meeting	Decisions Made	Remarks
1	16.10.90	Farmers agreed to close Srivaikundam north and south main channels during Advance Kar to carry out rehabilitation work.	Storage in the reservoir is very poor.
2	08.01.01	i. To close south main channel only during Advance Kar (April-May). ii. To close north main channel during Kar (June-September). iii. To close Marudur (Kelakkal and Melakkkal) during Advance Kar (April-May).	Storage improved and the reservoir had a surplus during December 1990.
3	07.02.91	i. To authorize, the fullest extent possible, in all four channels under last two anicuts for Advance Kar. ii. No water to be released even for banana and betel-vine from July to October. iii. Farmers have to give their consent for the above in writing and this should not be quoted as a precedent.	EE said that the storage is enough for 8,200 ha only. But farmers wanted 18,400 ha to be authorized. Farmers gave their consent in writing on 12.02.91. Collector informed the farmers to take up cultivation only after issue of government orders.

But the EE submitted a proposal to the government with the concurrence of the Collector which ran counter to these decisions. The main features of the proposal were to authorize cultivation of:

1. All the priority areas (4,210 ha) in south main channel.
2. 3,113 ha in the Marudur Keelakkal Channel.
3. 1,933 ha in the Marudur Melakkal Channel.

He also proposed to close the north main channel to undertake rehabilitation work and release water to industry through Marudur Keelakkal.

When the contradiction between these decisions was brought to the notice of the EE, he argued that the north main channel requires immediate repairs because of its siltation and further stated that if the available NWMP funds were not utilized now, the north main channel could not be repaired at all in the near future. Further, farmers of Marudur Keelakkal had foregone the last Kar crop and their area was also included for authorization.

To achieve this target, the EE proposed to draw 28.3 Mm^3 (1,000 Mcft) of water from the Manimuthar Reservoir during April-May. This is a deviation from the rules and regulations for the reservoir.

As the season was very favorable and because political activities had picked up due to general elections, the farmers decided to pressurize the government officials through the politicians. They also made representation to the Chief Engineer (Irrigation) stating that if their lands are authorized for Advance Kar, they will cooperate with the department in the execution of NWMP works during the Kar season. As a compromise between these pulls from different directions, the government decided to authorize cultivation in only 7,803 ha under the south main channel and the north main channel, as a priority. The Collector accordingly informed the farmers not to take up any cultivation in any area other than that notified; if they did so, it was at their own risk.

The farmers of Marudur Keelakkal and Marudur Kelakkal channels were disappointed very much with the above government notification and brought pressure on the officials. An ex-MLA informed the press that the Chief Engineer (Irrigation) has agreed to release water to save the standing crop. Meanwhile, the farmers decided to start a *satyagraha* on March 3, 1991. The sub-collector immediately reacted to this by convening a reconciliation meeting. Since the meeting did not succeed, the farmers with their families sat down on the road and prevented the movement of vehicles (road roko). The transport corporations withdrew their vehicles and traders closed down their shops and the public also supported the agitators. The Chidambaranar District Collector intervened and informed the public that he would consult the Secretary to the Government and announce the decisions of the government on the next day. The farmers then dispersed.

On the advise of the Secretary to the Government, the Collector undertook a field inspection with officials and farmers and found that cultivation had actually started only in 1,141 ha as against the 5,051 ha claimed by the farmers. A special release of water was authorized for this area (1,141 ha) only.

2.3.1. Comments

The Collector convened the meeting of the farmers and officials three times to decide on the execution of rehabilitation work under the NWMP and the area to be authorized for the Advance Kar season. But contradictory decisions were taken in each one of them. Finally, the EE made yet another proposal with the consent of the Collector. To avoid various political pressures, the government decided to adhere to the rules and regulations. The changes made in the decision-making processes show how easily decisions taken earlier are changed without going into the pros and cons of these.

While computing the quantum of water available for the Advance Kar, the EE assumed that 28.30 Mm^3 (1,000 Mcft) of water could be drawn from the Manimuthar Reservoir. But the rules and regulations do not permit the withdrawal of water from the Manimuthar Reservoir for this season. On verification of release data from Manimuthar, it is seen that no water has been drawn from the reservoir during this period. This reveals that the method of computation to assess the area to be authorized for Advance Kar needs a fresh look and revision.

