# Impact Assessment of Drip Irrigation in Maharashtra: A Case of Sugarcane

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



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# Preface

In view of the fast decline of available water potential and growing needs for irrigation water, various measures have been introduced to increase the efficiency of water use under flood method of irrigation. However, these measures could not bring any substantial improvement in the existing water use efficiency. Drip method of irrigation introduced somewhat recently in Indian agriculture proved to be an effective method in increasing the efficiency of water use. Drip method of irrigation supplies water directly at the root zone of the crops through a network of pipes and therefore, it substantially reduces the evaporation and distribution losses of water. Besides water saving, drip method of irrigation also significantly increases productivity of crops and that too with reduced cost of cultivation. Despite enormous advantages from drip method of irrigation, detailed studies using field level data are not available in the context of sugarcane, which is an important water-intensive crop. In this study, an attempt is made to examine the impact of drip method of irrigation on sugarcane cultivation using field level data collected from two districts in Maharashtra.

This report forms part of a larger study entitled *"Impact of Drip Irrigation on Sugarcane Cultivation 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 September 2001. 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.

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# Impact Assessment of Drip Irrigation in Maharashtra: A Case of Sugarcane

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Abstract

Considering the fast decline of irrigation water potential and low water use efficiency under flood (conventional) method of irrigation, one of the methods introduced recently in Indian agriculture to increase the water use efficiency is drip method of irrigation. Besides saving substantial amount of water, it also helps to increase the productivity of crops that too with reduced cost of cultivation. Though sugarcane is highly suitable for drip method of irrigation, detailed studies using field level data are not available in the context of sugarcane, which is a water-intensive crop. In this study, therefore, an attempt is made to evaluate the impact of drip method of irrigation on different parameters of sugarcane crop using farm level data collected from Maharashtra. Discounted cash flow technique is used to study the economic viability of drip investment in sugarcane cultivation. It is found that productivity of sugarcane cultivated under drip method of irrigation is 23 percent higher than that of cultivated under flood method of irrigation. While water saving is about 44 percent per hectare due to drip method of irrigation, electricity saving was estimated to be about 1059 kwh/ha. Benefit cost ratios with different discount rates indicate that drip investment in sugarcane cultivation remains economically viable even without subsidy. The study suggests that reduction in capital cost required for drip set, restructuring subsidy programmes and effective (quality) extension network are essential for promoting the cultivation of sugarcane under drip method of irrigation.

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# Impact Assessment of Drip Irrigation in Maharashtra: A Case of Sugarcane

## 1. Introduction:

Irrigation significantly helps to increase the use of yield enhancing inputs, cropping intensity and productivity of crops. It also greatly influences the quality of life parameters namely improving health and educational status as well as reducing poverty in a sustained manner (Mollinga, 2000; Narayanamoorthy, 2001; Shah, 1998). However, owing to various reasons, not only the available water for irrigation purpose has been declining rapidly but also the demand for irrigation water has been growing at a faster rate in India (CWC, 1996; Saleth, 1996). In such a condition of scarcity, efficient use of irrigation water is an important means to increase the benefits of irrigation. It is understood that the flood method of irrigation widely practiced in Indian agriculture directly leads to inefficient use of water owing to enormous losses in evaporation and distribution (INCID, 1994; Rosegrant, 1997). Since efficient use of irrigation water is paramount for sustainable agricultural development, different measures have been introduced to conserve water as well as to improve the efficiency in the use of irrigation water. However, the measures introduced for increasing the water use efficiency under flood method of irrigation have not brought expected changes so far.

