ECONOMICS OF IRRIGATION IN WATER-SCARCE REGIONS : A STUDY OF MAHARASHTRA

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PREFACE

The Gokhale Institute has a long standing interest in the economics of irrigation. The first study into the benefits of irrigation in India, in the Godavari and Pravara Canal areas, was carried out by (late) Prof. D.R. Gadgil in the Institute in 1938-40. Again, the first study in India into Cost-benefit analysis of a newly proposed multipurpose river dam project, at Hirakud on the river Mahanadi in Orissa, was undertaken in the Institute during 1954-58, by Prof. N.V. Sovani and N. Rath. The scholars in the Institute had also been associated with various other enquiries relating to irrigation in the State in later years. In more recent years, there was a growing feeling that there had been some basic change in the socio-economic conditions underlying irrigation in the drought prone, water-scarce regions of the Deccan, and a fresh look at the problem was necessary.

This study has its origin in the many discussions the then Director of the Institute, Prof. V.M. Dandekar and Prof. N. Rath had with the then member of the Central Water Commission (late) Shri C.V. Gole. The Institute proposed this study and the CWC approved it and agreed to finance it. Soon after the proposal was approved, Shri Gole retired and after a brief service abroad, suddenly expired. We would like to pay our tribute to his memory for his deep and persistent interest in not only the technical but also the

economic aspects of irrigation in India, which encouraged the Institute to propose this study to the CWC.

The study had an advisory committee whose members changed over the years. In course of our work we received considerable help and advice from Dr. A.B. Joshi, the then Vice-Chancellor of the Mahatma Phule Krishi Vidyapeeth and his successor Dr. D.K. Salunkhe. They made it easy for us to discuss the agronomic points with the faculty of the University, and the Professor of Agronomy made some of his research results available to us. We are thankful to all of them.

Shri V.R. Deuskar, the then Secretary of the Department of Irrigation and a veteran irrigation engineer, was not only a member of the Advisory Committee, but also took personal interest in the study, and arranged for us, students of economics, to become familiar with the technicalities and administrative arrangement of distribution of canal water. Our thanks are due to him.

Shri M.A. Chitale, who succeeded Shri Deuskar on the Advisory Committee, and is now the Chairman of the CWC, has been one of our most perceptive Advisors. He has helped us with a seasoned irrigation engineer's perception of the problem, and made many valuable suggestions on our draft chapters. We wish to record our personal gratitude to him.

Shri M.G. Padhye, who preceded Shri Chitale as Chairman, CWC, had read the second and parts of the third chapter and made useful comments and suggestions.

The succeeding Chief Engineers of Irrigation, Pune Division, and the Executive Engineers, Nira and Pravara Irrigation Systems, as well the concerned Section Officers of the canals, readily made all information available to us, and helped in a variety of other ways. Our thanks are due to them.

By the time our survey was under way, we came in contact with Shri H.V. Dhamdhere, (the then) Director of the Water and Land Management Institute (set up by the Government of Maharashtra) at Aurangabad, and his colleagues in the faculty. This continuing contact has been of abiding benefit to us. Not only have we discussed various aspects of our study with Shri Dhamdhere and Prof. S.B. Varade, Professor of Agronomy in the Institute, but they have gone through the draft report and made many useful suggestions, particularly on technical matters, which we have been able to incorporate in this study. Our mutual discussions resulted in one of us taking up a part of a study relating to the Mula canal system which WALMI was then undertaking at the behest of CWC.

Another senior engineer who has gone through the draft report, and also discussed with us the nature and requirements of the Rotational Water Supply System and the crop pattern requirements, is Shri S.N. Lele, the then Administrator,

Command Area Development Authority, Ahmednagar. We have learnt a lot from him, and we wish to record our deep appreciation of his help and advice.

We also record our thanks to the Economic and Statistical Adviser to the Ministry of Agriculture, Government of India, for permitting the Institute to copy out the detailed annual data relating to the crop costs and returns, based on the cost of production survey in Maharashtra every year since 1972-73. It placed valuable data of a type that it would not have been possible to collect in a single year, at our disposal.

It is not customary to thank colleagues in the Institute for all the help and assistance received. But we record our special thanks to Shri D.B. Sardesai for programming the tabulation and analysis of our voluminous data, and Shri S.M. Kulkarni for typing the report unhesitatingly, under pressure.

Needless to say that we alone are responsible for any errors that may remain.

This study owes its origin to the support of the Central Water Commission and we record our sincerest acknowledgement and thanks to the CWC.

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CHAPTER I

THE PROBLEM

1.1 Irrigation is crucial to the development of agriculture in India. It is necessary in order to ensure stability in crop production and fuller exploitation of cultivable land in all seasons. It is also necessary in order to derive and sustain benefits from biological improvements in crops, and technological improvements in cropping.

1.2 However, available estimates of potential total water resource for India as a whole show that it is in short supply compared to the requirements for irrigation.[1] In 1980-81, 49.585 m/ha of crop land, constituting only about 28 per cent of the total crop land (28.61 per cent of the gross cropped area, and 27.66 per cent of the net cropped area) in India was irrigated. The ultimate irrigation potential from all sources, surface and underground, is estimated, in the Seventh Five Year Plan document, to be 113.5 m/ha of gross cropped area. Assuming the 1980-81 intensity of irrigation, this implies that nearly 60.6 per cent of the gross cropped area, or about 63.3 per cent of the net cropped area in the country, can ever be irrigated. (Ref. Table 1.1)

1.3 While the all-India figure highlights the overall inadequacy of water for irrigation, the regional picture shows wide differences in this regard. The state-wise data, in Table 1.1, show that in the states of Assam, West Bengal, Bihar, U.P., Haryana and Punjab, covering the Brahmaputra

valley and the Indo-Gangetic plains, all the net sown area (or almost all of it) can ultimately be provided with irrigation. On the other hand, in the states of Rajasthan, Gujarat, Maharashtra and Karnataka the ultimate potential net irrigated area is expected to be between 25 and 40 per cent of total net sown area and between 30 and 40 per cent of gross cropped area, presuming the existing intensity of cropping on irrigated land. This percentage is only marginally higher for Madhya Pradesh, around 50 per cent. The states of Tamil Nadu, Andhra Pradesh and Orissa show a still higher percentage, between 60 and 70 per cent. But if the coastal plains of these three states, including the large river deltas, are separated, because of near 100 per cent ultimate irrigation potentiality there (the data are not separately available), then the remaining areas of these states lying in the upland plateau region, would also show percentages similar to those of Karnataka, Maharashtra and Gujarat. The entire plateau region (including the arid regions of Rajasthan) is characterised by rather low and uncertain rainfall, and poorer and more uncertain underground sources of water. In fact, between 40 and 45 per cent of the ultimate irrigation potential in these regions is expected to be from minor irrigation sources, mainly from underground, which are known to be more uncertain, and often with poor discharge capacity. The long term perspective of agricultural development in these regions, therefore, acquires a different and more serious dimension. It is obvious that the use of water in these regions has to be most economical if agriculture is to develop and sustain the vast

multitudes dependent on it.

1.4 The position and potentiality of irrigation in the State of Maharashtra well illustrates the problem. In Table 1.2 are given data about the present (i.e.,1982) position of irrigation and the ultimate potential from all state-sector sources of flow irrigation (major, medium and minor), districtwise[2]. The percentage figures in the last column show that except the eastern most districts of Bhandara and Chandrapur (including Gadchiroli) and Nagpur, the coastal districts, and the district of Kolhapur, only about 40 per cent or less of the net sown area in the other districts can ever be irrigated. The per cent is 30 or less in 6 of the nine districts of western Maharashtra, in 4 of the five districts of Marathwada, and in the three western-most districts of the Vidarbha region.

1.5 The ultimate irrigation potential in Table 1.1 and 1.2 is calculated on the basis of existing pattern of use of water for different crops, and the existing intensities of irrigation. Therefore, expressed in terms of net or gross cropped area, the figures cannot say anything clearly about the comparable availability of water for irrigation in the different districts. To make such a comparable statement, the Irrigation Department of the State Government has expressed the ultimate irrigation potential in every district in terms of "Rabi Jowar equivalent". It means the number of hectares of Rabi Jowar that can be ultimately irrigated with the quantity of water that is likely to be available in the district from the various flow irriga-

Table 1.1 : Present (1980-81) and Ultimate Potential (major and minor sources) Irrigated area (gross and net) as percentages of net and gross sown area

State	1980-81		Ultimate Potential	
	Net Irrig. Area as % of Net Sown area	Gross Irrig. Area as % of Gross cropped area	Net Irrg. area as % of Net sown area	Gross Irrig. Area as % of Gross cropped area
(1)	(2)	(3)	(4)	(5)
Andhra Pradesh	32.24	35.36	68.31	69.35
Assam	21.54	16.60	100.00*	77.48
Bihar	35.51	32.58	100.00*	100.00*
Gujarat	20.92	21.82	42.56	43.03
Haryana	59.24	60.58	81.45	77.08
Himachal Pradesh	16.08	16.49	34.62	32.88
Jammu & Kashmir	42.52	40.25	86.43	74.91
Karnataka	13.75	15.72	37.88	41.09
Kerala	10.92	13.31	60.18	59.88
Madhya Pradesh	12.47	11.46	51.85	46.82
Maharashtra	10.53	12.41	30.55	34.12
Orissa	19.82	19.56	68.35	59.24
Punjab	80.70	85.48	91.43	92.49
Rajasthan	19.54	21.61	26.84	29.20
Tamil Nadu	47.95	50.92	56.77	59.07
Uttar Pradesh	54.89	46.27	100.00*	95.22
West Bengal	26.76	20.22	100.00*	78.60
India	27.66	28.61	63.23	60.62

* indicates that the percentage is more than 100.

Source : Data relating to 1980-81 are taken from Indian Agriculture in Brief, 20th edition, (New Delhi : Ministry of Agriculture and Rural Development), Table 2.6, and the Ultimate Potential data are taken from Seventh Five Year Plan, 1985-90, Vol. II, Annexures 3-2 and 3-6.

(Footnote: See next page)

Footnote to Table 1.1

Method of calculation of Ultimate potential Percentages:

The method of calculation for every State is along the lines illustrated for all India in the following :

Present (1980-81) and Ultimate Potential Irrigated area (gross and net), as proportion of the estimated total crop area (gross and net) in India.

1.	Gross Cropped Area	(1980-81)	173.324 (M/ha)
2.	Net Cropped Area	"	140.270 (M/ha)
3.	Gross Irrigated Area		49.585 (M/ha)
4.	Net Irrigated Area		38.805 (M/ha)
5.	(3) as per cent of (1)		28.61%
6.	(4) as per cent of (2)		27.66%
7.	(4) as per cent of (3)		78.26%
8.	Ultimate Potential Irrigated Area (gross)		113.5 (M/ha)
9.	(8) minus (3)		63.915 (M/ha)
10.	Net irrigated area out of the additional gross irrigated area (9) x (7)		50.020 (M/ha)
11.	Ultimate potential net irrigated area : (4) plus (10)		80.825 (M/ha)
12.	Ultimate potential gross cropped area (1) plus ((9) minus (10))		187.219 (M/ha)
13.	Potential gross Irrigated area as per cent of total gross cropped area		60.6%
14.	Potential net Irrigated area as per cent of total net cropped area		63.23%

Note : In estimating potential net and gross cropped area as well as net irrigated area; the existing, i.e. 1980-81 relations of these have been used to estimate the future potential. If a greater intensity of cropping on irrigated land is visualised for the future, the percentage in rows 13 and 14 would be smaller than what is estimated in the table.

Table 1.2 : Present (1982) and additional potential irrigated cropped area in Maharashtra from State Sector Surface Irrigation Sources

(Area: in '000 ha.)

District	Irrigation Potential Created (Upto June 1982)	Additional Potential Irrigated Crop Area	Total (2+3)	Total Irrigated Area as % of Net Sown Area (1978-79)
(1)	(2)	(3)	(4)	(5)
1. Greater Bombay	-	-	-	-
2. Thane	8.39	129.83	138.22	52.14
3. Raigarh	23.32	138.21	161.53	82.50
4. Ratnagiri	4.70	139.97	144.67	40.60
KONKAN	36.41	408.01	444.42	54.38
5. Nashik	113.36	68.23	181.59	20.41
6. Dhule	64.55	51.47	116.02	16.46
7. Jalgaon	106.31	232.97	339.28	41.86
8. Ahmednagar	206.56	126.08	332.64	27.38
9. Pune	133.86	77.10	210.96	21.07
10. Satara	97.63	127.77	225.40	38.47
11. Sangli	75.41	115.48	190.89	30.98
12. Solapur	142.61	156.03	298.64	26.26
13. Kolhapur	59.53	192.83	252.36	59.56
WESTERN MAHARASHTRA	999.82	1147.96	2147.78	29.09
14. Aurangabad	101.69	143.23	244.92	20.17
15. Parbhani	135.01	150.52	285.53	28.35
16. Beed	73.23	139.75	212.98	26.31
17. Nanded	87.56	205.87	293.43	40.31
18. Osmanabad	69.96	88.51	158.47	14.21
MARATHWADA	464.45	727.88	1192.33	24.46
19. Buldhana	32.77	65.95	98.72	14.48
20. Akola	43.41	40.25	83.66	10.19
21. Amravati	14.25	119.76	144.01	19.92
22. Yavatmal	40.88	291.22	332.10	38.86
23. Wardha	27.62	155.54	183.16	41.44
24. Nagpur	68.11	261.52	329.63	58.29
25. Bhandara	132.56	325.90	458.46	118.06
26. Chandrapur	79.39	462.13	451.52	78.39
VIDARBHA	438.94	1722.27	2161.21	41.83
MAHARASHTRA	1939.62	4006.12	5945.74	32.59

Source: Col.2 from Table 7.4; Col.3 calculated on the basis of data in Tables 7.4 (Col.2), 7.5 (Col.2) and 7.7 (Cols. 3 & 4); Col.5 is Col.4 expressed as a percentage of data in col.5 of Table 7.3 of the Report of the Fact Finding Committee on Regional Imbalance in Maharashtra, April, 1984. (Bombay: Department of Planning, Government of Maharasht

tion sources in the State sector. These data are presented in Table 1.3, Col. 4, and they are expressed as percentage of net sown area of the district in Col. 6. The data show that if irrigation is provided to only a crop of Rabi Jowar, then the water ultimately available will suffice to irrigate 64 per cent of the net sown area of the State. This underlines the gross inadequacy of water for irrigation in the State as a whole. There are 11 district - five in Western Maharashtra, three in Marathwada, and three in Western Vidarbha - for which this percentage is lower than the State average; in many of these cases it is as low as 30 per cent or less. Since Rabi Jowar requires less irrigation water than other crops, these percentage figures highlight the great relative scarcity of irrigation water in the State in general and in the drought-prone agricultural regions of Western Maharashtra and Marathwada, and the 3 western-most districts of Vidarbha, in particular.

1.6 From the point of view of the social economy, irrigation water is the factor in shortest supply, shorter than land, in the agriculture of most parts of the State, particularly those located in the relatively low rainfall regions that are also drought prone. Under such factor supply situation, elementary economic logic as well as common sense suggest that maximisation of returns from agriculture would imply maximisation of return per unit of the factor in relatively short supply. In this case it should mean maximisation of net return per hectare-meter of irrigation water, and <u>not</u> per hectare of irrigated

Table 1.3 : Present (1982) and additional Potential Irrigated Area in terms of Rabi (Jowar) Equivalent.

(Area: in '000 ha)

District	Irrigation Potential under construction and future	Upto June 1982	Total	Net Sown Area (1978-79)	(4) as % of (5)
	(Rabi Equivalent)				
(1)	(2)	(3)	(4)	(5)	(6)
1. Greater Bombay	-	-	-	6:60	-
2. Thane	261:52	16.90	278.42	265:10	105.40
3. Raigarh	283.60	47.85	331.45	195.80	169:28
4. Ratnagiri	252.24	8:47	260.71	356.30	73:17
KONKAN	797.36	73.22	870.58	817.20	106.53
5. Nashik	113:11	187:93	301.04	889.60	33:84
6. Dhule	94;21	118:15	212:36	705:00	30:12
7. Jalgaon	481:55	219:74	701.29	810.50	86:53
8. Ahmednagar	256.65	420.48	677:13	1214:90	55:74
9. Pune	165.49	287:34	452.83	1001.00	45:24
10. Satara	277.05	211.74	488:79	585.90	83:43
11. Sangli	299.76	195:75	495:51	616:10	80:43
12. Solapur	345:92	316:17	662:09	1137:40	58:21
13. Kolhapur	798.28	246.44	1044.72	423.70	246.57
WESTERN MAHARASHTRA	2837.79	2203.74	5041.53	3784.10	68.28
14. Aurangabad	258.89	183.81	442.70	1214.00	36.47
15. Parbhani	376.35	337.57	713.92	1007.30	70.87
16. Beed	237.07	124.23	361.30	809.50	44.63
17. Nanded	424:43	180.52	604.95	727.90	83:11
18. Osmanabad	144:32	109.18	253.50	1115.00	22:74
MARATHWADA	1441.06	935.31	2376.37	4873.70	48.75
19. Buldhana	130.68	64.93	195.61	681.90	28.69
20. Akola	80:94	87.30	168:24	820.70	20.50
21. Amravati	202:38	24.08	226.46	722:90	31:33
22. Yavatmal	601.82	84:48	686.30	854.60	80:31
23. Wardha	307.20	54:55	361:75	442:00	81.84
24. Nagpur	402.21	104.75	509:96	565:50	90.18
25. Bhandara	420:36	170:98	591:34	388:30	152:29
26. Chandrapur	547:34	93:97	641:31	690.80	92.84
VIDARBHA	2713.90	684.74	3398:64	5166.70	65:78
MAHARASHTRA	7790.11	3897.01	11687.12	18241.70	64.07

Source: Tables 7.5 and 7.6 (Table 7.4 for Col.5) of the Report of the Fact Finding Committee on Regional Imbalance in Maharashtra.

land. The Irrigation Commission (1972) has also acknowledged this logic in regard to the relatively water-short regions. It says:

> "In areas other than those with ample water resources, ... our policy should aim at securing the maximum crop production per unit of water."[3]

1.7 This logic, of course, holds for individual farms as well as for the society as a whole. If an individual farmer is faced with a total quantum of water which is relatively short of what the total irrigable land at his disposal would require, then he must try to maximise returns per unit of water. If sometime one finds farmers behaving in a manner that can be interpreted to suggest as if they are trying to maximise return per hectare of irrigated land, it is most likely that they are individually faced with availability of more water than irrigable land, (possibly because of state policy in regard to supply of canal water), despite the overall regional shortage of water for irrigation.[4]

1.8 The pattern of canal irrigation that has developed in these relatively dry regions of Western Maharashtra over the last century has been quite different from that in many other parts of the country. In the first place, the culturable command area (C.C.A.) under a medium or major flow irrigation project is much larger than the area that is planned to be provided with irrigation water in any year, called the irrigable command area (I.C.A.) The I.C.A. is smaller for two main reasons : (i) The inadequacy of the quantity of water

available in the reservoir, at 75 per cent dependability, and (ii) the pattern of cropping under irrigation envisaged. Most of the flow irrigation projects were conceived essentially as protective irrigation projects, in view of low and uncertain rainfall in the region. It was, however, found early that the feasible cropping pattern under irrigation would not be able to generate enough income and water revenue to make these projects financially viable. The cropping pattern depended on the prevailing crops and culturable practices and the firm possibilities about it including normally expected yields in years of normal rainfall, the prices of various crops, the changes in land lay out and slope necessary for the purpose, and the possibility of raising necessary capital resources, and the possibility of raising necessary capital resources, and the worthwhileness of all these. Originally, these systems were designed to irrigate the seasonal crops, like jowar, bajra, cotton, etc., generally grown under rainfed conditions, in order to protect them from impact of adverse rainfall. The earliest canal system of the region was the Nira Canal System. The experience in this and the later canal systems in the regior was that farmers made poor use of irrigation water except in years of drought. The reason, as M. Viswesvaraya pointed out at that time, was that while these seasonal crops yielded more under irrigated condition, their costs of production under irrigation were also proportionately higher, leaving no more farm business income than under unirrigated condition in a year of

normal rainfall.[5] Because of this disincentive, the sugarcane "block" system, with assurance of water to a block of land for six years at a time, was introduced to persuade the farmers to use irrigation water, since this was the only important crop that could not be grown without irrigation, and was profitable. Entrepreneurs were encouraged to start sugar factories so that the farmers feel encouraged to cultivate sugarcane. This stress on sugarcane in the irrigable command areas of irrigation projects resulted in further shrinking of the originally planned I.C.A.

1.9 There is reason to believe that the underlying agronomic and economic conditions have undergone change in recent years, particularly the last two decades. New crops, new varieties of seeds of the traditional crops, new agronomic practices as well as different market conditions have emerged. This holds out greater possibility of more economic use of water in farming If the current sugarcane-centred pattern of use of canal water needs to be changed on such grounds, the question of sugarcane cultivation may be examined with the help of well-irrigation in the command areas, where wells can recycle the inevitably seeping canal water. Indeed, the Maharashtra Irrigation Commission, reporting in 1962, that is, even before the new seeds and crops had been introduced, had stressed this as a policy change, in the interest of wider use of canal water in the essentially drought prone regions of the State.[6]

1.10 Examination of this whole problem requires enquiry into a set of related questions. It is first of all necessary to

ascertain the quantity of canal water required and actually used to irrigate individual crops in each of the three seasons. Given this information, it would be possible to examine the types of crops and cropping pattern that would give the best return to society per unit of irrigation water. This requires examination of the levels of physical inputs and output of every one of the crops under irrigation, and their valuation at comparable prices. It also requires examination of crop notations and combinations at the farm level, from the agronomic and economics angles. The exercise has to be based on data not relating to a single year but to a number of years, in order to take account of variations in weather, yields, and prices. Estimates will have to be made taking into account different degrees of risk associated with these elements of farm business.

1.11 If wider coverage of irrigation water, than currently in vogue, is indicated by these exercises, then the additional costs of construction of these channels as well the greater losses of water through seepage have to be taken into account in estimating the final social benefits and costs. These are basically engineering problems.

1.12 This examination will be essentially in terms of the current rates of use of water by farmers for different crops and the current manner of supply of canal water by the irrigation authority. It is, however, possible to think of different rates of use of irrigation water by different crops in the region, aided by a different design and schedule of water distribution. This may lead to greater economy in the use of

water and, therefore, further expansion of the irrigable area.

1.13 The purpose of the present study is to examine mainly the first set of questions relating to the most economic utilization of irrigation water in the region. The related question of additional capital cost and cost due to seepage of water involved in drawing the distribution channels longer to cover wider areas, is essentially an engineering problem. We propose to use some study by other agencies to illustrate the problem. The last set of questions arising out of different methods of distribution of water can at present be mainly of a speculative character in the absence of solid ground level experience. We shall refer to these problems at the end, only in a general way.

1.14 It is proposed to examine the pattern of use of irrigation water and the economic alternatives, in the context of two well-established canal systems in this drought prone region, essentially to illustrate the problem. They are: the Pravara Left Bank Canal (PLBC, for short), and the Nira Left Bank Canal (NLBC).

1.15 The river Pravara in the Godavari basin is dammed at Bhandardara in Akola Taluka of Ahmednagar district. The construction of the dam began in 1911 and the dam as well as the entire canal system for distribution of water were completed by 1926, though by 1924, except for minor items, the essential storage capacity and distribution system were fully operative. The canals do not take off directly at Bhandardara. Instead, the stored water is let into the river and picked up at Ozar, 45 miles down stream, with the help of a pick up weir. The

two main canals, Pravara Left Bank Canal (PLBC) and Pravara Right Bank Canal (PRBC) take off from here to irrigate the command area. The main canals are 80.12 miles long (PLBC = 47.12 miles); the branches distributories and minors are 183 miles long (PLBC = 140.37 miles and PRBC = 43 miles). The gross command area of the system is 228,720 acres (PLBC = 154,957 acres and PRBC = 73,763 acres). Eighty per cent of this, i.e., 182,976 acres (PLBC = 124,561 acres and PRBC = 58,415 acres) is culturable command area, that is cultivable land that can be irrigated with the distributory system if water can be made available. Originally, the Dam was conceived to store 13,000 million cubic feet of water, and given the expected cropping pattern under irrigation, some 75,000 acres were expected to be irrigated annually (I.C.A.). However, the actual storage capacity created by 1926 was a little over 10 TMC, giving an I.C.A. of 57,000 acres, 40,040 under PLBC and 16,960 under PRBC. The balance was to be provided later by fixing gates at the spillways to raise the storage level by 10 feet. The Annual Report of the Irrigation Department began by 1932-33, mentioning the I.C.A. to be 52,000 acres, without any change in the reservoir capacity. By 1940-41, the height was increased by ft., but the expected area irrigable (ICA) remained unchanged.

1.16 The actual irrigated land, however, rarely reached the expected level. We shall mention here only the position with regard to the Pravara Left Bank Canal, though the situation under the Right Bank Canal has shown similar trends. Till

1938, that is for almost a decade after the completion of the canal system, the area under various crops under PLBC (counting the area under crops standing in the field for the whole year or for two seasons, Rabi and Kharif, only once) never exceeded 22,000 acres, and fluctuated below this level, while the ICA was more than 40,000 acres. From 1939-40 this area increased; but till today this area has fluctuated between 24 and 30 thousand acres. Besides the regularly irrigated areas, a certain amount of land is provided with "inadequate" irrigation (2 to 3 irrigations) mainly to lands growing sugarcane under wells in summer, to supplement their irrigation source. This was negligible before 1936; since then it has acquired considerable importance. Often it has been of the order of 10 to 14 thousand acres; it is essentially determined by the extent and distribution of rainfall during the year and the level of water in the irrigation wells in summer.

1.17 During the year 1978-79, the area irrigated with permission of canal authority under the PLBC was 26,734.52 acres. The division was as follows :

(Area in acres)

Sugarcane Block	4,077	Kharif	3,852.52
Fruit Block	353.44	Rabi	9,952.20
Garden Block	245.5	Total (K+R)	13,804.72
Three Seasonal Block	378.0	Sugarcane area under well getting 2/3 canal irrigations	4,050.65
Two seasonal Block	3,825.21		
Total under Blocks	8,879.15	Grand Total	26,734.52

1.18 Sugarcane Block area means that only one-fourth of the Block area is under sugarcane during the year (it used to be one-third until some years ago), apart from some overlap of the previous years' cane awaiting harvesting. The remainder of the sugarcane block is put under irrigated seasonal crops, as per the rotational plans of the cultivators. Besides these, a little over 4,000 acres of sugarcane, grown under wells in the command area, were given 2 or 3 supplementary irrigations from the canal during the year. In fact, during the 3 seasons, i.e., Kharif, Rabi and Hot-weather (also referred to as Early Kharif), the gross irrigated cropped area was just a little less than 25,000 acres. In addition there were 1,000 acres under sugarcane as an overlap of the earlier year, and about 4,000 acres of sugarcane under wells supplemented with water from the canal system in the Hot Weather. If we add these to the gross irrigated cropped area, it comes to about 29,000 acres. Thus, we find that the actual irrigated area under the PLBC varied between half to two-thirds of the expected I.C. area, and about 20 per cent of the culturable command area. Sugarcane was the dominant single crop, accounting for nearly 25 per cent of the gross cropped area (including the area 'inadequately' irrigated). If the area of crops irrigated in both the Kharif and Rabi seasons are added (i.e., perennials calculated twice), then more than 28 per cent of the gross irrigated area in the two seasons together was under sugarcane. And this may be compared with the proportion of area under sugarcane proposed under the estimated total I.C.A. of 72,000 acres under the

entire Pravara canals, that is, 10,000 acres or only 13.88 per cent. We propose to examine the net returns to the farm economy per acre inch of irrigation water under this pattern of use and compare it with alternative use patterns.

