Economics of Drip Irrigation in Banana and Grape Cultivation: A Study of Maharashtra

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(Report prepared for the Task Force on Micro-Irrigation)

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Preface

Importance of drip method of irrigation in increasing the productivity of crops and reducing water consumption has been recognised in most of the countries where it is used extensively. This method of irrigation was introduced in the early eighties in India through the government schemes. This method of irrigation is quite useful in the areas facing water scarcity. Though it has enormous benefits, the growth of area under drip method of irrigation is very insignificant except a few states as of today. In this study, using the filed level data collected from two districts in Maharashtra, we have studied the impact of drip method of irrigation on different parameters including its economic viability in two crops namely banana and grapes.

This report is drawn from an earlier study on *"Evaluation of Drip Irrigation System in Maharashtra"* carried out at the Agro-Economic Research Centre of the Institute and submitted to the Ministry of Agriculture, Government of India, New Delhi during March 1996 and a paper (Narayanamoorthy, 1997) published in *Indian Journal of Agricultural Economics*. This report is prepared for the Task Force on Micro-Irrigation as per the request of the Ministry of Agriculture, Government of India, New Delhi.

During the period of the study, many of my senior colleagues of the Institute and Government Officials involving in promoting drip method of irrigation in Maharashtra, have helped me in many ways to complete this study. At the outset, I wish to express my deep sense of gratitude to Dr. R. S. Deshpande (then Officer in-charge, AERC of our Institute), presently Professor and Head, Agricultural Development and Rural Transformation Unit, Institute for Social and Economic Change, Bangalore. I am grateful to Prof. D. C. Wadhwa, Director of our Institute during the time of the study, for his constant encouragement right from the beginning of the study. I would like to thank Prof. V. S. Chitre, Director of our Institute for his encouragement and support in completing the present report. Thanks are also due to Mr. V. B. Lokare and Mr. V. G. Kasbe for their meticulous research assistance. However, the author alone is responsible for errors remaining in the report.

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Abstract

Results of the studies conducted on the data from several research stations have confirmed that the drip method of irrigation results in considerable saving of water, increases productivity of crops and reduces the cost of cultivation in certain operations when compared with the surface method of irrigation. However, not many studies have brought out the importance of drip irrigation including its benefit cost pattern under field condition. In this paper, we have made an attempt to find out the impact of drip method of irrigation on different parameters including the economic viability of drip irrigation in two crops namely banana and grapes by using field level data collected from Maharashtra. It is found that drip irrigation reduces the cost of cultivation, increases water saving and productivity of crops as compared to flood method of irrigation. Due to reduced water consumption, electricity used for lifting water from wells also reduced significantly in drip method of irrigation as compared to flood method. The results of discounted cash flow analysis show that investment in drip irrigation is economically viable even for the farmers who own one hectare of land. It further shows that farmers can regenerate the capital cost of drip set from the profit of the very first year even without availing of the subsidy from government schemes.

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1. Introduction:

Irrigation is essential for increasing the use of yield increasing inputs and enhancing cropping intensity and crop productivity (Dhawan, 1988; Vaidyanathan, *et al.*, 1994a; Narayanamoorthy, 1996). While the water need for irrigation is bound to grow with agricultural expansion and intensification imperatives, resource side constraints on the one hand and growing water demand from non-irrigation sectors on the other hand are likely to limit the water availability for irrigation.[1] In such scarce condition, efficient use of available water will be an important means to expand irrigation benefits (Central Water Commission, 1995; Dhawan, 1995; Saleth, 1996). It is a known fact that the efficiency in the use of water is extremely low in the flood method of irrigation (FMI) because of evaporation and losses in conveyance and distribution (Sivanappan, 1994; Chaudhary, 1995).[2] Different measures (e.g., Command Area Development Programme and Water Users Organisation) have been introduced to improve water use efficiency under FMI. Unfortunately, these measures could not make any appreciable change in the existing pattern of water use.

Another method introduced in India recently to enhance water use efficiency in irrigation is the drip method of irrigation (DMI). Notably, the on-farm irrigation efficiency of properly designed and managed drip irrigation systems is about 90 per cent, whereas it is about 70 per cent for sprinklers but just about 45 per cent for surface irrigation method including FMI (Sivanappan, 1994; INCID, 1994). Obviously, the DMI is most useful for wide-spaced crops especially water scarce areas. In this method, since water is supplied straight to crop root zone through a network of pipes and drip emitters, water losses in conveyance and distribution are far lower than those under FMI (Shrestha and Gopalakrishnan, 1993).

Experimental results from research stations located in various parts of India do indicate that DMI increases crop yield and that too with reduced cultivation cost and water consumption (see Table 1). Realising such benefits,

Table 1: Water Saving and Productivity Gains through Drip Irrigation.