One of the methods introduced recently in India to increase the water use efficiency in irrigation is the drip method of irrigation (DMI). In this method, water is supplied constantly or at regular interval at the root zone of the crops through a network of pipes with the help of emitters. Primarily, it was used for cultivating vegetables in Israel and thus Israel could achieve higher productivity despite of severe water shortages. Unlike flood method of irrigation (FMI), since water is supplied straight to the crop root zone, the efficiency of water use is extremely high in DMI as it substantially reduces the evaporation, conveyance and distribution losses of water (Narayanamoorthy,

1996a; 1997b, Sivanappan, 1994). Available results in this regard show that the on-farm irrigation efficiency of properly designed and managed drip irrigation system is about 90 percent whereas it is about 70 percent for sprinklers but just about 40 percent for surface irrigation method (Sivanappan, 1994; INCID, 1994). Results of research stations located in various parts of India do indicate that DMI increases crop yield significantly and that too with reduced cost of cultivation when compared to FMI. Besides water saving and productivity gains, DMI is also well suited for undulating terrain, shallow soils, etc., (Sivanappan, 1994).

Similar to the results of experimental research stations, some of the field level studies have also established that DMI reduces the cost of cultivation and significantly increases water use efficiency as well as productivity of crops like banana and grapes (Narayanamoorthy, 1996a; 1997b). Despite enormous advantages from DMI, detailed studies using field level data are not available in the context of sugarcane, which is an important water-intensive crop. Most of the available studies in this respect have been carried out using the data supplied by the experimental research stations. Through the analysis of experimental data, studies have found a substantial water saving and productivity gains due to drip method of irrigation in sugarcane cultivation (Batta and Singh, 1998; Dash, 1998; Deshmukh, *et al.*, 1998; Dhonde and Banger, 1998; Hapase, *et al.,* 1992; Parikh *et al.*, 1993; Sankpal, *et al.,* 1998). Single cane weight, cane girth, cane length, number of inter-nodes, leaf length and leaf breadth were also found to be higher with sugarcane cultivated under drip method of irrigation when compared to that cultivated under flood method of irrigation (Venugopal and Rajkumar, 1998). Because of less moisture stress under DMI, the recovery rate of sugarcane cultivated under DMI was found to be higher when compared to the crop cultivated using FMI (Sankpal, *et al.,* 1998; Dhonde and Banger, 1998; Banger, 1998). Importantly, a study carried out on heavy soils and sub-humid climatic conditions of South Gujarat region suggests that a large scale adoption of drip method of irrigation in sugarcane in South Gujarat area can

help to solve the problem of water logging and secondary salinization which are increasing in this region (Parikh, *et al.*, 1993).

It is clear from the above that the adoption of drip method of irrigation in sugarcane cultivation not only increases water saving and productivity of sugarcane but also reduces the cost of cultivation and weed problems. Significantly, DMI also helps to increase the germination of seed (cane) and the recovery rate of sugarcane. Though drip method of irrigation is proved to be an effective technology for sugarcane crop, the results of research station based studies may not completely reflect the farm level problems associated with drip method of irrigation. Therefore, in this study, an attempt is made to assess the impact of drip method of irrigation on different parameters of sugarcane cultivation using field level data collected from Maharashtra, a western state of India. The main objectives of the study are:

1. To analyse the impact of drip irrigation technology on production and productivity of sugarcane by comparing non-drip irrigated sugarcane.

2. To analyse the water use pattern and water use efficiency under drip and non-drip irrigated sugarcane.

3. To estimate electricity saving due to drip method of irrigation in sugarcane cultivation.

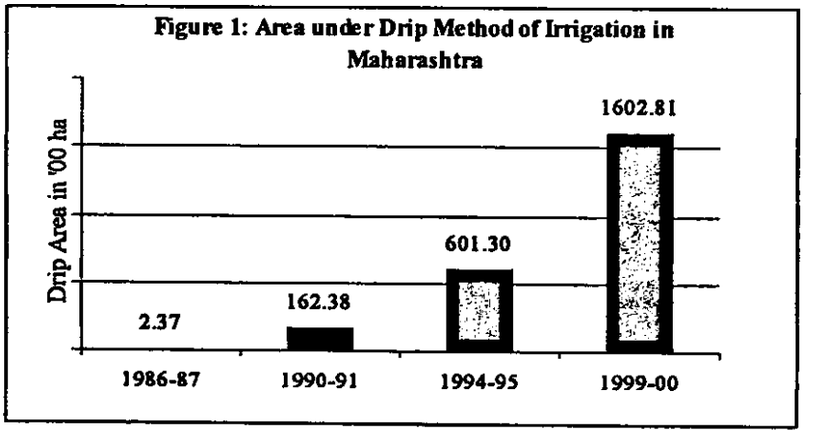
4. To analyse the economic viability of drip investment in sugarcane cultivation.

