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PROBLEMS OF IRRIGATION*

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Irrigation has been accepted as a major programme for developing India's agriculture. The emphasis is obvious from the financial allocations to irrigation in the three Five-Year Plans. The First and the Second Plan allocated Rs. 601 crores and Rs. 950 crores respectively to agriculture and irrigation together. Of this irrigation alone claimed Rs. 310 crores (50 per cent) and Rs. 420 crores (44.2 per cent) in the First and the Second Plan respectively. In the Third Plan, irrigation shares Rs. 650 crores (37.7 per cent) out of the total allocation of Rs. 1,718 crores to both agriculture and irrigation.

Within the irrigation programme, emphasis has however shifted to some extent from major and medium projects in the First and the Second Plan to minor projects in the Third Plan. This is evident from the fact that in the former two Plans, the outlay on minor irrigation accounted for 24.8 per cent and 22.6 per cent of the total allocation on irrigation in general, while the corresponding percentage in the Third Plan comes to be 27.2.

Progress of irrigation upto the end of the First and the Second Plan and the targets for the Third Plan in terms of area irrigated are shown in Table I.

TABLE I

	Net Area Irrigated		
	First Plan	Second Plan	Third Plan (targets)
	(In million acres)		
Major and medium irrigation	24.9	31.0	42.5
Minor irrigation	31.3	39.0	47.5
Total	56.2	70.0	90.0

Source : Third Five-Year Plan, p. 382.

One of the major problems in regard to irrigation is under-utilization or excess capacity. Of late, however, there has been some improvement in the utilization of irrigation waters. The percentage of utilization of irrigation capacity of major and medium irrigation projects is reported to have increased from 48 at the end of the First Plan to 76 at the end of the Second Plan.[1] The progress is thus encouraging. However the image at once changes when we look at financial side of the problem.

*This paper is the outcome of the two research projects undertaken by the Agricultural Economics Section of the Department of Economics, University of Bombay, in the years 1955-56 and 1956-57. Mr. K. D. Shah and Dr. V. S. Vyas helped us in the field work. As one of the authors was out of India for two years, completion of the paper was delayed. Authors are thankful to Prof. M. L. Dantwala for going through the draft and offering valuable suggestions. The authors however own the responsibility of any error in the paper.

1. Government of India: Third Five-Year Plan, p. 382.

The seriousness of the problem of under-utilization of irrigation capacity is revealed by heavy financial losses to the Government. With increase in investment in irrigation, such losses have tended to rise rapidly. The net profit from irrigation projects was Rs. 4 crores[2] in 1950-51. In 1955-56, there was a net loss of Rs. 5.1 crores, which increased to Rs. 19.3 crores in 1960-61 and is expected to rise to Rs. 33.7 crores for the year 1965-66. For the Third Plan period, the total loss is estimated to be Rs. 135.9 crores; this includes net profit/loss for irrigation portion of multi-purpose projects. This is so in spite of the upward revision of the water rates in most of the States during the last decade. In some States, the water rates have been nearly doubled. True, a part of the financial losses is anticipated in view of the undertaking of the irrigation project on the basis of the net social benefit and not on the net financial income to the Government. However, the loss can be reduced if irrigation capacity is more fully utilized. Viewed from this point even about 80 per cent utilization of irrigation capacity attained by now still leaves some scope for efforts to improve utilization of irrigation capacity.

In Gujarat State, particularly, the problem seems to be acute. The net financial loss is estimated for 1960-61 at Rs. 163 lakhs for 3.7 lakh acres of irrigated area against Rs. 1,936 lakhs for 333.2 lakh acres of irrigated area for all India. Heavy net financial losses in Gujarat are accounted for by very high working expenses and interest costs ; working expenses of Rs. 15.27 per acre are the highest for the year 1960-61 among all States. The capital outlay per acre in Gujarat is Rs. 457 and is not so high ; Gujarat State would rank fifth in this regard and the amount is nearly half of that for Maharashtra—Rs. 836 per acre—which is the highest. The interest charges at 4½ per cent would work out to Rs. 20.56 per irrigated acre which again are less as compared to those in Maharashtra, Kerala, Madras and Mysore States. The average receipt of Rs. 12.22 per acre was also the second highest for 1960-61 among all States. The heavy financial losses on irrigation account in Gujarat are thus mainly due to high maintenance expenses. It is believed that the heavy working expenses are due mainly to low utilization of irrigation capacity and not so much due to the type of soil, rainfall or other geographic reasons. So far we have stated the problem of utilization of irrigation capacity only in the context of area irrigable and irrigated. Since the data are available in this form discussion of the problem of excess capacity in this context is convenient and hence widely current. There is however another and more important aspect of the problem. It is the non-realization of the production potential on the area already under irrigation. Losses both direct and indirect caused by this shortfall can be heavier especially when irrigation is rapidly spreading. Precise data for this are not easy to obtain.

We report below the results of two research studies carried out in 1955-56 and 1956-57. These two studies suggest that the extent of excess capacity varies for different irrigation projects and the reasons behind the excess capacity are different for different regions. Besides, the available water supply is not put to the best use mainly because the complementary resources and funds to buy them are restricted in their supplies.

These two studies pertain to a cross-section of farmers at a point of time. The inferences are based therefore on comparisons of different groups of farmers.

2. Gross of interest charges for Hyderabad, Mysore, PEPSU and Madhya Bharat.

The comparisons relate to three groups of farmers : (*i*) not using irrigation, (*ii*) using irrigation very recently, and (*iii*) using irrigation for a long period of time ; and are made by reference to use of irrigation water for different crops, use of manure, improved seeds, etc. The causes of low irrigation utilization are then analysed. Section one gives an analysis of the use of available irrigation capacity in terms of extent—*i.e.*, area irrigated—and reasons for the excess capacity in this context. Section two studies the problem of optimum or intensive utilization of irrigation and carries further the analysis of reasons of under-utilization. Section three deals with the implications of the findings of the study.