Crop's Name	Water Consumption (mm/ha)		Yield (tonne/ha)		Water Saving over FMI (%)	Yield Increase over FMI (%)	Water Use Efficiency$	
	FMI	DMI	FMI	DMI			FMI	DMI
Vegetables:								
Ash gourd	840	740	10.84	12.03	12	12	77.49	61.51
Bottle gourd	840	740	38.01	55.79	12	47	22.09	13.26
Brinjal	900	420	28.00	32.00	53	14	32.14	13.13
Beet root	857	177	4.57	4.89	79	7	187.53	36.20
Sweet potato	631	252	4.24	5.89	61	40	148.82	42.78
Potato	200	200	23.57	34.42	Nil	46	8.49	5.81
Lady's finger	535	86	10.00	11.31	84	13	53.50	7.60
Onion	602	451	9.30	12.20	25	31	64.73	36.97
Radish	464	108	1.05	1.19	77	13	441.90	90.76
Tomato	498	107	6.18	8.87	79	43	80.58	12.06
Chillies	1097	417	4.23	6.09	62	44	259.34	68.47
Ridge gourd	420	172	17.13	20.00	59	17	24.52	8.60
Cabbage	660	267	19.58	20.00	60	2	33.71	13.35
Cauliflower	389	255	8.33	11.59	34	39	46.67	22.00
Fruit Crops:								
Papaya	2285	734	13.00	23.00	68	77	175.77	31.91
Banana	1760	970	57.50	87.50	45	52	30.61	11.09
Grapes	532	278	26.40	32.50	48	23	20.15	8.55
Lemon	42	8	1.88	2.52	81	35	22.34	3.17
Watermelon	800	800	29.47	88.23	Nil	179	27.15	9.07
Mosambi*	1660	640	100.00	150.00	61	50	16.60	4.27
Pomegranate*	1440	785	55.00	109.00	45	98	26.18	7.20
Other Crops:								
Sugarcane	2150	940	128.00	170.00	65	33	16.79	5.53
Cotton	856	302	2.60	3.26	60	25	329.23	92.64
Coconut	–	–	–	–	60	12	–	–
Groundnut	500	300	1.71	2.84	40	66	292.40	105.63

Notes: * - yield in 1000 numbers; $ - water consumption (mm) per quintal of yield.
Sources: INCID (1994) and NCPA (1990).

the Government of India has introduced many promotional schemes including subsidy for drip adopters to increase the area under drip irrigation. Since 1982-83, the Government of India has been providing subsidy for encouraging the use of sprinklers, drip systems and other water saving devices to the state governments under the centrally sponsored scheme. But, the growth of area under drip irrigation is insignificant barring a few states in India. For instance, at the end of 1997-98, India's total drip irrigated area was 2,46,000 hectare (ha) which is just 0.34 percent of gross irrigated area (GIA) and 0.64 percent of the net

groundwater irrigated area (NGWIA). Though DMI increases the crop productivity and saves water (Magar, *et al.*, 1988; Kulkarni, 1987), the huge initial investment needed for installing drip system remains the main deterrent for the widespread adoption of DMI.[3] To what extent this discouragement effect is real and to what extent such effect can be counterbalanced by government subsidy are important policy issues requiring empirical answers. Since past studies (e.g., INCID, 1994; Sivanappan, 1994) on the subject have either conducted benefit cost analysis without a proper methodology or relied on the experience of one or few farmers adopting DMI, there is a need for a study to empirically evaluate the economic viability of the new irrigation technique within a relatively more systematic methodological framework.

It is in this context that the present study aiming to empirically evaluate the economic viability of DMI assumes importance and relevance. Utilising field level data collected from 100 farmers - both adopters and non-adopters of DMI - spread in Jalgaon and Nashik districts of Maharashtra and a properly designed benefit-cost framework, this study attempts to empirically evaluate the economic viability of DMI in the case of two crops, i.e., banana and grapes, for which DMI is the most feasible irrigation technique. Specifically, this study addresses:

- Operation-wise cost of cultivation of drip and non-drip irrigated crops.
- The relative productivity gains due to drip method of irrigation.
- Water use efficiency possible with new irrigation technology,
- Saving in electricity consumption due to drip method of irrigation.
- The way the economic viability of investment on DMI is influenced by factors like fixed costs (i.e., the lumpiness of investment), government subsidies, and farmers' time preference (i.e., the differential discount rates).

2. Empirical Context:

Maharashtra, a state with nearly a half of the total drip irrigated area in the country as of 1997-98, provides the empirical context for this study.[4] Both the Central and State schemes of subsidies on drip irrigation sets are currently in operation to promote DMI in Maharashtra. State schemes are operating since 1986-87 while Central schemes have started functioning only from 1990-91. Under these schemes, upto the end of March 2002, the Government of

Maharashtra has distributed about Rs. 332 crores as subsidy to the drip adopters (GOM, 2003). Thanks to this initiative, the area under DMI has increased from 236 ha in 1986-87 to about 2,17,447 ha in 2000-02, signifying an increase of about 921 times. Currently, about 26 crops are being cultivated using DMI.[5] Among different crops being cultivated with DMI, five crops, i.e., banana, grapes, sugarcane, citrus crops and pomegranate together account for about 75 per cent of the total area in Maharashtra by the end of March 2000.

The sample for the study is designed as follows; First, based on the secondary data collected from the drip irrigation cell, Commissionerate of Agriculture, Government of Maharashtra, Pune, two districts with a relatively more extensive use of DMI were selected. The two districts selected are: Nashik and Jalgaon. Notably, these districts are dominant in terms of the area under DMI (about 27 per cent of the state total DMI area in 1994-95) since the introduction of the state scheme in 1986-87. Second, since the economic impact of drip irrigation varies by crop, two dominant crops in terms of the area under DMI - one from each sample district - were selected. Based on the crop and block-wise distribution of the area under DMI as obtained from the Agricultural Officers of the respective districts, two crops, i.e., banana for Jalgaon district and grapes for Nashik district were selected. Third, having identified the crops, two blocks - Niphad from Nashik district and Raver from Jalgaon district - with an extensive cultivation of these sample crops were selected for a detailed field survey. And, finally, with the help of the adopters' list available for 1992-93, 50 farmers consisting of 25 adopters and 25 non-adopters of DMI were selected for each district. While the adopters were selected using random sampling procedure, non-adopters were selected rather purposively. Thus, it is this sample of 100 farmers for whom the relevant data on the economics of DMI were collected during the year 1993-94 that forms the basis for the field level evaluation of DMI.