1.19 The Nira Left Bank Canal (NLBC) is the oldest canal system constructed by the British in the Bombay Deccan. It was started in 1876 and went into operation in 1885, with an estimated irrigation capacity of 113,000 acres. With the completion of a new storage work in 1929, the capacity of the Left Bank Canal was expanded and a new Nira Right Bank Canal was put into operation. The Nira Left Bank Canal consists of two zones - the perennial and non-perennial. The non-perennial zone, which is at the lower end of NLBC, comprises a part of the irrigation section (administrative) named 'Anthurne', the entire section called 'Nimgaon' and a part of the section named 'Bavda'. The main canal in this zone is 8 miles long. It has a gross command area of 41,909 acres, and C.C.A. of 39,085 acres. However, the I.C.A. is only 10,000 acres forming approximately 25 per cent of the C.C.A. A little more than half, i.e., 53 per cent of this was under two-seasonal blocks, and the rest under seasonal crops. Sugarcane or any other perennial crop is grown in this area entirely under wells. We propose to examine the pattern of use of canal water for different crops in this zone, and particularly the pattern of well water use for sugarcane.

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1.20 The system of water distribution in these and other canal systems is specific to the region. The Appendix A to this

Chapter gives a brief account of the methods and terms involved, as well as the water rates in force in 1978-79, the year of survey. The second chapter estimates the demand for irrigation water at the distributory head by different crops in the PLBC and NLBC (non-perennial), and then tries to calculate the extent of loss of water in transit in different parts of the distribution system. Chapter three examines the economics of use of canal water for different irrigated crops and crop patterns. Certain uncertainties associated with the yields, prices and quantity and frequency of water supply, associated with the calculations in Chapter three, are examined in Chapter four. The fifth chapter examines the prospects for sugarcane in the State in the light of the policy implications based on the findings of Chapters three and four, including the possibility of sugarcane under well. The sixth chapter makes a reference to the increased capital costs of the alternative pattern of water use suggested, and makes a very brief assessment of the benefit-cost ratio. The final chapter puts down the conclusions arising out of this study.

NOTES AND REFERENCES

1. The matter is more serious, if requirements of water for domestic use and for industrial purposes, sure to grow at rapid rate, are added to the requirements for irrigation.
2. While comparing the two sets of figures for Maharashtra in Tables 1.1 and 1.2, the following should be kept in mind : The figure in Table 1.1 refers to the ultimate irrigation potential from all sources, while that in Table 1.2 refers to all flow irrigation sources in the state sector, including a significant part of the minor irrigation potential. Secondly, while the percentages in Table 1.1 refers to net irrigated to net sown areas, the percentages in Table 1.2 refer to gross irrigated to net sown area.
3. Report of the Irrigation Commission, 1972, Volume I, New Delhi : Ministry of Irrigation and Power, p. 112.
4. The point is also made in "Committee to Study the Introduction of Eight Monthly Supply of Water on the Irrigation Projects in Maharashtra : Interim Report, Bombay : Government of Maharashtra, Feb. 1979, paras 30-32.
5. Ref. Minutes of Evidence : Bombay Presidency, (of the Indian Irrigation Commission), Calcutta : Office of Superintendent, Government Printing, 1902; Donald W. Attwood on the History of Deccan Canals in his paper "Irrigation and Imperialism : the causes and consequences of a shift from subsistence to cash cropping", Journal of Development Studies, 1986.
6. Maharashtra State Irrigation Commission Report, Bombay : Government of Maharashtra, 1962. Section 5.5.

APPENDIX - A

PRESENT SYSTEM OF DISTRIBUTION OF WATER

A.1 The system of irrigation as is now seen in Western Maharashtra is largely the outcome of physical factors such as topography, soil climatic complex, the nature of water resources, etc. Unlike in other parts of the country the soils in Maharashtra vary greatly from field to field and also water is not plentiful to be supplied to thenfarmers unrestricted.

A.2 The farmer has to decide in advance which crops he would like to irrigate and get the areas of each crop sanctioned by the Irrigation department. As stated in the Maharashtra State Irrigation Commission Report the sanctions are governed by the current irrigation policies such as maximising utilisation in Kharif season, encouraging the growing of foodgrain crops in Rabi season and minimising utilisation in summer season and most important of all the need to restrict the area under perennial crops to prevent large scale damage through waterlogging.

A.3 Under the present system of irrigation, sanction is given on seasonal basis in addition to the permanent commitments under the block system. Water is also supplied for casual irrigation on application in form No.7. After getting the areas under individual crops sanctioned, the farmer has to obtain permission at each rotation for irrigating the sanctioned crop. This is done through a system of 'passes' issued to farmers for growing crops as sanctioned. Before each rotation

the irrigation official enters the date, on which water would be supplied, on the passes, after which the farmers become entitled to get canal water for a particular crop and on the date specified. Sanctions for a variety of crops are given on long term basis, i.e., for six years or some times more. This is the "block system". The important types of blocks at present in force on the Deccan canals are (i) cane blocks, (ii) fruit blocks, (iii) garden blocks, (iv) garden and seasonal block, (v) two seasonal blocks and (vi) three seasonal blocks.[1]

A.4 (i) Cane Block: Cane Blocks are sanctioned in multiples of 1 acre and the basic cane area is restricted to one-third or one-fourth of the total block area depending upoh demand of irrigators. This is referred to as 'one in three' or 'one in four cane block'. That means (in case of one-in-four) if a farmer has a 4 acre cane block, he can plant only 1 acre of cane in that 4 acre block; and in the remainder of the block area seasonal crop is allowed to be grown during the Kharif and the rabi seasons, except crops like long staple cotton, lucerne or groundnut in the hot weather. The farmers rotate the cane plot within the block. As sugarcane necessarily requires 'overlap', (because 'Adsali' or 18 month sugarcane must stay in the field for more than a year and 'Suru' or annual sugarcane may have to stand in the field, awaiting harvesting for factory, beyond the stipulated period) additional cane area to the

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1 For a brief account of these prevailing methods and terms used in canal water distribution in the State, see P.R.Gandhi, History and Practice of Management of Irrigation Waters in Maharashtra, Aurangabad: Water and Land Management Institute, June 1981.

extent of 50 per cent of the basic cane area is allowed to be under sugarcane, but only during the months from July to March or with special sanction even in April but never in May or June. However, permission for 'overlap' has to be obtained separately every time. The normal period for this type of block is six years. The whole idea behind restricting the cane area to one-third or one-fourth area of the cane block is to keep control on the area of standing crop of cane in hot weather season. In the cane block if sugarcane is not planted, permission is given by the irrigation department to plant any seasonal crop whose water requirements are lighter than of sugarcane.

A.5 (ii) Fruit Block : In this block fruit trees which stand in the field for a long time, such as, mosambi, orange, mangoe, etc., are allowed in the entire block area. Usually the contract sanctioned for such block is for 12 years.

A.6 (iii) Garden Block : In this block short term fruit trees like papaya, and other light perennials like vegetables and lucerne grass are allowed on $\frac{1}{3}$ area. Of the remaining, $\frac{1}{3}$ can be under long staple cotton and another $\frac{1}{3}$ on any seasonal crops other than those mentioned above. The block is sanctioned for six years. The earlier Garden and Seasonal Blocks have been gradually converted into Garden Blocks after 1965.

A.7 (iv) Two seasonal Block : In this block, only Kharif and Rabi seasonals are allowed to be grown with 100 per cent of the area of the block can be under irrigation in each of the two seasons. Special sanction is needed for any summer crop

in the block. This block is also sanctioned for six years.

A.8 (v) Three Seasonal Block : Under this block only one-third of the block area can be put under long staple cotton or groundnut, or onion in summer, which may carry over into the next Kharif season. Further, one-third of the area can be put under kharif seasonal and another one-third under rabi seasonal. Thus one-third of the area of the three-seasonal block remains fallow in kharif and two-thirds or less of the same remain fallow in rabi.

A.9 It is to be noted that no preliminary programme of irrigation is made for the kharif season. Though the day-cusec of water released and area irrigated for each rotation in kharif season are recorded, these are not scrutinised for examining the efficiency of irrigation. On the 1st of October every year a 'preliminary irrigation programme' is prepared on the basis of the actual available water stored behind the dam, the anticipated overall river gains or losses between the dams and the weirs and the trend of water application in the past. Applications are then invited and these are sanctioned by the 15th of October. A schedule called the 'Shejpali' giving the turns of different irrigators in each rotation is then prepared before irrigation starts from 1st November. The irrigation begins from the tail end and proceeds towards the head as the irrigation progresses. The concerned irrigators are informed about their turns one or two days in advance. This schedule of irrigation can be modified depending upon late demand, sowing periods of different crops and unauthorised use. In practice,

however, actual modifications are seldom carried out and actual irrigation often does not proceed in the originally planned manner. This results in low reliability of water supply. Obviously, in this system there is a tendency to overdraw water by individual farmers, as time and quantity are not the essence of the sanction; only when an irrigators says he had enough water does the next man get his turn. This makes some others suffer, particularly the tail enders.

A.10 The 'preliminary irrigation programme' contains mainly the following information and data : (i) live storage available, (ii) deduction of tank evaporation losses in rabi and hot weather seasons on the experience of about the lastest 10 years, (iii) this gives net available quantity of water at canal head, (iv) transit losses in the canal on the basis of the average loss of the last 10 years or so, (v) this gives the quantity of water available at distributory head; and finally (vi) the seasonal duty to estimate the requirement of quantity of water at distributory head. The area of different crops is converted into standard acre of area on sugarcane basis.[2] Whiel preparing the programme the following points are observed. (i) Quota for

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2 The conversion rate are as follows : (Ref.Gandhi, op.cit.)

Rabi : While the actual sugarcane acre, including the overlap is treated as 1 acre, acre under garden block, fruit block, vegetables or high-yielding variety of wheat is equal to 0.67 acre sugarcane, and other hybrid crops like Hybrid jowar, 0.5 acre sugarcane, and other seasonal crops 0.33 acre sugarcane.

Hot weather : Acre under sugarcane and all hot weather seasonal crops treated on par; only acre under fruit block, garden block or vegetables equal to 0.67 acre of sugarcane.

perennial areas for rabi and hot weather is kept aside;
(ii) maximum rabi irrigation of wheat, jowar and gram is allowed, and then remaining water is proposed for hot weather seasonals and pre-seasonals of kharif crops.

A.11 As mentioned earlier, the application of the programme begins from 15th of October. The season is generally divided into 7 rotations in Rabi season and 9 rotations in hot weather season. The rotation is of 18 to 20 days in Rabi and about 14 to 15 days in hot weather season. The duration of the rabi season is of around 137 days and that of hot weather season is of around 120 days. The quota of water in each rotation is fixed. If the total quota of water of a particular distributory for Rabi season is 'X' Mcft, the quantity to be drawn in each rotation will be 'X' Mcft divided by 7. However this can not be achieved in each rotation (watering) in practice. Therefore, any extra quantity utilised in the first two rotations is required to be adjusted in the last 3 or 4 rotations by drawing less.

A.12 Once the quota of each distributory originating from the main canal is determined, the flow of water in day-cusec in each distributory is decided as per the water demand statement. Each distributory has got a measuring device called 'Standing Wave Flume' where discharge is measured each morning and evening. Also the data of day-cusecs utilised and the progressive total draw off in the rotation along with the approximate area irrigated and the progressive cumulative total of areas irrigated are recorded.

A.13 A number of 'water courses' take off from the 'distributory' or the 'minor' at different points in its course. A concrete structure with a vertical shutter device is installed at the point of take off of a water course to let out water into it from the distributory. There is, however, no water measuring device at this point. The cultivators take water into their fields by making a temporary breach in the bund of the water course separating their fields from the water course. They can also take water to a field when it is away from the water course by designing a field channels through the other farmer's field and breaching the bund of the water course at the head of the field channel.

A.14 From the above account it is clear that the last point at which the measuring device is fixed to measure the volume of water released is at the distributory head; beyond that point there is no provision for any measurement. Under the existing systems the farmers are at liberty to take as much water as they like, or till they are satisfied that the fields are fully irrigated; there is no time limit nor is there any volumetric measure of the water drawn.

Water rates

A.15 At present the prime source for the recovery of capital and operation and maintenance costs for irrigation works is the water charge. Different rates are charged for each crop, roughly corresponding to the amount of water utilized. The following are the present rates charged for different crops.

Name of the Crop or Season	Rates (Rs. per hectare) w.e.f. 1-7-75 (prevailing during 1978-79)
Sugarcane and Plantations	750
Other perennials	500
Kharif seasonal crops	50
Rabi seasonal crops	75
Hot weather seasonals	150
Hot weather cotton	250
Hot weather groundnuts	250
Pre-seasonal watering	75
Post-seasonal watering to kharif crops in rabi-season	20
Post Seasonal Watering to rabi crops in hot weather season	25

A.16 A 20 per cent local cess is levied on the water rates. An Employment Guarantee Scheme (EGS) cess is levied at the rate of Rs. 25 per hectare of irrigated land, and an Education cess varied with the crops grown as follows :

Crop	Rates (Rs.per hectare)
Sugarcane (perennial-irrigation)	190
Sugarcane (on other lands)	110
Irrigated cotton	40
Hybrid seeds	40-110
Irrigated groundnuts	40
Fruits	80-380
Turmeric	80
Tobacco	130

CHAPTER II

PATTERN OF USE OF WATER UNDER CANAL IRRIGATION

2.1 In order to estimate the most economic use of irrigation water, it is necessary, first of all, to ascertain the present pattern of use of canal water for different crops as well as the proper quantity and frequency of application of irrigation to different crops. Unfortunately, there is no information available about the quantities of water applied by farmers to fields growing different crops in the different seasons of the year, under any flow irrigation project in the state. The information available with the irrigation authority is briefly described below.

2.2 The information about the volume of water in the reservoir is available regularly and routinely. Daily information on the volume of water let out of the reservoir into the main canals is also maintained. The difference between the accretion plus depletion of water in the reservoir and its outflow through canals (and through the sluice gates, particularly in the rainy season) gives an estimation of the loss of water through seepage and evaporation. Similarly, for any period - a season or a year - the difference in the volume of water let out through the main canals, and the water let out from the canal to the distributories (as well as given to other users) gives an estimation of the volume and proportion of water lost through seepage and evaporation (mainly the

former) in the main canals. The last routine measuring of the volume of water let out is at the distributory head. Beyond this there is no provision to routinely measure the volume of water let out from the distributory at the outlet to water courses, nor is there any direct or indirect measure of the volume of water taken by an irrigator. Therefore, there is no clear measure of the quantity of water lost in transit in the distributory and the water courses and the water actually applied to the field.

2.3 However, in order to supply water to the approved areas under different crops on the fields in a given season indeed during each rotation of water supply, it is necessary for the canal authority to have a clear idea of the amount of water needed per crop at the field head as well as the proportion of water, let out at the distributory head, that may be lost in transit through seepage, etc. The irrigation authority uses certain norm of water requirement of various irrigated crops at the field head. These are given in Col. 2 of Table 2.1. The seasonal break up of the water requirements for perennials and two seasonals are also worked out. Then, in order to estimate the water requirement at the distributory head, an uniform 10 per cent loss is applied to the seasonal water requirement of each crop. The area under every irrigated crop under the distributory is then converted into equivalent sugarcane area, by using a conversion chart, presumably based on the respective water requirements of

Table 2.1 : Water Requirements of Different Crops at Field Head

(in acre inches per acre)

Irrigation Department*		As per Lift Irrigation Scheme**		As per Agronomists' Specification***	
Crop (1)	Acre inches per acre (2)	Crop (3)	Acre inches per acre (4)	Crop (5)	Acre inches per acre (6)
1. Sugarcane (1 year)	113	1. Sugarcane (Adsali 18 mths)	139	1. Sugarcane (1 year)	106.45
2. Plantains	112	2. Sugarcane (Suru 1 yr.)	127	2. Jowar CSH-5 (Kharif)	18.06
3. Lucerne, E.Grass, Guinca grass	112	3. Hybrid Jowar (Kharif)	9	3. Bajra (Kharif)	9.86
4. Vegetables in succession throughout the year	112	4. Bajra	6	4. Jowar CSH-1 (Rabi)	14.59
5. Papaya	87	5. Groundnut (Kharif)	6	5. Jowar CSH-8R (Rabi)	15.37
6. Citrus fruits	76	6. Rabi Jowar	12	6. Wheat (K.Sona)	15.69
7. Guava, Pamegranates	60	7. Hybrid Rabi Jowar	18	7. Wheat (N1-5439)	15.14
8. Rice (Kharif)	30	8. Gram	9	8. Gram	11.83
" (Rabi)	10	9. Wheat	18	9. Groundnut (SB-XI)	12.62
9. Kharif Seasonals	10	10. Groundnut (Summer)	36	10. Sunflower	10.25
10. Rabi Seasonals	12 to 16	11. Cotton (Long Staple)	33	11. Cotton (RHR-253) Hot weather	35.49
11. Hot Weather Seasonals	26				
12. Khapli Wheat	37				
13. Two Seasonal Vegetables	61				

* Gandhi, P.R., op.cit., p.31

** A Note on Preparation of Lift Irrigation Schemes, Bombay: Government of Maharashtra, Irrigation and Power Department, 1970, p.19.

*** Obtained from Professor of Agronomy, Mahatma Phule Krishi Vidyalaya, Rahuri, Maharashtra. These data ref. to consumptive use of water (Rainfall+irrigation) at field level.

various crops at the distributory head. This is illustrated for the Rabi and Hot weather seasons for the Nira Left Bank Canal in Table 2.2. The expected quantity of water that may be available per day of irrigation during the season at the distributory head (based on the experience of the previous 5 years), measured in terms of day-cusecs (discharge rate at the distributory head in cubic feet per second multiplied by 24 x 60 x 60 seconds) is then used to divide the sugarcane equivalent planned irrigated area. This ratio, that is, the ratio of area irrigated (AI) to day-cusecs (DC) shows how many acres of sugarcane equivalent area can be irrigated with the discharge at the rate of one cusec water for 24 hours. This AI/DC ratio normally varies from 3.5 to 4, depending upon mixture of crops in the command area of the distributory. It means, provision of water to irrigate about 4 acres of sugarcane upto a depth or 15 cm or 6 inches of water an acre during a day. The section officer in charge of the distributory can make minor variations in this from season to season, as long as the average AI/DC for the whole season does not exceed the estimated level.

2.4 This means that the discharge of water through the distributory head is determined by estimations of water requirement at the field head and loss of water in transit. However, since there is no volumetric control on the supply of water to any field and since there is no definite information about the extent of loss in the distributory and

Table 2.2.: Ratios to convert irrigated lands under different crops to irrigated sugarcane land, and Nira Left Bank Canal

Crop	Conversion factor
Rabi season :	
1. Sugarcane	100 %
2. Fruit Block	67 %
3. Garden Block	67 %
4. Vegetables in Sugarcane, two-seasonal and three-seasonal Blocks	67 %
5. High yielding wheat	67 %
6. Hybrid millets	50 %
7. Rabi seasonals	33 %
Summer (Hot-weather) :	
1. Sugarcane	100 %
2. Fruit Block, Garden Block, and vegetables in Hot Weather for one month	67 %
3. Hot weather Seasonals	100 %

Source : P.R. Gandhi, op.cit., Statements 4 and 6.

field channels through seepage and theft, great variations in the rate of application of water not only among different crops but among different locations of the irrigated lands are very likely. It is, however, not possible to ascertain these without detailed measurements in the field.

2.5 Therefore, it is proposed to follow two approaches in estimating irrigation water requirements of the different crops. The first is to take the different norms specified by different agencies and choose one for our exercise. The other is to estimate the actual demand for water by different crops in a season at the distributory head. This may provide some ground for a broad judgment about the loss of water in transit, which would raise questions about the steps to improve this as well as the present basis of official estimation.

2.6 Information on irrigation water requirements of different crops in the dry regions of western Maharashtra, obtained from 3 different sources, is presented in Table 2.1. The data presented in Shri Gandhi's book (quoted in the Table) relates to the figures generally used by the Irrigation department in its flow irrigation projects, after making suitable incrementals for canal and distributory losses, to arrive at estimates of demand for water for different crops at the main canal head. The data relating to requirements under lift irrigations can be considered as approximating to requirements at field level, since transit loss in such projects is sure to be minimal. The estimates obtained from the Agronomist include water obtained from rainfall, and therefore are sure to be more than needed from irrigation sources. The three sets of data are of course not the same; but considering the itemization of specifications and other

non-comparability, we take the lift irrigation figures to be the approximate figures for our purpose. These approximate data on water requirement can help in the indirect assessment of loss of water in the distributories and water courses. We, therefore, now turn to the assessment of such losses.

2.7 Before we turn to losses in the distributories and minors, we may examine the losses in the main canal, i.e. PLBC. Table 2.3 gives the seasonwise and annual total loss of water let out at the canal head, during 1978-79. During the year, 33.81 per cent of the water let out into the main canal was lost in transit, mainly due to seepage and, to an undermined extent, pilferage. Seasonally, the greatest loss, 39.15 per cent, was during summer, and the lowest, 31.13 per cent, in the Rabi season. This is much higher than the 20 per cent loss conventionally assumed by canal authorities in their calculation, including those for AI/DC at the canal head.

2.8 The Maharashtra State Irrigation Commission (1962) had examined this question at some length in its report. On the basis of data relating to canal losses on a number of major canals in the state in the preceding 15 to 20 years, the Commission observed great variations not only amongst canals, but even in the same canal from year to year. The range of variation can be seen from Table 2.4.

2.9 The Commission states[1] that the wide variation between the minimum and maximum is difficult to explain. It

Table 2.3 : Water Released at the Canal Head Received at the Distributory Head and Its Use (PLBC 1978-79)

	Season			
(1)	All Seasons (2)	Kharif (3)	Rabi (4)	Summer (5)
Water released at PLBC head in day cusec	139170	49334	58483	31353
Water received at distributory heads in day-cusec at				
Ashwi	5062	1935	2140	987
Loni	7548	2530	3446	1752
Khandala	9376	2955	4383	2038
N.B.	27389	8905	11440	7044
Belapur	21458	6439	9705	5314
Vadala	5339	1876	2680	783
Karegaon	6668	2361	3470	837
Bel-Pimpalgaon	5418	1905	3011	502
Total including left and N.I.P.	88258	28906	40275	19077
Taklibhantail tank (T.T.T.)	3852	3852	-	-
Losses	47060 (33.81%)	16576 (33.60%)	18208 (31.13%)	12276 (39.15%)

Table 2.4 : Range of Water Losses in the Main Canal, in Selected Major Canals in Maharashtra

Canal	Rabi Losses		Hot Weather Losses	
	Minimum	Maximum	Minimum	Maximum
Nira Left Bank Canal	31	55	38	59
Nira Right Bank Canal	25	45	33	54
Pravara Left Bank Canal	21	40	23	57
Pravara Right Bank Canal	20	52	25	60
Godavari Left Bank Canal	13	33	8	36
Godavari Right Bank Canal	23	90	26	90
Girna Left Bank Canal	10	34	8	40

Source : Maharashtra State Irrigation Commission Report, 1962, p. 139.

is often argued that the whole configuration of the state (through which the canal passes) and the sub-soil water level greatly influences losses in transit. This may at the most explain the difference between the losses on one canal as compared to those on another canal. But this would not explain the large variations on the same canal from year to year. Such annual variations are sometimes attributed to changing weather conditions, such as temperature, pressure, wind velocity and to the condition of the canal section, i.e., with or without silt film. The Commission goes on to argue that losses by evaporation in the canal are very small compared to total losses and are, therefore, normally neglected.

Weather conditions cannot explain such wide variations in canal losses. The other explanation based on the condition of the canal section (i.e. with or without silt film) cannot also be a major factor in respect of those canals which have been functioning for many years and thus have attained a certain stability in their sections. The Commission then concludes that acceptance of the wide variation in canal losses, to the extent indicated in the table earlier, can therefore be attributed mainly to two undesirable factors, viz., (a) wasteful use of water, and (b) inefficient management. A third possibility could be the variation in the volum of flow of water in the main canal due to variations in main storage and variation in demand for irrigation, from year to year in a particular season. Since seepage loss in the main canal would vary depending upon the area of canal surface in contact with water, the smaller the volume of water passing through the canal, the larger would be the proportion of loss through seepage. As per the Government of Maharashtra practice, the seepage loss in unlined main canals is assumed as follows :

(i) 15 cusecs/Mcft for discharge less than 250 cusecs;

(ii) 10 cusecs/Mcft for discharge above 250 cusecs.[2]

2.10 In point of fact, some of the canals on which test measurement were taken in 1978[3] showed average losses within these limits; for comparatively newer unlined canals the

averages were very much in excess. The data also showed, in some cases, more than double the rate of seepage at two not distant points of time in the same section of the same canal, the only variation observed being the rate of discharge. This only verifies the general proposition about the percentage of seepage being negatively related to the rate of discharge. It, however, would be difficult to explain the very large variations over the years in the same canal, observed in Table 2.4. Therefore, the inference of the Maharashtra Irrigation Commission, that wasteful use (presumably including large scale pilferage) and inefficient management are the principal factors responsible, appears justified. This suggests great scope for improvement in these directions, even without lining of canals, so that more water is available for irrigation.

2.11 There are no such test data readily available concerning transit losses below the distributory head. The official estimates of water demand at distributory head assume a 10 per cent loss in transit. It was therefore decided to first of all estimate the rate of water use, cropwise, at the distributory head. This may be used for comparison with the conversion ratios at the distributory head used by the canal authorities. Then, with the available information (norms) about water requirements of different crops at the field head, it would be possible to get a rough estimate of the loss in transit below the distributory head.

2.12 Data were collected from the canal offices about the quantity of water let out into every distributory, separately, during every irrigation rotation during the year 1978-79. The area figure of individual crops under every distributory irrigated during a particular rotations was also collected. The PLBC has 80 distributories or minors and 3 Lifts and the NLBC (non-perennial sections) has 13 distributories and minors. The number of waterings, or rotations as they are called, in PLBC were 5, 7 and 4 in Kharif, Rabi and Hot Weather respectively during 1978-79. In NLBC, these were 3, 4 and 7 (excluding one in kharif and two rotations during Rabi when no irrigation was required due to adequate rain in time).

2.13 The total amount of water let out into a distributory and used by the command area under it, is dependent on the areas of different crops irrigated by the water during the rotation, besides the water lost in transit. This may be stated in a functional form : $W = f(X_i)$

Where W is the volume of water let out into the distributory and X_i standing for the area of a crop irrigated, $i = 1 \ldots n$ standing for different crops. The following specific function was fitted to the available data :

$$W = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n$$

where W = the water let out into the distributory, in acre-inches

a = a constant

X_i = the area, in acres, of crops irrigated by the water,

and b_i = the regression coefficients, which indicate the additional water that would be needed, at the distributory head, to irrigate an extra acre of crop, X_i.

2.14 Regressions were run, separately for kharif, Rabi and Summer seasons for PLBC and NLBC, by taking the aggregate volume of water let out in every outlet during the total number of rotations in the season, and the corresponding areas of crops irrigated. The number of observations in each season, therefore varied from 79 to 82 for PLBC and 12 or 13 for NLBC due to one or two distributories recording no irrigation in a particular season. The results of the regression exercises are presented in Tables 2.5 and 2.6.