COVERAGE AND SAMPLE

The study covers two areas : (*i*) the Meshwa canal Region and (*ii*) the Kakrapar Canal Region. The former is located in the Kaira district and the latter in the Surat district of the Gujarat State. Both the canals supplied water mainly for supplementary irrigation. The methods of selection of villages and families were slightly different in two regions.

Meshwa Canal Region : The Sample Families

Six villages were purposively selected from the Meshwa canal region. Of them, two were selected from the "Kalambandhi"[3] group, two from non-Kalambandhi group and two selected as control villages which were from the same region but not commanded by canal waters. The villages from Kalambandhi group represent conditions of secured supply of irrigation waters for over several decades ; the villages from non-Kalambandhi group represent conditions of newly irrigated area with no security of supply of irrigation water. In the control villages irrigation is not absent but is mainly from wells and a tank. Before the villages were selected, the data regarding crop-pattern, distribution of holdings, and availability of co-operative credit were studied for the region and for villages, and those villages which represented the near-average conditions of the region were selected. From each village, 15 cultivating families were selected by stratified random sampling after grouping them according to the size of their holding. If we divide the families into two groups, (*i*) those cultivating holdings upto 5 acres, and (*ii*) those with holdings 5 acres and above, the first group consisted of 33 and the second of 57 families out of total 90 families. Of the 33 small cultivators 15 were from non-Kalambandhi villages, 7 from the Kalambandhi villages and 11 from control villages. Of the 57 medium and big holders 23 belonged to the Kalambandhi villages, 19 to control villages and only 15 to the non-Kalambandhi villages. Thus small farmers predominated in the non-Kalambandhi villages and medium and big farmers in the Kalambandhi villages. The average size of holding

A G	A G	A G
9-08	8-08	7-00

for the Kalambandhi villages was the largest; it was 8-08 and 7-00 for the non-Kalambandhi and the control villages respectively.

Out of the 90 families selected, 15 had no irrigation ; of the latter, 3 were from the Kalambandhi villages, 2 from the non-Kalambandhi villages and 10

3. "*Kalambandhi*" means that the area has priority in the use of irrigation water upto certain quantity which assures reasonable supply of water under a court decision. This related formerly to Knari-cut canal but when Meshwa canal was constructed the priority right was transferred to the latter.

from the control villages. Thus, in so far as farm families were concerned, the extent of irrigation was much higher in the canal region villages, and the control villages represented to a large extent the conditions of dry villages. Of the 27 families using irrigation water in the Kalambandhi villages, 17 had more than 75 per cent of the area under irrigation, and of 28 families using irrigation water in the non-Kalambandhi villages, again 17 irrigated more than 75 per cent of cultivated land. Thus, in both these instances, the extent of area irrigated was high. In the control villages, on the other hand, all the families using irrigation irrigated less than 75 per cent of their cultivated land.

Kakrapar Canal Region : The Sample Families

By contrast, in the Kakrapar canal region, wide variations obtained regarding the proportion of area under irrigation (including absence of irrigation) on individual holdings. Selection of control villages was, therefore, unnecessary. We selected 7 villages from the Bardoli taluka located on the left bank main canal where water was available for over 3 years when the survey was carried out. The villages selected were Ruwa, Bhamaiya, Khoj, Raem, Kantali, Singod and Timberva. These villages were selected on a random basis.

The families in these seven villages were first stratified on the basis of irrigation water used for 3 years, 2 years, 1 year and no irrigation. In each sub-group, families were arranged in descending order on the basis of holding and in all 106 families (about 15 from each village) were selected by systematic sampling with a random start. Of 106 families selected 42 families had cultivated holdings upto 5 acres, 40 families had holdings between 5 to 15 acres and 21, above 15 acres. Only 20 of 106 families, used irrigation water for all the three years, 49 irrigated their lands for 2 years and 37 did not avail of irrigation water at all.

I

EXTENT OF NON-UTILIZATION OF IRRIGATION CAPACITY

The extent of non-utilization has to be related to the estimate of irrigation capacity. However, capacity to irrigate is not a simple concept. Usually it is believed that the area that can be irrigated with a given amount of water depends on the type of crops, type of soil, soil moisture, temperature and the amount of rainfall.[4] It is also believed that the type of canal which supplies water also affects the area irrigated with given quantity of water at canal head, since with different types of canals (and field channels) amount of seepage on the way differs. It may be possible after taking account of all these factors to obtain a broad crude estimate of the capacity to irrigate for the irrigation project concerned. However, no such estimate can be framed for an individual farm. A crude measure of the irrigable area for a farm is the area of land lying in the command of canal waters. Judged on this basis, in the Kalambandhi villages, 90 per cent of the total land was irrigable for the sample families, about 77 per cent for the sample families in the non-Kalambandhi villages and about 73 per cent for the sample

4. Colin Clark reports in his recent publication "The Economics of Irrigation in Dry Climates" that the amount of water required does not differ from crop to crop . . . . p. 2.

families in the Kakrapar villages. In the control villages, the irrigable area, *i.e.*, area that can be irrigated by tank or well water, was about 17 per cent of the total land.