3. Methodology:

Since it is essentially an impact evaluation study, the basic approach used for assessing the relative economic impact of DMI in crop cultivation involves a comparison between adopters and non-adopters (who use FMI) in the context of the same crop. To evaluate the economic viability of drip investment, in the context of both banana and grapes, we have computed both the Net Present

Worth (NPW) and Benefit Cost Ratio (BCR) by utilising discounted cash flow technique. Since the NPW is the difference between the sum of the present value of benefits and that of costs for a given life period of the drip set, it collates the total benefits with the total costs covering items like capital and depreciation costs of the drip set. In terms of the NPW criterion, the investment on a drip set can be treated as economically viable if the present value of benefits is greater than the present value of costs.

The BCR is also related to NPW as it is obtained just by dividing the present worth of the benefit stream with that of the cost stream. Generally, if the BCR is more than one, then, the investment of that project can be considered as economically viable. A BCR greater than one obviously implies that the NPW of the benefit stream is higher than that of the cost stream. The NPW and BCR can be defined as follows:

$$NPW = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t}$$

$$BCR = \frac{\sum_{t=1}^{t=n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}}$$

where

B_t = benefit in year t,
C_t = cost in year t,
t = 1, 2, 3, ..., n,
n = project life in years, and
i = rate of discount (or the assumed opportunity cost of the investment).

Since drip irrigation involves fixed capital, it is necessary to take into account the income stream for the whole life span of drip investment. However, since it is difficult to generate the cash flows for the entire life span of drip investment in the absence of observed temporal information on benefits and costs, we need to make few assumptions so as to estimate both the cash inflows and cash outflows for drip investment. These assumptions are:

(i) The life period of a drip set is considered as five years for banana but ten years for grapes (see INCID, 1994).

(ii) The income stream from the drip set is uniform and constant over its entire life for both the crops. However, this assumption is later relaxed by considering alternative scenarios, wherein cash outflows are allowed to increase by 2 per cent and 5 per cent per annum over the corresponding cash inflows.

(iii) Differential rates of discount (interest rate) are considered to undertake the sensitivity of investment to the change in capital cost. These are assumed at 10, 12 and 15 per cent as alternatives representing various opportunity costs of capital.

(iv) And, finally the crop cultivation technology is assumed constant for both banana and grapes.

4. Cost of Cultivation:

As mentioned earlier, one of the advantages of drip irrigation is that it reduces the cost of cultivation particularly in labour intensive operations like weeding, irrigation, ploughing, etc. To understand the impact of drip irrigation on the cost of cultivation of different operations, we have compared the cost of each operation of drip crops with non-drip irrigated crops (our cost of cultivation refers to cost A2). To further analyse the irrigation expenditure, we have divided the irrigation expenditure that is incurred exclusively on labour and other items. Since studies have indicated that drip method of irrigation reduces the cost mainly in operations like ploughing, weeding, irrigation, fertilisers and pesticides, we have not given much importance for other operations in our analysis. Table 2 shows the details of operation-wise cost of cultivation per hectare for both the drip adopters and non-drip adopters for banana and grapes. First let us discuss about the operation-wise cost of cultivation of banana crop. It is clear from the table that drip irrigation reduces the total cost of cultivation by about Rs. 1300/ha for the drip adopters as compared with the non-drip adopters. Although the cost saving in terms of percentage is small (2.5 percent) in aggregate, it varies across different operations. Among the different operations, cost saving is very high in the labour cost of irrigation (about 26 percent). Since water is supplied through pipe network in drip method of irrigation, it does not require much of labour. However, in the case of surface method of irrigation, labour input is necessary to

control water supply (changing course of water from one field to other) and to govern leakage and seepage. Second highest saving under cost of cultivation is noticed in ploughing operation (about 18 percent). This is because of the fact that drip method of irrigation does not warrant much ploughing as it supplies water at the root zone of the crop. The cost saving is also high in weeding operation as indicated by the earlier studies. Drip irrigation does not allow weed to come up in the non-crop space as it does not spread water beyond the root zone of the crop. Some of the studies have reported that drip irrigation also reduces the cost of fertiliser as it can be supplied with water (liquid fertilisers). However, in our survey, no one has used liquid fertiliser and hence the cost of cultivation on this account does not reduce significantly for the banana crop.

Table 2: Cost of Cultivation (selected operations) of Drip and Flood Irrigated Crops

(Rs/ha)

Operations	Banana			Grapes		
	DMI	FMI	% change over FMI	DMI	FMI	% change over FMI
Ploughing	2633.20	3223.20	18.30	5917.80	6131.00	3.50
Fertiliser	16377.70	17493.60	6.40	21828.00	25329.30	13.80
Pesticides	9.90	—	–	47695.40	50107.40	4.80
Weeding	1825.70	2122.90	14.00	7782.30	8854.70	12.10
Irrigation						
a) Labour	3816.60	5170.00	26.20	7863.35	8840.40	11.10
b) Others*	1940.10	1208.70	-60.50	722.50	588.60	-22.75
Others**	24832.00	23520.10	-5.60	42696.90	48063.70	11.20
Total (Cost A2)	51436.70	52738.60	2.50	134506.20	147915.00	9.10

Notes: Negative sign means cost is higher for drip adopters than non-drip adopters
DMI – drip method of irrigation; FMI – flood method of irrigation;
* - includes electricity cost and operation and maintenance cost of the system;
** - includes cost of seed and sowing, farm yard manure, harvesting, marketing and cost on miscellaneous items.
Source: Field survey data.

As in the case of banana crop, we have also studied the operation-wise cost saving for grapes by comparing with non-drip irrigated crops. It is clear from the table that drip technology saves more cost for grapes than banana. In banana, cost saving due to drip method of irrigation is only about 2.5 percent, whereas the same is about 9 percent in grapes for drip adopters. As in the case of banana crop, cost saving varies with operations. Cost saving is found in

operations like weeding, irrigation, fertiliser, ploughing and pesticides use. However, cost saving is higher in the operations which are more labour-intensive. On the whole, our survey results have clearly shown that drip irrigation has reduced the cost of cultivation in many labour intensive operations for both banana and grapes.