2.4. Reliability

Irrigation Management aims at achieving an adequate and timely supply of water, equitably delivered over the area with predictable reliability. In practice, however, the management of an irrigation system distributes available resources to a group of farmers to share among themselves with a certain reliability. Unreliable supply causes excess irrigation at the upper reaches depriving those in the lower reaches.

Irrigation Department officials decided to improve the reliability of the water supply by opening the channels on a fixed date. Though the Pishanam season has to start on October 1, 1991 the opening of the channel was delayed by a fortnight to facilitate completion of NWMP works. Information regarding the opening of all the channels on October 16, 1991 for the Pishanam was communicated to the farmers through local dailies and through luscars. On the morning of the 16th, the farmers were informed through All India Radio that all the channels were opened as intimated earlier and requested the farmers to start cultivation immediately. To ensure the simultaneous release of water in all the channels, the EE drew water from the reservoir starting three days earlier and allowed the water levels in the anicuts to build up to their full height. In earlier years, the water was drawn in the head-reach anicuts first and it took 5-7 days to reach the tail-end anicuts.

The EE is of the opinion that the confidence of the farmers in the system, about its capability to discharge water on the date which was previously decided and announced, should be built up. But the response of the farmers in starting cultivation operations immediately was very poor. In the Nadhiyunni Channel, many farmers did not start the cultivation operations even after a month. From this reluctant response of the farmers, it is understood that the farmers are changing from the long-duration (150-day) rice crop to medium-duration (135-day) and short- duration (110-day) crops during the Pishanam season. The commencing date of the Pishanam season (October 1) has now become more and more unsuitable due to the climatic conditions. Particularly, the heavy rainfall during

October-November coincides with the flowering of short-duration rice. Hence, farmers delay the cultivation operation up to the second fortnight of November.

2.4.1. Comments

The Irrigation officials in charge of the project, intent on building the confidence of the farmers, saw this as an extension exercise. But their good intentions did not have the desired result due to other agronomical compulsions. Switching over to the short-duration crop has not been accomplished by all farmers; in 50 percent of the area, some farmers are still raising medium- duration crops. The EE is, therefore, compelled to release the water at the commencement of the season, i.e., October 1, as per rule. All this indicate that the operation rules which fix the commencement of Pishanam as October 1, need a second look.

2.5. Installation of AWLRS

The Irrigation Department is making observations of the flow in the channels four times a day. Except for the last anicut, all other anicuts are at some distance away from the nearest village. They do not have any lighting; moreover the area is infested with snakes. The records to be made by the luscars on flow at 8:00 a.m., 12 noon at 4:00 p.m. are made at all the anicuts. And the last reading at 8:00 p.m. is not observed in most cases. The daily issues are being calculated with these three readings only. Any fluctuations in between the observations will not be recorded. Automatic Water Level Recorders were installed to record the actual happenings.

2.5.1. Comments

Test-case observations in two channels, namely Nadhiyunni (26.09.91 to 18.12.91) and Tirunelveli (25.09.91 to 18.12.91) are shown in Figure 5. There are wide variations between values recorded by the luscar and the AWLR in the Tirunelveli channel. For the other channel, both readings are reasonably coinciding with each other. This indicates the bebavioural difference between the luscars of the two channels.

Figure 6 shows the comparison of hourly discharges observed in the Nadhiyunni Channel by AWLR and computed with the recording of the luscar, at 8:00 a.m., 12:00 noon and 4:00 p.m. It clearly indicates a variation in readings; the variation in flow between observation is not accounted for by the department.

Figure 5. Test-case observation in the Nadhiyunni channels.