**2. Study Area and Methodology:**

Maharashtra state has been selected purposively for this study due to various reasons. First, Maharashtra state is one of the water scarce states in India. Area under irrigation in the state is about 17 percent of the gross cropped area, which is quite low compared to many states and to the national level average of about 37 percent in 1997-98. Despite severe water scarcity, sugarcane (an important water-intensive crop) has been extensively cultivated using surface (flood) method of irrigation in the state.[1] Studies have confirmed that sugarcane not only consumes bulk of the available water but the returns per unit of water is also very low (Rath and Mitra, 1989). Given the limited availability of irrigation water, over exploitation phenomenon

and lower percentage of irrigated area, there is an urgent need to increase the efficiency in the existing use of irrigation water in the state. State government is also keen on promoting drip irrigation by providing subsidy to the farmers. Due to concerted efforts taken by the government agencies along with some drip set manufacturers, the area under drip irrigation increased from 236 ha in 1986-87 to 160281 ha in 1999-2000 (see, Figure 1). The state also has a distinction in accounting for the highest area under drip method of irrigation in India. For instance, at the end of 1997-98, India's total drip irrigated area created through various state sponsored schemes was 246006 hectares (AFC, 1998). Of this total, Maharashtra state alone accounted for 122995 hectares, which is nearly 50 per cent of the total area. Drip irrigation method has also already made significant advantages especially in water use efficiency and productivity in crops like banana and grapes in the state (Narayanamoorthy, 1997a; 1997b; 1997c). The situation of water balance in the state requires an efficient use of water by optimising the returns per unit of water. Therefore, from the point of view of water scarcity and efficiency angle of water use, Maharashtra becomes the most obvious choice to empirically evaluate the impact of drip irrigation on sugarcane cultivation.

**Figure 1: Area under Drip Method of Irrigation in Maharashtra**




The adoption of drip irrigation technology is not uniform across the districts of Maharashtra. Therefore, two important districts from the state where drip irrigation is being extensively used for cultivating sugarcane have been selected with the help of secondary data collected from Drip Irrigation

Cell, Commissionerate of Agriculture, Government of Maharashtra, Pune. District-wise data on drip irrigated area pertaining to the year 1998-99 was used for selecting two important districts. The two selected districts as per this method are Pune and Ahmednagar. In 1998-99, Pune (23.30 percent) and Ahmednagar (19.43 percent) together have accounted for 42.73 percent of total area under drip irrigated sugarcane in Maharashtra. Similar to the method followed for selecting the districts, two important blocks, one from each district, where area under drip irrigated sugarcane is higher, have been selected using the information supplied by the Agricultural Officer of the respective district. The two blocks selected in this method are Baramati from Pune district and Shrirampur from Ahmednagar district.

From each district, 50 farmers consisting of 25 drip adopters and 25 non-drip adopters have been selected. Thus, a total of 100 sample farmers, 50 drip adopters and 50 non-drip adopters have been selected from the two selected districts to conduct detailed field survey. In Maharashtra, farmers who own well (groundwater) are only using drip method of irrigation. Therefore, only the farmers who cultivate sugarcane using groundwater source of irrigation under both drip and flood irrigated condition are considered for this study. This is followed specifically to avoid the differential impact of source of irrigation on productivity of sugarcane. Since the state has a structured scheme for promoting drip irrigation, the list of names of drip adopters related to the year 1998-99 have been used for selecting the drip adopters. While the drip adopters have been selected on the basis of random sampling method, the farmers who cultivate sugarcane using flood method of irrigation (groundwater as source) nearest to the field of drip adopters have been selected purposively as non-drip adopters. This is followed specifically to reduce the differences in soil quality and other agro-economic factors between the two categories of farmers. The field level information from the sample farmers has been collected pertaining to the year 1998-99. To assess the economic impact of drip irrigation in sugarcane cultivation, comparison has been made between drip and non-drip farmers in each aspect. In order to understand the economic viability of drip investment in sugarcane

cultivation, the Net Present Worth (NPW) and the Benefit-Cost Ratio (BCR) have been computed using discounted cash flow technique.