TABLE II—PERCENTAGE OF IRRIGATED LAND TO TOTAL IRRIGABLE LAND FOR SAMPLE FAMILIES USING IRRIGATION FACILITIES

Region	Below 5 acres	5 to 15 acres	Above 15 acres	All Farms
Meshwa Canal Region				
(*a*) Kalambandhi Villages ..	93.6	93.1	—	93.4
(*b*) Non-Kalambandhi Villages..	82.3	92.3	—	91.3
Kakrapar Canal Region	26.6	30.0	30.5	29.7

For Kakrapar region, since the number of farmers not using irrigation is substantial, it is useful to analyse whether size of holding was a relevant factor for them.

TABLE III—IRRIGATION AND SIZE OF HOLDING IN KAKRAPAR CANAL REGION

	Below 5 acres	5 to 15 acres	Above 15 acres
Number of families using irrigation	19	29	21
Number of families not using irrigation	23	11	3

The above table suggests a positive correlation between the size of holding and use of irrigation facility. However, interpreted together with the previous table it would imply that once the farmer decides to use the irrigation facility (which means that he prepares field channels, etc.) he makes as extensive use of the given facility as is possible within the constraints of crop pattern and other resources and at this stage size of holding does not exercise important influence.

Variations in utilization of irrigation capacity by farmers with holdings of different sizes were however less important than the difference in utilization between the two areas. What is important to note is that even in regions with a long history of irrigation such as the Kalambandhi villages full utilization, *i.e.*, 100 per cent use of irrigation capacity was not reached. For all practical purposes, therefore, above 90 per cent utilization of irrigation capacity may be termed as full utilization. From this point of view, the non-utilized capacity was glaringly large only for sample families from the Kakrapar region.

The extent of non-utilization of irrigation capacity even regarding the area under irrigation should be considered for all the seasons in order to obtain a complete picture. However, the concept of irrigation capacity becomes vague when

applied to seasons other than monsoon. For the post-monsoon season, besides the commanded area, we have to consider very carefully the quantity of water available. In the year of scanty rainfall, the supply of water in the rainfed rivers dwindles reducing the irrigation capacity; in the year of heavy rainfall the situation is reverse. The need for irrigation varies rather inversely ; in the year of scanty rainfall the need to irrigate the second crop will be over a much larger area and vice versa.

In view of this difficulty we study the extent of double cropped area instead of utilization of the irrigation capacity for seasons other than monsoon. We assume that the extent of double-cropping in the Kalambandhi villages indicates the nearly full use of irrigation capacity. This assumption is rather drastic but not unrealistic. We can then measure the extent of non-utilization in the other villages by comparison with the Kalambandhi villages.

TABLE IV

	Percentage of Double cropped Area to Net Sown Area
Meshwa Canal Region	
Kalambandhi villages	51.3
Non-Kalambandhi villages	20.6
Kakrapar Canal Region	4.0

The comparison of the non-Kalambandhi villages and the villages of the Kakrapar canal region with the villages in the Kalambandhi area brings out clearly the extent of non-utilization of irrigation capacity in seasons other than monsoon. From personal knowledge of the region and the interviews with irrigation officers we also know that during the years under study, the supply of irrigation water was in excess of the actual demand during winter and summer seasons in the non-Kalambandhi villages and the Kakrapar canal region. In both these areas there was uncertainty regarding the quantity of water that would be supplied in the post-monsoon season.

Here again we are able to observe that inter-regional difference in the utilization of irrigation capacity was more glaring rather than the difference between the farmers with different sizes of cultivated holdings. For instance, farmers with holdings upto 5 acres of land double-cropped 66.7 per cent of their net sown area, as against 49.8 per cent of the net sown area by the farmers with holdings of 5 acres or more in the Kalambandhi villages. In the non-Kalambandhi villages the respective percentages were 29.3 and 18.3. It is interesting to note that in so far as the use of irrigation capacity in terms of area irrigated in post-monsoon seasons is concerned, the small farmers have a relatively better record of achievement.

In so far as extensive use of irrigation (in terms of area under irrigation) is concerned, we may conclude at this stage that Kalambandhi villages, where

irrigation water has been in use for decades, make near-full utilization of irrigation capacity. Of the two regions that benefited by irrigation recently, the non-Kalambandhi villages of the Meshwa canal region used near-full capacity of irrigation facilities during the monsoon; however, they had a large unutilized irrigation capacity during winter and summer seasons. In the Kakrapar canal villages the irrigation capacity was unutilized to a large extent even in the monsoon season and much more so in the other seasons. So far as the use of irrigation capacity on individual farms was concerned, size of holding was not a major factor of influence. However, in regard to the decision whether to avail of irrigation facility at all, the size of holding was a major influence as seen in the Kakrapar region.

Reasons for Non-utilization of Irrigation Capacity

Since the regional differences in utilization of irrigation are important, our analysis has to be on regional basis. We take up first the Kakrapar region which provides, of all the three, the worst case of non-utilization of irrigation capacity. For the purpose of ascertaining the reasons we have relied on the answers of the farmers (in the sample) to the questions included in the schedule canvassed for the purpose.

In the Kakrapar region we canvassed two questions : (*i*) why did farmers not avail of the irrigation facilities and (*ii*) why did they avail of the irrigation water only partially? Question one was canvassed with those who did not use irrigation water, question two was canvassed with those who did not irrigate the entire irrigable area. Table V summarises their replies.

TABLE V—REASONS FOR PARTIAL OR NO IRRIGATION AS INDICATED BY THE SAMPLE FAMILIES IN THE KAKRAPAR CANAL REGION

Reasons	Number of Reporting Families						Families with holdings less than 5 acres and no irrigation	
	Partial Irrigation		No Irrigation		Total			
Absence of field channels	51	(73.9)	14	(37.9)	65	(61.3)	11	(47.9)
Unsuitability of land	10	(14.4)	20	(54.0)	30	(28.3)	12	(52.1)
Others	8	(11.7)	3	(8.1)	11	(10.4)	—	
Total	69	(100)	37	(100)	106	(100)	23	(100)

Figures in brackets denote percentages.