2.15 The constant term a has a negative sign while it should be normally positive. In any case, it is very small. Running the regressions without the constant term, therefore, does not materially alter the regression coefficients.

2.16 It is not surprising that the R^2s are as high as they are, indicating a very good fit. Indeed, the maximum difference between the expected and observed variable (W and $\overline{W}$), was less than 1.5 per cent in 2 out of 3 seasons and about 6 per cent in the third in PLBC. This is to be expected, since the water to be let out is calculated on the basis of the crop area to be irrigated and all the water is used up in the process.

Table 2.5 : Regression Co-efficients of different Crop Areas under PLBC

Kharif Season (1)	N 81	Value b_i (2)	Standard Error (3)	T. Test (4)
Constant Term		-151.89406	24.25656	-2.04553
Sugarcane (X_1)		11.90215	0.95028	12.52556**
Other Perennials (X_2)		6.48947	1.21669	5.33370**
Hybrid Jowar (X_3)		5.97189	0.43893	13.60557**
Bajra (X_4)		10.63263	1.18607	8.96458**
Groundnut (X_5)		6.16980	2.49538	2.47249*
Paddy (X_6)		7.66914	3.15292	2.43299*
Others (X_7)		1.71129	2.43404	0.70306
R^2		0.99189		
F		1275.79534		
Rabi Season	N 82			
Constant Term		-140.38457	91.76761	-1.52978
Sugarcane (X_1)		7.55294	1.03046	7.32970**
Other Perennials (X_2)		8.04299	1.15123	6.98645**
Jowar (X_3)		7.14021	0.29476	24.22354**
Wheat (X_4)		7.76334	0.34950	22.21254**
Gram (X_5)		17.41328	2.28101	7.65404
R^2		0.99481		
F		2914.33269**		

Contd.....

Table 2.5 : (Contd.)

(1)	Value b_i (2)	Standard Error (3)	T. Test (4)
Summer Season N 79			
Constant Term	-188.29855	83.53309	-2.25418**
Sugarcane (X_1)	12.15764	0.36809	33.02819**
Other perennial (X_2)	6.75009	1.47748	4.56863**
Cotton	25.98090	11.93810	2.17721*
Groundnut	14.29696	11.89097	2.39493*
Other crop	14.29696	5.58544	2.55969*
R^2	0.96950		
F	464.12349**		

** Significant at 1% level. * Significant at 5% level.

2.17 The regression coefficients, which indicate the demand for water at the distributors head for an extra acre of the crop concerned, however, appear high in some cases. Sugarcane appeared to have used nearly 12 acre inches of water per acre per rotation at the distributory head in the kharif (monsoon) season under PLBC, almost the same as in summer! Though other perennials as well as seasonals, like hybrid jowar and groundnut in the kharif season, demanded about half as much water per acre as sugarcane, Bajra, another kharif seasonal, recorded

Table 2.6 : Regression Coefficients of different crop areas under NLBC

Rabi Season N 13 (1)	Value b_i (2)	Standard Error (3)	T. Test (4)
Constant Term	-507.12705	1085614.06598	-1.69569
Jowar (X_1)	9.45030	694.79557	49.37364**
Gram (X_2)	12.69725	9608.97326	4.79667**
R^2	0.997658		
F	2148.70346**		
Summer Season N 12			
Constant Term	-276.32482	1472192.21636	-0.68134
Cotton (X_1)	15.50360	7578.96702	7.42556**
Groundnut (X_2)	9.06448	6169.74742	5.33313**
R^2	0.99346		
F	683.24264**		

** Significant at 1% level.

very high demand for water, 10.6 acre inches, almost as much as sugarcane! In the Rabi season not only was the demand for water for sugarcane (at distributory head) the lowest of all the 3 seasons, it was about the same as that of Rabi Jowar and wheat, while the other perennials had a marginally higher demand. In summer (hot-weather), on the other hand, it was

just the reverse : other perennials required just about half the water by sugarcane in a rotation. The co-efficients for Long Staple Cotton and groundnut appear extremely high : 26 acre inches for cotton and 14 acre-inches for groundnut per rotation. In NLBC, the regression coefficient for Rabi Jowar appears high, but that for Gram is higher still, about 12.6 acre-inches, which is similar to that in PLBC. In summer, cotton and groundnut also show very high demands, though somewhat lower than the same crops under PLBC.

2.18 The above coefficients relate to the total supply of water at the distributory head during all the rotations in a season and the total of area under each crop irrigated in all those rotations. In view of the rather unexpected results from these total figures we decided to run regressions separately for each rotation in the season. The results are given in Tables 2.7 and 2.8. The regression coefficients for any particular crop show wide variations from rotation to rotation in a given season. Variations in water requirements at the distributory head can be expected between rotations for a variety of reasons, but the estimated order of variation appears on the very high side.

2.19 Variations in demand for water at the distributory head are possible from season to season. Requirement for actual irrigation would vary, from rotation to rotation and even from distributory to distributory, depending upon whether

Table 2.7 : Regression co-efficients of different crop areas under PLBC, rotationwise

Equation	N	Constant term	Sugarcane X1	Other perennial X2	Hybrid Jowar X3	Bajra X4
(1)		(2)	(3)	(4)	(5)	(6)
Kharif : Rotation I (K I)						
1. b Value	63	- 5.62487	7.01511	5.98199	7.09276	6.75923
2. Std. Error		11.36810	0.85867	0.98269	0.39745	1.35725
3. T. Test		- 0.49479	8.16972	6.08732	17.84547	4.98007
K II						
1. b Value	83	7.43807	11.80879	-12.86054	6.58544	12.61984
2. Std. Error		32.88051	2.47009	2.47713	0.68606	1.30529
3. T. Test		0.22621	4.78070	- 5.19169	9.59886	9.66758
K III						
1. b Value	82	-37.48893	9.09626	2.39066	6.35953	10.79831
2. Std. Error		19.43661	0.63910	1.41300	0.35593	0.90356
3. T. Test		- 1.92877	14.23283	1.69189	17.86730	11.95082
K IV						
1. b Value	82	-43.99687	9.65803	8.00413	4.83670	13.67891
2. Std. Error		26.69495	0.88795	2.00350	0.64356	1.33565
3. T. Test		- 1.64813	10.87677	3.99506	7.51546	10.24131
K V						
1. b Value	63	-29.34210	4.51604	9.41159	7.59833	13.72194
2. Std. Error		21.73752	0.95755	2.32189	0.38753	2.18846
3. T. Test		- 1.34983	4.71620	4.05341	19.60680	6.27012

Contd....

Table 2.7 : PLBC (Continued)

Equation	N	Groundnut X5 (7)	Paddy X6 (8)	Others X7 (9)	R^2 (10)	F (11)
K I						
1. b Value	63	6.35702	6.97429	9.12227	0.99334	1173.38680
2. Std. Error		1.71480	3.62564	2.04662		
3. T. Test		3.70713	1.92359	4.45723		
K II						
1. b Value	83	-7.72311	17.70275	6.18811	0.96615	385.89068
2. Std. Error		4.72589	4.12323	3.58100		
3. T. test		-1.63421	4.29341	1.72803		
K III						
1. b Value	82	16.41012	15.48381	6.93103	0.99203	1317.20830
2. Std. Error		3.47553	2.06721	1.77466		
3. T. Test		4.72161	7.49016	3.90554		
K IV						
1. b Value	82	19.26381	9.76331	17.22388	0.98740	828.77029
2. Std. Error		4.36648	5.12934	2.99992		
3. T. Test		4.41182	1.90342	5.74144		
K V						
1. b Value	63	9.74379	4.15783	6.26941	0.97981	381.42766
2. Std. Error		2.96914	8.98187	2.42251		
3. T. Test		3.28168	0.46291	2.58797		

Contd....

Table 2.7 : (Contd.) PLBC - Rabi

Equation	N	Constant term (1)	Sugarcane X1 (2)	Other perennial X2 (3)	Jowar X3 (4)	Wheat X4 (5)
Rabi - Rotation I (R I)						
1. b Value	81	-37.72509	5.12274	7.22678	7.32694	8.61036
2. Std. Error		24.66430	1.75614	1.92840	0.38252	0.45698
3. T. Test		- 1.52954	2.91704	3.74754	19.15409	18.84170
R-II						
1. b Value	68	-19.15403	1.10783	5.33972	7.11636	8.56008
2. Std. Error		32.00877	1.56953	2.05983	0.37271	0.41136
3. T. Test		- 0.59839	0.70583	2.59230	19.09319	20.80891
R-III						
1. b Value	58	-38.34778	6.68136	3.59079	6.82322	8.05660
2. Std. Error		34.61374	1.60453	2.20431	0.36959	0.51194
3. T. Test		- 1.10787	4.16405	1.62898	18.46146	15.73729
R-IV						
1. b Value	85	-34.82934	7.99042	5.70118	7.44281	8.00739
2. Std. Error		26.50265	0.56048	2.04261	0.25561	0.28701
3. T. Test		- 1.31418	14.25619	2.79112	29.11690	27.89891
R-V						
1. b Value	82	-34.95492	11.98083	8.43387	7.96800	6.88939
2. Std. Error		15.70202	1.15795	1.16625	0.38925	0.24513
3. T. Test		- 2.22614	10.34657	7.23158	20.46997	28.10429
R-VI						
1. b Value	78	-22.82664	9.48302	4.66808	5.86677	7.80545
2. Std. Error		19.93500	1.38239	1.35575	0.41610	0.30822
3. T. Test		- 1.14505	6.85983	3.44315	14.09916	25.32392

Contd...

Table 2.7 : PLBC - Rabi (Contd.)

Equation	N	Gram X5	R^2	F
R-I				
1. b Value	81	9.44814	0.99013	1505.30643
2. Std. Error		1.97990		
3. T. Test		4.77202		
R-II				
1. b Value	68	26.24598	0.98322	727.01053
2. Std. Error		3.26476		
3. T. Test		8.03915		
R-III				
1. b Value	58	13.47218	0.98855	989.07938
2. Std. Error		2.93138		
3. T. test		4.59583		
R-IV				
1. b Value	85	9.09900	0.99289	1983.46052
2. Std. Error		2.21425		
3. T. Test		4.10927		
R-V				
1. b Value	82	9.69477	0.99379	2433.75469
2. Std. Error		2.39583		
3. T. Test		4.04651		
R-VI				
1. b Value	78	11.41300	0.98494	942.00428
2. Std. Error		5.32765		
3. T. Test		2.14221		

Contd....

Table 2.7 : (Contd.) PLBC - Summer

Equation	N	Constant Term (1)	Sugarcane X1 (2)	Other perennial X2 (3)	Cotton X3 (4)	Ground-nut X4 (5)	Other crops X5 (6)	R^2 (7)	F (8)
Summer - Rotation I (S I)									
1. b Value	74	-15.85766	11.62890	6.98706			8.4822	0.96764	697.913*1
2. Std.Error		9.97217	0.45561	0.64023			0.72335		
3. T. Test		- 1.59819	25.52358	10.91326			11.72628		
S-II									
1. b Value	66	-14.93238	11.36003	8.93170	11.43648			0.95609	450.09433
2. Std.Error		10.96935	0.41867	0.63888	6.22469				
3. T.test		- 1.36128	27.13321	13.98006	1.83727				
S-III									
1. b Value	82	166.38451	10.02376	2.61224	22.61816	10.79651	49.79353	0.40341	18.27831
2. Std.Error		152.14404	1.98811	13.21670	49.66897	54.65375	77.95703		
3. T.Test		1.09307	5.84183	0.19764	0.45537	0.19754	0.63873		
S-IV									
1. b Value	79	-38.46792	12.29322	8.08767	45.54884	11.4869	13.25544	0.93436	207.82639
2. Std. Error		50.72685	0.48106	3.93600	19.32167	19.87310	28.14903		
3. T.Test		- 0.68062	25.55438	2.05479	2.35739	0.56099	9.47090		

Table 2.8 : Regression Coefficients of Different Crops and NLBC, rotationwise

	N	Constant term	Jowar (X1)	Gram (X2)	R^2	F
Rabi Season						
Rotation III (R-III)						
1. b Value	8	-97.64318	10.50899	2.21349	0.99167	297.83022
2. Std. Error		179.24226	0.78141	4.03622		
3. T. Test		- 0.54475	13.44872	0.54840		
R-IV						
1. b Value	12	-55.01964	9.40166	28.42759	0.98982	437.94000
2. Std. Error		344.67035	0.36182	5.87511		
3. T. Test		- 0.15962	25.98389	4.83864		
R-V						
1. b Value	13	-97.70497	9.03065	-2.19806	0.99903	5176.83373
2. Std. Error		67.03470	0.11985	3.53225		
3. T. Test		- 1.45752	75.34746	-0.62228		

Note : No irrigation during the first two rotations.

Table 2.8 : (Contd.) NLBC - Summer Season

Equation No.	N	Constant Term	Cotton	Groundnut	R^2	F
Summer Rotation I (S-I)						
1. b Value	12	8.63003	11.80336	-	0.96046	262.97186
2. Std. Error		59.38016	0.75722			
3. T. Test		0.14533	15.58755			
S-II						
1. b Value	12	- 0.46553	12.34322	10.99351	0.99094	492.34321
2. Std. Error		56.26690	1.00148	1.93193		
3. T. Test		- 8.27376	11.21959	5.69041		
S-III						
1. b Value	12	373.12159	-0.06555	7.68032	0.66560	8.95732
2. Std. Error		204.16646	6.70690	4.85072		
3. T. Test		1.82753	- 9.77393	1.58333		
S-IV						
1. b Value	8	-265.33015	1.40343	30.84107	0.95051	48.02013
2. Std. Error		292.00810	4.29752	3.33218		
3. T. Test		- 0.90863	0.32656	9.25550		
S-V						
1. b Value	12	-119.53730	15.00112	11.92668	0.9215	569.39442
2. Std. Error		57.77204	1.94382	1.76959		
3. T. Test		- 2.06912	7.71732	6.73977		
S-VI						
1. b Value	12	-138.18565	17.74997	8.70028	0.98870	393.73351
2. Std. Error		123.32895	2.95230	1.69507		
3. T. Test		1.12046	6.01223	5.13268		
S-VII						
1. b Value	9	41.98032	6.82377	15.01317	0.99889	1865.40597
2. Std. Error		36.97455	1.83228	1.44831		
3. T. Test		1.13538	3.72419	10.36598		

there was rainfall in the area on the eve of the rotation, as well as on the state of moisture in the soil. This is more likely in the Kharif and the early Rabi seasons. Secondly, certain crops, like sugarcane and other perennials, need water in every rotation while many seasonal crops need water less frequently. Since there is no uniformity of cropping under irrigation in the area served even by a single water course, not to speak of a distributory, the length of channels that water will have to travel to reach the fields to be irrigated is sure to vary from rotation to rotation and season to season. The longer the channel compared to the quantity of water applied to the field, the greater will be the loss in transit. Appendix Table A.2.1 and A.2.2, showing the area actually irrigated during different rotations in 1978-79, indicate the extent of this fluctuation. Distributory-wise this is even greater. Thirdly, the longer the interval between the two rotations, particularly in summer, more than proportionately greater the application of water in the fields. In the black cotton area, the soil dries and cracks up in a situation of prolonged absence of irrigation in the dry season. When finally water is available, the cultivator per force applies very large quantities of water in order to ensure that the root zone of the crop is fully wetted and more. Indeed, during visit to farmers' fields in summer, we "heard" irrigation water flowing into the field but could not "see" it for quite some time :

irrigation water was flowing considerably below the surface, making noise, and could be seen only through the very wide and deep cracks in the groundnut field! Under PLBC, in 1978-79, only four irrigations were provided during the summer, a smaller number than normally necessary; therefore larger water application in the groundnut and cotton fields may be expected. In addition to the normal tendency of farmers to over-irrigate their fields, these abnormal situations lead to very high water application. Fourthly, loss of water in transit is partly due to defective state of the distributories and the outlets for the water courses. Finally, there is the very real situation of unauthorised and undetected and/or unaccounted use - simply "theft" - of canal water. While checking the irrigation use, through field visits, under one distributory in the Nira Canal System we came across some land, amounting to about 10 per cent of the total authorised irrigated land, supposedly under well irrigation, that was in fact using canal water unauthorisedly for sugarcane. While this had been noticed, it could not be "detected" for what in local paralance are called "political" reasons. Besides these real circumstances on the ground, some of the regression coefficients would not be significant because of very small land area under irrigation during a season or rotation, as the case may be. Thus, the areas under paddy in Kharif and groundnut and cotton in the hot weather were small and scattered under

many distributories, and are not likely to yield reliable results for that reason.

2.20 All these go to suggest that, in the first place, the norms about the quantum of water demanded at the distributory or canal heads used by the irrigation department are quite different from what is actual on the ground. The conversion ratios used to convert all irrigated crop areas to sugarcane equivalent area were presented in Table 2.2. Now, in Tables 2.9 and 2.10 we present the water requirements at the canal head for different crops, as given in the Maharashtra State Irrigation Commission's Report (1972), and the requirements at the distributory head on the basis of our regression coefficients for PLBC, respectively. Apart from the fact that the Commission's figures refer to demand at the main canal head (which make the figures appear much lower than warranted in terms of our distributory head estimates) the inter-crop variations are also quite significant.

2.21 Secondly, these discussions also suggest that there is considerable scope for improvement in the maintenance and management of the canal system and the pattern of water supply, all of which would reduce the loss of water in transit as well as on the field and thereby make lower demand for water at the canal/distributory head for irrigating a given crop pattern.

Table 2.9 : Water Requirements of Crops at the Canal Head as Given in Irrigation Commission's Report (in Acre inch)

Name of the crop	No. of waterings	Quantity per watering	Total	No. of waterings	Quantity per watering	Total	No. of waterings	Quantity per watering	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	-----Kharif--------			------Rabi-------			-----Summer-------		
Sugarcane	7	5.2	36.4	15	5.2	78.0	12	5.2	62.4
Other perennial	7	5.2	36.4	15	5.2	78.0	12	5.2	62.4
Kharif Jowar	2	3.9	7.8	-	-	-	-	-	-
Bajra	2	3.9	7.8	-	-	-	-	-	-
Groundnut	3	3.9	11.7	-	-	-	6	3.9	23.4
Paddy	5	5.2	26.0	-	-	-	4	5.2	20.8
Jowar	-	-	-	4	3.9	15.6	-	-	-
Wheat	-	-	-	6	3.9	23.4	-	-	-
Cotton	2	3.9	7.8	2	3.9	7.8	7	3.9	27.3
Gram	-	-	-	3	3.9	11.7	-	-	-

Source : Maharashtra State Irrigation Commission Report (1972), Tables 36 and 37.

Table 2.10 : Water Requirement of the Crops at Distributory Head as Estimated through regression (Acre inch)

Name of the crop	Kharif			Rabi			Summer		
	No. of waterings	Quantity per watering	Total	No. of waterings	Quantity per watering	Total	No. of waterings	Quantity per watering	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sugarcane	5	11.90	59.50	6	7.55	45.30	4	12.16	48.64
Other Perennial	5	6.49	42.25	6	8.04	48.24	4	6.75	27.00
Hybrid Jowar	3	5.97	17.91	-	-	-	-	-	-
Bajra	2	10.63	21.26	-	-	-	-	-	-
Groundnut	3	6.17	18.51	-	-	-	2	14.30	28.60
Paddy	4	7.66	29.64	-	-	-	-	-	-
Jowar	-	-	-	3	7.14	21.42	-	-	-
Wheat	-	-	-	4	7.76	31.04	-	-	-
Gram	-	-	-	3	17.41	52.23	-	-	-
Cotton	-	-	-	-	-	-	3	25.98	77.94

Note : The canal ran for 5 rotations (watering) in kharif, 6 rotations in rabi and 4 rotations in hot weather season in 1978-79. But, except for sugarcane and other perennials no other crop is necessarily irrigated in all the waterings.

2.22 Since no firm information is available about the actual application of irrigation water by farmers in the field, we propose to use the data put out by the Irrigation Department for the Lift Irrigation Schemes (See Table 2.11, which is the same as in columns 3 and 4 of Table 2.1 given separately for Kharif, Rabi and Summer seasons.) which broadly relate to field level requirement of irrigation, to estimate the loss of water in transit below the distributory head, in the year 1978-79. The method used is as follows : The total irrigation water required in one season at the field level is taken as that given in Table 2.11. But the actual number of irrigations available to a crop in the particular season during 1978-79 in PLBC/NLBC was different from the number of irrigations specified in the Lift Scheme (Table 2.11). We have estimated the water per irrigation for a particular crop in a season to be the total water required for the crop in the season divided by the number of irrigations actually available. The actual water let out through the distributories and the quantity required for irrigation, calculated in this manner are presented below in Tables 2.12 and 2.13.

2.23 We find that, on the whole, 50 per cent of the water let out into the distributories was necessary for irrigating the standing crops in the fields in PLBC; the remaining 50 per cent was therefore lost in transit. In NLBC (non-perennial section) the use was only about 45 per cent; 55 per

Table 2.11 : Irrigation Water Requirement of Crops as Prescribed in the Lift Irrigation Schemes, Government of Maharashtra (Acre inch)

Name of the Crop	Kharif			Rabi			Summer		
	No.of waterings	Quantity per watering	Total	No.of waterings	Quantity per watering	Total	No.of waterings	Quantity per watering	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sugarcane	4	3.0	12.0	12	3.5	42.0	12	4.5	54.0
Other perennial	4	2.5	10.0	12	2.5	30.0	12	3.0	36.0
Kharif Jowar	2	3.0	6.0	-	-	-	-	-	-
Bajra	2	3.0	6.0	-	-	-	-	-	-
Groundnut	2	3.0	6.0	-	-	-	12	3.0	36.0
Paddy	2	4.0	8.0	-	-	-	5	4.5	22.5
Jowar	-	-	-	4	3.0	12.0	-	-	-
Wheat	-	-	-	6	3.0	18.0	-	-	-
Gram	-	-	-	3	3.0	9.0	-	-	-
Cotton	2	3.0	6.0	2	3.0	6.0	7	3.0	21.0

Table 2.12 : Estimated Utilisation of Water as Proportion to the Actual Amount of Water Released from Distributory Head Under PLBC

Season	Water actually released in the distributories/ minors in acre inches	Estimated utilisation of water at the field level acre inches	Percentage utilisation at field level
Kharif	291121	123892	42.56
Rabi	497759	236458	47.50
Summer	161830	116290	71.86
Total :	950710	476640	50.14

Table 2.13 : Estimated Utilisation of Water as Proportion to the Actual Amount of Water Released from Distributory Head Under NLBC (non-perennial zone)

Season	Water actually released in the distributories/ minors in acre inches	Estimated utilisation of water at the field level in acre inches	Percentage utilisation at field level
Kharif	54546	34330	62.95
Rabi	146106	61972	42.42
Summer	94511	35732	37.81
Total	295163	132034	44.73

cent was lost in transit. The seasonal variation was quite significant. In PLBC the percentage of water used was the lowest in Kharif, 43 per cent, and highest in summer, 72 per cent. In NLBC, it was just the reverse : 63 per cent in Kharif and 38 per cent in Summer. While concentration of sugarcane area under irrigation in Summer in PLBC may account for the high utilization level in that season, the variations are too much. The factors discussed earlier (para 2.19) surely must be responsible for this.

2.24 We noted earlier that nearly 34 per cent of the water let out into the Pravara Left Bank Canal in 1978-79 was lost in transit in the main canal. Of the 66 per cent water let out into the distributories only half was estimated to be used on the field. This means, of the total water let out into the canal, roughly one-third was lost in the main canal, another one-third in the distributories and water courses, and only one third was used by the farmers on their fields.

2.25 While these estimates are based on norms, rather than on the basis of actual field measurements, they appear to agree with similar estimates made by researchers in the Water and Land Management Institute at Aurangabad (Maharashtra). Dhamdhere and Padhye in discussing the scheduling of irrigation, illustrated for the Mula Irrigation System, write :[4]

"Based on the losses actually observed, following efficiencies are assumed :

	Cumulative losses from Head works	Efficiency
Distributory Head	28	72
Minor Head	35	65
Outlet Head	42	58
Turn out (Farm gate)	53	47
Root Zone	65	35 . "

While the authors do not cite any source or give information about the "actual observations", it is presumed it relates to their measurements on the Mula system. It shows a loss of 28 per cent in the main canal, against 34 per cent in PLBC in 1978-79. Between the distributory head and the field head 25 per cent of the water is lost, according to their estimates, while ours comes to 33 per cent. While our estimate of loss on the main canal is based on actual measurement, the loss below the distributory head is an estimate. If we assume their estimates for Mula to apply to PLBC as well, the total water lost in transit will be 59 per cent (34 + 25). The high percentage loss of water in transit is borne out. This is not entirely due to unavoidable seepage in unlined canals. The bad maintenance, management of canal and undetected unauthorised use of water are also important reasons for this.

2.26 There appears very considerable scope for improvement in the management and maintenance of the canal system.

Moreover, proper assessment of need of irrigation water at different stages of the growth of a crop, determination of the frequency of water supply to the crop and design of a system of delivery that will ensure delivery of the required quantity of water at the field level will ensure more efficient use of irrigation water than is practiced today. It is proposed to discuss these questions in a general way at a later stage. The next chapter will take the present estimated water requirements at the field level for granted, and examine the economics of the use of water under the existing crop pattern and any alternatives, with a view to maximising returns per unit of water.

NOTES AND REFERENCES

1. Maharashtra State Irrigation Commission Report, 1982, p. 139.

2. Maharashtra Composite Irrigation Project : Feasibility Report, New Delhi : Water and Power Development Consultancy Service (India) Ltd., May 1979, Vol.I, pp. 43-45.

3. Ibid.

4. Dhamdhere, H.V. and Padhye, V.S. "Scheduling of Irrigation", published in National Workshop in Scheduling of Irrigation, Nov. 12-13, 1983, Aurangabad : Water and Land Management Institute, November 1983 (Publication No. 5), p.42.

APPENDIX TABLES

Table A.2.1 : Irrigated area under different crops during each rotation, under PLBC, 1978-79

(Area in Acres)

Season/ Rotation	Sugar-cane	Other perennials	Hybrid Jowar	Bajra	Ground-nut	Paddy	Others	Total
Kharif:								
1	985.92	436.58	2585.89	392.64	164.99	85.63	123.5	4774.9
2	1183.89	473.83	5862.59	1117.65	267.01	189.5	489.46	9583.9
3	1937.43	465.83	6380.23	1041.52	277.36	205.0	471.14	10778.5
4	2319.83	471.98	5609.38	924.26	261.11	187.5	409.38	10191.4
5	1332.73	337.75	3222.14	228.35	172.01	74.25	163.77	5531.0
K. Total	7759.8	2185.97	23660.23	3704.42	1142.48	741.88	1657.25	40859.7

Rabi	Sugar-cane	Other perennials	Jowar	Wheat	Gram	Total
1	1249.12	440.13	6021.03	3992.60	392.24	12094.9
2	1235.23	395.48	3131.51	5145.21	205.64	10121.0
3	1306.21	325.50	3163.14	5474.16	360.76	10629.
4	1745.69	426.40	5490.86	8096.06	435.13	16194.
5	1306.65	264.80	1235.18	6972.25	191.70	9970.
6	1074.52	430.91	1178.47	4991.14	63.00	7738.
R. Total	7917.42	2283.22	20220.19	34671.42	1648.47	66748.