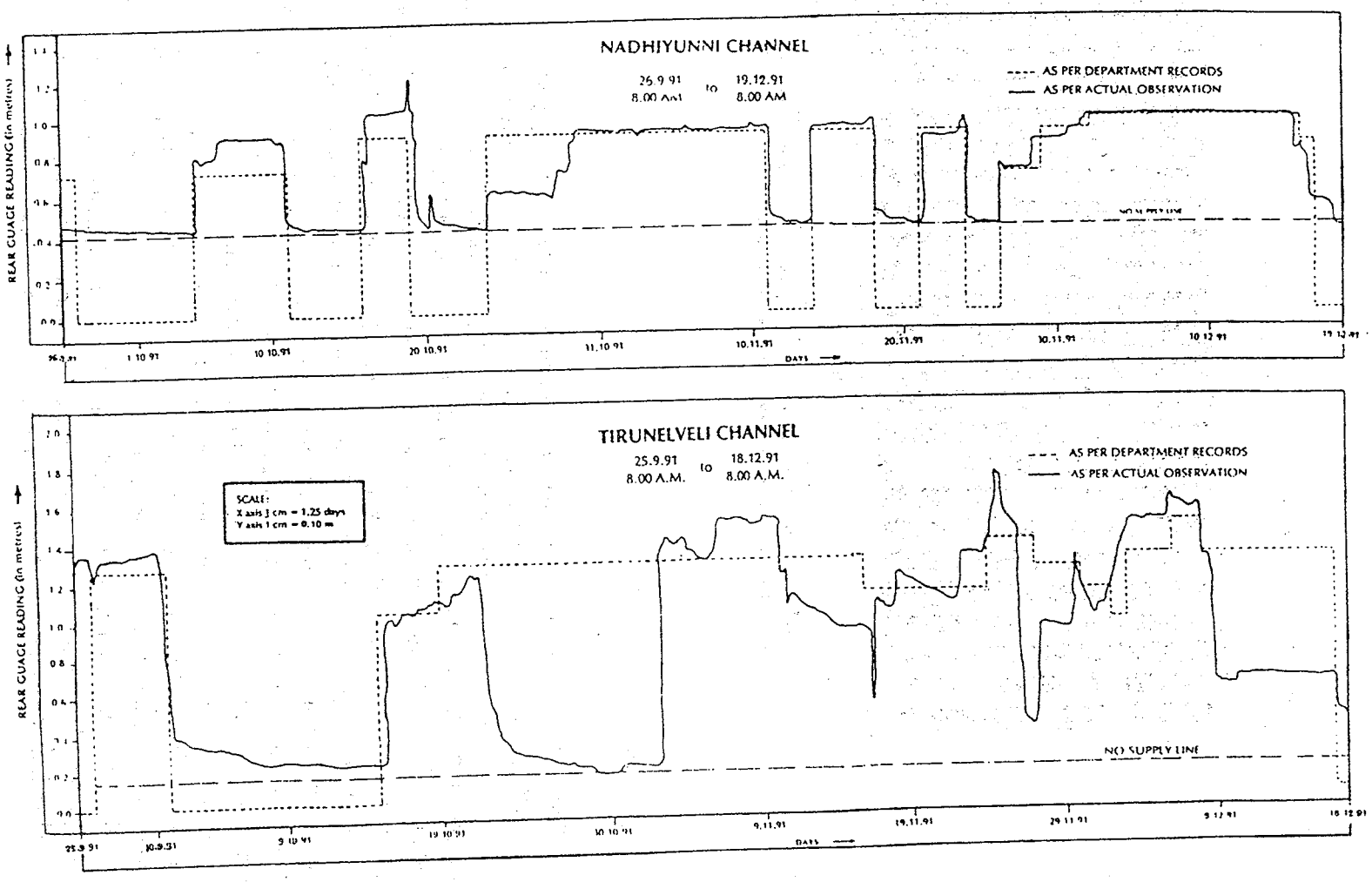
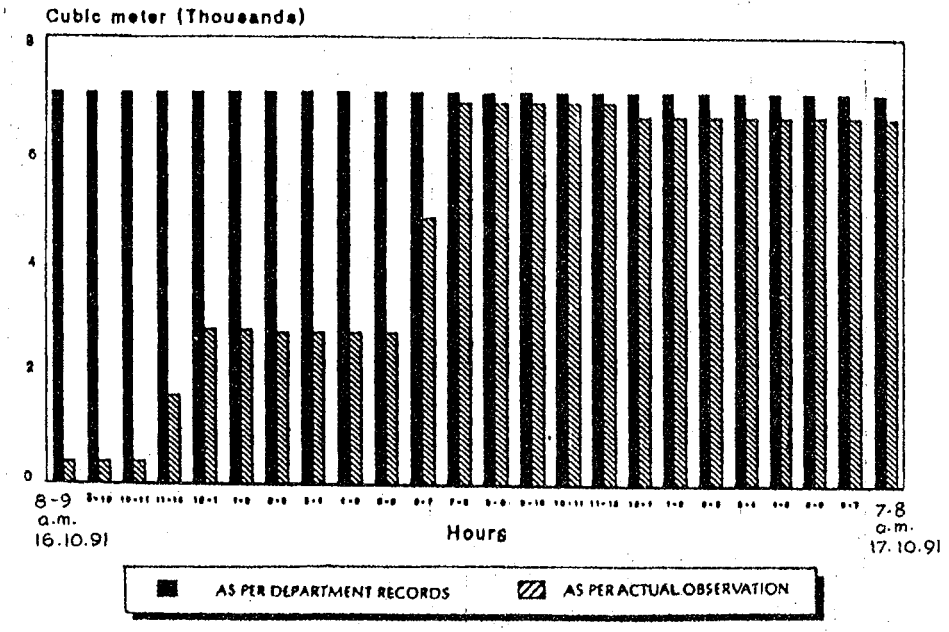