Two distinct groups of farmers can be observed : (*i*) those who faced the problem of field channels and (*ii*) those who found land unsuitable for irrigation. Digging field channels involves a combination of technical, social and economic problems. To illustrate, canals do not always run at a high enough level which would enable to supply water through gravitation force only to all the farms on either bank. There are some farms at a level above that of the canal. Lifting

water to irrigate elevated farms is a laborious and expensive proposition. Besides, farmers require some investment for digging field channels and more than that some technical guidance. In spite of this, the problem of digging field channels has not deterred farmers from availing of canal irrigation water.

The total refusal of irrigation water was mostly due to the lack of suitable land. The black cotton soil, it is believed by farmers, is not quite suitable for irrigation since its water holding capacity is very low and in this they are not absolutely without the support of technical opinion.[5]

The Bardoli region receives rainfall of about 60″ to 65″ annually which may be considered ordinarily more than sufficient for the crops grown. This however was not an important reason for total refusal of irrigation water. However it was the sole reason for the occasional non-use of irrigation water. Of 69 families using irrigation water, 49 farmers used irrigation water only for 2 out of 3 years studied and all of them replied that the rainfall was more than enough in the year in which they refused water.

It would seem from the above analysis that the absence of field channels was the most important reason for the unutilized capacity especially when the partial irrigation is considered. What is puzzling in the above analysis is that the absence of field channels is a major reason for partial irrigation, but not so important for 'non-irrigation'. We have already observed earlier that the size of holding is a major factor for 'non-irrigation'. This would imply that the small farmers faced financial difficulty which prevented them from investing in the field channels. But Table V shows that for 'non-irrigation', unsuitability of land was a major reason and not the absence of field channels. It is difficult to believe that most of the small farmers have unsuitable land. In fact more than 52 per cent of small farmers reported unsuitable land as a major reason for not irrigating even a part of their holdings. Besides, it is pertinent to observe that whereas the absence of field channels proved a major obstacle in the Kakrapar region, it did not prove a problem at all in the non-Kalambandhi villages where too irrigation was availed of recently—not more than five years had elapsed since the availability of irrigation.

Since in the Meshwa canal region in the *Kharif* season near-full capacity was used, the farmers were asked a question regarding only adequacy of water supply, to which 26 out of 27 families using irrigation in the Kalambandhi villages replied that water supply was inadequate. Against this, in the non-Kalambandhi villages, only 13 (52 per cent) out of 25 families with irrigation reported inadequacy of irrigation water. These replies represent a condition of the demand exceeding the supply in the Kalambandhi villages where growing of *Rabi* crops was strongly favoured; in fact, *Rabi* crops already occupied an important place in the crop pattern of these villages. In the non-Kalambandhi villages where water supply was less regular and less certain, the horizon of the farmers was limited to *Kharif* crops and the demand-supply disparity as revealed through their answers regarding adequacy of the water supply was relatively less.

5. Report of the Indian Irrigation Commission, 1901-03, Part I—General, Government of India, Calcutta, 1903, p. 5.

Supplementary Irrigation

To ascertain the attitude of farmers to irrigation farming, two more questions were asked: (*i*) Between perennial and supplementary irrigation what was preferred by them and (*ii*) was irrigation expensive? Answers to these questions reveal some additional reasons for the existence of unused irrigation capacity.

In response to the first question, only 19 per cent of the farmers in the sample from the Kalambandhi villages indicated their preference for perennial irrigation; in non-Kalambandhi villages all the farmers in the sample were in favour of supplementary irrigation. This would mean that the economic horizon of the farmers in the recently irrigated area seems to be limited, unless there were some strong technical reasons against perennial irrigation in the non-Kalambandhi villages. Field investigations revealed no such technological barrier to perennial irrigation in these villages.

The answers in response to the second question further support the view of 'limited economic horizon'. Whereas in the Kalambandhi villages only 26 per cent of farmers believed irrigation to be expensive, in the non-Kalambandhi villages 89 per cent of farmers considered irrigation a costly pursuit. The remaining 11 per cent in the non-Kalambandhi villages could not give a specific answer, while 41 per cent of farmers from the Kalambandhi villages definitely expressed irrigation water as *not an expensive resource*. Limited economic horizon and the view that considers irrigation expensive, would easily lead to non-utilization of irrigation water. Whether this was a mere psychological problem or one borne out of some economic experiences would of course need further investigation.

In the Kakrapar canal region the position was reverse. Growing of sugarcane, fruits and vegetables was known though not widely. Besides monsoon rain was sufficient in many years for the *Rabi* crop of *wal* if not wheat. In this region farmers therefore favoured perennial irrigation. Out of 69 farmers using irrigation 33 (47.82 per cent) showed preference for perennial irrigation. We shall see later that the excess capacity in the Kakrapar canal region is to be explained in terms other than limited economic horizon.

II

INTENSIVE USE OF IRRIGATION WATER

We shall now study the intensive use of irrigation. By intensive use of irrigation we imply combining other inputs with irrigation water to an extent which maximizes output per irrigated acre with given irrigation charges and prices of other inputs. Whereas with some knowledge of irrigation, farmers easily take to extensive use of irrigation, the intensive utilization of irrigative water is a gradual process and result from a great deal of rural extension work.

Intensive use of irrigation water can be examined on two scores : one, substitution of lower per-acre-value crops by those with higher per-acre-value ; and two, increased physical yields per acre. On both these scores, we shall find that newly irrigated area do not have an impressive record.