Contd....

Appendix Table A.2.1 : (Contd.)

Summer	Sugar-cane	Other Pere-nnials	Cotton	Ground-nut	Others	Total
1	1050.77	428.28	-	44.0	421.89	1900.94
2	1007.03	422.78	22.26	-	1.5	1452.07
3	4425.60	412.78	60.56	64.0	40.5	5003.44
4	5033.01	447.78	43.13	64.0	31.15	5619.07
S. Total	11516.41	1711.62	125.95	172.0	495.04	13975.52

Table A.2.2 : Irrigated area under different crops during each rotation, under NLBC, 1978-79

(Area in acres)

Season/ Rotation	Ground-nut	Cotton	Hybrid jowar	Bajra	Tur	Maize	Fodder	Total
Kharif								
1	928.00	888.25	956.25	187.00	90.50	140.5	7.5	3198.00
2	1564.5	1615.5	1006.75	699.13	225.00	262.5	8.0	5381.38
3	271.38	428.5	953.5	271.75	207.00	239.0	7.5	2378.63
4	10.00	60.0	28.0	-	-	-	-	98.00
K.Total	2773.88	2992.25	2944.5	1157.88	522.5	642.0	23.0	11056.01

Rabi	Jowar	Gram	Total
3	2226.38	252.9	2479.28
4	6461.05	359.5	6820.55
5	5790.86	173.4	5964.26
6	208.00	47.0	255.00
R. Total	14686.29	832.8	15519.09

Summer	Cotton	Gr. nut	Total
1	562.0	-	562.0
2	748.88	359.13	1108.01
3	528.75	606.14	1134.89
4	273.00	485.11	758.11
5	772.26	995.88	1768.14
6	793.38	1032.08	1825.46
7	400.00	437.88	837.88
S. Total	4078.27	3916.22	7994.49

Note: The first two rotations in Rabi were not given since there was sufficient rainfall at the times.

CHAPTER III

ECONOMICS OF THE USE OF IRRIGATION WATER

3.1 Irrigation in the dry, drought prone regions of Maharashtra is mainly sugarcane centred. A little over 10 per cent of the total irrigated area in the State is under sugarcane. However, since sugarcane is a heavy water using crop compared to others, it uses between 50 to 60 per cent of the total irrigation water in the State. Sugarcane is concentrated in the dry, drought prone regions; and, therefore, the percentage of irrigation water used by sugarcane in this region is likely to be even higher.

3.2 Does this pattern of use of water give the best return per unit of water? The question is particularly relevant in the context of canal water, which can be used in varying amounts and for varying periods during the 8 months after the supply reservoir is filled by the beginning of October every year. The same approach would not work for wells, though given his endowments of land and water, the irrigator with a well may also be expected to maximise return per unit of the factor in relatively short supply. In order to estimate the net returns to the farmer per unit of water under canal irrigation, it is necessary first of all to find out the net returns per acre of different irrigated crops. Then the returns per unit of irrigation water used in different crops/ crop rotations can be calculated and compared.

3.3 For this purpose two different sources of data are sought to be used. The first is a survey into the costs and returns of a sample of farmers selected from the command areas of PLBC and

NLBC (non-perennial zone), relating to the year 1978-79. The second is the data extracted from the enquiries into costs of production of farm products, conducted by the Ministry of Agriculture of the Government of India, in all regions since 1972-73. We have used the data relating to the irrigated crops in the samples drawn from regions in or near which our selected command areas are located. We present below brief accounts of the composition of the sample farms and the costs and returns relating to different crops from these two sources.

The Sample

3.4 The Pravara Left Bank Canal had approximately 25,000 acres of net irrigated area (1978-79), of which 22,000 acres came under perennial irrigation zone and around 2,300 acres under non-perennial irrigation zones. As mentioned earlier non-perennial zone is a zone where no perennial crops are allowed to be grown on canal water. It was decided to cover a 5 per cent sample of the irrigated area each from the perennial part and non-perennial part, which amounted to 1,100 acres and 115 acres respectively. The entire length of the left bank canal was divided into 4 parts, each part having roughly 25 per cent of the irrigated area. In the next stage such number of the distributories from each part were chosen at random so as to cover roughly 275 acres from each part in the perennial area of the canal. The third stage of the sampling was to cover all the beneficiary farmers under the command area of the selected distributories. However, wherever because of the inclusion of a large distributory/water course, the total irrigated area exceeded 275 acres, the beneficiary farmers in such distributories were again chosen randomly so as to confine the area

surveyed to around 275 acres. Similarly, from the non-perennial area the distributories were chosen randomly, so as to cover around 115 acres of irrigated area, and all the beneficiary farmers were covered under those distributories. Similar procedure of sampling was followed in case of the Nira Left Bank Canal (non-perennial zone).

3.5 The household size and agricultural worker composition of the sample households classified according to their size of operated land holding are presented in Appendix Tables A.3.1 and A.3.2. Size of the household, the number of agricultural workers per household and the number of annual farm servants per household increases with the size of operated holding.

3.6 The smallest size group of operational holdings, with 5 acres or less of land, constituted 40.5 per cent of all cultivators, but cultivated only 13.3 per cent of the total cultivated land. On the other hand, the largest cultivating households, with holdings of more than 10 acres, constituted 28 per cent of all cultivators, but cultivated 60.9 per cent of all cultivated land, in PLBC area (Ref. Appendix Table A.3.3). The average size of operational holdings was 9.35 acres.

3.7 In NLBC (non-perennial zone), the size distribution was somewhat different. Here the large size farmers constituted the largest single group, 42.73 per cent of all cultivators and accounted for 74.26 per cent of all cultivated land. The small and medium cultivators were in roughly equal proportions, though of course the medium operated about 3 times the land area operated by the small. This was a region of comparatively larger holdings than PLBC area. The average size of holding was 11.53 acres (Ref.Table A.3.4).

3.8 Only one-third of the total operated land of the cultivators under the PLBC command, was irrigated by the canal. Another 42 per cent of their land was irrigated by wells in or near the command area. One-fourth (24.67 per cent) of their land was without any irrigation facility. Size-wise the smallest cultivators had the maximum, i.e., 51.68 per cent of their land irrigated by the canal, the largest had only 29 per cent of their land under canal. Incidence of well-irrigation however was less uneven : the smallest had 36.23 per cent well irrigated land while the largest had 40.22 per cent; only the middle farmers had about 50 per cent of their land under wells. Therefore, the unirrigated lands with the smallest sized farmers was only 12 per cent while in case of the largest it was nearly 31 per cent.

3.9 In the non-perennial zone under NLBC, on the other hand, much smaller per cent of the total operated area of the cultivators in the command area, 18.58 per cent only, was under canal irrigation. Land under wells accounted for another 20 per cent, leaving more thai 61 per cent of the total operated area of the farmers unirrigated. Here also the smallest farmers had nearly half their land irrigated by canals, the medium about 30 per cent, while the large farms only 13 per cent. The extent of well irrigation did not vary significantly among the three size-classes. Greater irrigation facility has, all along in India, been associated with small average size of land holding. That again appears to be borne out by the difference between PLBC and NLBC (non-perennial) regions, observed here. Another point worth noting in the context of these two regions is that larger the proportion of operated area of farmers covered by canal water, the larger the extent of well irrigation. This is

plausible, since the wells are able to tap and recycle seeped canal water, and greater the coverage under canals, greater this possibility of tapping underground water.

3.10 The cropping pattern of the sample farms is presented in Appendix Tables A.3.5, A.3.6, A.3.7 and A.3.8 for the two regions separately. Under PLBC, only 5 per cent of the gross cropped area, canal irrigated, was under sugarcane. This is broadly in keeping with the sugarcane block area mentioned earlier. However, nearly four times as much sugarcane land, normally irrigated by wells were provided with 2/3 irrigations from the canal in summer. If we add this area as well as the sugarcane area which was an overlap of 1977-78 year and took water pending harvest, mainly in the Kharif and early Rabi seasons, to the gross cropped area under canal as well as to area under sugarcane, we find that nearly 24 per cent of the gross cropped area under canal was under sugarcane. Cereal crops, millets and wheat accounted for the bulk of the canal irrigated land. As against this, not only was the total area under well irrigation under PLBC higher, but the area under sugarcane was nearly 28 per cent of the gross irrigated area under wells. If we add the sugarcane overlap area to the total as well as to the sugarcane area, sugarcane accounts for nearly 40 per cent of the gross irrigated area under wells. The area under well-irrigated millets was just about as large as the area under sugarcane. Wheat was another important cereal. Long staple cotton was grown mainly under well irrigation in summer, while it was very little under canal. Besides, a wide range of seasonal crops as well as fodder and lucerne were grown mainly under well irrigation. In the unirrigated portion of the land holdings of the sample farmers the main

crops grow were local variety of jowar in the Rabi season (nearly 70 per cent of the gross cropped area), bajra and a variety of pulses in the kharif season.

3.11 The distribution of the total gross cropped area (irrigated plus unirrigated), according to the size class of land holdings, is presented in Appendix Tables A.3.7 and A.3.8. An interesting fact to note in this context is that while the small farmers had more than half their land irrigated by canal and nearly 88 per cent of their total land irrigated from either source, the area under sugarcane constituted just about 10 per cent of their gross cropped area. What is more, most of this sugarcane was under wells; the sugarcane area under canal in their case was very small, constituting less than 1 per cent of their net irrigated area under canal. (Data not separately presented.) Out of the total sugarcane area under canal (excluding overlap area), 60 per cent was with the large farmers, over 38 per cent with the medium, and only about 2 per cent with the small farmers, while they occupied 53, 26 and 21 per cents respectively of the total canal irrigated land. Even if we include the overlap sugarcane areas, the distribution amongst the size classes remains broadly unchanged. This shows that, under the block system of giving canal water to sugarcane land, the small farmers had little place; the blocks were mainly with the medium and large farmers, more so with the latter. The small farmers were recipients of canal water for seasonal crops (presumably under Form VII which is given after the available water has been apportioned to the various block areas). We shall return to this inequality of distribution of sugarcane blocks among farmers of different size holdings in a later chapter.

3.12 In the non-perennial zone of NLBC the canal irrigated land was devoted to mainly 3 crops: Rabi jowar, Kharif and Summer groundnut and long staple cotton in summer. Under well irrigation about 10 per cent of the gross cropped area was under sugarcane. Wheat, maize and cotton were the other important crops, besides Rabi jowar. Here too, like under wells in PLBC command area, a number of other seasonal crops were grown in the kharif and Rabi seasons, a phenomenon much less visible in the lands irrigated by the canals. On the unirrigated lands, which formed the bulk of the total cultivated area, Rabi jowar and Kharif pulses were the only two crops being grown.

Net Income from Irrigated Crops

3.13 Detailed data on inputs, costs and outputs, cropwise, were collected from the sample farmers. These were valued at the prevailing prices paid or received by the farmers during the year. The net income per acre was calculated for the various crops grown by the farmer under canal and well irrigation, as well as under rainfed condition. The net income was calculated by valuing the main product plus the by-product, if any, of a crop and deducting from this the values of all material inputs, whether purchased or home-supplied, including feed, fodder, etc., expenses of bullocks or cost of hiring bullocks, irrigation costs and the wages paid to casual or annual farm workers hired for operations on the crop and imputed wages of family labour. The average per acre costs and returns for a number of irrigated crops are presented in Tables 3.1 and 3.2 for PLBC and NLBC respectively.

3.14 We examined such data separately for farmers in the three different size classes of land holdings (data not presented here),

Table 3.1 : Cost and Return Per Acre of Principal Crops Grown in PLBC Command Area, as per Sample Survey

Name of the crop		Seed (Kg.)	F.Y.M. (cart load)	Fertilizer (Kg.)	Pesticide	Cultivation exp. incl. labour	Irrigation charges	Total cost	Main product (Quin)	By-product (stalks)	Gross income	Net income (11-8)
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1. Sugarcane	Q.	13000 sets	10	700	-	-	-	-	37 tons	-	-	-
	Value Rs.	600	150	1050	-	1000	550	3350	4810	-	4810	1460
2. Hybrid Jowar	Q.	3	2	50	-	-	-	-	7	300	-	-
	Value Rs.	35	30	75	20	280	30	470	735	113	848	378
3. Jowar	Q.	4	2	25	-	-	-	-	4	300	-	-
	Value Rs.	8	30	40	-	220	30	328	500	120	620	292
4. Bajra	Q.	2.5	2	20	-	-	-	-	3	280	-	-
	Value Rs.	9	30	30	-	230	30	320	375	100	475	155
5. Wheat	Q.	40	1	85	-	-	-	-	6	6	-	-
	Value Rs.	88	15	130	15	280	30	558	900	50	950	392
6. Gram	Q.	25	-	-	-	-	-	-	2	-	-	-
	Value Rs.	50	-	-	-	160	30	240	360	30	390	150
7. Cotton	Q.	2	5	160	-	-	-	-	4	-	-	-
	Value Rs.	75	75	225	150	400	60	985	1600	-	1600	615
8. Groundnut	Q.	30	6	70	-	-	-	-	5	-	-	-
	Value Rs.	165	90	105	-	320	50	730	1250	-	1250	520
9. Fodder (lucern grass)	Q.	16	30	300	-	-	-	-	530	-	-	-
	Value Rs.	640	450	450	30	350	100	2020	2915	-	2915	895

Table 3.2 : Cost and Return Per Acre of Principal Crops Grown in NLBC (Non-Perennial Zone) Command Area as per Sample Survey

Name of the crop (1)		Seed (2)	F.Y.M. (3)	Fertilizer (4)	Pesticide (5)	Cultivation expenses (6)	Irrigation charges (7)	Total cost (8)	Main product (9)	By-product (10)	Gross income (11)	Net income (11-8) (12)
1. Sugarcane	Q.	12500 sets	10 C.L.	800 Kg	-	-	-	-	38 tonnes	-	-	-
	Value Rs.	565	180	1200	-	1000	550	3495	4940	-	4940	1445
2. Hybrid Jowar	Q.	3 Kg	5 C.L.	60 Kg	-	-	-	-	8 Quin.	300 stalks	-	-
	Value Rs.	35	75	90	20	280	30	530	850	100	940	410
3. Jowar	Q.	4 Kg	3 C.L.	25	-	-	-	-	3 Quin	280 stalks	-	-
	Value Rs.	8	45	35	-	200	30	318	375	100	475	157
4. Bajra	Q.	2 Kg	2 C.L.	-	-	-	-	-	2 Quin.	250 stalks	-	-
	Value Rs.	7	30	-	-	200	20	257	250	100	350	93
5. Wheat	Q.	40 Kg	3 C.L.	100 Kg.	-	-	-	-	6 Quin.	6 qun.	-	-
	Value Rs.	80	45	150	15	280	30	600	900	50	950	350
6. Gram	Q.	20 Kg	-	-	-	-	-	-	2½ Quin.	-	-	-
	Value Rs.	50	-	-	-	180	30	260	375	20	395	135
7. Cotton	Q.	2 Kg	12 C.L.	150	-	-	-	-	4 Quin.	-	-	-
	Value Rs.	70	120	200	150	400	60	1000	1600	-	1600	600
8. Groundnut	Q.	40 Kg	10 C.L.	30 Kg	-	-	-	-	5.5 Quin.	-	-	-
	Value Rs.	200	160	45	-	350	50	805	1375	-	1375	570

C.L. = Cart Load.

but did not find any significant differences among these. Difference between canal and well irrigation, in terms of inputs and outputs were not noticeable in case of many crops, like jowar, bajra, groundnut, etc. But in case of three crops, namely sugarcane, wheat and long staple cotton, the inputs, mainly fertilizer application, were somewhat higher on the well irrigated lands and so was the output per acre. As against this the labour cost per acre was higher on canal irrigated lands, particularly for sugarcane, and the cost of irrigation was higher under well irrigation. The relatively higher fertilizer application on these crops, irrigated by wells, was possibly due to the greater control over water supply, particularly in terms of frequency and timeliness. Fertilizer is applied on the eve of water application, and there is longer interval and greater uncertainty associated with canal irrigation. The higher labour charge is presumably due to the practice of contracting out of a number of operations on the sugarcane field, particularly by the large and even some medium farmers who alone were having canal water for sugarcane, while the small farmers who had almost entirely well irrigation used less of hired labour and there too less contracting out of work to labour gangs. Because of these higher and lower costs and returns in regard to these three crops, the net income per acre in these cases was only marginally higher on well-irrigated lands. We have, therefore, chosen to take the weighted averages of the per acre costs, outputs and net incomes of these as well as the other crops grown under canals and wells. This means that in using these net income data to compare the net incomes per unit of irrigation water used in different crops under canal irrigation, we are somewhat over-

stating the case for sugarcane in particular. This does not matter. Hopefully, improved management of canals, now being slowly started, would lead to this difference being wiped out. In any case, the other set of data relating to farm costs and returns over a number of years which we also propose to use for our exercise, does not permit us meaningful separation of canal and well irrigated crop lands, due to smallness of the samples. For all these reasons, the data in Tables 3.1 and 3.2 give the weighted average per acre costs, returns and net income of a number of crops under irrigation in the sampled farms during 1978-79.

3.15 The data show that the net income per acre under irrigation is the highest for sugarcane. Indeed, it is more than 50 per cent higher than the next highest net income yielding crops, onion and lucern grass. It was 9 times that of irrigated Bajra, 5 times that of irrigated Rabi jowar and 4 times that of hybrid Kharif jowar; and so on. It is not surprising that given ample supply of irrigation water compared to this total land holding, a farmer in this region would prefer to grow sugarcane, except to the extent required by rotational requirements of good agronomic practice.

Net Returns Based on Farm Cost Enquiries

3.16 The farm costs and return data presented above related to the PLBC and NLBC areas, for a particular year. Year to year variations in costs and returns are not unreasonable to expect, even under irrigated conditions, not only due to variations in weather, but also variations in frequency and quantum of water supply as well market conditions. The data collected by the field survey relating to a single year cannot help take care of this. Moreover, these data were collected by a quick survey of the

sample farms. There is possibility of errors arising out of inaccuracy in recollection by the respondents. Greater reliability can be ensured if daily accounts could be kept by the farmers or for him, for the entire agricultural year. But this would have proved very expensive and time consuming.

3.17 Fortunately, such data were (and are) available for the irrigated crops in the region for a number of years. Since 1973 the Union Ministry of Agriculture has been conducting, with the help of Agricultural Universities and other institutions, a comprehensive scheme for collection of data on costs of cultivation of different crops in the country. For each crop, called the main crop, a systematic multistage sample is drawn from the region(s) of the State predominantly growing that crop. The information from the main sample, and, after a few years, of a sub-sample, is collected continuously for a certain number of years. For Maharashtra, we copied out, with the permission of the Economic and Statistical Adviser to the Ministry of Agriculture, detailed information relating to 3 main crop samples, sugarcane, jowar and bajra. Under the scheme the talukas in each district are selected where the particular crop is grown as main crop. From each taluka (cluster) five villages are selected and from each village two farms growing the crop as main crop are selected, keeping in view different sizes of holdings. In addition two progressive farms are also selected from these villages. Thus, in each cluster twelve farms are selected for the particular crop. Detailed information from these farmers relating to land holding, land revenue, imputed rent on own land as well as rent paid for leased in land (plotwise). particulars of attached farm servants, material imputs and irriga-

tion charges (cropwise) record of production (cropwise), running and maintenance expenses of farm machinery and implements is collected periodically. In addition, records of daily operations, plotwise for each crop are also kept by the cost-accounting method. Data on the above items are recorded not only for the main crops but also for the other crops grown by the selected farmers.

3.18 We obtained data for 5 districts, viz., Nashik, Ahmednagar, Pune, Satara and Solapur, for our purpose. For the sugarcane main sample, data are available for the years 1973-74, 1974-75, 1975-76, 1976-77 and 1977-78. For jowar main sample, data are available for 1973-74, 1974-75, 1975-76 and 1977-78, and for bajra main sample, data are available for only 1976-77. In all, data for 61 clusters were available and collected; as mentioned earlier, on the basis of 12 farmers per cluster, it works out to 723 farmers, for whom the data on the above-mentioned variables were available.

3.19 It may be mentioned here that so far as sugarcane, jowar and bajra are concerned, the input-output analysis is based only on the data from each of the respective main sample clusters; for instance, for sugarcane the data are processed only for sugarcane grown in the main sample sugarcane cluster and not for sugarcane grown in jowar and bajra clusters. Similarly, for jowar and bajra data are processed only from their main sample clusters. It is only in the case of other crops (other than sugarcane, jowar and bajra) that the data from all the main sample clusters are pooled together for the individual crops separately for further processing and analysis. Other than sugarcane, jowar and bajra, only those crops are considered which show a sizeable area under cultivation in the sample farms, and not all crops that are reported to be grown by the sample farmers.

3.20 Making use of the data of the sample farms mentioned above we have computed the amount of each of the physical inputs used and output realised per unit (acre) of land for different crops. Before we go into the results of the physical input coefficients of different crops estimated, it is necessary to take note of a few things.

3.21 First of all, scrutiny of the recorded data shows that size groupwise break-up of the input-output data, cropwise, leaves the sample size for each crop in each size-group so small, in terms of area under the crop, that estimating average input coefficient from such a small sample does not seem to be very meaningful. In those cases, however, where area under given crop was found to be substantial in each size-group, the estimates of input coefficients for different inputs did not show any marked variation from one size group to the other except for fertilizer in some cases. While estimating input coefficient, therefore, we have pooled the data for all the size-groups together. So the estimates of inputs coefficients are in the nature of averages for all farms, irrespective of size.

3.22 Secondly, the input-output data for each crop are recorded separately for that grown under well irrigation, canal irrigation and under dry condition. Again, if we considered the cases of a crop grown on well and canal separately, the sample size (area under the crop) would be very small. Further, estimated input coefficients for a given crop grown on well and on canal did not show any marked variation from each other. In view of this our estimated input coefficients are in the nature of averages for irrigated crops, irrespective of source of irrigation.

3.23 Thirdly, the year to year variation in input coefficients is also not found to be significant, in other words, there is no marked variation from one year to other in the use of basic inputs, like seed, human labour, farm yard manure,irrigation,etc. As per the annual Season and Crop Report of the State Government, the years 1973-74, 1974-75, 1975-76, 1976-77 and 1977-78, for which we have the data recorded for most of the major crops grown, have been more or less normal years in terms of rainfall and its distribution, except 1974-75, when the rainfall and its distribution was less than normal. But even for 1974-75, most of the basic inputs were not significantly different from those of other years. In view of this, the input estimates are not presented for each year separately, but only the average of the years. Since the PLBC command area, located in Ahmednagar district is the subject of study, the data from the cost of production survey in Ahmednagar district alone is used here. The estimated input coefficients are presented in Table 3.3.

3.24 An interesting aspect relating to the use of inputs, particularly fertilizers and insecticides, in different crops, as seen from these data, may be noted here. It is seen that only in case of five crops - sugarcane, groundnut, cotton, onion and wheat - was there any significant application of fertilizers. There was little of it in case of all the other irrigated crops, not to mention the dry ones. Sugarcane recorded the highest amount per acre, but it was quite below the doses recommended by the extension agency. In case of the other four crops, it was even lesser. Similar was the picture in regard to farm yard manure. Insecticides/pesticides were reportedly used only on irrigated cotton fields, and to a

Table 3.3 : Per Acre Inputs and Outputs in Physical and in Value Terms for the Principal Crops (Ahmednagar District)

(1)		Name of the Crop: Cotton (HYV) (2)	Ground-nut (HYV) Kh. Irri-gated (3)	Ground-nut (HYV) Kh. Dry (4)	Ground-nut (Local) Kh. Irri. (5)	Ground-nut (Local) Kh. Dry (6)	Maize (Irri-gated) (7)	Onion (Irri-gated) (8)	Lucern (Irri-gated) Fodder (9)
Area under the crop (Acres)		7.41	18.41	18.88	10.83	25.02	4.42	4.67	8.21
1) Seed	Q. (Kg)	2	35	28	40	39	10	4	11
	V. (Rs.)	40	175		160	171	25	180	25
2) F.Y.M.	Q. (kg)	1000	500	200	500	450	2000	1500	1000
	V. (Rs.)	35	20	5	15	15	70	55	35
3) Fertilizer	Q. (Kg.)	100	50	-	25	-	50	150	- -
	V. (Rs.)	50	75	-	40	-	75	225	-
4) Pesticide	Q. (Kg)	-	-	-	-	-	-	-	-
	V. (Rs.)	100	-	-	-	-	-	75	-
5) Irrigation charges (Canal)	V. (Rs.)	50	30	-	30	-	30	50	300
6) Human labour days	Q.	70	45	30	30	20	30	90	20
	V. (Rs.)	280	180	120	120	80	120	360	80
7) Animal labour days	Q.	8	8	6	8	6	10	8	4
	V. (Rs.)	96	95	70	95	70	120	95	48
8) Machine hours	Q.	134	22	-	24	-	25	100	38
	V. (Rs.)	94	20	-	18	-	19	100	21
9) Diesel Oil Ltrs. (Irrg)	Q.	150	80	-	70	-	-	100	-
	V. (Rs.)	375	200	-	175	-	-	250	-
10) Total Cost Excl. Cls. 8 & 9	V. (Rs.)	751	650	341	460	336	440	1040	488
11) Main Product	Q.	3.5	4.5	2.0	3.0	2.0	5.5	60.0	70.0
	V. (Rs.)	1400.0	1125.0	500.0	750.0	500.0	825.0	2100.0	1050.0
12) By-product (quintal)	Q.	-	6.0	2.5	4.0	2.0	6.0	-	-
	V. (Rs.)	-	50.0	30.0	50.0	25.0	50.0	-	-

(continued)

Table 3.3 : (continued)

(1)		Name of the Crop: Jowar (Hy.) (Irri.) (10)	Jowar (Local) (Irri.) (11)	Jowar (Local) (Dry) (12)	Bajra (Hy.) (Irri.) (13)	Bajra (Local) (Irri.) (14)	Bajra (Local) (Dry) (15)	Wheat (Hy.) (Irri.) (16)	Wheat (Local) (Irri.) (17)
Area under crop (Acres)		16.83	57.53	162.90	17.62	18.90	59.23	180.66	85.90
1)	Q. (Kg.)	3.0	4.0	4.0	2.5	2.0	2.5	37	35
	V. (Rs.)	35.0	8.0	8.0	25.0	4.0	5.0	88	77
2)	Q. (Kg)	1500	1000	100	1500	1200	200	1000	700
	V. (Rs.)	50	35	5	50	40	7	35	25
3)	Q. (Kg)	30	15	-	20	15	-	100	50
	V. (Rs.)	50	20	-	30	25	-	50	75
4)	Q. (Kg)	3	-	-	-	-	-	-	-
	V. (Rs.)	20	-	-	-	-	-	-	-
5)	V. (Rs.)	30	30	-	30	30	-	30	30
6)	Q. (days)	40	25	15	40	30	15	36	30
	V. (Rs.)	160	100	60	160	120	60	145	120
7)	Q. (days)	7	7	4	7	7	5	8	7
	V. (Rs.)	80	80	48	84	80	60	95	80
8)	Q. (Hrs)	4	10	-	14	13	-	42	29
	V. (Rs.)	1	3	-	12	11	-	19	24
9)	Q. (Ltrs)	40	20	-	35	15	-	75	50
	V. (Rs.)	100	50	-	85	35	-	185	125
10)	V. (Rs.)	425	273	121	379	299	132	543	407
11)	Q.	8.0	4.0	1.5	6.0	4.0	2.0	6.5	4.0
	V. (Rs.)	840.0	500.0	187.0	750.0	500.0	250.0	975.0	600.0
12)	Q.	15.0	18.0	6.0	13.0	8.0	6.0	7.0	7.0
	V. (Rs.)	70.0	90.0	35.0	70.0	50.0	36.0	60.0	50.0

(continued)

Table 3.3 : (continued)

(1)		Wheat (Local) (18)	Gram Irrigated (19)	Gram Dry (20)	Cotton (Hy.) Hot weather (21)	Groundnut (Hy.) Hot weather (22)	Sugarcane (Adsali) (23)	Sugarcane (Suru) (24)
Area under crop (Acres)		34.79	54.51	79.43			62.64	13.75
1)	Q. (Kg)	27	21	19	2	30	13,500	13,000
	V. (Rs.)	54	46	38	70	130	600	600
2)	Q. (Kg)	100	115	-	1500	1000	5000	4160
	V. (Rs.)	5	6	-	55	35	175	145
3)	Q. (Kg)	-	25	-	150	100	600	480
	V. (Rs.)	-	40	-	225	50	900	700
4)	Q. (Kg)	-	-	-	-	-	-	-
	V. (Rs.)	-	-	-	100	-	-	-
5)	V. (Rs.)	-	30	-	150	100	550	400
6)	Q. (days)	15	22	15	80	45	140	120
	V. (Rs.)	60	88	60	320	180	700	600
7)	Q. (days)	5	6	4	10	8	20	20
	V. (Rs.)	60	70	48	120	95	240	240
8)	Q. (Hrs.)	-	12	-	-	-	350	280
	V. (Rs.)	-	8	-	-	-	350	280
9)	Q. (Ltrs)	-	25	-	-	-	350	280
	V. (Rs.)	-	60	-	-	-	875	700
10)	V. (Rs.)	179	280	146	1040	690	3165	2705
11)	Q.	2.0	3.0	1.5	4.5	4.5	360.0	300.0
	V. (Rs.)	300.0	540.0	270.0	1800.0	1125.0	4680.0	3900.0
12)	Q.	3.0	3.0	1.0	-	6.0	-	-
	V. (Rs.)	20.0	30.0	10.0	-	50.0	-	-

(continued)

Table 3.3 : (continued)

Notes : 1) Physical coefficients of inputs are based on averages for the year 1973-74 to 1975-76 in the case of jowar, for the year 1976-77 in the case of Bajra, for the year 1973-74 to 1977-78 in the case of Sugarcane and all other crops.