**3. Cost of Cultivation:**

As mentioned earlier, although the importance of drip method of irrigation in increasing the yield of sugarcane and water saving has been proved by some research studies based on data from research stations, wider analysis using field level data with regard to sugarcane has not been noted. Since sugarcane is a water-intensive crop, it is useful to understand the impact of drip method of irrigation on cost of cultivation and productivity of sugarcane, using field survey data, in order to arrive at policy conclusions. Land holding size of the farmers and source of irrigation that they use for cultivation determine the adoption of DMI to a considerable extent, besides capital availability. Therefore, it is better to understand these before going to analyse the cost of cultivation and other details of DMI.

Since drip method of irrigation is capital intensive technology, size of land holding of the adopters group is generally expected to be higher than that of the non-adopters group (Narayanamoorthy, 1997b; Shrestha and Gopalakrishnan, 1993). However, the average (of two districts) land size is only marginally higher for the adopters group (2.89 ha) when compared to the non-adopters group (2.72 ha). Similar to the average land holding size, the average size of net sown area, area cultivated more than once and gross cropped area of the adopters group are also marginally higher than the non-adopters group. Like land, source of irrigation is also an important factor for adopting drip method of irrigation. The existing technology of drip is proved to be most suitable for ground water source of irrigation. In both the districts and in both the group of farmers, the main source of irrigation is groundwater, which accounts for 85-88 percent in the net irrigated area. Canal irrigation occupies nearly 14 per cent of the irrigated area in the adopters group, while the same accounts for about 11 percent in the non-adopters group. Rain-fed area is very less among both the groups of sample farmers in both districts.

As regards the cost of cultivation, studies carried out using field level data in crops like banana and grapes have already confirmed that DMI reduces the cost of cultivation, especially in labour intensive operations like weeding, irrigation, ploughing, etc. (Narayanamoorthy 1996a; 1997c; Narayanamoorthy and Deshpande, 1997). When labour cost reduces, total cost of cultivation also reduces because labour cost constitutes a considerable portion in the total cost of cultivation. Table 1 shows the operation-wise cost of cultivation of sugarcane per hectare for both the adopters and the non-adopters. First let us see the cost of cultivation of Pune district. It is clear from the table that drip irrigation reduces the total cost of cultivation by about Rs.5843/ha (nearly 12 percent) for the adopters as compared with the non-adopters of Pune district. Though the total cost saving in terms of percentage is not very high in aggregate, it varies across different operations. Among the different operations, cost saving is very high in seed and seed sowing (nearly 20 per cent). Second highest saving under cost of cultivation is found in fertilisers (about 13 percent). This is because of the reason that some of the adopters have used liquid fertilisers and thus, the cost incurred on fertilisers is relatively less. A few earlier studies have reported that drip irrigation also reduces the cost of fertilisers enormously as it can be supplied along with water – liquid fertilisers.[2] Some of the farmers have argued that even without using liquid form of fertilisers, it can be reduced by avoiding wastage under drip method of irrigation. Third highest saving is found in irrigation cost (about 12 percent).[3] Since water is supplied through pipe network under drip method of irrigation, it does not require more labour. But, 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. In addition to saving in cost of labour, cost incurred on electricity for operating pump-set is also less as drip requires less amount of water as compared to flood method. Fourth highest saving under cost of cultivation is

Table 1: Cost of Cultivation of Sugarcane for the Adopters and the Non-Adopters of Drip Irrigation.