Crop Pattern Changes Subsequent to Irrigation

The following two tables give the details of crop pattern changes. Table VI relating to the Kakrapar canal region gives comparison of the area under different crops for families using irrigation and families not using irrigation. Table VII gives crop data for Kalambandhi, non-Kalambandhi and control villages of the Meshwa canal region.

TABLE VI—CROPS GROWN BY SAMPLE FAMILIES IN THE KAKRAPAR VILLAGES IN 1955-56

Crops	Families not using irrigation water	Families using irrigation water	All Families
	(Percentage to gross cropped area)		
Paddy	10.62	19.36	17.70
Cotton	52.17	43.82	45.41
Jowar	12.07	8.49	9.26
Sugarcane	—	0.22	0.20
Wheat	1.48	0.16	0.38
Fodder	14.49	13.02	13.21
Wal	5.79	11.43	10.36
Vegetables	—	0.79	0.64
Others	3.38	2.71	2.84
Total gross cropped area (acres and gunthas) ..	206-24	883-02	1089-26
Double-cropped area (acres and gunthas)	4-13	46-35	51-8
Per cent of double-cropped to gross-cropped area..	1.98	5.21	4.64

TABLE VII—CROPS GROWN IN 1954-55 BY SAMPLE FAMILIES IN THE MESHWA CANAL VILLAGES AND CONTROL VILLAGES OF THE MESHWA CANAL REGION

Crops	Kalam-bandhi villages	Non-Kalam-bandhi villages	Control villages
	(Percentage to gross cropped area)		
Paddy	48.7	63.1	17.3
Jowar (fodder)	5.7	10.1	9.1
Bajri	3.3	4.7	22.8
Pulses	0.3	1.0	5.7
Cotton	3.8	3.7	14.2
Oilseeds	—	—	9.1
Kodara	—	—	8.6
Bavato	—	—	7.6
Tobacco	—	—	5.6
Wheat	38.2	17.4	—
Total gross cropped area	100	100	100
(Acres and gunthas)	(418-32)	(297-32)	(136-27)

In the Kakrapar canal region the crop pattern of farmers using irrigation water does not materially differ from that of farmers not using irrigation water. Only a small beginning seems to have been made in regard to sugarcane and vegetables. Paddy and *wal* (a type of pulse) were grown relatively to a larger extent on irrigated land. This shift to paddy was mainly from the area under *Jowar* and cotton and to some extent from fodder. Comparison of crop patterns in the three groups of villages in the Meshwa canal region suggests, in the first place, that irrigation leads to more specialization in cropping, especially when irrigation is introduced in the areas of low and uncertain rain. Diversification of crops is supposed to provide a measure of security in absence of irrigation. In control villages the number of crops grown was much larger. Both in the Kalambandhi and the non-Kalambandhi villages only few crops were grown, the inferior cereals and cotton were substituted by paddy. If we confine our analysis to *Kharif* crops we find that paddy occupied an equally important place in the Kalambandhi and the non-Kalambandhi villages with 78.4 per cent and 76.4 per cent respectively of area cropped in the *Kharif* season in the two groups of villages. Wheat was an important second crop. However, not even a beginning has been made regarding sugarcane, vegetables and fruits.

Farmers in both the regions were asked a question as to why they did not take to sugarcane and vegetables and fruits. In the Kakrapar canal region 46 farmers (*i.e.*, 66.66 per cent) out of the total 69 farmers using irrigation water replied that the reason was absence of perennial water supply.

In the Meshwa canal region farmers advanced the following reasons for not growing sugarcane and other heavy duty crops.[6]

TABLE VIII

	Kalam-bandhi villages	Non-Kalam-bandhi villages
	(Number of reporting farmers)	
Absence of perennial water supply	—	1 (3.9)
Unsuitability of land	15 (55.6)	24 (85.1)
Lack of knowledge	9 (33.3)	2 (7.1)
Others	3 (11.1)	1 (3.9)
Total	27 (100)	28 (100)

Figures in brackets denote percentages.

Though unsuitability of land was a more important reason than inadequacy of water supply for the absence of heavy duty crops for both the groups of villages, in the Kalambandhi villages with favourable position of irrigation water supply and long history of irrigation, a substantial number of farmers (about 33 per cent of farmers using irrigation water) indicated a desire to accept the new idea for heavy duty crops if required technical knowledge was made available to them.

6. Heavy duty crops are crops requiring large amount of irrigation water per acre.

In the Kakrapar canal region even before canal irrigation became available banana, *chikkoo* and other fruits and vegetables were grown with well water. The knowledge about these crops was already there but perennial supply of water was not forth coming. Probably it is this desire of farmers to extend cultivation of heavy duty crops which is reflected in the replies of the farmers when 85.5 per cent of farmers using irrigation replied that the supply of water was inadequate for perennial crops.

From the above analysis and the analysis given earlier, we face an apparently conflicting situation. The conflict arises because it seems there is a large potential demand for irrigation, though in fact the available irrigation water is not fully utilized. Again, the low income farmers do not consider their financial inability to invest but the unsuitability of land as the major cause for not availing of the irrigation water and the analysis would show that to a large extent only the small farmers are left out from irrigation. One probable explanation that may resolve the above riddle is that in this region of long staple cotton, farmers probably consider substitution of cotton by paddy uneconomical though they would certainly take to such irrigated crops as sugarcane more willingly, the latter being distinctly paying. The excess capacity of irrigation in this region is then the result of the process of profit maximization with the given constraint of the irrigation water being available mainly within the monsoon and immediate post-monsoon period. Even the decision of the majority of small farmers not to irrigate their lands arises from the unattractiveness of paddy and wheat as substitutes for cotton.[7] For small farmers especially paddy as substitute for *jowar* may not be a working proposition since that would interrupt their rotation programme. Loss sustained in cotton yields due to inadequate rotation can be made good only by irrigation and more intensive manuring which small farmers may not be able to undertake.[8]

Yields per Acre

We shall analyse here the physical yields per acre for different crops. Table IX gives the data for the two regions.