2) Irrigation charges shown in the computation of total cost per acre are for canal irrigation only. In the case of lift irrigation, instead of canal irrigation charges, cost of machine hours and either of diesel oil or of electricity need be considered assuming that the entire machine hours is for irrigation only.

lesser extent on wheat. In regard to all other crops, neither provision of irrigation nor use of improved seeds appeared to had led to any noticeable use of chemical fertilizers,insecticides,etc.

3.25 There was considerable variation in the rates of yield of most crops from year to year as well from farm to farm in the same year. This was largely due to differences in local soil climate conditions and cultural practices besides the weather. Therefore, the average of yield rates over the years and sectors have been calculated and are given in Table 3.3. The problems arising out of the variations noticed will be discussed in the next chapter.

3.26 The physical inputs and outputs, which are averages of the observed figures for a number of years, are valued at 1978-79 prices, as in case of the special sample survey farmers, presented earlier. The problems arising out of the variations in the relative prices of various outputs as well as inputs will be taken up in the next chapter.

3.27 The gross value of output per acre includes the value of by-products as well as the main product. The costs (inputs) taken into account include costs of all materials used, whether purchased or home supplied, costs of bullock labour hired, purchased or farm supplied, the labour charges, both hired as well as the imputed value of family labour. Since the interest is in estimating the net income due to a unit of canal water, the costs due to machine hours and diesel oil used, essentially in irrigation from wells, presented in rows 8 and 9 of Table 3.3, are excluded in calculating the total cost given in row 10.

3.28 The comparative picture per acre of net return of various crops under irrigation, given in Table 3.4, is very similar to

Table 3.4 : Cost and Return per Acre of Principal Crops (Irrigated) from Cost of Production Survey

(Ahmednagar District)

Name of the Crop (all Irrigated)	Avg. cost of cultivation per acre	Avg. production per acre		Value of production per acre		Total	Net income (per acre) (7) - (2)
		Main product (Quintal)	By-product (Quintal)	Main product (Rs.)	By-product (Rs.)	(Rs.)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sugarcane (Adsali)	3,165	360.0	-	4,680	-	4,680	1,515
Sugarcane (Suru)	2,705	300.0	-	3,900	-	3,900	1,195
Hybrid Jowar-Kharif	425	8.0	15	840	70	910	485
Jowar (local) Rabi	273	4.0	18	500	90	590	317
Bajra (HYV)	379	6.0	13	750	70	820	441
Bajra (local)	299	4.0	8	500	50	550	251
Wheat (HYV)	543	6.5	7	975	60	1,035	492
Wheat (local)	407	4.0	7	600	50	650	243
Groundnut (HYV) - Kh.	650	4.5	6	1,125	50	1,175	525
Groundnut (local) Kh.	460	3.0	4	750	50	800	340
Cotton (HYV)-Kharif	751	3.5	-	1,400	-	1,400	649
Gram (local)	280	3.0	3	540	30	570	290
Maize (local)	440	5.5	6	825	50	875	435
Lucern (Fodder)	488	70.0	-	1,050	-	1,050	562
Onion	1,040	60.0	-	2,100	-	2,100	1,060
Cotton (HYV) HW	1,040	4.5	-	1,800	-	1,800	760
Groundnut (HYV) HW	690	4.5	6	1,125	50	1,175	485

what was seen earlier under the sample survey of PLBC and NLBC farmers. Sugarcane, whether Adsali (18-20 months) or Suru (annual) gives the highest net income per acre under irrigation. The next highest irrigated crop, onion, gives only two-thirds of the income from Adsali sugarcane, but was not far below the annual sugarcane. The irrigated cereals, like wheat (HYV), Hybrid Jowar and Hybrid Bajra gave less than one-third of the income of Adsali sugarcane. But, this is not the proper way to compare the data. In the first place, Adsali sugarcane stands for 18 to 20 months on the field before harvest, and Suru for about 12 months. Most seasonal crops stand for about $4\frac{1}{2}$ months, so that at least two seasonal crops can be grown in a year and more than 3 in 18-20 months on the same land Moreover, the requirements of water of these crops are quite different. Therefore, the proper way to compare these returns is t calculate the net return per unit of irrigation water from every crop.

Net Return Per Unit of Irrigation Water

3.29 In order to calculate the net return per unit of water from different crops, we should have the data on total irrigation water requirement of different crops. For this purpose we propose to use our estimate of demand from different crops at the distributory hea presented in Table 2.10, after some adjustments made on the basis of other relevant data. These are given in Table 3.5. It is usefu to use the estimated water requirments of different crops at the distributory head rather than at the field head in order to take account of the loss in transit. This is also how the irrigation department estimates irrigation requirements as well as allocation of water to crops in a season. This leaves the possibility of

Table 3.5 : Irrigation Water Requirement of Crops at Distributory Head and the Net Value of Product Per Unit of Water Used (1978-79)

Name of the Crop	Water requirement (acre inch)	Area that can be irrigated per Mcft. of water (acres)	Net profit per acre (Rs.)	Net value of produce per Mcft (Rs.)
(1)	(2)	(3)	(4)	(5)
1. Sugarcane (Adsali)	175	1.55	1,515	2,348
2. Sugarcane (Suru)	136	2.00	1,195	2,390
3. Bajra (HYV-Kharif)	20	13.80	441	6,086
4. Bajra (local)	20	13.80	251	3,464
5. Groundnut (HYV-kharif)	24	11.50	525	6,038
6. Groundnut (Local-kharif)	24	11.50	340	3,910
7. Cotton (HYV-kharif)	24	11.50	649	7,463
8. Maize (local kharif)	20	13.80	435	6,003
9. Hybrid Jowar (Kh.)	15	18.40	485	8,924
10. Jowar (Local-rabi)	22	12.50	317	3,962
10a. Jowar (Hy-Rabi)	22	12.50	485	6,063
11. Wheat (HYV)	30	9.20	492	4,526
12. Wheat (Local)	30	9.20	243	2,235
13. Onion (Rabi)	36	7.65	1,060	8,109
14. Gram (Local)	18	15.30	290	4,437
15. Onion (Hot weather)	42	6.55	1,060	6,943
16. Maize (Hot weather)	36	7.65	435	3,328
17. Cotton L.S. (hot weather)	42	6.55	760	4,978
18. Groundnut (hot weather)	36	7.65	485	3,710

improvement in the water distribution system that can further reduce the demand of various crops at the distributory head open. Now, given a discharge of one million cubic feet (Mcft) of water at the distributory head we calculate the area of a crop that can be irrigated with that quantity of water in the command area below the distributory. These are also given in Table 3.5. Given the area of a crop that can be irrigated, the net income generated by that area of the crop is estimated by multiplying it with the net income per acre in Table 3.4. The last column of Table 3.5 gives this. A similar set of data, based on the per acre costs and returns of different irrigated crops, derived from the special survey in PLBC command, (Table 3.1) are also presented in Table 3.6. Since the two tables show similar results, we propose to use the information in Table 3.5 for discussion and further use.

Table 3.6 : Economics of Alternative Crops in Terms of Net Income Per Unit (Mcft) of Water

Crop	Per acre water requirement in acre inches	Area that can be irrigated per Mcft of water in acres	*Net value of produce per Mcft of water in Rs.
(1)	(2)	(3)	(4)
Sugarcane	175	1.60	2336
Hybrid jowar	15	18.40	6955
Bajra	20	13.80	2139
Groundnut (Kharif)	24	11.50	5980
Jowar	22	12.50	3650
Wheat	31	9.20	3606
Gram	18	15.30	2295
Cotton (Summer)	42	6.60	4059

* Net income per acre of irrigated land taken from Table 5.1.

3.30 The net income per Mcft of irrigation water, generated from different crops reverses the ranking of crops seen on a per acre basis earlier. Sugarcane turns out to be the crop that generates the lowest income per Mcft of water, at the given level of prices of the inputs and outputs. All the cereals crops show a higher net income per Mcft of water; hybrid jowar in particular shows comparatively very high net income. Among the cash crops, cotton, onion and groundnut show very high incomes. All this happens because though the net income generated per acre of the irrigated seasonal crops is lower than that from sugarcane, many more acres of the seasonal can be irrigated with an Mcft of water. It is clear that in situation like in the drought prone dry agricultural regions of Maharashtra, where irrigation water is potentially in short supply and where therefore the question of choice of crop or crops for irrigation arises, use of the water for sugarcane turns out to be economically least efficient.

3.31 The matter can be examined from a somewhat broader social angle as well. The calculations above have been in terms of the net income generated, per acre or acre-inch of water. The measure of net income used is relevant for the farmer in deciding the choice of crops for the use of scarce water. The matter can be looked at from the social point of view, where it would be useful to find out what addition to the gross national product can the use of a given quantum of water make in agriculture of the region. The approximate gross national product or gross value added per acre of the different irrigated crops are arrived at by deducting the cost of all material inputs from the gross value of output. In our calculation in Table 3.3, the only item that will not be taken into account is

the cost of human labour, both family and hired. The gross value added per acre of different irrigated crops is presented in Appendix Table A.3.9. The picture is very similar to that relating to net income per acre. The gross value added per Mcft of water also shows a similar relative position as net income per acre inch of water. It is clear that under prevailing conditions use of irrigation water for sugarcane adds the least to social income. Most other crops are much better placed in that regard.

3.32 It was noted earlier (Chapter I) that cultivators in the past were reluctant to use water for irrigating seasonal crops, except in years of abnormally low rainfall. M. Visweswaraya had mentioned that while irrigating a seasonal cereal crop gave greater yield, its cost was also higher, leaving no greater net income than what the unirrigated crop would give in a year of normal rainfall. This picture appears to have changed. The net incomes per acre of irrigated jowar and bajra are higher than that of unirrigated ones. What is more, the new hybrids give a distinctly higher net income. There is no reason to think that farmers would be reluctant to irrigate hybrid jowar or bajra crops even in a year of good rainfall in these drought prone regions. Newer varieties, stabler and higher yielding, are gradually being introduced; these and better extension would lead to greater use of plant nutrients leading to higher net incomes from these seasonal crops. The developments are likely to further improve the efficiency of irrigation water in all such crops.

3.33 While most other irrigated crops give a higher net income compared to sugarcane, one cannot expect farmers to grow any one of these crops exclusively. Normally, farmers follow certain crop

rotations, depending on soil condition, agronomic requirements, labour supply position, besides market condition. A number of such crop rotations, as alternatives to (i) Adsali sugarcane, which stands on the field for 18-20 months (July to February) and (ii) Suru sugarcane which stands on the field for 12 months (November to November) are proposed in Table 3.7. These rotations have been finalised in consultation with and on the advice of the Professor of Agronomy at the Water and Land Management Institute at Aurangabad.

3.34 On the basis of these crop rotations, the total water requirement of the entire rotation can be estimated and the number of acres on which every one of these rotations can be practised with one Mcft of irrigation can be worked out. This gives a basis for estimating the net income from every one these crop rotations from one Mcft of water, which can then be compared with the net income from the corresponding area under Adsali or Suru sugarcane, as the case may be. This is attempted in Table 3.8.

3.35 The exercises show that every alternative crop rotation generates greater total net income than sugarcane, in all cases more than two times that of sugarcane. Further, if any of the alternative crop rotations is followed on a single plot of land (on which the alternative is sugarcane), then the alternatives to Adsali sugarcane can irrigate 30 to 60 per cent more net sown area, and the alternatives to Suru, 50 to 100 per cent more net sown area, depending upon the alternative crop rotation.

3.36 This point of view has acquired growing acceptance and support from informed irrigation engineers, scholars and knowledgeable public men. In the Interim Report of the Committee (set up

Table 3.7 : Alternative Crop Rotations to (i) Adsali and (ii) Puru Sugarcane

	Kharif	Rabi	Summer
	Sugarcane (Adsali) (July plantation)	Sugarcane	Sugarcane
	Sugarcane	Sugarcane (harvested by the end of February)	
	Alternative to Adsali Cane		
1st	Groundnut (HYV) (mid June-October end)	Wheat (HYV) (Mid Nov.-February end)	Cotton (L.S.) (Mid March)
	Cotton (L.S.) - Sept. end)	Hybrid Jowar (Mid Oct.-Mid Feb.)	
2nd	Hybrid Jowar (Mid June-Sept. end)	Wheat (HYV) (Nov.-end Feb.)	Groundnut (HYV) (March-June) Mid Mid
	Bajra (HYV) (July-Oct.)	Wheat (HYV) (Nov.-end Feb.)	
3rd	Cotton (L.S.) (Mid June-Mid Nov.)	Gram (Nov.end-Feb.end)	Groundnut (HYV) (Mar.mid-June mid)
	Hybrid Jowar (July-Mid Oct.)	Onion (Oct. end - Dec. end)	
4th	Bajra (HYV) (Mid June - Mid Oct.)	Wheat (HYV) (Nov. - Feb.)	Cotton (L.S. (Mid March -
	Cotton (L.S.) (Mid Oct.)	Gram (Nov. end - Feb. end)	
5th	Cotton (HYV) (Mid June - Mid Nov.)	Wheat (HYV) (Nov. end - Mid March)	Groundnut (HYV) (April-June mid)
	Hy. Bajra (July-Mid.Oct.)	Onion (Oct. end - Jan. end)	

Table 3.7 : (Continued)

	Kharif	Rabi	Summer
6th	Groundnut (HYV) (Mid June - Sept. end)	Wheat (HYV) (Nov.-End Feb.)	Onion (March-May end)
	Bajra (HYV) (Mid June - Mid Sept.)	Hy. Jowar (Oct.-Mid Jan.)	

	Kharif	Rabi	Summer
		Sugarcane (Suru) (November-plantation)	Sugarcane
	Sugarcane	Sugarcane (harvested by the end of November)	
	Alternative to Suru'Cane		
1st		Hybrid Jowar (Beg.Oct. - Feb.)	Groundnut (HYV) (Mar.-June) Mid Mid
	Bajra (HYV) (July-Oct.)		
2nd		Wheat (HYV) (Nov.-Feb.end)	Groundnut (Mid-March Mid June)
	Hy. Jowar (July-Oct.)		
3rd		Wheat (HYV) (Nov.-End Feb.)	Groundnut (Mid March-Mid May)
	Cotton (HYV) (June-Nov.)		

Table 3.8 : Economic Alternatives of Different Crop Combinations in Terms of Net Value of Produce Per Mcft of Water (1978-79)

Crop Combination	Water requirement (Cubic feet)	Area that can be irrigated per Mcft of water (acres)	Net value of produce per Mcft of water (Rs.)
(1)	(2)	(3)	(4)
Sugarcane (Adsali) 1 1/2 Year Crop (July planting)	635,250	1.55	2,348
Alternative Combinations to Adsali cane			
1st combination	428,340	2.35	5,316
2nd combination	475,530	2.10	5,030
3rd combination	468,270	2.15	6,383
4th combination	399,300	2.50	4,958
5th combination	529,980	1.89	5,910
6th combination	500,940	2.00	6,006
Sugarcane (Suru) One year crop (November planting)	500,940	2.00	2,390
Alternative combinations to Suru cane			
1st combination	283,140	3.55	5,009
2nd combination	294,030	3.40	4,971
3rd combination	326,700	3.06	4,976

by the Government of Maharashtra) to study the Introduction of Eight monthly supply of water on the Irrigation Projects in Maharashtra, this point of view has been very strongly advocated. In fact, this Committee for a comparatively smaller irrigation project on the same Pravara river (Mahaldevi Project) shows (Table 8 of the Report) difference among returns to per acre-inch of water from different crops, similar to those calculated here in this study. Indeed, in the serious water scarce regions, the Committee advocates extensive irrigation, covering one-fourth of the total cultivated area of the cultivator in the Kharif season and another one-fourth in the Rabi season, thus covering 50 per cent of the command area with irrigation. Our crop rotations above are in the nature of intensive irrigated farming on the same piece of land, three crops being grown in the three seasons of the year. If this is relaxed and farmers are persuaded or permitted to take water of only a given amount, without any specification of crop rotation on a given piece of land, a much wider area can be irrigated for at least one, possibly two crops during the year. This, of course, would not affect the net income generation, estimated earlier. We shall turn to these and other related questions in Chapter V. But before that it is necessary to raise and answer some questions relating to the basis of our calculations in this chapter, and the farmers' attitudes in the matter, to which we now turn.

APPENDIX TABLES

Table A.3.1 : Average Size of Sample Households of Which Working in Agriculture and Average Number of Permanent Farm Servants per Household in PLBC

Size-group of operated holding (in acres) (1)	No. of house-holds (2)	Average size of house-holds (3)	Of which engaged in agriculture			Annual farm servants per household (7)
			Male (4)	Female (5)	Children (6)	
1. Upto 5.00	149	7.09	1.61	1.40	0.06	0.12
2. 5.01 to 10.00	116	8.14	1.74	1.47	0.02	0.51
3. 10.01 and above	103	9.47	2.14	1.63	0.08	1.16
Total	368	8.08	1.80	1.49	0.05	0.53

Table A.3.2 : Average Size of Sample Households, of Which Working in Agriculture and Average Number of Permanent Farm Servants Per Household in NLBC

Size-group of operated holding (in acres) (1)	No. of house-holds (2)	Average size of house-hold (3)	Of which engaged in agriculture			Annual farm servants per household (7)
			Male (4)	Female (5)	Children (6)	
1. Upto 5.0	67	6.43	1.64	1.75	0.07	0.06
2. 5.01 to 10.00	63	8.81	1.94	1.95	0.11	0.29
3. 10.01 and above	97	10.35	2.70	2.36	0.17	0.63
Total	227	8.77	2.18	2.07	0.13	0.37

Table A.3.3 : Operated Area Irrigated Sourcewise, in the Sample Farms in PLBC

(Area in acres)

Operational land holding size-group (acres) (1)	No. of house-holds (2)	Total oper-ated area (3)	Irrigated		Un-irri-gated (6)	Average operated area (7)
			Canal (4)	Wells (5)		
Upto 5.00	149 (40.5)	459.67 (13.3)	237.55 (56.68)	166.53 (36.23)	55.59 (12.09)	3.09
5.01 - 10.00	116 (31.5)	887.54 (25.8)	302.26 (34.06)	436.84 (49.22)	148.44 (16.72)	7.65
10.01 and above	103 (28.0)	2095.27 (60.9)	607.65 (29.00)	842.64 (40.22)	644.98 (30.78)	20.34
Total	368 (100.0)	3442.48 (100.0)	1147.46 (33.33)	1446.01 (42.00)	849.01 (24.67)	9.35

Note: Figures in brackets are percentages to total figures in brackets in cols.4, 5, 6 are percentage to the total operated area in the row.

Table A.3.4 : Operated Area Irrigated Sourcewise, in the Sample Farms in NLBC

(Area in acres)

Operational land holding size-group (acres) (1)	No.of house-holds (2)	Total oper-ated area (3)	Irrigated		Un-irri-gated (6)	Average operated area (7)
			Canal (4)	Wells (5)		
Upto 5.00	67 (29.52)	181.18 (6.92)	88.42 (48.80)	36.93 (20.38)	55.83 (30.82)	2.70
5.01 - 10.00	63 (27.95)	492.45 (18.82)	146.75 (29.80)	111.22 (22.59)	234.48 (47.61)	7.82
10.01 and above	97 (42.73)	1943.06 (74.26)	250.96 (12.92)	370.90 (19.09)	1321.20 (67.99)	20.03
Total	227 (100.0)	2616.69 (100.0)	486.13 (18.58)	519.05 (19.84)	1611.59 (61.58)	11.53

Note: Figures in brackets are percentages to total figures in brackets in cols.4, 5, 6 are percentages to the total operated area in the row.

Table A.3.5 : Distribution of Gross Cropped Area of Sample Farms, Under PLBC, in 1978-79, According to Source of Irrigation

(in acres)

Season/ Crop (1)	Canal irrigated (2)	Well irrigated (3)	Un-irrigated (4)	Total (5)
1. Sugarcane	72.04*	451.84	-	523.88
Kharif				
2. Bajra	156.78	98.08	127.33	382.19
3. Groundnut	46.28	33.51	-	79.79
4. Pulses	5.00	7.25	37.83	50.08
5. Others	1.00	2.63	17.75	21.38
6. Maize	2.75	11.88	-	14.63
7. Hy. Jowar	225.35	120.24	2.65	348.24
8. Vegetable	0.50	14.21	-	14.71
9. Cotton	-	4.50	-	4.50
10. Onion	-	-	-	-
11. Paddy	6.00	4.50	-	10.50
12. Lucern	8.43	74.59	-	83.02
13. Fodder	11.50	23.29	-	34.79
14. Chillies	-	1.63	-	1.63
Rabi				
15. Wheat	308.34	302.66	4.00	615.00
16. Gram	48.05	32.96	11.48	92.49
17. Jowar	498.18	224.96	479.40	1202.54
18. Onion	-	3.16	-	3.16
19. Chillies	-	0.25	-	0.25
20. Fodder	-	1.50	-	1.50
21. Vegetables	-	4.64	-	4.64
22. Fruits	3.95	3.78	-	7.73
Summer				
23. Cotton	11.75	204.42	-	216.17
24. Groundnut	8.75	13.25	1.00	23.00
25. Fodder	-	2.00	-	2.00
Total	1414.65	1641.73	681.44	3737.82

* Besides this, there was an overlap of 60.34 acres of sugarcane from 1977-78.

** Besides this, the overlap from 1977-78 was 326.45 acres.

Table A.3.6 : Distribution of Gross Cropped Area of Sample Farms, Under NLBC, in 1978-79, according to Source of Irrigation

(Area in acres)

Season/ Crop (1)	Canal irrigated (2)	Well irrigated (3)	Un-irrigated (4)	Total (5)
1. Sugarcane	6.71*	73.11**		
Kharif				
2. Bajra	11.00	6.45	4.00	21.45
3. Groundnut	34.20	13.50	-	47.70
4. Pulses	8.25	2.58	310.55	321.38
5. Others	-	1.50	-	1.50
6. Maize	11.60	89.71	-	101.31
7. Hy. Jowar	10.00	18.13	1.25	29.38
8. Vegetables	0.25	13.38	-	13.63
9. Cotton	12.00	46.95	-	58.95
10. Onion	-	3.50	-	3.50
11. Paddy	1.50	7.26	-	8.76
12. Lucern	-	-	-	-
13. Fodder	1.50	19.94	-	21.44
14. Chillies	-	2.25	-	2.25
Rabi				
15. Wheat	20.45	105.13	-	125.58
16. Gram	6.75	16.13	5.00	27.88
17. Jowar	426.80	254.84	1120.64	1802.28
18. Onion	-	3.50	-	-
19. Chillies	-	-	-	-
20. Fodder	-	-	-	-
21. Vegetables	-	7.75	-	7.75
22. Fruits	-	5.13	-	5.13
Summer				
23. Cotton	43.35	51.25	-	94.60
24. Groundnut	68.50	11.00	-	79.50
25. Fodder	-	-	-	-
Total	662.86	752.99	1441.44	2857.29

* Besides this, overlap of 1977-78 area under sugarcane, 3.88 acres.

** Besides this, overlap of 1977-78 area under sugarcane, 52.41 acres.

Table A.3.7 : Cropping Pattern of the Sample Farmers on Their Total Operated Holdings - Pravara Left Bank Canal

(Area in acres)

Size group of operational holding (1)	Rabi jowar (2)	Wheat (3)	Bajra (4)	Sugar-cane (5)	Hybrid jowar (6)	Summer Cotton (7)	Ground-nut (8)	Lucern fodder (9)	Pulses (10)	Others (11)	Gross cropped area (12)
1. Upto 5 acres	154.10 (25.99)	142.60 (24.06)	30.01 (5.06)	63.38 (10.69)	83.54 (14.09	42.24 (7.13)	27.01 (4.57)	23.94 (3.70)	14.29 (2.41)	13.37 (2.30)	594.48 (100.00)
2. Above 5 acres and upto 10 acres	638.96 (30.25)	359.20 (17.01)	244.68 (11.59)	299.60 (14.19)	190.20 (9.01)	140.43 (6.65)	48.28 (2.29)	70.92 (3.34)	66.28 (3.14)	53.26 (2.55)	2111.81 (100.00)
3. Above 10 acres	409.48 (39.70)	113.20 (10.98)	107.50 (10.42)	160.90 (15.60)	74.50 (7.22)	33.50 (3.25)	27.50 (2.67)	26.45 (2.47)	62.00 (6.01)	16.50 (1.70)	1031.53 (100.00)
	1202.54 (32.19)	615.00 (16.46)	382.19 (10.23)	523.88 (14.02)	348.24 (9.82)	216.17 (5.79)	102.79 (2.75)	121.31 (3.15)	142.57 (3.82)	83.13 (2.25)	3737.82 (100.00)

Note : Figures in the parentheses indicate percentages to gross cropped area.