(Rs/ha)

| Operations | Pune District | | | Ahmednagar District | | | Two Districts Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | DMI | FMI | % change over FMI | DMI | FMI | % change over FMI | DMI | FMI | % change over FMI |
| 1. Ploughing and Preparation | 3630.40 (718.99) | 4068.60 (570.24) | -10.77 | 3139.80 (539.76) | 4106.20 (671.23) | -23.53 | 3385.10 (676.24) | 4087.40 (616.69) | -17.18 |
| 2. Furrows and Bunding | 1588.00 (496.08) | 1721.60 (206.90) | -7.76 | 1278.20 (424.07) | 1952.00 (790.76) | -34.51 | 1433.10 (482.81) | 1836.80 (583.76) | -21.98 |
| 3. Seed and Seed Sowing | 6871.00 (1957.79) | 8501.60 (927.05) | -19.17 | 7439.00 (1820.49) | 8530.00 (1269.10) | -12.79 | 7155.00 (1892.86) | 8515.80 (1100.01) | -15.98 |
| 4. Fertilizers (in-organic) | 9586.60 (2269.20) | 11042.40 (1701.56) | -13.18 | 9205.80 (1956.78) | 9463.00 (2947.89) | -2.71 | 9396.20 (2105.83) | 10252.70 (2512.13) | -8.35 |
| 5. Farm Yard Manure | 7817.00 (2439.80) | 8263.00 (1883.33) | -5.39 | 6062.00 (2210.15) | 6605.00 (2615.18) | -8.22 | 6939.50 (2468.57) | 7434.00 (2405.90) | -6.65 |
| 6. Pesticides | 1241.20 (520.95) | 1042.00 (243.79) | 19.11 | 740.40 (203.41) | 903.00 (403.97) | -18.00 | 990.80 (466.02) | 972.50 (337.60) | 1.88 |
| 7. Weeding and Interculture | 4869.20 (1030.25) | 4934.80 (1237.08) | -1.32 | 4297.00 (761.59) | 5482.00 (740.62) | -21.61 | 4583.10 (942.07) | 5208.40 (1046.24) | -12.00 |
| 8. Irrigation[a] | 5948.00 (1326.53) | 6822.00 (2179.41) | -12.81 | 5404.80 (1252.18) | 7568.00 (1278.58) | -28.58 | 5676.40 (1305.81) | 7195.00 (1808.07) | -21.11 |
| 9. Others | 2178.00 (743.59) | 3176.56 (1145.94) | -31.43 | 2690.00 (977.99) | 2898.00 (925.39) | -7.17 | 2434.00 (897.87) | 3037.28 (1040.39) | -19.86 |
| 10. Total Cost of Cultivation[b] | 43729.40 (7729.43) | 49572.56 (4357.57) | -11.78 | 40257.00 (3454.87) | 47507.20 (7229.26) | -15.26 | 41993.20 (6179.37) | 48539.88 (5998.87) | -13.49 |

Notes: a - Includes operation and maintenance costs of pump set and drip set; b - Costs of harvesting, transport and marketing are not included here since sugar factories have incurred these costs.

Figures in brackets are standard deviation.

Source: Calculated from field survey data.

noticed in ploughing and preparatory operation (about 10 per cent). 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 crops. Though earlier studies have indicated that the cost saving is very high in weeding operation, data related to Pune district did not support this. It should however be noted that the cost of cultivation varies with situational factors like soil quality, condition of the terrain, farmers' approach, etc.