TABLE IX—YIELDS PER ACRE (in lbs.)

Crop	Meshwa Canal Region			Kakrapar Villages		
	Kalam-bandhi villages	Non-Kalam-bandhi villages	Control villages	Families without irrigation	Families with irrigation	All Families
Paddy	1,520	1,312	884	944	1,200	1,164
Wheat	200	274	—	—	—	
Cotton (Pods)	604	112	208	272	308	280
Bajri	240	220	520	—	—	
Jowar	—	—	—	268	311	300
Sugarcane (Cane) ..	—	—	—	—	—	8,800

7. Of late even in paddy growing regions of the Surat district cotton has encroached on paddy.
8. We may recall at this stage that in the Meshwa canal region most of the farmers preferred supplementary irrigation to perennial irrigation.

Paddy is an important crop and its yield responds much better to irrigation. Both in the non-Kalambandhi villages and the Kakrapar region, per-acre yield of paddy were fairly above those in the control villages but were below those in the Kalambandhi villages, the villages where irrigation had a long history behind. Irrigation water was in use for about five years in the non-Kalambandhi villages and for more than 3 years in the villages of the Kakrapar region. Larger wheat yields in the non-Kalambandhi villages compared well with those in the Kalambandhi villages and larger *bajri* yields in the control villages compared well with those in both the Kalambandhi and the non-Kalambandhi villages; this may be explained either in terms of better lands or better treatment. Wheat in the non-Kalambandhi villages accounted for only 17.4 per cent of gross cropped area as compared to 38.2 per cent of gross cropped area in the Kalambandhi villages. It is likely that relatively better lands were under wheat crops in the non-Kalambandhi villages where only a small proportion of area was brought under wheat crop.

Bajri was the most important single crop in the control villages. Farmers therefore could pay relatively more attention to it. Besides, in both the Kalambandhi and the non-Kalambandhi villages, *bajri* occupied less than 5 per cent (3.3 per cent and 4.7 per cent respectively) of the gross cropped area. Being unimportant and unirrigated and low-value crop, only the undulated and inferior land which would otherwise lie fallow was devoted to *bajri* crop in irrigation villages. Hence the yield per acre of *bajri* was low in these villages.

It is pertinent to note that in the Kakrapar villages yields of crops for farms with canal irrigation were higher by about 8 per cent (cotton) to 33 per cent (paddy), but they were much below the expected level.

Manuring

One of the major factors influencing yields per acre and hence intensive utilization of irrigation water is the use of manures. It was observed that relatively smaller quantity of manure was applied in the newly irrigated regions especially when we consider the commercial manures like fertilizers and oilcakes.

Area Manured

In regard to the area manured, there seems to prevail a tendency to manure half of the cropped area in all the villages, only non-Kalambandhi villages were exceptions to this.

TABLE X—AREA MANURED AS PERCENTAGE TO AREA CROPPED FOR SAMPLE FAMILIES

Villages/Region	Families		
	With irrigation on less than 75 per cent of area	With irrigation on more than 75 per cent of area	All
Meshwa Canal Region			
Kalambandhi villages	35.6	52.1	46.3
Non-Kalambandhi villages ..	19.4	28.7	25.10
Control villages	—	—	52.13
	Without irrigation	With irrigation	
Kakrapar Canal Region	43.1	53.0	50.71

What is important to note is the fact that between the farmers using irrigation and not using irrigation, the former manured larger part of their holding ; so also between the farmers having more than 75 per cent of land under irrigation and those with area smaller than that under irrigation, once again the former had larger proportion of area manured. This suggests that irrigation and manuring have high complementarity. The smaller percentage of area under manure in the non-Kalambandhi villages compared to control villages, is then more puzzling especially when we note later that the per-acre input of soil nutrients (especially nitrogen) was much larger in the non-Kalambandhi villages.

Type and Levels of Manures Used

The distinction between the advanced and the advancing villages and families using irrigation water and those not using irrigation water can be observed in regard to types and levels of manures applied.

TABLE XI—TYPES OF MANURES APPLIED

	Meshwa Canal Region		Kakrapar Villages		
	Kalam-bandhi villages	Non-Kalam-bandhi villages	Without irriga-tion	With irriga-tion	All Families
	All Families	All Families			
	(Percentage to Total Nitrogen Content)				
Farmyard manure	78.41	93.40	100.00	93.34	94.21
Ammonium sulphate	1.58	3.10	—	4.48	3.83
Oilcakes	19.21	1.99	—	1.86	1.61
Manure mixture	0.80	1.51	—	0.32	0.29
Total (per cent)	100	100	100	100	100
Total (lbs.) of nitrogen content	5058	3867	1158	7675	8833
All manures per acre of paddy (lbs. of nitrogen content)	50.58	94.31	82.71	47.37	50.18
Manures per acre of paddy excluding farmyard manure (lbs. of nitrogen content)	11.22	6.22	nil	3.15	2.91

Following observations emerge from the above table :

(*i*) Farmyard manure predominated even as a source of nitrogen in all the regions including the Kalambandhi villages which had irrigation water in use for a very long time.

(*ii*) Oilcakes made a major headway only in the Kalambandhi villages.

(*iii*) Chemical fertilizers (especially ammonium sulphate) were used by families with irrigation in the Kakrapar region and by families with extensive irrigation in the Meshwa canal irrigation villages.

(*iv*) The Kalambandhi villages relied to a smaller extent on ammonium sulphate than on oilcakes.