Figure 6. Comparison of hourly discharges (16.10.91-8.00 a.m. to 17.10.91-8.00 a .m.) of the Nadhiyunni channel.



3. DISCUSSIONS

The extent of Advance Kar will be notified by the middle of March, every year, after duly considering the storage position in the reservoirs, the normal summer flows and left-over storages in the tanks. The areas approved for cultivation, from 1969 to 1991, (Figure 7) show wide variations; the maximum area was 18,667 ha in 1984 (53.4 percent of the total command) and the minimum was nil, in 4 of the 23 years whereas the average area in Advance Kar constituted around 14.2 percent of the total. Short-duration rice varieties are grown during April-July and the average yield is 5,235 kg/ha as per the crop-cutting experiments conducted during 1990-91. The crop water requirement works out to 1,048 mm for Advance Kar as against 1,205 mm for the Kar season of the same duration. Productivity per m^3 of water works out to 0.5 kg as against 0.350 kg for the Kar crop. Bright weather prevailing during the Advance Kar season helps to produce a higher yield.

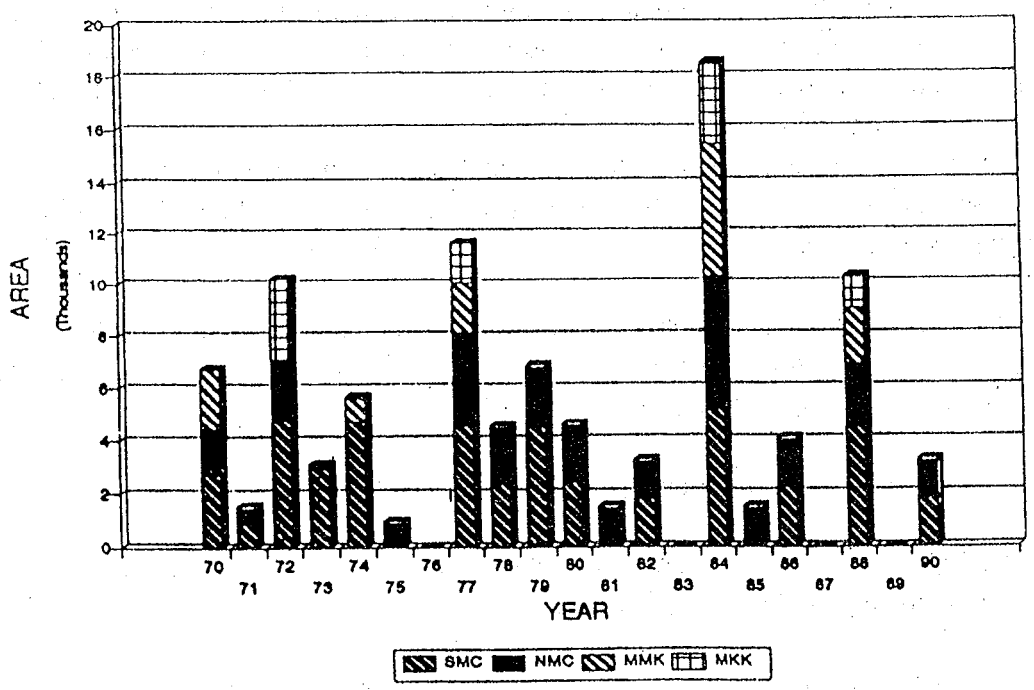
Advance Kar is preferred by the farmers for the following reasons: It gives a higher yield and returns compared to Kar and Pishnam seasons. At the time of harvesting of Advance Kar, bright weather with an absence of rainfall, helps in harvesting and drying the produce; both grain and straw fare better than in the Kar crop which coincides with the onset of the northeast monsoon. In the Kar season, the loss of grain and straw due to bad weather is usually more than 20 percent. Absence of pests and diseases during the Advance Kar season further reduces the cost of cultivation.