Cost saving due to drip method of irrigation is relatively higher in Ahmednagar district (Rs. 7250/ha) when compared to Pune district (Rs.5843/ha). This is also true across different operations like irrigation, weeding and inter-culture, pesticides, furrows and bunding, and ploughing and preparatory operation. Of this, except furrows and bunding operation, cost saving in other operations is mainly due to the adoption of drip method of irrigation. As indicated earlier, since water is supplied through pipe network under DMI, it reduces both labour and electricity cost required for irrigation. Cost saving in weeding operation is high because it does not allow weed to come up in the non-crop space by not supplying water beyond the root zone of the crop. As the requirement of ploughing for cultivating crop under drip method of irrigation is relatively less, cost saving is found over 23 percent in ploughing and preparatory operation. On the whole, cost saving due to drip method of irrigation is nearly 14 percent. Major difference in cost of cultivation between the adopters and the non-adopters is observed in irrigation, weeding and inter-culture, ploughing and preparation, and seed and sowing.

**4. Productivity Differences:**

Productivity of a crop is directly related with the amount of use of yield increasing inputs besides source of irrigation. Productivity of canal irrigated crops is higher than the tank irrigated crops. Similarly, productivity of crops, which are cultivated using groundwater irrigation, is much higher than canal and tank irrigated crops (Dhawan, 1988; Vaidyanathan, *et al.*, 1994). Most of the time yield is affected because of moisture stress faced by crops. It is difficult to maintain the water supply constantly for crops by surface method

of irrigation due to various reasons. Studies related to drip method irrigation have confirmed that problem of moisture stress is completely reduced by providing irrigation through drip as it supplies water at the root zone of the crops at a required frequency and quantity. As a result, the yield of crops cultivated under drip method of irrigation is much higher than the crops which are cultivated under the method of surface irrigation.

Table 2: Productivity of Sugarcane under Drip and Flood Irrigated Condition.

(tonnes/ha)

| Method of Irrigation | Pune District | Ahmednagar District | Two Districts Average |
|---|---|---|---|
| Drip Method | 141.32 (22.17) | 135.40 (17.33) | 138.36 (19.92) |
| Flood Method | 116.80 (12.90) | 108.08 (10.48) | 112.44 (12.44) |
| *Yield Increase over FMI* | | | |
| (i) Percentage | 20.99 | 25.27 | 23.05 |
| (ii) Quantity | 24.52 | 27.32 | 25.92 |

Note: Figures in brackets are standard deviation.
Source: Field survey data.

As expected, productivity is significantly higher for the farmers who adopt drip method irrigation as compared to the non-drip adopters in both the districts selected for survey (Table 2). The yield difference in absolute term between the adopters and the non-adopters of drip method of irrigation comes to about 24 tonnes per hectare for Pune district and about 27 tonnes per hectare for Ahmednagar district. In terms of percentage, productivity of sugarcane cultivated under drip method of irrigation is higher by 20 and 25 percent respectively for Pune and Ahmednagar district. The important point to be mentioned here is that despite incurring more cost on yield increasing inputs, productivity of sugarcane cultivated under FMI is significantly lower than that of DMI. There are mainly three reasons for higher yield in drip irrigated sugarcane. First, because of less moisture stress, the growth of sugarcane was good which ultimately helped to increase the productivity. Second, unlike surface method of irrigation, drip does not encourage any growth of weed, especially in the non-crop zone. Weeds consume considerable amount of yield increasing inputs and reduce the yield of crops

in surface method of irrigation.[4] Third, unlike surface method of irrigation, fertiliser losses occurring through evaporation and leaching through water are less under drip method of irrigation as it supplies water only for crop and not for the land. Though the expenditure incurred by the non-adopters on different yield increasing inputs is more than the adopters in both the districts, this does not coincide with increased yield of sugarcane. Hence, it can be concluded that this yield increase is because of drip method of irrigation.

Table 3: Expenditure Incurred to Produce one tonne of Sugarcane under Drip and Non-Drip Irrigated Condition.

| Particulars | Pune District | | Ahmednagar District | | Two Districts Avg. | |
|---|---|---|---|---|---|---|
| | DMI | FMI | DMI | FMI | DMI | FMI |
| 1. Yield (tonnes/ha) | 141.32 (22.17) | 116.80 (12.90) | 135.40 (17.33) | 108.08 (10.48) | 138.36 (19.92) | 112.44 (12.44) |
| 2. Cost of Cultivation (Rs/ha) | 43729.40 (7729.43) | 49572.60 (4357.57) | 40257.20 (3454.87) | 47507.20 (7229.26) | 41993.20 (6179.37) | 48539.88 (5998.87) |
| 3. Per tonne Cost (Rs/ha) | 309.44 | 424.43 | 297.32 | 439.56 | 303.51 | 431.70 |

Note: Figures in brackets are standard deviation.
Source: Field survey data.