Table A.3.8 : Cropping Pattern of the Sample Farmers on Their Total Operated Holdings - Neera Left Bank (Non-Perennial Zone)

(Area in acres)

Size group of operational holding	Sugar-cane	Pulses	Maize	Vege-tables	Wheat	Rabi jowar	Cotton (Mainly hot weather)	Ground-nut (Mainly hot weather)	Others	Total Gross cropped area
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1. Upto 5.00 acres	0.75 (0.35)	3.50 (1.66)	7.75 (3.67)	1.25 (0.59)	5.20 (2.46)	154.38 (73.05)	15.00 (7.10)	19.50 (9.23)	4.00 (1.89)	211.33 (100.00)
2. Above 5.00 acres and upto 10.00 acres	15.23 (2.72)	32.05 (5.73)	21.56 (3.86)	3.38 (0.60)	37.89 (6.78)	354.03 (63.31)	44.25 (7.91)	28.00 (5.01)	22.84 (4.08)	559.23 (100.00)
3. Above 10 acres	63.84 (3.06)	285.83 (13.70)	72.00 (3.45)	26.00 (1.25)	82.49 (3.95)	1293.87 (62.00)	94.30 (4.52)	79.70 (3.82)	88.70 (4.25)	2086.73 (100.00)
All sizes	79.82 (2.79)	321.38 (11.25)	101.31 (3.55)	30.63 (1.07)	125.58 (4.40)	1802.28 (63.08)	153.55 (5.37)	127.20 (4.45)	115.54 (4.04)	2857.29 (100.00)

Note : Figures in the parentheses indicate percentages to total gross cropped area.

Table A.3.9 : Gross Value Added by Different Crops Per Mcft of Irrigation Water

Crops (1)	Gross Value Added per acre (Rs.) (2)	No. of acres irrigable with Mcft (acres) (3)	Total Gross Value Added (2 x 3) (Rs.) (4)
Irrigated Crops			
1. Sugarcane (Adsali)	2,215	1.55	3,433
2. Sugarcane (Suru)	1,795	2.00	3,590
3. Cotton	929	11.50	10,683
4. Groundnut (HYV-Kh)	705	11.50	8,108
5. Groundnut - HYV Sum.	665	7.65	5,087
7. Cotton - HYV-Summer	1,080	6.55	7,074
8. Maize - Kharif	555	13.80	7,659
9. Onion - Summer	1,420	7.65	10,863
10. Jowar - Hybrid	645	18.40	11,868
11. Jowar - Local Rabi	417	12.50	5,212
12. Bajra - Hybrid	601	13.80	8,294
13. Bajra - Local	371	13.80	5,120
14. Wheat - HYV	637	9.20	5,860
15. Wheat - Local	363	9.20	3,340
16. Gram	378	15.30	5,783
Unirrigated			
18. Groundnut - HYV Kh.	309	-	-
19. Groundnut - Local	269	-	-
20. Jowar - Local	161	-	-
21. Bajra - Local	214	-	-
22. Wheat - Local	201	-	-
23. Gram	194	-	-

CHAPTER IV

RETURNS TO IRRIGATION WATER UNDER UNCERTAINTIES

4.1 In the preceding chapter, the superiority of different combinations of seasonal crops over a sugarcane based irrigation system, in terms of net returns per unit of water, was established. Despite this, most farmers, given an opportunity, appear to go in for sugarcane in preference to seasonal crops under irrigation. One reason is state policy with regard to supply of irrigation water: if the state is willing to supply unlimited water to farmers for growing sugarcane in specified areas, the farmers have no reason to refuse. But there are other considerations besides this. During the field survey, discussion with many farmers brought out their acceptance of the greater returns from irrigated seasonal crops than from sugarcane, for a given quantity of water. But they mentioned a number of other reasons that, in their opinion, make the farmers prefer sugarcane to seasonal crops. These may be summarised below:

(i) The minimum price of sugarcane is not only fixed (by government), but it is more than supported by the co-operative sugar factories. As against this, the prices of seasonal crops fluctuate highly from year to year and there is no effective check on this in the market.

(ii) Sugarcane is largely free from pests and diseases, and fluctuations in weather have the minimal impact on yield of sugarcane. On the other hand, the seasonal crops are subject to many diseases and pests and, even when irrigated, are affected by changes in temperature and rainfall.

(iii) Canal irrigation is not very regular and reliable

despite the formal rules laid down by the irrigation department. Sugarcane can stand the stress arising out of this; most seasonal crops cannot, and therefore suffer in yield. Hence the preference for sugarcane.

(iv) Seasonal crops demand labour at different times, the operations are fixed and time specific and, therefore, cannot be postponed. Sugarcane is just the opposite, with the requirement of labour after planting being essentially for irrigation and application of fertilizers which can stand postponement to a greater extent. And, finally, sugarcane does not demand as much of routine attention and care from the farmer as the seasonal crops do.

These various considerations are sought to be examined in what follows.

Fluctuation in Prices

4.2 In the exercises in Chapter III, the prices of outputs and inputs used were those for the year 1978-79, prevailing in the PLBC area. However, it is necessary to examine how the relative prices have behaved over the years, in order to be reasonably assured that these prices are not of an exceptional type. For this purpose, the relative prices of a number of relevant crops were examined for a period of 16 years preceding 1978-79. Monthly average price data were collected from the Statistical Abstract of Maharashtra State, published by the Directorate of Economics and Statistics of the Government of Maharashtra, for 16 years, beginning 1960, for some selected primary market centres in the drought prone region, viz., Ahmednagar, Srirampur, Pune, Barsi. The annual average prices were calculated as simple averages of the relevant monthly prices. The annual average price of every other commodity in a year was

expressed as a percentage of that year's price of Bajra, which was used as the base crop for the purpose. The years or centres for which Bajra prices were not available systematically, the price of Jowar was used as the base price. The relative prices of different crops, calculated in this manner, for years 1960 to 1976, for the four market centres, are given in Appendix Tables A.4.1 to A.4.4.

4.3 A perusal of the relative prices shows that except for groundnut and pulses, the relative prices of other crops show no particular trend, though, of course, there are fluctuations from year to year.

4.4 Similarly, independent studies[1] show that the relative value of wage rates in agriculture in Maharashtra, that is, the money wage rates deflated by the prices of farm products entering into the consumption of the labourers, show no upward or downward trend over long years. On the other hand, the relative prices of the two other major inputs, fertilizers and diesel oil, had shown a rising trend after 1973.

4.5 It is useful to ask the question how low can the relative price of any of the seasonal crops-relative to sugarcane - can go before the net income per mcft. of water from that crop becomes lower than that of sugarcane? In order to estimate this limit, we have tried to estimate the gross value of output, per mcft. of water, from every one of the seasonal crops which will give the same level of net income as annual (suru) sugarcane. Compared to the observed gross value for the year 1978-79, it indicates upto what extent, given the observed yield rate and the costs of inputs, the price of the seasonal crops can go down before sugarcane becomes more economical. Alternatively, the same percentage can be interpreted as

the extent to which the per acre physical yield of the seasonal crops can go down, given the prices and costs of all crops (at 1978-79 level) before sugarcane becomes more economical in the use of irrigation water. The figures below indicate these percentages for various crops:

1.	Jowar - Hybrid-Kharif	- 48%
2.	Bajra - Hybrid-Kharif	- 36%
3.	Onion - Rabi and Summer	- 33.3%
4.	Cotton - HYV-Summer	- 33.3%
5.	Cotton - HYV-Kharif	- 32%
6.	Groundnut - HYV-Kharif	- 28%
7.	Maize - Kharif & Summer	- 26%
8.	Jowar - Local-Rabi	- 26%
9.	Wheat - HYV	- 24%
10.	Gram - Local	- 24%
11.	Bajra - Local	- 16%
12.	Groundnut - Summer	- 16%
13.	Groundnut - Local-Kharif	- 16%

4.6 The above table shows that the price of most crops had to fall by 25 per cent relative to the price of sugarcane, and in case of crops like cotton, onion and hybrid bajra by one-third and in case of hybrid jowar in the kharif season by nearly half, compared to the price of annual (Suru) sugarcane before these crops would yield a lower net income per mcft. of water let out at the distributory head, than sugarcane. Comparison with Adsali sugarcane would make these percentages somewhat higher.

4.7 In point of fact, in most of the years since 1960-61, and particularly since 1968-69, the prices of the first 10 crops listed above compared to sugarcane, had not fallen lower than the percentages indicated. Only the price of wheat compared to sugarcane had fallen by about 32 per cent in 20 per cent of the years and the

price of jowar by nearly 50 per cent for nearly one-third of the time. One important reason for the price of jowar having remained low compared to the price of sugarcane or bajra for some years, was the policy of monopoly procurement of jowar by the State Government. Since this was given up, the relative price has not gone down to the extent estimated.

4.8 All this goes to suggest that even with very considerable lowering of the relative prices of the irrigated seasonal crops, these crops continue to show greater return per Mcft. of irrigation water than sugarcane. The cultivator's fears do not appear to be borne out, except the fact that fluctuations in the prices of these crops results in fluctuation in net income from these irrigated crops, while this is less so in the case of sugarcane. This may give rise to the feeling of the farmers noted in the beginning of this chapter.

4.9 Another factor responsible for this feeling is the variation in the prices of seasonal crops within a year. This variation, while not uniform from year to year, is sometimes quite high. This can cause genuine feeling of loss to the grower of seasonal crop(s) compared to sugarcane, which exhibits no such post-harvest price fluctuations. One important policy measure to reduce such fluctuations is the formulation and implementation of a minimum support price for the seasonal crops. While the Agricultural Price Commission (now called the Commission on Agricultural Costs and Prices) has been recommending and the Government announcing support prices for most of these crops, for more than two decades now, there is often no purchasing agency available at the primary market level to purchase at the announced support price, in most parts of the

country excepting the wheat-rice belt in northern and north-western India, and a few pockets elsewhere. For millets (jowar and bajra) and gram and oilseeds there is no such effective agency in the field; for onions, NAFED has been carrying out this operation irregularly. Cotton is now under monopoly state marketing in Maharashtra. A proper mechanism to enforce support prices would go a long way in erasing this uncertainty relating to price of seasonal crops from the minds of the farmers.

4.10 A related exercise in the context of changing relative prices has also been carried out by using the prices prevailing in the year 1981-82. During this year the price of sugarcane doubled (from Rs. 130 a tonne to Rs. 260), while that of the seasonal crops went up to a much smaller extent: local jowar and bajra Rs. 180 (from Rs. 125); hybrid jowar Rs. 140 (Rs. 105); wheat Rs. 220 (Rs. 150); groundnut Rs. 350 (Rs. 250); maize Rs. 180 (Rs. 150); gram Rs. 200 (Rs. 180); onion Rs. 60 (Rs. 35); cotton Rs. 500 (Rs. 400). Similarly prices of many inputs also rose. The net income per Mcft. of irrigation water separately for all these crops, by using the 1981-82 prices, but the same physical inputs and outputs as before, are given in Table 4.1. Table 4.2 gives the income from the different crops rotations mentioned in Chapter III.

4.11 The data show that despite a very high increase in the relative price of sugarcane - more than 50 per cent compared to other crops - the other crops, that is, all high yielding varieties and hybrids as well as onion, show a higher net income per Mcft. of water than sugarcane. Therefore, some crop rotations with these crops in particular, are still seen to be comparable to sugarcane.

Table 4.1 : Net Income Per Acre and Per Mcft. of Irrigation Water, from Different Crops, at 1981-82 Prices

Name of the Crop	Net income per acre	Net income per Mcft of water
	(Rs.)	(Rs.)
1. Sugarcane (Adsali)	5,765	8,936
2. Sugarcane (Suru)	4,735	9,470
3. Bajra (HYV)	736	10,157
4. Bajra (Local)	451	6,224
5. Groundnut (HYV-Kharif)	927	10,660
6. Groundnut (Local-Kharif)	610	7,015
7. Cotton (HYV-Kharif)	904	10,396
8. Maize (Local-Kharif)	567	7,825
9. Hybrid Jowar (Kharif)	732	13,469
10. Jowar (Local-Rabi)	517	6,463
10a. Jowar (Hy. - Rabi)	732	9,150
11. Wheat (HYV)	896	8,243
12. Wheat (Local)	518	4,766
13. Onion (Rabi)	1,207	9,234
14. Gram (Local)	344	5,263
15. Onion (Hot weather)	1,207	7,906
16. Cotton (L.S. Hot weather)	1,093	7,159
17. Groundnut (Hot weather)	875	6,694
18. Maize (Hot weather)	567	4,338

Table 4.2 : Economic Alternatives of Different Crop Combinations in Terms of Net Income Per Mcft. of Water, at 1981-82 Prices

Crop Combinations	Water requirement (Cubic feet)	Area that can be irrigated per Mcft of water (acres)	Net income per Mcft of water (Rs.)
Sugarcane (Adsali - one and half year crop - July planting)	6,35,250	1.55	8,936
Alternative Crop-mix to 'adsali' cane			
1st combination	4,28,340	2.35	8,573
2nd combination	4,75,530	2.10	8,684
3rd combination	4,68,270	2.15	8,733
4th combination	3,99,300	2.50	7,673
5th combination	5,29,980	1.89	8,728
6th combination	5,00,940	2.00	8,996
Sugarcane (Suru - One year crop - November planting)	5,00,940	2.00	9,470
Alternative crop combination to 'Suru' cane			
1st combination	2,83,140	3.55	8,318
2nd combination	2,94,030	3.40	8,500
3rd combination	3,26,700	3.06	8,186

Fluctuation in Yield

4.12 . Fluctuations in yields of seasonal crops even under irrigation can be another source of lower returns and uncertainty in that context. However, the table in paragraph 4.5 above can also be interpreted to mean the extent to which the yields of the

listed crops can fall below the levels indicated for 1978-79 in this study, without any change in prices and quantities of inputs and prices of all outputs, before sugarcane becomes the higher net income generating crop.

4.13 The observed fluctuations in the average yield rate of seasonal crops from year to year are quite significant. So is the variation in the yield rates of different farmers growing the crop in any particular year. (The detailed coefficients of variation calculated are not presented here.) As far as the year to year variations are concerned, the data in paragraph 4.5 indicates that in most situations crops and crop combinations including the first 4 crops, will prove superior to sugarcane most of the time.

4.14 It is useful to remember that low yield rates and low relative prices of all crops compared to sugarcane do not occur to the same or stated extent, in a particular year. While for exercise here such an assumption has been made, in actuality it would be different and therefore the greater economic justifiability of these crops and crop-combinations vis-a-vis sugarcane will be strengthened.

Regularity and Frequency of Irrigation

4.15 Another factor that is said to inhibit irrigation of seasonal crops under canal is the lesser frequency of irrigation available, and, therefore, the greater interval between irrigations and above all the uncertainty associated with it. Our survey into well as well as canal irrigation in the command area of PLBC and NLBC shows that for the same crop in the same season there were, by and large, more irrigations given from wells and at shorter intervals. (Ref. Tables A.4.5 and A.4.6 in the Appendix.) The patterns of cropping under canal and well irrigation, given in Chapter II, show clearly

that the farmers grew a wider variety of seasonal crops under well irrigation than under canal.

4.16 The quantum of irrigation water and the interval between two irrigations depend upon the nature of the soil, the root structure of the plant, the stage of growth of the plant and the rate of evapotranspiration. Given the structure of the soil, the shallower rooted plants would require replenishment of moisture around the root zone at more frequent intervals. In a canal system, serving different types of crops in the same season under the same distributory/water course, the rotations can be only a common rotation, not necessarily designed to suit every individual crop separately. In the system in the Deccan, the intervals are worked out, in different seasons, in a manner that will suit a crop like sugarcane, which can stand water stress, without much adverse effect, for long periods. This naturally discourages farmers from growing a wide variety of seasonal crops under canal irrigation, and sometimes affect adversely those crops that are usually grown. Given the demonstrated superiority of seasonal crops over sugarcane in the economic use of water, farmers can be encouraged to adopt these alt natives, if supply of water can be ensured at reasonable intervals.

4.17 Experimental work by agronomists and irrigation engineers working in the Command Area Development Authorities in the State of Maharashtra have resulted in different recommendations. One suggestion is to provide water more frequently but in smaller doses to the fields, through the canal system. This, it is said, can be done by examining continuously the rate of evaporation through Evaporation Pans at suitable locations in the command area. Since different crops need different quantities of water, for a given

evaporation rate, a weighted average can be worked out depending upon the crop pattern in the command area at the time, and their stages of growth. Once the water is found to have gone below a certain specified level, irrigation should be provided. This irrigation should be in the smallest possible dose, say 35 to 40 mm. The frequency will vary with the rate of loss of soil moisture, but it is sure to be more frequent than what is practised. Frequent irrigation has also the advantage of cycling irrigation to specific distributory, minors and outlets; larger intervals result in simultaneous demand all round, resulting in greater costs and losses to the canal system. In black cotton soils, the appropriate interva appear to be 14 days in Rabi and 7 days in the Hot Weather.[2]

4.18 Another suggestion[3] for scheduling irrigations in vertisols, which are subject to water logging, is the opposite of the earlier one. This advocates deficit irrigation for crops, at somewhat larger intervals, say 21 days in the Rabi season, so that the crop develops some water stress, while at the same time the actual evapotranspiration is less than under full irrigation. While this may affect yield per acre somewhat, the total production from the given quantum of irrigation water in the system will be higher since the quantum of water saved can be used to irrigate wider areas. While this has some justification, the stress in summer may require a lesser interval than 21 days; similarly taking a deep rooted crop like sugarcane out of the irrigation system may lower the interval by increasing the stress factor.

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4.19 One essential point in both these experiments is the necessity of ensuring supply of a given quantum of water to a crop on the field at the time of irrigation. Unfortunately, the existing canal

system in the Deccan has no mechanism for ensuring this. As noted earlier, under present practice, there is no control over the volume of water supplied to a field: only when one farmer says he had had enough, does the next man get his turn. Fortunately, control over volumetric supply of water to a field can be established through the warabandi method, common in canal systems in the North, and now modified into the Rotational Water Supply System (RWS) in Maharashtra.[4]

4.20 The essence of RWS is to ensure stated volumes of water per rotation to the fields of every cultivator by ensuring a specified volume of flow at the outlet of the water course and fixing the time for which the cultivator can divert the water from the water course to his field. Most outlets to water courses, from the distributory or minor, are supposed to be designed to discharge one cusec of water. Given the area and the crop to be irrigated and the requirement of water per irrigation for that crop, the total volume of water and therefore the time period for which the water in the water course can be diverted by the cultivator to his field can be calculated. The RWS in Maharashtra was further designed to supply water in smaller doses, about 2 acre inches at a time in two successive doses in two consecutive weeks, leaving the third week as a gap - the cycle starting again from the fourth week. The irrigation should begin with the tail-end water course and also from the tail end farmer along the water course. Given these requirements the turn and time for each irrigator can be worked out before the rotation, in a meeting of the officials and the irrigators. This method ensures timely supply of a specified volume of water to every field.

4.21 While this method, first tried out in some sections of a couple of projects, is being gradually extended, the real difficulty

appears to be the defective design of many outlets, which despite the stipulation, do not in fact record one cusec discharge but much less. This involves remodelling the outlets in most cases - a time-consuming process, delaying the introduction of RWS. Of course, pending such redesigning, the time period for every farmer for irrigating from the water course can be worked out on the basis of the actual discharge at the outlet. But this requires that the actual discharge at every outlet must first be measured, and it must be ensured that there are no other defects that can upset this arrangement. For, if the trust of the irrigator in the capacity of the channel to deliver the stated quantity of water in the specified period is upset, the entire arrangement is sure to break down. Therefore, in the interest of more economic use of water, it appears urgently necessary to undertake these tasks in the existing irrigation projects and ensure the compliance of actual construction to these required norms in the new projects.

4.22 The calculation about the delivery of a stated volume of water to the field, given a stated discharge at the outlet head, also depends upon negligible loss of water in transit in the water course. This requires that the length of the water course, and therefore the command area of a water course, should be reasonably small. The norm set out by irrigation engineers for the purpose is about 8 ha. (i.e., 20 acres). However, many water courses have, in fact, much larger command areas, offer more than 40 ha. (i.e., 100 acres), and are consequently much longer. It is necessary to ensure a shorter length and smaller command area in the new projects. In the existing ones, redesigning, whenever possible, will be useful. Otherwise, it would be necessary to line the water courses in order to

eliminate loss of water in transit, so that the stipulated volume of water to the field can be supplied under the RWS. If a case for lining of canals is to be made, it appears it must start from the water course, for the reason mentioned here.

4.23 Other experimental works have been carried out to see if there can be greater economy in the application of water in the field by having different designs of layout of the field, and strips and furrows for cropping.[5] If these and any other methods turn out to be effective and can be reasonably adopted by farmers, the field water requirements of different crops can be further reduced, thereby increasing the irrigable area under the canal system. The more water economising methods of irrigation, like sprinkler and drip, now being advocated under the well/tube well systems - drip mainly for orchards and certain plantation crops - will require considerable redesign in the canal irrigation system and use of power, and are, therefore, not immediate prospects. Pending all these, the introduction of the RWS appears urgently necessary to ensure timely and controlled volume of water supply, not only to prevent loss of water on the field, but to take out a major source of uncertainty faced by the irrigators in irrigating seasonal crops.

Labour Constraints

4.24 The labour problem involved in the alternative crop patterns to sugarcane centred irrigation can be looked at from two points of view. Firstly, will the demand for total labour, self-employed plus wage labour, be greater or less under the alternative croppings than sugarcane? Secondly, is there a possibility of seasonal constraints in supply compared to demand under alternative cropping systems? The first question may be taken up first for examination.

4.25 The following Table 4.3 gives the total number of labour days that would be required to grow different crops with one Mcft. of irrigation water. The data on average per acre labour days required are taken from the cost of production enquiries conducted by the Union Ministry of Agriculture. It is quite clear that except for hot weather maize, every alternative crop to sugarcane generates more labour days of employment, with the help of one Mcft. of water than sugarcane. Any of the crop rotations/combinations, mentioned in Chapter III, would also generate greater demand for labour. In an economy where rural underemployment is widespread and chronic, leading to high incidence of poverty, a cropping system under irrigation giving rise to greater employment opportunity should be a most desirable proposition.

Table 4.3 : Total Number of Labour Days Required by the Individual Crops That Can be Irrigated with One Mcft. of Water

Crop	Labour days per acre	No. of acres per Mcft. of water	Total labour days (2 x 3)
1. Sugarcane (Adsali)	140	1.55	217
2. Sugarcane (Suru)	120	2.00	240
3. Bajra (Hy.-Kh.)	40	13.80	552
4. Groundnut (HYV-Kh)	45	11.50	518
5. Groundnut (L-Kh)	30	11.50	345
6. Cotton (HYV-Kh)	70	11.50	805
7. Maize (L-Kh)	30	13.80	414
8. Jowar (Hy-Kh)	40	18.40	736
9. Jowar (L-R)	25	12.50	313
10. Wheat (HYV-R)	36	9.20	331
11. Wheat (L-R)	30	9.20	276
12. Onion (R)	90	7.65	689
13. Gram (L)	22	15.30	337
14. Onion (HW)	90	6.55	590
15. Maize (HW)	30	7.65	230
16. Cotton (HYV-HW)	80	6.55	524
17. Groundnut (HW)	45	7.65	344

Kh. = Kharif; R = Rabi; HW = Hot Weather; Hy = Hybrid, HYV = High yielding variety; L = Local variety.

4.26 Would the alternative cropping patterns generate constraints of labour supply in seasons of peak labour demand? Surely, seasonal demand for labour would be higher under the alternative cropping patterns than sugarcane. But two things have to be remembered in this context. First, as noted earlier (Chapter III), substitution of the alternative cropping patterns to sugarcane, in which there is a separate crop on the irrigated land in the three seasons of the year, will lead to increase in net irrigated area by 30 to 60 per cent. If cultivators grow only two irrigated crops a year on any irrigated plot of land, then the net irrigated area would easily double. This will mean not only the bringing of the presently unirrigated lands in the irrigated villages under irrigation but extend irrigation to other lands that are currently deprived of it. The greater irrigated area and therefore greater labour demand would be spread over wider areas. The consequent coverage of larger number of households, as farmers and wage labourers, would obviate the problem of shortage of labour at seasons of peak demand. Moreover, labour today seasonally migrates from unirrigated villages in the neighbourhood and more distantly located, to the sugarcane growing areas. There is nothing to prevent this from happening in these drought prone regions, where nearly half the cultivated land is, in any event, going to remain unirrigated. If labour migrates seasonally to the irrigated rice and wheat fields of the Punjab from long distances, there is no reason to doubt this from happening in Maharashtra, without cross country movements. Indeed, dispersal of migrant labour over wider irrigated area may be more desirable than the concerted demand that sugarcane makes. In any case, there need be no fear of labour shortage at peak seasons.

4.27 The analysis of the problems arising out of fluctuations in prices and yields and uncertainty of water supply shows that despite these uncertainties the alternatives to sugarcane under canal irrigation yield better returns, and improvement through price support policy and improvements in the design of water courses and distribution system will further improve the situation. Not only will greater area, and, therefore, larger number of farmers receive irrigation, but also it will generate greater total employment than sugarcane based irrigation. This, however, raises the question of the status of sugarcane in these drought prone regions of Maharashtra, which accounts for a substantial portion of sugar production in the country. This question will be examined in the next chapter.