The Agriculture Department as well the farmers feel that the area allocated for Advance Kar should be increased so as to realize more yields and returns. However, the irrigation authorities find it difficult to assess the demand and schedule the irrigation water accordingly, since the areas under different crops cannot be assessed in advance. While allocating land for Advance Kar, the entire *ayacut* is taken as a rice crop and the extent of banana and betel vine cultivations are not considered. The irrigation authorities feel that the cropping pattern has to be rescheduled and brought to a fixed or predetermined pattern as in mono-cropping. It is neither practicable nor possible to force the farmers to take such a decision.

3.1. Crop Diversification -- Banana

Crop diversification is taking place in all rice-based irrigation systems of the state. In the Tamiravaruni System, the area under banana has increased from 6 percent to 32.4 percent of the command area in the past three decades (Figure 4). The main reason for the increase in the banana area is the higher income provided by a better market than that for rice. The income for 2 crops of rice works out to Rs 12,500.00 per ha as compared to Rs 40,500.00 per ha for one banana crop. Due to the high income from banana, the rich farmers allocate more area for this crop.

Figure 7. Tamiravaruni System: Advance Kar area (in hectares), 1970-90.



Rice is a labor-intensive crop which requires 370 man-days for two crops of rice in one hectare of land during a period of 8 months, whereas 463 man-days are required for one hectare of banana for a period of 12 months. Labor scarcity during rice transplanting and harvesting has driven certain farmers to banana cultivation. Contract laborers are utilized mostly for banana cultivation and 80 percent of the labor is male, whereas in rice cultivation female labor is more -- in fact, more than 60 percent.

Rice-Rice-Banana is the usual two-year rotation followed in the head reaches. In tail-end areas, where the soil is highly fertile, banana is ratooned more than 6 times and the crop remains in the field for 6 to 7 years. Banana requires 1,600 mm of water whereas two rice crops consume more than 2,000 mm of water. During April-May, due to the closure of channels, scarcity of water may occur. Since the area under banana is more at the last two anicuts, farmers utilize tank water or groundwater in a limited number of cases. In contrast, in the upper reaches, some farmers pump water from the river flows. Farmers adopt the trench method of cultivation to avoid water stagnation during the rainy season. Wind damage to the crops is avoided by planting in the month of June and harvesting before the onset of the windy period.

3.2. Role of Organizations

The NWMP work was successfully carried out in the Kodagan Channel by foregoing one Kar crop but this could not be done in Marudur Keelakkal, where the farmers did not cooperate in completing the work. In the Kodagan Channel, the farmers can forego a rice crop, by which they may loose a profit of Rs 6,000.00 per ha, whereas the farmers of Marudur Kellakkal if they forego a banana crop, would lose a profit of Rs 40,500.00 per ha (32 percent of the cropped area is under banana); and if they lose one crop of banana they may have to lose the ratoon crops also. Hence, the farmers will not agree to the closing of the channel for a period of 6 months and the NWMP has to look for other ways of carrying out improvement works.

Farmers' organizations cooperated with the Irrigation Department fully in the Kodagan Channel as they felt a need to clean the channel. The Irrigation Department also had a keen desire to clean up the channel for many reasons:

1. The channels had been in bad shape with the result that the water took more than 75 days to reach the tail end. For a 105-day crop, if there is a time lag of 75 days, the Irrigation Department has to supply water for 180 days.

2. The quantity of water drawn rose high, to reach 83 Mm^3 (2,900 Mcft).

3. As the height of the anicut was not sufficient to push this quantity, the department had to raise its level by putting sand bags on top of it.

4. Even with all these measures, the tail-end area could not get water.

After the work was completed, the Irrigation Department met the demands of the farmers with 67 Mm^3 (2,350 Mcft) of water and the time lag was reduced to 30 days. These factors were verified by the recorded water release data and results of inquiries from farmers in various reaches of the channel.

On the other hand, in the Marudur Keelakkal, the channel length is shorter and in the tail end, the farmers will always get the additional water required from the return flow of the upper anicuts. Hence there is not much of a "felt need" either among the farmers or in the Irrigation Department.