5. Productivity Gains:

Though productivity of a crop is determined by many factors, most of the time yield is affected because of moisture stress. It is difficult to maintain water supply constantly for crops by surface method of irrigation. Studies related to drip irrigation have confirmed that problems of moisture stress are completely absent by providing irrigation water through drip method as it supplies water continuously at the root zone of the crops. As a result, the yield of drip irrigated crops is much higher than the crops which cultivated under the flood method of irrigation. Table 3 shows that the productivity of banana and grapes cultivated under drip and surface method of irrigation. It is clear that the productivity is significantly higher for the farmers who adopt drip method of irrigation than those of surface method of irrigation for both crops. In the case of banana, the yield of drip irrigated crops is about 29 percent higher than that of non-drip irrigated crop. Similarly, grape's yield is about19 percent higher for the drip adopters than the non-drip adopters. There are mainly two reasons for higher yield in drip irrigated crops. First, because of less moisture stress, the number of fruits in each bunch of banana and grapes have increased. Second, unlike the surface method of irrigation, drip does not encourage any growth of weed which has ultimately helped to increase the yield of crop. Although the costs incurred by the non-drip adopters on different yield increasing inputs are more than the drip adopters in both the crops, this does not coincide with increased yield of the crops. Hence, one can conclude that this yield increase is because of the influence of drip method of irrigation.

Table 3: Productivity of Drip and Flood Irrigated Crops

Crop	Productivity (Quintal/ha)		Gain over FMI	
	DMI	FMI	In Quantity (Qtl)	In Percent
Banana	679.54	526.35	153.54	29.10
Grapes	243.25	204.29	38.96	19.07

Source: Computed from field survey data.

6. Water Use Efficiency:

Water conservation and water use efficiency are among the two most important advantages of drip irrigation. Since water is supplied straight to the crop root zone through a network of pipes and drip lets, DMI leads to substantial reduction in water losses occurring from evaporation, conveyance and distribution. While quantifying such DMI induced water loss reduction or water use efficiency improvement requires an exact measurement of water delivery and actual water consumption by crops, in the context of a sample based on a field study like the present one, it is inevitable to use the nearest practicable proxy like irrigation time in terms of the Horse Power (HP) hours to get a fair idea of the amount of water used. The HP hours of water are computed by multiplying the HP of the pumpset with the number of hours of irrigation. The amount of water use as measured in terms of HP hours of irrigation for drip and non-drip crops is presented in Table 4.

Table 4: Water Consumption and Water Use Efficiency in Drip and non-Drip Irrigated Crops

Particulars	Water consumption/ha@		Water use per quintal of yield	
	Banana	Grapes	Banana	Grapes
Drip crops (HP hours)	7884.70	3310.36	11.60	13.61
Non-drip crops (HP hours)	11130.34	5278.38	21.14	25.84
Water saved by DMI:				
In percentage	29.15	37.28	45.13	47.33
In HP hours	3245.64	1968.02	9.54	12.23

Note: @ Our sample contains only the farmers using well irrigation by electric pumpsets.
Source: Computed from field level data.

It is clear from the Table 4 that the amount of water applied for crops under drip irrigation is significantly lower than the same for crops, which are cultivated under FMI. The extent of water saving as reflected through our proxy measure works out to be about 29 per cent for banana and about 37 per cent for grapes. In terms of HP hours, however, water saving is substantially higher for water intensive crop like banana when compared with grapes. With an overall 30 per cent of saving in water can be effected through drip technology, one can estimate the additional area that can be irrigated even within the existing level of water

availability. Our calculation shows that an additional area of 0.60 ha (1.48 acres) under grapes and 0.41 ha (1.01 acres) under banana can be irrigated by adopting DMI.

While the extent of additional area irrigated with a given amount of water is an important indicator for evaluating water use efficiency under DMI, a somewhat more precise method to judge the efficiency of water use in drip and non-drip irrigated conditions is to ascertain their relative water use per quintal of output. Note that the per quintal requirement of water is arrived by dividing the per hectare water consumption by the per hectare yield. The results (see Table 4) show that water use efficiency is substantially higher for the drip irrigated crops. Under DMI, banana consumes only 11.60 HP hours of water to produce one quintal of banana output as against the use of 21.14 HP hours of water for the same quantity of yield under non-drip condition. Similarly, in the case of grapes, each quintal of output involves the use of just 13.6 HP hours of water under DMI as compared to the use of 25.84 HP hours under non-drip condition. On the whole, it is clear that DMI saves substantial amount of water as compared to FMI in both banana and grapes cultivation.

7. Electricity Consumption:

Owing to the rapid development of rural electrification and energisation of pumpsets, consumption of electricity by the agricultural sector has been increasing continuously. Generally, consumption of electricity increases with the number of electric pumpsets. In India, pumpset which is used to lift water from wells consumes about 70 percent of the electricity in agriculture (Sharma A, 1994). Studies related to drip irrigation shown that this micro-irrigation technology is not only useful to reduce the consumption of water but also useful in energy saving. It is obvious that as the number of working hours of pumpset reduces the consumption of electricity also reduces. Thus consumption of electricity is positively related to the hours of operation of the pumpset.

We saw in the previous section that hours of water used per hectare under drip method of irrigation are less than flood method of irrigation. As indicated earlier that while working hours of pumpset reduce, consumption of electricity also reduces. In order to know the impact of drip irrigation on electricity saving, we have estimated electricity consumption based on the hours of pumpset operation

for both drip and non-drip crops. Further for estimating electricity, we have assumed that for every hour of operation of pumpset, 0.75 kwh of power is used per HP. Since all the farmers in both the groups have used only electrical pumpsets, we have simply multiplied HP hours of water with assumed power consumption of 0.75/kwh/HP to arrive at the per hectare electricity consumption. Table 5 shows the per hectare consumption of electricity in KWH. It is clear from the table that DMI using farmers consume very less amount of electricity, for both the crops, compared to non-users. Farmers who cultivate banana under DMI save about 2430 kwh of electricity per hectare as compared to non-users. Likewise, in grapes, DMI helps to save about 1470 kwh of electricity per hectare as compared to flood method of irrigation.