(*v*) Families without irrigation relied entirely on farmyard manure for nitrogen. This was true about the control villages as well as the Kakrapar villages. In central villages 99.09 per cent of manured area was covered with farmyard manure only.

(*vi*) Level of manurial dose was almost equal both for the Kalambandhi and the Kakrapar villages. In the non-Kalambandhi villages per-acre quantity of nitrogen was little less than double that for the other two regions.

(*vii*) However, if we consider commercial manures (those other than farmyard manure) we find that for the paddy crop the dose of nitrogen was the biggest in the Kalambandhi villages and the smallest in the Kakrapar villages.

On the whole, thus the predominance of farmyard manure imposed a limit to increases in crop yields which was only marginally overcome in the Kalambandhi villages and to a much smaller extent in other irrigation villages.

Reasons for Smaller Dose of Manure

Questions were canvassed to elicit reasons for low levels of manure application. To the question; "Is the manure supply with you sufficient ?", 81.13 per cent of the total sample families from the Kakrapar region replied negatively. A similar large proportion of 81.48 per cent and 85.71 per cent of the sample families from the Kalambandhi and the non-Kalambandhi villages replied negatively.

There was no major difference in regard to the experience of insufficiency of manure supply between families using irrigation and those not using irrigation in the Kakrapar region. The percentages of families replying negatively to the above mentioned question were 84 and 76 in the two groups respectively.

Farmers replying in affirmative to the question regarding insufficiency of manure supply were further asked the reasons for it. They replied "We cannot afford to buy"; this can be interpreted to mean either they lacked requisite finance at the right time or they found it unprofitable to increase the dose of manure beyond this level. The major reason for low dose of manure—the result of low supplies—according to the families investigated was lack of purchasing capacity. The lack of supplies was the second important reason. The details are given in Table XII.

What is significant to note in Table XII is that those families using irrigation compared to those not using irrigation in the Kakrapar region stressed lack of supply of manures more. This might mean, however, lack of supply of the type of the manure they were used to, *viz.*, the farmyard manure. The practice of green manuring was not observed to any perceptible extent in the villages surveyed.

TABLE XII—REASONS FOR LOW MANURIAL DOSES

	Meshwa Canal Region		Kakrapar Region		
	Kalam-bandhi villages	Non-Kalam-bandhi villages	Families with irrigation	Families without irrigation	All Families
	(Percentage of families to total sample families)				
Lack of purchasing power	55.55	46.42	47.83	62.16	52.83
Lack of supplies	29.62	35.71	40.58	10.81	30.19
Others	15.83	17.87	12.59	27.03	16.98
Total	100	100	100	100	100

III

IMPLICATIONS

There are two major implications of the foregoing analysis of field investigations regarding the use of irrigation water ; one relates to benefit-cost calculations and the other to the problem of size of holding and average productivity of land.

Implications for Benefit-Cost Analysis

Benefit-cost criterion for allocation of investment resources has been subjected to criticism and yet with all its admitted deficiencies continues to be advocated, if not adopted in practice. One major merit of this criterion is that it accepts the basic principle of profit maximization, though profit is more liberally interpreted in a social context when public investment is considered. Often, a plea is made for inclusion of such indirect benefits as balance of payments effects, employment effect and even income-distribution effect to widen the content and meaning of benefit. All these considerations have relevance in the social context.

However, both at theoretical and at empirical level, several deficiencies are found in the application of benefit-cost criterion for the decision regarding the allocation of investment resources. Theoretically it ignores or assumes away the supply function for investment or in fact takes for granted its shape. Empirically, there are innumerable difficulties in measuring the wider (all indirect primary or secondary) benefits (some of which are indicated above) and similar difficulty is experienced regarding measurement of cost.

As we shall show, our analysis has relation to the measurement of benefit and costs and has a theoretical implication too in so far as the assumptions underlying the theory are concerned. Theoretically benefit-cost calculations are required to be *ex-ante*. In practice, however, this being not possible, either the current or the past experiences of other irrigation projects regarding economic data are projected in future and are then considered together with technological data to

arrive at the benefit-cost relation for the proposed irrigation projects. To illustrate, the direct primary benefit will be calculated by taking the difference between the physical yields on dry and irrigated land and an allowance is made for the change in the crop-pattern both on the basis of the experience of dry and irrigated areas in the same or comparable regions.

However, if the relative benefit generating capacity of a given unit of investment is comparable for different projects, whatever the economic and technological data, the present method of measuring benefit would be flawless. Our analysis indicates that the assumption of comparability of experiences of the past and the proposed projects is contrary to reality.

The crop-pattern changes and increase in yields consequent on introduction of irrigation vary as our analysis indicates from project to project and these inter-project variations in the crop-pattern changes and yields would depend on the willingness and the capacity of farmers to adjust to the required change and the profitability of such adjustments. We found, for instance, in the non-Kalambandhi villages the change in the crop-pattern was easy and relatively quick. In a period of less than five years, these villages took on the pattern comparable to that prevailing in the Kalambandhi villages which have a long history of irrigation. Against this, in the Kakrapar villages, the crop-pattern between families using irrigation and those without canal irrigation facilities did not perceptibly differ, except for a small beginning in sugarcane cultivation.

As we saw earlier, this lag in crop-pattern changes was partly due to the variations in irrigation water supply and partly due to the deliberate preference of farmers for some of the traditional crops.

Whether ultimately, after a lapse of a sufficiently long period, the crop pattern in newly irrigated area will conform to that in the area with settled irrigation practices, is purely a matter of guess. What is important to note is that a significantly long period elapses between the introduction of irrigation water and the full evolution of the crop pattern similar to that available in the areas of settled irrigation practices. This gestation period is distinctly different from the technical gestation period accounted for mainly by the time taken for construction of the dam and main canals. This economic gestation would vary from project to project inasmuch as the economic backgrounds of different regions would differ and more significantly so in underdeveloped economies.