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APPENDIX TABLES

Table A.4.1 : Relative Prices of Principal Crops in Ahmednagar Market
(Base Crop : Bajra = 100)

Crops	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
1. Wheat	124.44	118.15	128.18	135.67	148.55	112.80	123.62	153.93	138.92
2. Jowar	90.15	78.11	91.38	86.74	77.07	50.87	63.78	65.19	64.67
3. Gram	93.43	99.12	98.73	115.20	132.72	129.68	177.75	214.90	103.29
4. Tur	-	82.04	102.69	141.92	116.76	83.79	110.04	158.16	106.49
5. Mung	120.25	113.00	-	-	-	-	145.66	162.98	135.93
6. Groundnut	147.25	153.21	137.16	154.39	119.45	113.22	187.79	160.27	136.83
7. Sesamum	275.34	272.43	229.43	222.99	-	-	-	-	-
8. Safflower	129.82	114.78	127.29	126.32	102.57	86.05	146.98	114.39	101.10
9. Gur	-	83.81	124.58	198.36	118.75	55.11	91.59	210.67	185.63
10. Cotton	280.01	285.50	304.98	345.87	195.59	170.77	299.60	206.45	131.74
11. Sugarcane	-	-	-	-	8.52	6.08	7.44	20.17	13.47
12. Potato	-	-	-	-	-	-	-	-	-

(continued)

Table A.4.1 : (continued)
(Base Crop : Bajra = 100)

Crops	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
1. Wheat	127.60	134.53	141.79	101.20	126.14	120.16	125.90	138.77
2. Jowar	64.35	68.42	76.11	50.11	41.83	100.15	112.50	128.08
3. Gram	102.78	128.93	134.21	118.86	131.70	142.09	124.56	117.84
4. Tur	105.96	139.84	160.03	129.13	119.32	117.25	103.80	142.60
5. Mung	135.25	134.54	159.69	196.48	-	128.26	205.08	-
6. Groundnut	136.14	199.99	191.63	152.87	166.12	170.51	135.61	217.77
7. Sesamum	-	-	-	-	-	-	-	-
8. Safflower	100.00	179.12	153.47	121.70	126.14	144.85	105.08	190.20
9. Gur	184.70	91.46	170.90	142.43	107.84	99.99	117.19	169.50
10. Cotton	131.08	318.04	340.53	108.46	-	-	-	-
11. Sugarcane	10.01	11.47	18.08	12.80	10.03	8.97	9.44	10.70
12. Potato	-	-	-	-	-	-	-	-

Table A.4.2 : Relative Prices of Principal Crops in Barsi Market
(Base Crop : Jowar = 100)

Crops	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
1. Wheat	127.99	139.83	118.88	134.18	217.65	217.65	194.76	228.56	205.56
3. Bajra	-	-	-	-	-	-	-	-	-
4. Gram	-	-	88.90	110.73	160.48	249.84	267.13	317.44	144.91
5. Tur	100.99	98.72	104.20	150.29	170.24	158.43	160.04	225.93	157.09
6. Mung	118.41	124.77	-	-	-	-	-	-	216.20
7. Groundnut	157.54	179.00	130.06	167.90	180.46	209.16	287.81	219.76	215.13
9. Safflower	131.92	129.55	118.00	118.87	141.60	167.98	226.39	161.57	155.41
11. Cotton	209.02	236.90	195.62	-	-	-	-	-	-

	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
1. Wheat	198.30	195.06	177.37	198.05	301.56	124.45	98.77	105.87
2. Bajra	-	-	-	-	-	-	-	-
3. Gram	197.22	167.44	168.75	226.20	310.55	141.10	108.28	85.23
5. Tur	190.74	227.78	219.64	272.32	268.75	126.38	105.26	129.29
6. Mung	184.72	179.17	237.50	392.09	304.69	126.38	134.36	-
7. Groundnut	288.74	307.09	235.27	303.41	420.03	159.00	116.56	167.55
9. Safflower	238.74	254.31	190.62	230.21	-	138.71	100.97	143.12
11. Cotton	-	-	-	-	-	-	-	-

Table A.4.3 : Relative Prices of Principal Crops in Pune Market
(Base Crop : Bajra = 100)

Crop	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
1. Wheat	134.63	114.14	117.70	132.98	127.07	120.49	-	-	-
2. Jowar	-	-	108.94	101.05	92.42	50.13	65.65	62.47	64.93
10. Gur	115.09	80.81	135.75	220.74	130.44	60.62	110.76	220.67	199.59
12. Onion	30.01	45.29	45.43	50.12	34.41	20.23	42.04	21.69	42.38
13. Potato	69.81	109.59	104.47	95.35	88.09	48.49	84.10	85.71	53.60
14. Sugarcane	-	-	-	-	8.66	6.34	7.34	20.24	12.98

Crop	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
1. Wheat	-	-	-	-	126.91	-	-	-
2. Jowar	66.25	61.71	73.91	48.43	42.08	99.87	118.40	-
10. Gur	110.62	99.62	145.61	148.39	122.41	109.01	134.82	179.73
12. Onion	35.79	26.76	42.23	36.39	41.64	26.29	59.90	32.66
13. Potato	65.02	81.80	71.93	65.10	64.11	55.14	55.06	85.78
14. Sugarcane	10.67	11.08	18.08	11.37	9.86	8.88	9.27	11.23

Table A.4.4 : Relative Prices of Principal Crops in Srirampur Market
(Base Crop : Bajra = 100)

Crop	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
1. Wheat	117.98	-	121.77	129.65	132.75	110.47	119.95	145.47	128.36
2. Jowar	85.14	78.52	89.09	86.91	84.77	50.04	65.13	63.78	60.85
7. Groundnut	136.63	134.04	135.64	169.39	116.68	105.97	159.74	139.71	134.28
10. Gur	97.14	78.68	124.79	202.74	121.65	66.48	114.45	206.90	175.68
12. Sugarcane	-	-	-	-	-	-	8.20	18.31	62.72

Crop	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
1. Wheat	115.69	120.14	132.62	101.73	132.55	115.84	133.00	131.10
2. Jowar	60.17	62.73	75.34	50.99	43.96	102.13	127.76	128.55
7. Groundnut	163.14	174.49	181.62	149.78	197.38	164.49	150.14	204.18
10. Gur	71.41	85.01	171.30	150.23	112.64	102.39	130.90	176.81
12. Sugarcane	9.98	10.57	17.10	12.51	9.60	9.22	10.95	11.16

Table A.4.5 : Number of Waterings and Interval between Waterings, in Different Seasons, for Different Crops Under Canal and Under Wells in PLBC Command Area

Season	No. of waterings		Interval between waterings (days)	
	Canal	Well	Canal	Well
Sugarcane (Adsali)				
1. Summer 1978	4 - 5	7 - 9	26	15 - 17
2. Kharif 1978	5	7	17 - 21	16
3. Rabi 1978	6 - 7	9	20	14
4. Kharif 1979	5	7	21	16
5. Rabi 1979	6 - 7	6 - 8	18	15
Sugarcane (Ratoon)				
1. Summer 1978	4	7	27	17
2. Kharif 1978	5	7	20	16
3. Rabi 1978	6	8	20	16
4. Kharif 1979	6	7	20	16
5. Rabi 1979	3-7	7	19	15
Sugarcane (Suru)				
1. Summer 1978	6	8	21	20
2. Kharif 1978	5	7	18	16
3. Rabi 1978	8	8	17	14
4. Kharif 1979	6	6	18	16
5. Rabi 1979	7	8	15	15
Bajra				
2. Kharif 1978	2	2	24	21
4. Kharif 1979	5	2	15	10
Groundnut (Kh.)				
1. Summer 1978	-	9	-	15
2. Kharif 1978	4	5	20	17
3. Rabi 1978	-	9	-	15
4. Kharif 1979	4	3	18	21
Pulses				
2. Kharif 1978	3	2	21	22
3. Rabi 1978	-	4	-	21

(continued)

Table A.4.5 : (continued)

Season	No.of waterings		Interval between waterings (days)	
	Canal	Well	Canal	Well
		Maize		
2. Kharif 1978	3	3	22	21
3. Rabi 1978	4	4	21	15
4. Kharif 1979	3	5	20	18
		Hybrid Jowar		
2. Kharif 1978	3	3	22	21
3. Rabi 1978	2	-	26	-
4. Kharif 1979	2	2	36	22
		Cotton		
2. Kharif 1978	-	5	-	13
3. Rabi 1978	-	7	-	15
		Lucern		
1. Summer 1978	5	11	21	11
2. Kharif 1978	5	8	19	14
3. Rabi 1978	6	11	19	12
4. Kharif 1979	5	9	15	14
5. Rabi 1979	7	13	8	8
		Wheat		
3. Rabi 1978	4	5	22	17
		Gram		
3. Rabi 1978	2	2	24	22
		Onion		
3. Rabi 1978	-	10	-	11
		Jowar (R)		
3. Rabi 1978	2	3	25	22
		Chillies (K and R)		
2. Kharif 1978	-	9	-	13
3. Rabi 1978	-	7	-	16
4. Kharif 1979	-	14	-	8
		Vegetables (K and R)		
2. Kharif 1978	6	6	15	15
3. Rabi 1978	3	5	20	15
4. Kharif 1979	6	6	20	19
		Cotton (Summer)		
1. Summer 1978	4	5	18	16
2. Kharif 1978	4	4	19	15
		Groundnut (Summer)		
1. Summer 1978	4	3	22	17
2. Kharif 1978	3	4	23	20
		Fruits		
1. Summer 1978	3	6	26	20
2. Kharif 1978	4	5	24	16
3. Rabi 1978	5	7	22	18
4. Kharif 1979	-	4	-	15
5. Rabi 1979	-	8	-	15

Table A.4.6 : Number of Waterings and Interval between Waterings in Different Seasons, for Sugarcane and Onion, under Canal and Well Irrigation in NLBC Command Area

Season	No. of waterings		Interval between waterings	
	Canal	Well	Canal	Well
		Sugarcane (Adsali)*		
1. Summer 1978	6.5	8.47	18.75	14.57
2. Kharif 1978	6.15	6.0	18	18.46
3. Rabi 1978	10.73	8.43	11.6	14.07
4. Kharif 1979	5.5	5.65	17.5	18.71
5. Rabi 1979	12	7.7	10	12.75
		Sugarcane (Ratoon)		
1. Summer 1978	-	9.62	-	11
2. Kharif 1978	-	6.15	-	17.55
3. Rabi 1978	-	10.21	-	12.59
4. Kharif 1979	-	6.3	-	18.5
5. Rabi 1979	-	7.75	-	15.13
		Sugarcane (Suru)		
1. Summer 1978	-	7	-	16.3
2. Kharif 1978	-	6	-	19
3. Rabi 1978	-	6.6	-	15.83
4. Kharif 1979	-	6.5	-	17.18
5. Rabi 1979	-	6.67	-	16.29
		Onion (K and R)		
2. Kharif 1978	-	6.33	-	17.33
3. Rabi 1978	-	14.3	-	10.00

* The canal irrigated in this non-perennial zone, is partly by special permission, and in other cases appear unauthorised. That may account for many rotations, taking water twice in the same rotation!

CHAPTER V

PROSPECTS FOR SUGARCANE UNDER WELLS

5.1 The distinct superiority of seasonal crops over sugarcane, in generating income from a given quantity of irrigation water, would imply a denial of canal water for sugarcane in the potentially water-short regions of the State. This policy implication raises a number of questions: (a) In the first place, it is pointed out that Maharashtra today produces a sizeable proportion of the total sugarcane and sugar produced in the country. A sudden cessation of this will seriously affect not only the sugar supply position, but will greatly raise the relative price of sugar. This in turn will affect the relative economics of sugarcane and seasonal crops under canal irrigation in the State, thereby upsetting the very empirical basis of the policy. (b) Even if the new policy is applied, to start with, to only the new irrigation projects to be brought into existence in the State, and the change over in the old project areas is only slow and gradual, this may affect the relative price of sugarcane, arising out of the growing demand for sugarcane, that has a fairly high income elasticity of demand, in the years to come. The result may be the same as in (a) above. (c) Maharashtra has developed a large number of sugar mills, most of them in the co-operative sector, (more than 60) during the last three and half decades, based on water for sugarcane. A reversal of policy in this regard will see huge losses for the sugar mill enterprises, and decline and death of this industry that has been the source of growth of indigenous

enterprise in many other fields, as well as considerable social investments and development. These questions are sought to be discussed in what follows.

5.2 The demonstration of the inferiority of sugarcane under canal irrigation, from the point of view of the social economy, cannot be construed to mean a sudden reversal of the present policy of assured irrigation water to sugarcane grown on certain portion of the ICA of any existing project. Apart from the unreality or impracticability of such a sudden switch over, there are problems of organising the irrigation system to meet the requirements of the new approach. Some of these were examined in the previous chapter. What one might reasonably advocate and expect to be followed is the adoption of this new policy in all the newer flow irrigation projects in the water scarce regions of the State. In addition, it would be necessary to correct the irrigation channel structures in the existing flow irrigation project to operate the RWS system, and simultaneously notify the irrigators in the command area of a gradual reduction in sugarcane area under canal, including well-irrigated sugarcane area getting supplementary water from canals, to nil by the end of a reasonable number of years.

5.3 This policy will bring about no sudden changes in the supply of sugarcane in these areas. What is more, it is fair to expect other sources of sugarcane supply to step into these potential vacuum caused by the change in irrigation policy. Two of these deserve mention here.

5.4 In the first place, it is fair to expect the potentially irrigation water abundant regions to grow sugarcane, assuming other agronomic conditions are favourable. The Indo-Gangetic

plains, which are such regions have been traditionally sugarcane growing areas. Agronomically, these are also considered suitable regions. For variety of reasons, the production of sugarcane there has been of a poorer quality and quantity. The growing need to diversify agriculture from the overwhelming stress on wheat and rice, should lead to better growth of cane in the region. The pressing market situation with regard to both wheat and rice and the emerging situation with regard to sugarcane is likely to promote this development.

5.5 The implicit rise in the relative price of sugarcane, can be expected to be held in check by this development. At the same time, it is useful to remind ourselves that even a 50 per cent or higher rise in the relative price of sugarcane in 1981-82 did not appear to put sugarcane in a superior position vis-a-vis other crops in Western Maharashtra. This is a reasonable limit within which the relative price of sugarcane may be expected to fluctuate in the ensuing years, thereby creating no condition to upset the factual basis of the new policy.

5.6 A second source of supply of sugarcane in Maharashtra is wells, and this is likely to continue to be so. Indeed, over years, wells in the command areas of the flow irrigation projects in Western Maharashtra have come to be the major source of production of sugarcane. In 1962, the Maharashtra State Irrigation Commission pointed out that while 12,000 acres of sugarcane were under perennial flow irrigation in the two Pravara canal areas, the sugarcane area under wells in the command was about 10,000 acres. By 1980, while the canal irrigated basic sugarcane area had come down to about 7,500 acres, the sugarcane area under wells

had risen from 10,000 acres to 27,000 acres.

5.7 Indeed, realising the social injustice of concentrating the bulk of the scarce irrigation water on a small portion of the cultivated land (and cultivators) growing sugarcane under the block system, the State Government by a resolution in 1965[1] introduced the 1:4 Block system in place of the 1:3 blocks for sugarcane. However, wherever this has been implemented, the reduction of area under canal has been more than made good by the increase in area under well irrigation. Of course, it is necessary to note here that in many instances the sugarcane lands normally irrigated from wells, are given a few supplementary irrigations from canals in the hot weather when the water in the well becomes inadequate for the purpose.

5.8 The major source of ground water in the command areas of irrigation projects is the water seeped underground from the canals and the irrigated fields. The data and observations of the Ground Water Survey and Development Agency in the state also bear out the fact that the ground water potential, reusable for irrigation, is larger in the command areas of perennial canals. Ground water potential, without and with canal irrigation, has been assessed by the Agency for six different project areas, given below.

Number of wells possible in the command areas of some irrigation projects in Maharashtra, with and without recharge from canals

Name of Project	No.of wells possible without recharge from canals	No.of wells possible with recharge from canals
1. Bhima	1,530	6,700
2. Krishna	1,905	3,340
3. Kukadi	5,255	4,860
4. Upper Panganga	1,620	3,530
5. Upper Wardha	1,475	2,230
6. Warna	1,770	4,800
TOTAL.:	13,555	25,460

Source: Maharashtra Composite Irrigation Project, Feasibility Report, Vol. I, New Delhi : Water and Power Development and Consultancy Service (India) Ltd., May 1979, Table 1, p. 103.

5.9 - Data relating to areas irrigated from canals and wells in case of the sample farmers in PLBC and NLBC (non-perennial zone) presented in Tables A.3.3, A.3.4, A.3.5 and A.3.6 above, bear this out. The data show that the larger the total irrigated area under canals the larger the total area irrigated by wells. This is essentially due to greater seepage. For the same reason, given the total net irrigated area from canals, the greater the area under sugarcane, proportionately higher the area irrigated from wells in the command. This is indicated by the gross cropped area under wells as a proportion of the gross cropped area under canals being somewhat higher in case of the sample farmers under PLBC, which had sugarcane under canal, than under NLBC, which had little, being in the non-perennial zone.

5.10 The quantity of water in the wells in the command area and outside, in different seasons of the year, has been routinely

collected for consecutive years by the GSDA for a few (7 or 8) observation wells in the Pravara Canal area. The height of water columns in the wells during October, December, March and May are presented for 4 years in Appendix Table A.5.1. These data naturally show variations from well to well. But the general feature that comes out of these data is that the water column in the wells located outside the command area becomes smaller by May, than that in the wells located within the command area, while the wells outside the command area are on an average, deeper than those within the command. However, these data relate to a few wells only.

5.11 In order to get information from a large sample of wells about this and other relevant information, a special survey of wells was conducted in the command areas of PLBC and NLBC. The total number of wells surveyed during 1979-80 in PLBC command was 299, and in the NLBC (non-perennial zone) command was 209. A few wells, 14 and 8 respectively, were also surveyed outside the PLBC and NLBC commands. The number of wells outside the command was understandably much smaller, and it would have meant field work over very wide areas to cover a larger number of wells. Some relevant data relating to the wells are presented in Appendix Tables A.5.2 to A.5.7. Distribution of wells according to the height of the water column in the different seasons shows that a large proportion of wells outside the command had smaller water columns, particularly in the Rabi and Summer seasons than those within the neighbouring canal command. Similarly, pumps on a somewhat larger percentage of wells within the command could pump for longer hours at a time, and a somewhat larger percentage of wells within the command took less time to refill than those

outside the command, particularly in summer and even in Rabi season. This is because of the recharging of ground water from canals and irrigated fields, through seepage, a facility absent for wells outside the command. The most important point, however, is the much larger number of wells in the command area, due to the possibility of tapping seeped water.

5.12 Thus, there is no doubt that sugarcane can be and is grown under well irrigation in the command areas of irrigation projects without any water being provided specifically to sugarcane from the canal. Of course, the area under sugarcane will be limited to the area that can be irrigated from the wells in summer. The ability of the wells, even in the command area, to irrigate, goes down very considerably in summer. Tables A.5.2 and A.5.5 show that while more than 80 per cent of the wells in PLBC command and 70 per cent of the wells in NLBC command had water columns of more than 11 feet in Kharif and Rabi seasons, about 47 per cent of the wells in PLBC command had less than 7 feet of water in summer, and this proportion in NLBC command was as high as 62 per cent. It is not surprising, therefore, that on about 40 per cent of wells in PLBC command pumps could work for less than 2 hours at a time in summer, and more than half the wells needed more than 8 hours to be refilled for the next 2 hours of pumping. In NLBC command the situation was a little more difficult: more than 53 per cent of the wells could stand continuous pumping of water for less than 2 hours only, and more than 71 per cent of the wells needed more than 8 hours rest to be refilled to permit another round of pumping for an hour or two.

5.13 The observed differences between the irrigation capacity of wells in these two commands, as elsewhere, would depend partly

on the underground geological structure, and partly on the amount of water flowing through the canals and the amounts applied to the fields. We have little information on the first aspect. But, as for the second, it is known that a larger proportion of the gross cropped area of farmers in the command of PLBC came under canal irrigation and more than 30 per cent of the total canal water was given to sugarcane. Therefore the percentage of gross cropped area under well irrigation was also high - somewhat higher than under canal irrigation, but nearly 28 per cent of the total cropped area under wells was under sugarcane. As against this, in the non-perennial zone of NLBC a smaller percentage of the gross cropped area of farmers covered by the canal command was under canal irrigation, and therefore the percentage of area under well irrigation was also smaller, though it was higher than under canal. But what is more, only 10 per cent of the gross cropped area under wells was under sugarcane. This was mainly because the volume of water per acre of net irrigated land was smaller here since there was no sugarcane under canal, and hence the wells had lesser seeped water to trap. It is necessary to mention here that the 28 per cent of cropland under sugarcane in the well-irrigated lands in PLBC command overstates the potentiality of the wells there; for a sizeable part of this sugarcane-under-wells heavily depended on 2-3 supplementary irrigations from the canal in summer.

5.14 Similar example presented in the Interim Report of Committee to study the Introduction of Eight Monthly Supply of Water on the Irrigation Projects of Maharashtra (February, 1979), relating to the Adhala Project in Ahmednagar district (paragraphs 47 to 52), shows that while 10 of the 20 thousands acres of the culturable

command area was being irrigated in the 3 seasons, without sugarcane or other perennials, there was more than 2,500 acres under wells in the command of which anywhere between 40 to 50 per cent was under sugarcane.

5.15 Therefore, while it is difficult to predict with any degree of accuracy the extent to which sugarcane can be grown under wells in the command area of canals not providing any water to sugarcane and other perennial crops, it appears reasonable to suggest that at least as much area can be brought under wells as under canals, and the sugarcane area under wells can vary from 10 to 40 per cent of the gross cropped area under wells, depending on the soil structure, sub-soil layers and the number of wells sunk in the command area.

5.16 Before discussing the further problems arising out of growing of sugarcane under well irrigation in the command area of canals, a couple of related questions may be examined here. In the first place, it is possible to consider other forms of conjunctive use of surface and ground water visualised here, namely canal water for non-perennials only and well water for all crops including sugarcane and other heavy water using crops. The Maharashtra State Irrigation Commission, in its Report in 1962 examined four different alternatives. (These have been fully examined in the Interim Report, referred to in paragraph 5.14 above.) The Commission did not visualise complete stoppage of canal water for sugarcane, while the canal was running for all the 12 months. It, however, examined cessation of canal water supply to sugarcane for Kharif and Rabi periods. This was ruled out on the ground that since canal would be flowing during the period for other crops, it would be administratively difficult to control unauthorised use of canal water for

sugarcane. If the proposal mooted here had been examined, it presumably would have been rejected on identical ground. The proposal to close the canals from March to May was also rejected since stoppage of flow in the canals would dry up the wells as well, leading to cessation of sugarcane. Therefore, alternative irrigations for sugarcane, with the other half from wells, was the alternative form of conjunctive use of surface and ground water advocated by the Commission.

5.17 The introduction of valumetric water supply, calculated for each field, under the RWS system should go a long way to meet the administrative difficulties the Commission visualised for a seasonal crop based irrigation. Since every irrigator's volume of water and therefore the time available for irrigation is to be rigidly fixed, there is no chance of stealing water under the pretext of the "field not yet being fully irrigated", as is the situation at present. Of course, this would not preclude an irrigator from using his water quota for sugarcane, even if the amount had been worked out on the basis of a seasonal crop. If a farmer does so, he can irrigate only a small fraction of his total irrigable area, since sugarcane takes many times more water than other seasonal crops. If the exercises in this study are correct representation of the prevailing economics of use of water, the farmer will suffer a loss of total income thereby. If nevertheless he chooses to do so, it would not be necessary to seek to force him to do what was planned. That, in any case, would be administratively difficult. Therefore, the proper approach appears to be to calculate the volume of water a cultivator would need in a season - and in its rotations - based on an economic seasonal crop pattern, and ensure prorata delivery

each rotation. Then it should be left to the cultivator to decide the particular use to which he will put this water.[2] If he chooses to grow sugarcane with that water, no one need hold back his hand. Hopefully such farmers will learn, sooner than later. Sugarcane in canal areas of Maharashtra is popularly in the village referred to as the "idleman's crop", since it requires the least attention and timely care. If the farmer chooses to be "idle" and pay a price for this in terms of lost income, it cannot be helped. It is, however, reasonable to think that most farmers will see the loss and act otherwise.

5.18 One reason why farmers do not follow this logic in regard to their well water may be this. However, one would think that if a farmer has more water in the well compared to his land area, he would be economically rational in using the excess water for sugarcane. From the social point of view, such a situation does not exist in regard to canal water, and, therefore, its use for sugarcane does not appear justifiable.

5.19 Confining canal irrigation to seasonal crops would result in the actual irrigated area being extended beyond that when it is permitted. In regard to PLBC, we find that sugarcane used more than 2.9 lakh acre inches of the 9.5 lakh acre inches of water let out at the distributory head, calculating on the basis of the regression coefficients in Chapter II and the rotation-wise total sugarcane area receiving water. This makes it over 31 per cent of the total irrigation water. It is presumably more, may be about 40 per cent, for reasons discussed in Chapter II. If this water were to be made available to a single crop in the Rabi season, say jowar or wheat (HYV) then the irrigated area under PLBC can extend by at least

12 thousand or 8,500 acres (possibly more). Today only about 25,000 of the 40,000 acres under ICA are provided with water from PLBC. The alternative will cover the bulk of I.C.A. If the water is given for two different seasonal crops, say Jowar (Hy.) in Kharif and Wheat and/or onion in Rabi, then the net irrigated area can expand by another 3 thousand acres.

5.20 Such a diversion does not imply no irrigation in summer. Indeed, as we have seen in PLBC and NLBC command, groundnut and long-staple cotton are also irrigated in Summer, besides Rabi crops like onion which have a carry over requirement of water in early summer. This will keep the canals flowing, even if the full 3-season crop rotations discussed in Chapter III are not fully followed. That in turn will recharge the wells, which will help sugarcane in summer. An even more important requirement is the need for drinking water in summer, which in many areas depends heavily on the canals flowing in summer. It is for these reasons that complete closure of canals after February or March may not be justifiable.

5.21 Extension of the irrigable area under the canal would not seriously affect the area under sugarcane, since a growingly larger proportion of the sugarcane in the canal areas is being grown under well water. Stoppage of sugarcane under canal, including supplementary irrigation in summer to sugarcane under wells, will directly reduce the sugarcane area under canal and also reduce somewhat the area under wells in the existing irrigated area. As against this, extension of canal irrigation to unirrigated areas will increase the scope for sinking wells and using a part of this water for sugarcane. This may, in the net, result in greater spread of well irrigation, including sugarcane under wells. The historical

development of concentrated area of sugarcane cultivation under canal has resulted in concentration in well irrigation as well. That largely explains the growth of individual sugar factories, starting with a crushing capacity of 400 tonnes, now reaching more than 4,000 tonnes. It is this geographical concentration of sugarcane cultivation which is likely to be affected by the change in the use pattern of canal water. In the areas to be newly irrigated by new irrigation projects in the region, this may mean smaller sugar mills scattered over the entire irrigated area, possibly manufacturing brown sugar, with a single central cooperatively owned mill processing all this brown sugar into white the year round. These are technical possibilities, the economics of which has to be worked out before adoption. In the already established commands, the change over has to be gradual, and wells in the command, existing and new, should be able to meet the normal needs of the established sugar factories. In recent years the crushing season has often extended beyond appropriate limits to accommodate excessive sugarcane supply in the season. Restoration of normalcy in this matter should not cause any difficulties. The Interim Report, referred to above, visualises at most relocation of a stray factory in the Pravara belt. All in all, therefore, there appears no possibility of sugarcane disappearing or its area in the existing canal commands being substantially reduced as a result of change in policy in regard to use of canal water. The advantages will be substantial: not only will canal water irrigate larger areas bringing greater stability to seasonal agriculture in this drought prone region and benefit larger body of farmers, but also spread the benefits of well

irrigation, including cultivation of sugarcane and other perennials, over wider areas and larger body of farmers.

NOTES AND REFERENCES

1. Gandhi, P.R., op.cit., p. 127.

2. A similar approach has been advocated by Dhamdhere and Padhye in their paper, op.cit.

APPENDIX TABLES

Table A.5.1 : Height of Water Column in Meters During Different Periods in a Year in the Observation Wells

(a) Outside the Command Area of P.L.B.C.

Obs. Well No.	Depth of well	1975 March	1975 May	1975 October	1975 Dec.	1976 March	1976 May	1976 October	1976 Dec.
1	13.41	4.12	3.03	3.97	6.61	6.74	5.75	6.09	11.02
2	14.25	-	-	-	-	-	-	-	-
3	10.51	5.17	3.15	7.72	8.28	7.46	5.58	8.42	9.70
4	-9.14	4.33	3.25	7.79	7.76	7.05	6.24	6.65	8.35
5	9.14	3.58	3.10	5.15	3.61	3.35	Dry	3.60	7.05
6	15.66	10.13	9.17	14.25	13.01	12.31	11.63	12.76	14.33
7	12.10	10.88	10.93	11.04	11.03	11.03	10.84	10.83	10.75

Obs. Well No.	Depth of well	1977 March	1977 May	1977 October	1977 Dec.	1978 March	1978 May	1978 October	1978 Dec.	1979 March	1979 May
1	13.41	5.21	3.46	3.91	4.41	4.11	3.81	-	-	-	-
2	14.25	-	-	-	-	-	-	-	3.00	1.90	1.30
3	10.51	7.16	5.56	5.61	5.76	5.41	3.51	4.03	4.66	4.01	Dry
4	9.14	6.14	5.64	5.89	6.24	6.14	4.89	5.14	5.24	4.94	2.84
5	9.14	1.24	0.24	3.59	3.54	3.54	0.49	2.24	2.64	2.84	1.84
6	15.66	11.56	10.61	10.31	12.61	11.81	10.31	11.56	11.81	-	9.16
7	12.10	10.95	10.80	10.85	11.10	10.95	10.90	10.90	-	-	6.00

Contd.