Table 5: Electricity Consumption and Electricity Use Efficiency in Drip and non-Drip Irrigated Crops

Particulars	Electricity consumption/ha		Electricity use per quintal of yield	
	Banana	Grapes	Banana	Grapes
Drip crops (KWH)	5913.53	2482.77	8.70	10.21
Non-drip crops (KWH)	8347.75	3958.78	15.60	19.37
Electricity saved by DMI:				
In percentage	29.15	37.28	44.23	47.29
In KWH	2434.00	1476.01	6.90	9.16
In monetary terms (Rs)*	1217.00	738.00	—	—

Note: *- It is assumed 0.50 paise/kwh to estimate electricity cost in terms of rupees.
Source: Computed from field level data.

It is clear from the above analysis that farmers with drip irrigation operate less number of hour of pumpsets and because of this consumption of electricity is quite low. This will also reduce the electricity cost to be paid by the farmers. To understand this, we have calculated the money saved in the total electricity bill per hectare by energy saving for both banana and grapes. Since state supplies electricity on flat-rate (FR) basis for agriculture, it was not possible to get per kwh price of electricity. Therefore, we have assumed 50 paise/kwh as a nominal rate to estimate the electricity bill in monetary terms. According to the calculations, about Rs.1217/ha in banana and Rs.738/ha in grapes can be saved on electricity bill alone. This indicates that drip irrigation

technology not only helps to save the precious inputs like electricity but also reduce the cost of cultivation enormously by reducing the cost of electricity.

To explain the saving of electricity in a simplest way in drip irrigation, we have calculated electricity consumed to produce one quintal of yield under both the conditions – DMI and FMI. As in water consumption, energy used to produce one quintal of yield is computed by dividing per hectare energy consumption by yield. Table 5 shows the per quintal consumption of energy for both grapes and banana. As we expected, energy consumed to produce one quintal of yield is quite low for drip adopters both for banana and grapes. Among the two crops, consumption of energy per quintal is higher for grapes when compared with banana. For instance, grape cultivators under DMI spend about 10.21 kwh to produce one quintal of yield whereas, the same is only 8.70 kwh for banana. This is due to the higher yield of banana than grapes. However, both for banana and grapes, drip adopters save more than 40 percent of energy compared with the non-drip adopters to produce one quintal of yield of the crop. For cultivating banana, drip farmers spend about 8.7 kwh/quintal as against 15.86 kwh/quintal by the non-adopters of drip. Likewise, for grapes, the electricity consumption is 10.21 kwh/quintal and 19.37 kwh/quintal respectively for drip and non-drip adopters. Because of higher productivity of drip crops, per quintal consumption of electricity is much less in drip crops.

8. Income and Expenditure Pattern:

It is understood from the above that DMI reduces cost of cultivation, increases the productivity of crops and saves water as well as electricity consumption. In this section, we briefly discuss about the income and expenditure pattern of drip and non-drip irrigated crops. The profit of a crop is determined by not only its total quantity of the output but also its quality. Quality produce can fetch good price in the market and help to earn more profit. Studies have indicated that drip method of irrigation not only helps to increase the yield of the crops but also quality of the produce. Let us analyse the how the profit varies between the drip and non-drip crops in our study. In this calculation, while gross income was obtained by multiplying yield with the prevailing per quintal selling price, the total cost was calculated by considering only the variable costs but not

the fixed cost components like interest rate and depreciation. As can be seen from Table 6, the average profit among drip adopters is significantly higher than that among non-drip adopters in the case of both crops. For grapes, the profit level among drip adopters is Rs. 50,187/ha higher than that of the non-adopters, whereas the same is about Rs. 32,400/ha for banana. While the profit differential is substantial for DMI, it cannot be taken as a conclusive indicator of the comparative advantages of the new irrigation technique as our profit calculation is based only on the variable cost but ignores fixed cost components like the interest rate and depreciation.

Table 6: Income and Expenditure Pattern of Drip and Flood Method Irrigated Crops

Particulars	Total Expenditure (Cost of cultivation)	Total Income	Farm Business Income (Profit)**
Banana:			
Drip Method	51436.70	134043.75	82607.10
Flood Method	52738.60	102934.70	50196.20
Grapes:			
Drip Method	134506.20	247817.00	113310.80
Flood Method	147915.00	211037.90	63123.00
Gains over Flood Method (%):			
Banana	2.50	30.22	64.60
Grapes	9.10	17.43	79.50

Notes: * return over expenses spent from farmers' Pocket (Cost A2).
Source: Calculated from field survey data.

9. Capital and Production Cost:

DMI requires fixed capital for installing the drip system, the magnitude of which varies by crop. Wide-spaced crops require relatively low fixed capital but narrow spaced crops need higher fixed capital. Besides the crop type, the size of the fixed capital requirement is also sensitive to the quality of the materials used for the systems as well as the distance between the well and the field (NABARD, 1989). Let us now evaluate the empirical pattern of both the capital cost of the drip system and the production cost for our sample crops. The capital cost, subsidy, production cost (cost of cultivation) and gross value of production obtained for our sample are given in Table 7. Since both the crops are wide-spaced, there is only a marginal difference between the average capital cost of DMI for banana (Rs. 33,595/ha) and for grapes (Rs. 32,721/ha).