Another interesting feature which came up was that the farmers' organization in the tank of Kodagan Channel have a long history compared to that of Marudur Keelakkal. Instances of the community effort of the farmers of Chatram Pudukulam (Kodagan Channel) have been reported in "Managing Common Property" by Nirmal Sen Gupta (1991).

On the economic side also, the farmers of these tail-end tanks of Kodagan Channel have a stake in growing pulses. The normal cropping pattern is rice-rice-pulse. Prior to the harvest of the Pishanam crop, the farmers sow pulses, which will grow on the residual moisture. The crop comes to maturity in 60-70 days. This is remunerative to the tune of Rs 4,000.00 to Rs 5,000.00 per ha, as a net return. The villages have a tradition of allowing all the cattle in the village to graze in the rice field before ploughing for the Kar season. This has a dual purpose; to feed cattle and manure the fields with cow dung. As it is a community activity, the farmers have to harvest their pulses before this activity. In other areas, where this common activity is not practiced, there is no protection from stray cattle if anybody grows pulses. With the guaranteed income of Rs 4,000.00 per ha on pulses, the farmers of Kodagan Channel are keen to have their Pishanam harvested before 15th March. Any delay will definitely cause an economic loss.

3.3. Advance Kar

The farmers will take a different stand depending on the availability of water in the reservoir. First, the farmers agreed to forego the Advance Kar crop but due to the improved storage position at a later stage, they were tempted to grow a crop which will produce a better output and profits than a Kar crop. In such circumstances, maintenance work has to be postponed to a lean year when the storage position is very low. The farmers of north main channel were fully aware of the first priority and they did not want to leave the opportunity to the other areas which would normally have the second or third priority.

Agronomically, the Advance Kar season is favorable to the rice crop, which yields about 5 tonnes/ha compared with 4 tonnes/ha and 3.5 tonnes/ha in Kar and Pishanam, respectively. There is also diversification to banana to an alarming extent. These factors greatly change the performance of the system. The quantity of water available for utilization 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 get less.

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

construction of 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, the area increased to 9,000 ha only. This was intended to reduce the water demand in the Kar season when the normal availability is limited, compared to the Pishanam season. If the Advance Kar area is limited to 9,000 ha, then the Kar area would have been 20,000 ha. In the previous years the area allocated had gone up to 19,000 ha (Figure 7). Hence, only 10,000 ha could be irrigated during Kar under normal circumstances. The first 6 anicuts have an area of 16,260 ha: those who farm 6,000 ha are deprived of their legitimate crop. 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?

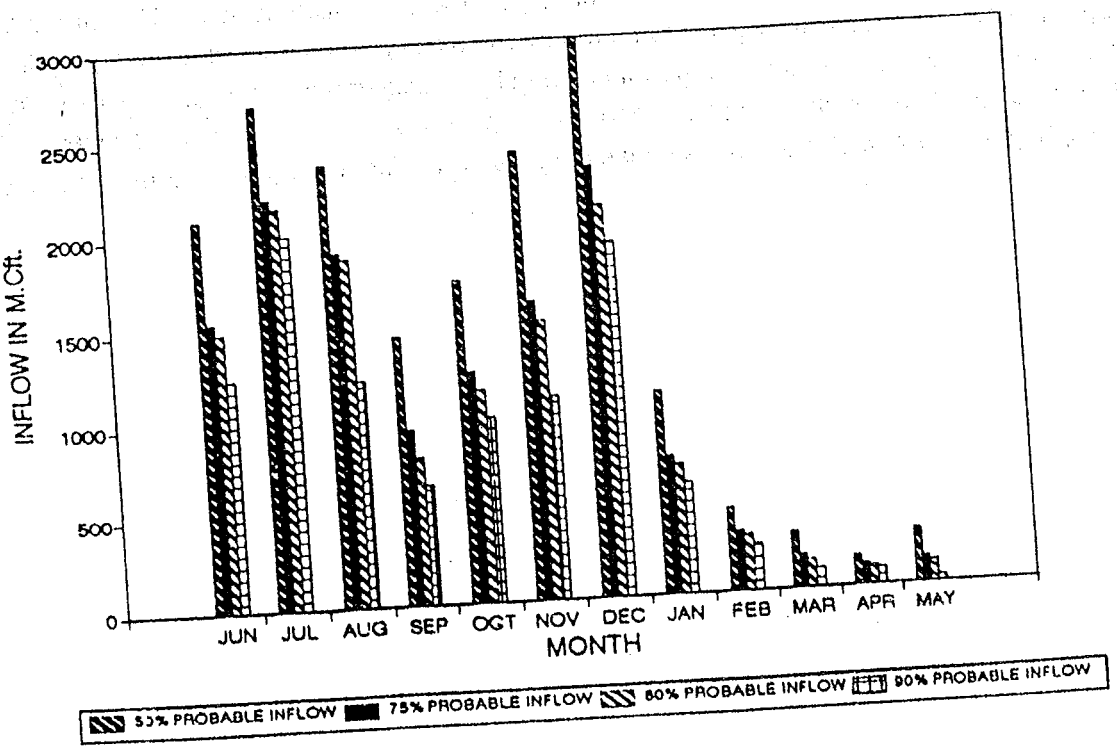
3. Can we develop an alternative way to decide on the Advance Kar area?