The above observation applies with more vigour in regard to per-acre physical yields. As we have already observed, the main contributory factor—the manure—was used at varying levels, even the types of manures applied differed and in regard to the latter probably the farmer's preference might have emerged from his acquaintances with a particular type of manure. To recall, the farmers in the Kalambandhi villages relied relatively more on oilcakes for nitrogen supply than on chemical fertilizers.

Size of Holdings and Yields

Almost all the farm management surveys in 1954-55 farm management series and other individual village surveys and cost studies, indicate inverse re-

lationship between crop yields per acre and size of holding measured in acres of surface area. The detailed data for individual villages also support this conclusion. Though no conclusion can be drawn regarding the returns to scale from the observation, it is suggested at least that the small farmers, even though they are short of capital do not seem to use land less efficiently. These farmers compensate the capital deficiency by utilizing intensively the abundant labour they have. This picture does not seem to hold when we introduce irrigation as a new resource.. Higher yields for irrigation are obtained not by use of water alone. For fuller utilization of irrigation water, in fact, complementary capital resources have to be employed in adequate proportions. We have found that the potential of irrigation was not fully utilized in newly irrigated regions. This was so because the small and the medium farmers did not seem to be able to make good this deficiency by more intensive use of labour.[9]

Severe rationing in regard to funds to buy manures for small farmers is illustrated by Table XIII.

TABLE XIII—KAKRAPAR REGION—OBSTACLES TO EXTENDING USE OF MANURES

Obstacles	Size of Holding		
	0.1 to 5 acres	5 acres to 15 acres	Above 15 acres
	(Percentage to total families in the group)		
Supply not available	11.9	27.5	66.7
Could not afford to buy	66.7	57.5	20.8
Others	21.4	15.0	12.5
Total	100	100	100

As shown by Table XIV the non-Kalambandhi villages and the Kalambandhi villages reveal a similar experience. The table gives the details of sources of nitrogen supply according to the size of holding.

TABLE XIV—RELATIVE IMPORTANCE OF SOURCES OF NITROGEN SUPPLY

(Per cent)

Sources	Kalambandhi villages		Non-Kalambandhi villages	
	0.1 to 5 acres	Above 5 acres	0.1 to 5 acres	Above 5 acres
Farmyard manure	81.19	77.82	100	91.67
Oilcakes	18.45	19.02	—	2.51
Manure Mixture	0.36	1.39	—	1.91
Ammonium Sulphate	—	1.77	—	3.91
Total	100	100	100	100

9. The actual examination of yield data suggested for irrigated crops slightly larger yields for medium and big farms than for small farms for all the groups of villages with the exception of wheat in the non-Kalambandhi villages.

The table clearly brings out that the small farmers in newly irrigated regions rely entirely on farmyard manure for nitrogen supply for manuring. Only in the Kalambandhi villages, the small farmer obtained nitrogen though to a smaller extent compared to larger farmers, from sources other than farmyard manure. The reason for this can be lack of funds, the external capital rationing in general, and more so for small farmers in newly irrigated areas. Only when incomes rise, and hence own savings expand, farmers can afford to use improved manures and also undertake the risk accompanying it. It is probably this capital rationing which would explain larger average size of holdings in the Kalambandhi villages. Even in the sample we had only 7 holdings out of 30 below 5 acres in the Kalambandhi villages as against 15 below 5 acres out of a total of 30 holdings in the non-Kalambandhi villages.

Other things remaining the same, the type of the capital rationing indicated above, would imply an extent of increasing returns to scale too.

Better yields on bigger farms for irrigated regions or for irrigated crops (and also increasing return to scale) would imply a need for State policy to foster expansion of the size of holding. Alternately, the State has to increase the flow of funds for which it must relax its restraints on private and/or institutional lendings, especially by the co-operative societies. It may however be noted that in almost all the villages investigated there were co-operative lending facilities.

CONCLUSIONS

There is an excess capacity in irrigation ; this exists even in areas with long irrigation history. For newly irrigated areas, the excess is substantial. The excess is measured ordinarily in terms of area under irrigation. In this regard, for monsoon crops, the excess capacity is found to vary from year to year owing to variations in rainfall. For *rabi* crops, the real reason for the variation in excess capacity would be firstly, the nature of irrigation water supply (whether it is regular and certain, and perennial or supplementary) ; secondly, the willingness and the capacity of farmers to fully utilize the supply of irrigation water; and thirdly the profitability of substitution of irrigated crops for dry or lightly irrigated crops at prevailing relative prices of crops. There are a few farmers who are psychologically averse to any major change in their farming practices, but for most of the farmers it is the lack of capacity to effect the change or the non-availability of the complementary resources that prevents them from taking to new methods of cultivation and new crops. In particular, the shortage of investment funds available with farmers is noteworthy. It is due to this that the full potential of irrigation water is not realized ; crop yields per acre especially in newly irrigated areas still tend to be lower than what could be obtained with similar irrigation facilities.

Two major implications of the study are : (*a*) the economic gestation period —the period of adjustment before full potential of irrigation water is realized— tends to be different for different areas. This means that no uniform formula for benefit-cost measurement would be valid for two projects to be alternatively

located in two different regions, much less can the past experience be applied without adjustment to proposed projects, (*b*) among other factors, lack of funds for investment in complementary resources (the external capital rationing) is responsible for under-utilization of irrigation by small farmers. Other things being the same, this would mean the State policy should foster expansion of holdings or relax restraints on its lending policy through institutional agencies like co-operatives.