As noted earlier, since DMI is capital intensive in nature, both the Central and State Governments try to grant nearly 50 per cent of the capital cost as subsidy to encourage the adopting farmers in Maharashtra.[6] The average capital subsidy comes to Rs. 11,359/ha for banana and Rs. 12,620/ha for grapes. As a proportion of the total capital cost of drip set, subsidy accounts for nearly 34 per cent for banana and 39 per cent for grapes. With this subsidy, the fixed capital cost of drip set comes down to about Rs. 22,236/ha for banana and about Rs. 20,101/ha for grapes.

Table 7: Capital Cost, Subsidy and Production Cost for Drip Irrigated Crops

(Rs/ha)

Particulars	Banana (Jalgaon)	Grapes (Nashik)
Capital cost of drip set[a]		
i. Total cost of set	33595.00	32721.00
ii. Cost after deducting subsidy	22236.00	20101.00
Production cost (cost of cultivation)[b]	51437.00	134506.19
Gross value of production	134043.75	247817.02
Subsidy	11359.00	12620.00

Notes: a - It does not cover pumpset cost.
b - Production cost includes also the operation and maintenance cost of drip set and pumpset.
Source: Computed from field level data.

10. Benefit-Cost Analysis:

Drip irrigation system is an investment yielding returns over time and the cash flows can change over time. Therefore, the analysis requires assumptions not only about the pattern but on the volatility of cash flows. In order to assess the potential role that subsidy plays in the adoption of DMI, computations are done separately by including subsidy and by excluding subsidy in the total fixed capital cost of drip set. Financial viability analysis under different rates of discount will indicate the stability of investment at various levels of the opportunity cost of investment. Although the BCR is sensitive to discount rate and the degree of such sensitivity depends on the pattern of cash flows, it is interesting to observe the sensitivity of the BCR when there is simultaneous change in both subsidy and discount factor. Table 8 presents the results of such the sensitivity analysis computed under the assumption that there will not be any change in the cost of production and gross income during the entire life period of drip set. As

expected, the NPW of the investment with subsidy is marginally higher than that under 'no subsidy' option. For instance, at 15 per cent discount rate, the NPW of drip investment for banana is about Rs. 2,47,753/ha without subsidy but Rs. 2,57,635/ha with subsidy. This means that the subsidy enables farmers to get an additional benefit of Rs. 9,882/ha. It can also be noted that the difference between the NPW under the two scenarios is decreasing along with each increase in discount rate. The difference in NPW for the two scenarios which is Rs. 10,325 for banana and Rs. 11,471 for grapes at 10 per cent discount rate declines to Rs. 9,882 and Rs. 10,979 for banana and grapes respectively at 15 per cent discount rate. This differential behaviour of NPW across discount rates for the two crops is attributable to the observed differences in cash flows and cultivation practices and the assumed difference in drip set life span for the two crops. As seen from the Table 8, the BCR without subsidy that for banana is about 2.253 at 10 per cent discount rate slides down to 2.228 at 15 per cent discount rate. For grapes, in contrast, the BCR declines only marginally as the rate of discount increases. Although the same pattern of decline in BCR is observed across discount rates even under the alternative scenario of cash flows with subsidy, the BCR is higher with subsidy than otherwise. This suggests the positive role that subsidy plays in improving the economic viability of DMI for our sample crops irrespective of the time preference of the farmers.

Another policy wise important economic issue in the context of DMI adoption is the number of years needed to recover fully the capital costs involved in drip installation. Our computation of NPW for both banana and grapes clearly shows that farmers can recover the entire capital cost of the drip set from their net profit in the very first year itself. This finding contradicts the general belief that the capital cost recovery for drip investment takes more time. More importantly, when farmers can recover the capital costs within a year, the role of discount rate as a device to capture the time preference of farmer seems to be of considerably lesser importance than one might think. However, in order to have a more definite answers to the economic and social viability of DMI, we need a social rather than the private cost-benefit evaluation being attempted here. A comprehensive evaluation can be done by incorporating both the social benefits in the form of water saving, additional irrigation, lower soil degradation and

retention of soil fertility as well as the social costs in terms of the negative food and fodder in the crop pattern shift and labour displacement.

Table 8: Sensitivity Analysis of NPW and BCR Computed by Assuming no Change in the Cost of Production and Gross Income During the Life Period of the Drip Set.

Particulars	Scenario – I		Scenario – II	
	Banana	Grapes	Banana	Grapes
Present worth of Gross Income(Rs/ha)				
At 10 percent discount rate	508026	1522588	508026	1522588
At 12 percent discount rate	483228	1400166	483228	1400166
At 15 percent discount rate	449449	1243794	449449	1243794
Present worth of Gross Income(Rs/ha)				
At 10 percent discount rate	225484	856148	215159	844677
At 12 percent discount rate	215431	789179	205287	777909
At 15 percent discount rate	201696	703553	191814	692574
Net present worth (Rs/ha)				
At 10 percent discount rate	282542	666440	292867	677911
At 12 percent discount rate	267797	610987	277941	622257
At 15 percent discount rate	247753	540241	257635	551220
Benefit-cost ratio				
At 10 percent discount rate	2.253	1.778	2.361	1.802
At 12 percent discount rate	2.243	1.774	2.353	1.799
At 15 percent discount rate	2.228	1.767	2.343	1.795

Notes: Scenario-I is computed without considering capital subsidy for drip set.
Scenario-II is computed after deducting capital subsidy for drip set.
Source: Computed from field level data.