An important set of data to decide on the optimal extent of Advance Kar is the anticipated inflow into the reservoir. Normally the EE considers the mean monthly inflows of the available past records. But a more rational way would have been to work at the Return period and find the 90 percent, 80 percent, 75 percent and 50 percent probabilities. This had been worked out for the 24 years of records from 1967. The probable inflows are shown in Figure 8. With 75 percent dependable inflow, the total quantity that is available for Advance Kar is 7.64 Mm^3 (270 Mcft). The maximum storage as on 2nd April for the past 30 years had been 85 Mm^3 (3,000 Mcft). The industrial need for April and May is 10 Mm^3 (350 Mcft) and the quantum to be left in the reservoir for Kar cultivation is 14.15 Mm^3 (500 Mcft). The actual quantum that can be spared for Advance Kar is around 68 Mm^3. With this quantity, only 3,900 ha can be irrigated. Clearly, the problem is complex and will have to be examined in detail with reference to tank storages, and agronomic and economic factors before the optimum area under Advance Kar can be computed.

3.4. Reliability

As far as a reliable water supply is concerned the decision made by the EE in releasing the water in all the eleven channels simultaneously for the Pishanam crop on October 16th, 1991 was welcomed by the farmers. The water was, in fact, released exactly on the 16th in all 11 channels. Even after a month, it was observed that there was no cultivation operation going on in the fields and that the released water was left unutilized. There seems to be a long gap of more than a month between the Kar and Pishanam crops. The reason for the long gap may be the change in the duration of varieties of rice grown, from 150 days to 135 or 105 days. If the farmers take up short-duration rice varieties in the Pishanam season, immediately after harvesting the Kar crop, the flowering of short-duration varieties will coincide with heavy rains and spoil the crop. Hence the farmers delay the planting of the Pishanam crop.

Figure 8. Papanasam and Servalar reservoirs: Probable inflows.



Farmers want to start the Kar season by June 1, so that the crop is ready for harvesting before the northeast monsoon sets in. If it is delayed by a fortnight, taking into account the time lag in agricultural operations, most of the matured rice will be affected by the onset of the monsoon.

So, when the Irrigation Department tries to ensure the opening of all canals simultaneously on the announced date, the farmers should have responded favorably. But the poor response indicates the lack of extension work on the part of the Irrigation Department. Though the EE had tried his best to reach all farmers over the radio and the press, his field staff does not seem to have passed on the information to the farmers of their canal commands as anticipated. Extension work and its feedback will be useful to the EE in improving system performance in the coming years. A mechanism such as "Irrigation Extension" may be a useful device.

4. CONCLUSION

A traditionally simple rice irrigation system with abundant water has been gradually transformed into a more complex system of commercial production during the past 50 years. These changes can be attributed to physical improvements like the construction of reservoirs, crop diversification from rice

to banana, industrial development of the Tamiravaruni communities and the shifting of political sympathies towards the farmers' organizations to meet their current demands.

This complexity of factors affected the performance of the irrigation system. The management of the system has also transformed itself to meet the pressures exerted in various forms by the above factors. This study of the system's performance and its management control processes throws more light on how these forces interacted to bring about such results. The events explained in the last paragraphs not only reveal the various causes but also give rise to more questions to be answered.

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