Table A:5.1 : (Contd.)

(b) Within the Command Area of P.L.B.C.

Obs. Well No.	Depth of Well	1975 March	1975 May	1975 October	1975 Dec.	1976 March	1976 May	1976 October	1976 Dec.
1	10.28	3.38	2.63	6.62	4.58	2.72	1.77	3.42	7.96
2	11.88	7.00	4.72	7.42	8.19	7.59	6.50	7.38	10.43
3	8.53	3.65	-	5.01	4.38	4.29	3.78	4.49	7.17
4	11.58	3.40	2.49	4.88	3.96	10.54	3.28	2.99	8.82
5	10.36	3.31	2.49	5.05	4.90	5.59	5.57	6.09	9.11
6	13.72	6.71	3.19	9.96	8.43	6.80	6.34	8.28	11.88
7	11.28	6.02	4.77	5.54	5.48	5.41	5.21	4.70	9.27
8	13.25	9.43	8.72	11.99	10.84	9.67	8.42	10.36	12.11

Obs. Well No.	Depth of Well	1977 March	1977 May	1977 October	1977 Dec.	1978 March	1978 May	1978 October	1978 Dec.	1979 March	1979 May
1	10.28	2.58	1.83	2.78	2.68	2.08	2.08	3.49	3.48	2.58	2.30
2	11.88	6.73	5.93	6.38	6.43	4.63	4.13	5.41	5.88	4.93	3.43
3	8.53	4.03	3.03	3.83	4.33	4.13	3.58	4.08	4.83	4.43	4.13
4	11.58	2.58	1.93	2.83	2.48	2.58	1.98	2.43	-	-	-
5	10.36	6.16	6.31	6.66	7.06	7.26	-	-	7.16	6.46	-
6	13.72	7.12	6.52	9.72	7.82	7.37	6.67	7.20	7.72	6.92	7.38
7	11.28	4.70	4.53	5.28	5.13	4.23	4.58	3.98	5.13	4.13	3.73
8	13.25	8.25	7.20	8.00	9.00	8.15	6.70	5.26	7.30	7.10	5.77

Source : Ground Water Survey Development Agency, Government of Maharashtra, Pune

Table A.5.2 : Distribution wells within and outside PLBC command, according to water column in three seasons, 1979-80

Water Column (ft.)	Wells				Water Column in Summer (ft.)	Wells	
	Within Command		Outside				
	Kharif	Rabi	Kharif	Rabi		Within command	Outside
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
More than 20'	170 (56.86)	93 (31.1)	8	6	More than 15'	17 (5.69)	-
11' to 20'	109 (36.45)	167 (55.85)	3	5	8' - 15'	131 (43.81)	6
6' to 10'	10 (3.35)	25 (8.36)	-	-	4' - 7'	113 (37.79)	4
5' or less	3 (1.00)	6 (2.01)	1	1	3'or less	26 (8.7)	2
Not observed	7 (2.34)	8 (2.68)	2	2	Not observed	12 (4.01)	2
TOTAL	299 (100)	299 (100)	14	14	TOTAL	299 (100)	14

Figures in brackets are percentages to total.

Source : Special Sample Survey.

Table A.5.3 : Distribution of wells according to hours of pumping from well at a time, in 3 seasons in 1979-80, in and outside PLBC command

Working Hours of Pump	Wells Within Command			Wells Outside		
	Kharif	Rabi	Summer	Kharif	Rabi	Summer
(1)	(2)	(3)	(4)	(5)	(6)	(7)
- 2 hrs.	7 (2.34)	9 (3.01)	115 (38.46)	1	2	6
2 - 4 hrs.	15 (5.02)	30 (10.03)	68 (22.74)	2	1	4
4 - 6 hrs.	17 (5.69)	38 (12.71)	29 (9.7)	1	2	1
6 - 8 hrs.	17 (5.69)	36 (12.04)	31 (10.37)	2	2	1
More than 8 hrs.	229 (76.59)	170 (56.86)	36 (12.04)	7	6	-
Not stated	14 (5.68)	16 (5.35)	20 (6.69)	1	1	2
TOTAL	299 (100)	299 (100)	299 (100)	14	14	14

Figures in brackets indicate percentages to total.

Source : Special Sample Survey.

Table A.5.4 : Distribution of wells according to hours taken to refill in 3 seasons in 1979-80, within and outside the PLBC Command

Hours taken to Refill	Wells Within Command			Wells Outside		
	Kharif	Rabi	Summer	Kharif	Rabi	Summer
- 2 hrs.	201 (67.23)	144 (48.16)	39 (13.05)	6	5	-
2 - 4 hrs.	18 (6.02)	28 (9.36)	25 (8.36)	2	3	-
4 - 6 hrs.	14 (4.68)	27 (9.03)	39 (13.04)	-	1	-
6 - 8 hrs.	14 (4.68)	21 (7.02)	24 (8.03)	1	-	2
More than 8 hrs.	34 (11.37)	60 (20.07)	151 (50.5)	4	4	10
Not stated	18 (6.02)	19 (6.35)	21 (7.02)	1	1	2
Total	299 (100)	299 (100)	299 (100)	14	14	14

Figures in brackets indicate percentages to total.

Source : Special Sample Survey.

Table A.5.5: Well classified according to water column in NLBC (Non-P) Command, and outside, during three seasons, 1979-80

Water Column (ft.)	Wells: Within Command		Wells: Outside Command		Water Column in Summer (ft)	Wells	
	Kharif	Rabi	Kharif	Rabi		Within command	Outside command
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
More than 20'	106 (50.72)	58 (27.75)	3	1	More than 15'	4 (1.91)	-
11' to 20'	78 (37.32)	94 (44.98)	2	3	8' to 15'	57 (27.27)	1
6' to 10'	13 (6.22)	44 (21.05)	2	3	4' to 7'	93 (44.50)	3
5 or less	2 (0.96)	3 (1.44)	-	-	3' or less	37 (17.70)	2
Not observed	10 (4.78)	10 (4.78)	1	1	Not observed	18 (8.61)	2
TOTAL	209 (100)	209 (100)	8	8	TOTAL	209 (100)	8

Figures in brackets indicate percentages to total.

Source : Special Sample Survey.

Table A.5.6 : Distribution of wells according to hours of pumping from well at a time, in 3 seasons in 1979-80, within and outside NLBC command

Working Hours of Pump	Wells Within Command			Wells Outside		
	Kharif	Rabi	Summer	Kharif	Rabi	Summer
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Upto 2 hrs.	3 (1.44)	8 (3.83)	111 (53.11)	-	-	4
2 - 4 hrs.	26 (12.44)	49 (23.44)	46 (22.01)	2	3	1
4 - 6 hrs	16 (7.66)	32 (15.31)	9 (4.31)	2	3	-
6 - 8 hrs.	17 (8.13)	22 (10.53)	3 (1.44)	1	-	-
Above 8 hours	135 (64.59)	86 (41.15)	7 (3.35)	2	1	-
Unstated	12 (5.74)	12 (5.74)	33 (15.79)	1	1	3
TOTAL	209 (100)	209 (100)	209 (100)	8	8	8

Figures within brackets indicate percentages to total.

Source : Special Sample Survey.

Table A.5.7 : Distribution of wells according to hours taken to refill, in 3 seasons in 1979-80, within and outside the NLBC Command

Hours Taken to Refill	Wells within command			Wells outside		
	Kharif	Rabi	Summer	Kharif	Rabi	Summer
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Upto 2 hrs.	93 (44.5)	47 (22.49)	7 (3.35)	2	1	-
2 - 4 hrs.	6 (2.87)	5 (2.39)	10 (4.78)	1	1	-
4 - 6 hrs.	13 (6.22)	8 (3.83)	6 (2.87)	-	-	-
6 - 8 hrs.	7 (3.35)	16 (7.66)	3 (1.44)	1	1	1
Above 8 hrs.	50 (23.92)	98 (46.88)	149 (71.29)	3	4	4
Unstated	40 (19.14)	35 (16.75)	34 (16.27)	1	1	3
TOTAL	209 (100)	209 (100)	209 (100)	8	8	8

Figures within brackets indicate percentages to total.

Source : Special Sample Survey.

CHAPTER VI

COSTS OF THE CHANGE IN PATTERN OF USE OF CANAL WATER

6.1 The examination of the economics of change in use of canal water has so far been in terms of the net returns from irrigation with a given quantity of water. The alternative use patterns would also mean a change in cost of supplying water. These costs will be mainly of two types: Given the total volume of water stored in the reservoir,[1] a larger irrigated area will mean longer canals, distributories, minors and water courses, thereby increasing capital cost of the project. Secondly, carrying a given volume of water over longer distances in the channels will mean greater loss of water through seepage, and this loss, which depends essentially on the soil surface that the water comes in contact with, will be proportionately higher than the increase in the length of the carrying channels. The increased net incomes have to be juxtaposed against these increased capital costs in order to find out if the project is economically justifiable.

6.2 If the canals have to be extended to irrigate larger areas, the capital cost of the project, including the headworks, per acre of irrigated land will be smaller: while the canal costs per kilometer may be assumed to be uniform, the fixed costs of the headwork, etc., would now be distributed over a larger irrigated area.

6.3 As for the loss of water in transit, it is necessary to recognise that while carrying water over longer distance will

increase loss through seepage, not providing water to sugarcane will mean less water supply in summer and therefore a smaller storage in summer in the reservoir. Since loss through evaporation in the reservoir and seepage in the channels is the maximum in summer, it may not be far wrong to assume that in the net there will be no more loss of water than under the sugarcane based irrigation. Therefore, the cost of longer carrying channels is the only additional cost that may be taken into account.

6.4 In the established irrigation systems, like PLBC, this additional channel cost will be the minimum. As was noted in the beginning of this study, the Pravara canal systems were completed by 1924 to irrigate an irrigable command of 40,000 acres under PLBC. But no more than 25,000 acres have been irrigated so far. Our exercise suggests extension of the irrigated area to cover the entire projected ICA. Since the channels already exist, there is no increased capital cost than putting them into working order. The Interim Report had estimated a capital cost of the additional canals for the upper Pravara River Project to be around Rs. 813 per acre of irrigated land, at 1975-76 prices. By 1978-79, this may be expected to have increased by about 10 per cent, say to Rs. 900. Applying that to PLBC area, and calculating interest at 10 per cent, and depreciation at 1 per cent of capital cost, as is the current practice, with the project authorities,[2] the annual cost per additional acre will come to Rs. 79. This is considerably lower than the net income expected to be generated by the crops

to be grown on an irrigated acre (without deducting the irrigation charge as cost); for Jowar (Hy-Kharif) it is Rs. 515, for wheat (HyV) it is Rs. 522, for onion in Rabi or summer, Rs. 1110,etc. There is no possibility of any adverse effect on the Benefit-cost ratio of the entire project.

6.5 A similar tentative calculation can be made for the Bhima irrigation system, located in the Solapur district of the State. It was originally projected to have a total irrigated area of 1,26,000 ha, with 1,50,570 ha. to be cropped.[3] The area under sugarcane was planned to be 7,938 ha, i.e., 6.3 per cent of the net irrigable area. The capital cost of the entire distribution system, fully lined upto sub-minors (or water courses), serving 8 ha chaks, was estimated at Rs.12,008 per hectare of net irrigated area, or approximately Rs.4,800 per acre. A completely unlined structure would cost much more per acre, since lesser quantity of water would be available for irrigation due to seepage. The ultimate irrigation efficiency is estimated at 50 per cent under lined canals and only 14 per cent under unlined, and the per net irrigated acre capital cost under unlined canals is put at 1.43 times that of lined, that is at Rs. 6,860 approximately.[4] This appears very high compared to the figure quoted in the Interim Report for Upper Pravara canals, and needs checking, which is not attempted here.

6.6 Sugarcane is denied water and the water saved is given to two seasonal crops on a plot of land in the Kharif and Rabi seasons, say Jowar (Hy-Kharif) and Wheat (HYV) and/or

Onion in Rabi season. The net area irrigable would be about 3.89 times, or approximately 4 times the area under sugarcane. This will mean an extension of the net irrigated area by about 24,000 hectares, thereby increasing the net irrigable area under the Bhima Project by 19 per cent.

6.7 The additional capital cost per acre per year would be Rs. 560/- for fully lined canals. The capital cost due to headworks may be added to this. The headworks cost was estimated at Rs. 3,546 per ha. or Rs. 1,418 per acre. Expansion of net irrigated area by 19 per cent will reduce the per acre cost to Rs. 1,192 per acre. The annual equivalent of this, calculated by current methods would be Rs. 131. The total capital cost per year would therefore be Rs. 691 for lined canal. For unlined canals it would be 1.43 times, that is Rs. 988.

6.8 The net returns per acre (gross of irrigation charge) of the 32,000 acres which may be under two irrigated seasonal crops, Jowar (Hy-Kharif) and Wheat (HYV)/Onion, would come to Rs. 1,331 an acre.[5] The Benefit-Cost Ratio would be 1.93 for lined canals and 1.38 for unlined canals. All this, without changing the proposed cropping pattern in the rest of the irrigated area. There is nothing to suggest that the capital cost involved in the more extensive irrigation will be too high to adversely affect the Benefit-Cost Ratio.

6.9 A fully worked out crop pattern and its Benefits and Costs for the entire irrigated area under the new policy for water use would surely not affect the Benefit-Cost ratio

adversely. Indeed, a more judicious choice of crops, including a lesser stress on high water consuming seasonal crops in summer may improve the B/C. However, there should be no rigidity but flexibility in the matter to face variations in market conditions.

NOTES AND REFERENCES

1. The Interim Report (op.cit.) assumes a change in this as well. This is because the Committee advocate design of irrigation dams with 50 per cent dependability instead of 75 per cent as per current practice. This question is not examined in the present study.
2. This practice does not appear proper; for, as depreciation is recovered year after year, the interest will have to be charged on a reduced value of net investment in succeeding years. The better arithmetic would be to charge an equated instalment at given interest rate and life time of the asset.
3. The data are taken up for an illustrative exercise from the Maharashtra Composite Irrigation Project - Feasibility Report, Vol. I, op.cit., from the data relating to the Bhima project in chapters X and IV.
4. As estimated in the Report cited above, Ibid., pp. 109-110.
5. The administrative cost, that is operation and maintenance cost is not taken into account here. But according to the State Government of Maharashtra it varies between Rs. 8 and Rs. 20 per acre per year.

CHAPTER VII

CONCLUSION

7.1 The basins of most of the rivers flowing in uplands Maharashtra, excepting those in the 5 eastern most districts and to a certain extent the Krishna basin, are potentially water short. These are also regions where rainfall is mostly less than 30 inches in the year and subject to great variation not only from year to year, but also right within the rainy season. Agriculture in these regions is therefore low yielding and very unstable. Sizeable parts of this region fall in what are called 'famine' and 'scarcity belts'.

7.2 The severe scarcity of irrigation water in relation to total agricultural land in these basins calls for the most economical use of irrigation water. The way to do this is to use the flow irrigation water such as to maximise net returns per unit of water.

7.3 Amongst the crops grown under canal irrigation, sugarcane is the most water using. Though sugarcane occupies less than 10 per cent of the total irrigated land under canals, it consumes at least half the total irrigation water.

7.4 Examination of the economics of net returns per unit of water under irrigation has shown that sugarcane generates the smallest net income per unit of water; indeed most of the foodgrains, like jowar, bajra, wheat (especially the hybrid or high-yielding varieties of these) give two to four times as much net income as sugarcane, and other seasonal crops, like cotton and groundnut in the Kharif season and onion,

chillies in Rabi give almost 2½ times as much. Whatever might have been the justification in the past to make sugarcane the central crop under a canal system, the bio-technological developments of the last two decades have changed that.

7.5 The superiority of these other crops over sugarcane remains even in the face of a 25 per cent fall in the relative price or of yield of these crops in any year.

7.6 Even if an acre of irrigated land, taken out from under sugarcane, is put under three succeeding seasonal crops in the three seasons of the year, (thereby increasing the intensity of cropping on this land, as conventionally measured, from 100 to 300) the net irrigated area will increase by anywhere between 30 and 60 per cent, or 50 to 100 per cent in case of sure sugarcane, depending on the crop pattern followed.

7.7 It is, however, not necessary that every acre of land denied canal water for irrigation, must be given water for 3 crops in three seasons. If every plot of land is given water for seasonal crops in any two of the seasons, and not all the three, the net irrigated area can further expand by a third. Estimates also show that even in a new irrigation project with fully lined canals, this meets more than adequately the financial benefit-cost norms. To the benefits must be added the average annual expenditure on famine and scarcity relief works, which will be saved in these areas.

7.8 This wider distribution of water would bring greater stability to agriculture of the region. It would also be much more equitable, in the sense that larger number of farmers can

benefit from irrigation by stabilizing their agriculture and reaping higher incomes, though possibly not as high as sugarcane would have permitted.

7.9 Indeed, the present system of irrigation, with the Blocks for various crops, is characterised by inequality of distribution of benefits. The pattern of cropping of the sample farmers surveyed in PLBC command showed that while the smallest size group of farmers had almost half their total operational holding under canal command, they had little land under sugarcane in their canal operated part. Almost all their sugarcane land was under wells. It means, the small farmers in the irrigated villages got little share in the sugarcane blocks that were cornered by the rest, with the largest size group getting the greatest proportionate land under sugarcane block. This was quite contrary to what the Report of the Irrigation Enquiry Committee appointed by the Government of Bombay, under the chairmanship of Sir M. Visvesvaraya, very firmly recommended in 1938. Their recommendations are so important and interesting in the context of the considerations of equity in distribution of scarce water that some extensive quotations may bear reproduction here.

7.10 Laying down the basic approach to the distribution of water, the Committee said:

> "26. ... It is now proposed to redistribute the irrigable area under each canal as equitably as possible by giving to each village, and as far as possible to each cultivator in it, just enough irrigable land and no more, so that the

acreage available for irrigation may nowhere constitute a surfeit, and the cultivator, and also the village collectively, may show a better appreciation of the water advantages placed at their disposal."

"29. ... From the known carrying capacity of a canal and the storage impounded in its reservoir at the end of the monsoon the discharges that can be advantageously maintained in the canal or canals in each of the three seasons - kharif, rabi and hot weather - can be determined. These discharges will show what crop areas can be maintained on canal water in the three seasons and what the total acreage of all classes of crops should be in a year of average rainfall.

"The acreage of the various crops which can be cultivated under the whole canal being thus determined, this acreage should be distributed by sections - each section representing, say, about 10 miles of the main canal. The crop areas in each section are in their turn distributed by villages, each village receiving 25 to 40 per cent of the total cropped area of the village."

"30. ... The crop areas allotted to each village will have to be distributed equitably among the whole body of cultivators residing in it by an authoritative Government Committee whose personnel should inspire confidence in the cultivators. Share lists should be prepared for each village on the basis of the acreage of the holdings of individual cultivators.

"The extent and nature of crop areas given to each village and the shares allotted to individual cultivators in its being known, the grouping of the shares into blocks - sugarcane and two seasonal - should be arranged by the Committee with the consent and co-operation of the cultivators."

"31. Block system of irrigation - It has been explained that the bagait or irrigable area allotted to a village should be about one-third of its total cropped area where the whole of it is under command of a canal distributory or distributories, and that the total acreage allotted to the village should be distributed among its resident cultivators in proportion to the areas of their holdings in the village."

"32. ... The object of the block system has been defined to be to distribute the benefits of an irrigation work over as large a number of villages as possible, and at the same time to concentrate the irrigation given to each village on areas or blocks of a specified extent and in selected soils and situations favourable to irrigation."

"34. ... In the land chosen for blocks the owner of the land will not be permitted to irrigate more than the share allotted to him. On the rest of the land belonging to but not used by him he can only practise dry cultivation. Since he cannot make use of the land himself there will be every inducement for him to lease it to a neighbour either in exchange for a larger area of other land or for some

other consideration to persons who may want land to utilize their share of the irrigation available.

"The contemplated exchange of land will be naturally distasteful to the cultivator and opposition must be expected. But we think that the necessary exchange can be effected and Blocks formed with the aid of a Committee of two or three competent officers specially appointed to introduce the system. The officers would select suitable land, plan blocks, negotiate with the cultivators and endeavour to bring about a speedy understanding between them so that all who are eligible for a share in irrigation may find a place within the blocks."

7.11 The Visvesvaraya Committee Report has been quoted extensively above in order to give a clear understanding of the concern for and necessity of equitable distribution of scarce irrigation water among villages in the command and among all cultivators in a village. There are many who swear by Visvesvaraya's Block system of irrigation in the Deccan (he introduced it in 1903-04 in the Nira Left Bank Canal and it was recommended by the Indian Irrigation Commission of 1904 to be followed in other systems in the region), but they do not recognise that the principle of equitable distribution, so central to his scheme, was not followed after 1938, like it had been changed after 1903-04 when the equitable distribution had been worked out by a local committee similar to one recommended in the Report. Whatever the operational deficiencies of the block system, (pointed out by the Maharashtra

State Irrigation Commission, and in the Interim Report) the need for equitable distribution emphasized in the Report remains.

7.12 Equitable distribution of water, in addition to the most economical use of water, has to be a central consideration in designing irrigation systems in these potentially water deficit regions. The considerations that led to the pattern of water use in which sugarcane occupied the most important position during the long years till the Second World War, have changed during the last two decades, leading to the advocacy of a policy of denying canal water to sugarcane. But even under this new approach there will not be enough water for even one irrigated seasonal crop on every piece of land in these regions. Therefore, the necessity of equitable distribution of water, geographical as well as cultivatorwise, so much emphasised by Visvesvaraya, remains.

7.13 The illustrative exercise with regard to the Pravara Left Bank Canal in this study has shown, as stated above, that even if water is given to three different seasonal crops in the three seasons in place of sugarcane for the whole year, the net irrigated area can increase by 30 to 60 per cent. But this will increase the total net irrigated by only a small percentage since sugarcane occupies a small part of the net irrigated area. If water is given in any two seasons to a field then the net irrigated area will be almost 3½ to 4 times the area under sugarcane. All this will not bring even the Irrigable Command Area of 40 thousand acres under two-season irrigation, while the total culturable command area is 1,24,561 acres!

7.14 This implies that irrigation water should be distributed over all the villages in the culturable command area proportionately. The implication of this is that not all cultivated land in the village can be irrigated. The aim should, therefore, be to irrigate as many acres in the village as can be provided with water for any two seasons, the greater emphasis being on Kharif and Rabi, and only a smaller part in summer. But at the same time, it must be ensured that every cultivator in the village has pro-rata share in the irrigation water. If this requires some redistribution of land amongst cultivators, because of locational disadvantages in relation to the water courses faced by some, this must be brought about by mutual arrangement with official intervention, before any land in the village is provided irrigation water. Finally, a greater weightage should be given to the smallest farmer households, say, those with less than 1 ha. of cultivated land; they should be provided irrigation, of the type specified, on their total holding, and redistribution should take care of that as well. It will not be advisable to confine irrigation of a piece of land to a single season and design the canal system accordingly, as it would mean very low benefit cost ratio per acre of land.

7.15 The Committee, set up by the Government of Maharashtra, to study the introduction of eight monthly supply of water on irrigation projects in Maharashtra, has also recognised, in its Interim Report, the need for equitable distribution of water geographically and cultivator-wise. Its recommendations on the matter (contained in paragraphs 70 to 74) are broadly

along similar lines, and deserve serious consideration. The approach of the "Pani-Panchayat" in Pune district, by which the limited water from wells and percolation tanks is sought to be distributed in terms of a given area of irrigated land (growing only low water using crops) per person in the household, irrespective of the total size of land holding, strongly underlines the need for equitable distribution of water.[1]

7.16 Equitable distribution of water requires control over the volume of water supplied to farmers. This needs adoption of the Rotation Water Supply System that ensures volumetric supply of water to the field. One advantage of this system would be a single water rate, per unit of water supplied, irrespective of the crop to which it is applied. Once the volume of water to be supplied to a farmer's fiedls is estimated on the basis of relevant seasonal crops' requirements, there need be no effort made to ensure that the farmer adheres to that crop pattern. If someone chooses to use the specified quantity of water for growing sugarcane, no objection need be taken, since administratively it would be difficult. Given the economics of use of water for different crops, a farmer is sure to learn, sooner than later, about the loss of income implicit in the use of the limited water for a heavy water using crop like sugarcane grown on a fraction of the irrigable area.

7.17 There appears no immediate prospects of sharp decline in area under sugarcane or cessation of any further increase in its area in the region, as a result of this policy. Wells in the command areas of canal irrigation projects will take

care of that.

7.18 Greater economy in the use of irrigation water is sure to be the growing necessity in these water scarce regions of the state. The question will be attacked from many angles, in the years to come. Greater economy in application of water to the fields by various cultural devices, will be one. The adoption of the sprinkler and drip irrigation methods will be another, though their use in canal irrigation will require both power and further capital investments and, therefore, appear to have only a distant possibility. These can be tried out on wells, and already small experiments have been started by farmers. A third line of approach will be the choice of less water consuming crops, depending on emerging market conditions. As elsewhere in India, the average size of cultivated holding in Maharashtra is steadily declining, and larger proportions of cultivators are becoming small and marginal farmers. Simultaneously, urbanisation is growing, making a growing demand for diverse kinds of farm products like fruits, vegetables, flowers, milk and meat. Many of these are low water using crops (grapes require about as much water as any seasonal crops; so do lucerne/fodder crops, important for dairy and sheep breeding for meat, etc.) with growing market prospects. The small cultivators can earn a better living growing such products on their lands, by economically using irrigation water. Of course, these are not immediate prospects; but the system of water management should evolve in appropriate direction keeping such prospects in view.

7.19 The policy of using water for crops giving the highest net social return per unit of water, is crucial for adjustment to changing prospects. In the present context, it is thrice blessed: it generates greater total social income from a given volume of irrigation water; it ensures a more equitable distribution of this greater social income through more extensive irrigation involving larger body of farmers; and finally, by providing irrigation to larger cultivated areas, growing seasonal crops, it provides greater stability to agriculture of the region, characterised today by high fluctuations in yield and periodic scarcities and famines. Such policy change is, therefore, imperative for the water scarce regions of Maharashtra, as well as similar other regions in peninsular India.

NOTES AND REFERENCES

1 It is interesting to note that this policy of ensuring the supply of water to crops that help generate the highest income per unit of water is relevant not only for the canal irrigation schemes, but also for lift irrigation schemes. K.P. Deo in his unpublished Ph.D. dissertation entitled "Economic Evaluation of the Lift Irrigation Schemes in Maharashtra" (submitted to the University of Poona in July 1979, and deposited in the libraries of the University and the Gokhale Institute of Politics and Economics, Pune) has worked out the net returns to an acre inch of water under alternative cropping patterns for five cooperative lift irrigation schemes operating on Pavana river in Pune district. He shows that the use pattern in which sugarcane is one of the crops generates the smallest net income, and benefits, for the quantity of water permitted by the Government to be pumped from the river, almost half as many acres and cultivators, as under alternative crop patterns excluding sugarcane examined by him in consultation with local cultivators. Unfortunately, financing institutions giving term loans for such projects as well as the irrigation Department giving permission for pumping a given quantity of water during the year, have not examined if the crop pattern proposed by the cooperatives gives the highest net income per unit of water and benefits the largest number of cultivators. It appears necessary that this approach be followed in assessing proposals for lift irrigation from rivers and streams in the region, before loans are sanctioned for the purpose.