While the sensitiveness of both the BCR and NPW to discount rate and subsidy has already been shown, let us now show how these project criteria and hence, the viability analysis are influenced by differential temporal behaviour of cost (cash outflow) and income (cash inflow) streams. Of particular importance from the viewpoint of economic viability of DMI is the issue of what happens when cost stream in terms of cash outflow increases at a rate higher than the income stream. If the cash out-flows increase at a rate sufficient to exceed the rate of increase in the income stream, the investment may prove to be non-viable after a while. This means that the viability of DMI depends crucially on factors like farm cost escalation and inflation. To address the influence of input cost escalation on the economic viability of drip investment, we perform viability computation by assuming an annual cost escalation of 2 and 5 per cent. The results of the

sensitivity analysis for the two crops are presented in Tables 9 and 10 respectively.

Table 9: Sensitivity Analysis of NPW and BCR under Different Scenarios for Banana

Particulars	Scenario A-I[1]	Scenario A-II[2]	Scenario B-I[3]	Scenario B-II[4]
Present worth of Gross Income (Rs/ha)				
At 10 percent discount rate	508026	508026	508026	508026
At 12 percent discount rate	483228	483228	483228	483228
At 15 percent discount rate	449449	449449	449449	449449
Present Worth of Gross Cost (Rs/ha)				
At 10 percent discount rate	232678	217256	222353	233664
At 12 percent discount rate	222138	232679	211994	222536
At 15 percent discount rate	207749	243986	197867	207374
Net present worth (Rs/ha)				
At 10 percent discount rate	275348	264037	285673	274362
At 12 percent discount rate	261090	250549	271234	260692
At 15 percent discount rate	241700	232192	251582	242075
Benefit-cost ratio				
At 10 percent discount rate	2.183	2.082	2.285	2.174
At 12 percent discount rate	2.175	2.077	2.279	2.171
At 15 percent discount rate	2.163	2.069	2.271	2.167

Notes: 1. Scenario A-I is computed by assuming 2 per cent increase per annum in the cost of production and without considering subsidy amount of the capital cost of drip set.
2. Scenario A-II is computed by assuming 5 per cent increase per annum in the cost of production and without considering subsidy amount of the capital cost of drip set.
3. Scenario B-I is computed by assuming 2 per cent increase per annum in the cost of production and after deducting subsidy amount from the capital cost of drip set.
4. Scenario B-II is computed by assuming 5 per cent increase per annum in the cost of production and after deducting subsidy amount in the capital cost of drip set.

Source: Computed from field level data.

The lowest BCR observed for grapes is 1.47 with discount rate at 10 per cent and cost escalation at 5 per cent. In the case of grapes although the BCR declines with the rate of discount, the change is not perceptible. Over all, the sensitivity analysis under various contexts indicates that drip investment remains economically viable even without subsidy. Even though subsidy is not needed to enhance the economic viability of the drip system, it is still needed to enhance the incentive for the widespread adoption of DMI particularly among smaller farmers. From the policy point of view this result suggests that subsidy can be phased out

eventually once the new irrigation technology covered an area adequate enough to expand subsequently through the demonstration effect.

Table 10: Sensitivity Analysis of NPW and BCR under Different Scenarios for Grapes.

Particulars	Scenario A-I[1]	Scenario A-II[2]	Scenario B-I[3]	Scenario B-II[4]
Present Worth of Gross Income (Rs/ha)				
At 10 percent discount rate	1522588	1522588	1522588	1522588
At 12 percent discount rate	1400166	1400166	1400166	1400166
At 15 percent discount rate	1243794	1243794	1243794	1243794
Present Worth of Gross Cost (Rs/ha)				
At 10 percent discount rate	920819	1030391	909348	1018990
At 12 percent discount rate	846330	942929	835060	931659
At 15 percent discount rate	751389	831958	740410	820978
Net present worth (Rs/ha)				
At 10 percent discount rate	601768	492197	613240	503668
At 12 percent discount rate	553836	457237	565106	468507
At 15 percent discount rate	492405	411836	503384	422815
Benefit-cost ratio				
At 10 percent discount rate	1.654	1.477	1.674	1.494
At 12 percent discount rate	1.654	1.484	1.676	1.502
At 15 percent discount rate	1.655	1.495	1.679	1.515

Notes: 1. Scenario A-I is computed by assuming 2 per cent increase per annum in the cost of production and without considering subsidy amount of the capital cost of drip set.
2. Scenario A-II is computed by assuming 5 per cent increase per annum in the cost of production and without considering subsidy amount of the capital cost of drip set.
3. Scenario B-I is computed by assuming 2 per cent increase per annum in the cost of production and after deducting subsidy amount from the capital cost of drip set.
4. Scenario B-II is computed by assuming 5 per cent increase per annum in the cost of production and after deducting subsidy amount in the capital cost of drip set.

Source: Computed from field level data.

10. Major Findings and Policy Recommendations:

The field level results reported in this study confirm that DMI not only contributes to water conservation and additional irrigation benefits but also reduces cultivation cost and increases the crop productivity as compared to conventional irrigation methods. The NPW calculation shows that in the case of banana and grapes cultivation, farmers can recover the fixed investment cost on

drip irrigation system at the end of the first year itself even in the absence of government subsidy. The major findings of the study are presented below:

- In both banana and grapes, per hectare cost of cultivation is much less for the crops cultivated under drip method irrigation. The cost saving is about Rs. 1300/ ha for banana and about Rs. 13400/ha for grapes as compared to the same crop which is cultivated under flood method of irrigation. Cost saving is found to be relatively more in irrigation, weeding, ploughing and fertilisers.
- Productivity of banana is about 29 percent (153 quintals) higher in the case of drip adopters than the non-drip adopters, while the same is about 19 percent (38 quintals) in grapes. Cost incurred to produce (cost efficiency) one quintal of output is also significantly less in the case of drip irrigated crops.
- Water saving due to drip method of irrigation is found to be very significant in both banana and grapes. Water saving is estimated to be 29 percent in banana and about 37 percent in grapes. It is estimated that, from the saving of water, an additional amount of 0.60 ha (1.48 acre) in grapes and about 0.41 ha (1.01 acre) in banana can be brought under irrigation for every hectare of drip method of irrigation. Water consumed to produce one quintal of yield (water use efficiency) is also substantially lower for those crops cultivated under drip method as compared to flood method.
- Electricity saving due to drip method of irrigation is estimated to be about 2430 kwh/ha for banana and 1470 kwh/ha for grapes. Electricity required to produce one quintal of yield is also found to be very low for the drip irrigated crops.
- Profit (farm business income) of drip irrigated crops is significantly higher than that of flood irrigated crops. In grapes, profit of the drip adopters is about Rs. 50100/ha more than the profit of the non-drip adopters. Similarly, for banana, profit of the drip adopters is about Rs. 32400/ha more than the profit of the non-drip adopters. The huge profit of drip irrigation is not because of price effect but only due to yield effect.

- The economic viability of the drip system computed using discounted cash flow technique suggests that drip method of irrigation is economically viable even for farmers with just one hectare of land. The benefit-cost ratio computed with different discount rates stands between 2.07 and 2.36 for banana and between 1.48 and 1.80 for grapes.

Though DMI has many economic and resource related advantages over FMI, its growth in terms of area is not appreciable barring a few states. The results from our field-based study reveals that the slow growth of DMI is not only due to economic reasons but mainly due to the lack of awareness among the farmers about the real economic and resource-related advantages of the new irrigation technology. This means that apart from provision of capital subsidy there is also an urgent need for an awareness campaign through an effective extension network including field level demonstration in targeted areas. Besides, every state government needs to formulate a target oriented programme including incentive packages as being followed in Maharashtra to increase the area under DMI. While subsidy has an important role in the immediate stage, the long-term strategy involves the creation of an effective extension network and service centres for drip irrigation technology. The specific policy recommendations are presented below:

- Majority of the farmers in our study have expressed that initial investment required to install drip irrigation is very high. Because of this reason, most of the farmers are reluctant to adopt drip method of irrigation for crops which give less remuneration. If it is made available in less cost, area under drip irrigation can be increased at a faster rate. Hence, measures can primarily be taken to reduce the fixed cost of drip irrigation by providing tax concession to drip manufacturers and also by promoting research and development activities.
- Because of non-availability of subsidy through government schemes, majority of the non-drip adopters are forced to adopt flood method of irrigation for crop cultivation. It is understood that this is because of the

inadequate allotment of fund for each district. Government can make way for providing subsidy to all farmers who are ready to adopt drip irrigation by increasing the total amount of subsidy allotment. Allocation to different districts should be revised by taking in to account the progress of the schemes.

- Presently central scheme does not provide subsidy for sugarcane crop. Since it is an important and also a more water consuming crop in Maharashtra, this restriction should be removed to increase the drip irrigated area at a faster rate.
- Currently rate of subsidy is fixed uniformly for both water intensive and less water intensive crops. This needs to be restructured and special subsidy programme may be introduced for water intensive crops like sugarcane, banana, vegetables, etc. Differential subsidy rates can be fixed based on the types of crops and the rates of consumption of water. In any case, higher subsidy should be provided to those areas where the over-exploitation of water is higher.
- Despite significant growth of drip method of irrigation in Maharashtra, farmers still have inadequate knowledge regarding the usefulness of drip irrigation technology. Even the adopters do not know how much of subsidy is exactly available per hectare for different crops. Owing to poor exposure, farmers are reluctant to invest such huge money on drip irrigation. In fact, many farmers do not believe the fact that drip irrigation can also be used efficiently and economically for narrow spaced crops like sugarcane, cotton, vegetables, etc. These problems can be removed by giving wide publicity and by strengthening the existing extension services.
- For speedy growth of drip irrigation, priority can be given in providing bank loan for digging wells and electricity connection for those farmers who accept to adopt drip irrigation for crop cultivation.
- Last but not least, as the drip irrigation technology is still in the early stage of adoption, drip set manufacturing companies should be asked to involve intensively in promoting drip irrigation by introducing frequent demonstration at farmers field wherever possible.

Notes:

1. Irrigation water demand, accounting a three-fourth share in total water demand, is projected to increase from 470 cubic kilo metre (ckm) in 1985 to 740 ckm by 2025 AD. Such a faster growth of water demand in the face of emerging supply constraints is likely to result in a supply gap for irrigation water in the near future. In the meantime, the non-irrigation water demand is projected to grow from 70 ckm in 1985 to 280 ckm by 2025 AD, indicating a four fold increase. This will additionally put pressure on water resources (see Vaidyanathan 1994; Saleth, 1996).

2. Estimates show that the total water loss in conveyance is as high as about 70 per cent - about 15 per cent in canals, seven per cent in distributaries, 22 per cent in water courses and 27 per cent in farm fields (Chaudhary, 1995).

3. The capital cost of drip system varies depending upon the nature of crops, terrain condition and the distance of water source. As per the estimate of National Committee on the Use of Plastics in Agriculture (NCPA), the capital cost of drip set varies from Rs.30000 to 33000/ha for crops like sugarcane and vegetables and from Rs.11000 to 19000/ha for wide spaced crops like coconut, orange, mango and pomegranate (INCID, 1994).

4. In 1997-98, India's total drip irrigated area was 2,46,006 ha of which, Maharashtra state alone accounted for 1,22,995 ha. This is about 50 per cent of the national total area under DMI.

5. For more details in this regard, see Narayanamoorthy (1996).

6. In the new guidelines effective from May 14, 1992, the subsidy that remains invariant across land holding size is limited to either 50 per cent of the actual capital cost or Rs. 15000/ha whichever is lower. Unlike other schemes, here, there is no direct link between subsidy and bank loan. Subsidy is sanctioned on the basis of the recommendation and verification by the agricultural officials.

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