Besides increasing productivity of crops, DMI also increases the efficiency of cost. In order to understand the cost efficiency of drip and non-drip irrigated sugarcane, we have calculated expenditure incurred to produce one tonne of sugarcane for both the adopters and the non-adopters for both districts. Per tonne cost is calculated by dividing the total cost of cultivation with per hectare yield of sugarcane. It is evident from the Table 3 that the non-adopters spend about Rs.115 over the adopters to produce every tonne of sugarcane in Pune district. Likewise, in Ahmednagar district, non-adopters spend about Rs.139 per tonne over the adopters. This indicates that not only the productivity of drip irrigated sugarcane is higher but cost efficiency is also very high in drip irrigated sugarcane than the flood irrigated sugarcane.

**5. Water Consumption and Saving:**

Water consumption per hectare for any crop is determined by factors like horse power of the pumpset, water level of the well, capacity of the

pump, size of delivery pipes, condition of the water extraction machineries (WEMs), distance between place of water source and field to be irrigated, quality of soil, terrain condition, etc. These factors vary considerably across farmers. Pumpsets with higher horse power lift more water per unit of land compared to the pumpset which has lower horse power. Most of the studies based on research station data[5] have measured water consumption in terms of centimeter (CM) in drip irrigation. But, in practice, measuring water in terms of CM is not an easy task at field level as horse power (HP) of the pumpsets and water level of the well changes considerably across the farmers. Because of these difficulties, we have measured water consumption in terms of horse power (HP) hours of irrigation. HP hours of water is computed by multiplying HP of the pump-set with hours of water used.

Table 4: Water Consumption by Drip and Non-Drip Irrigated Sugarcane.

| District | Water Consumption (HP hour/ha) | | Water Saving over FMI | |
|---|---|---|---|---|
| | DMI | FMI | In Percent | In quantity |
| Pune District | 1740.08 | 2934.08 | 40.69 | 1194.00 |
| Ahmednagar District | 1793.92 | 3425.88 | 47.63 | 1631.96 |
| Two Districts Average | 1767.00 | 3179.98 | 44.43 | 1412.98 |

Note: Additional irrigated area estimated from water saving is 0.69 ha for Pune district; 0.91 ha for Ahmednagar district and the average of two districts is 0.80 ha.
Source: Estimated using field survey data.

It is evident from the Table 4 that the consumption of water by sugarcane under drip method of irrigation is significantly less than flood method irrigation (FMI). While water saving together for two districts comes to about 44 percent, it is about 40 percent for Pune district and about 47 percent for Ahmednagar district. Among the two districts, water saving in terms of HP hours is much higher for Ahmednagar district when compared to Pune district. For instance, for Pune district, drip saves about 2934 HP hours of water per hectare, while it is about 3425 HP hours for Ahmednagar. Since water scarcity is more severe in Ahmednagar district, the adopters are forced to use less amount of water. Though there are differences in water saving

between the two districts, our results clearly show that drip technology helps saving more water in water intensive crops like sugarcane.

From the saving of water, it is possible to increase the area under irrigation. To understand this, we have estimated how much of additional area can be brought under irrigation by saving water under sugarcane. Our estimates show that with saving of water (from one hectare), an additional area of about 0.80 ha (0.69 ha in Pune district and 0.91 ha in Ahmednagar district) can be brought under irrigation by adopting drip method of irrigation in sugarcane in Maharashtra.[6] This reinforces the fact that DMI also helps to bring additional area under irrigation through saving of water besides increasing productivity of crops significantly.

The consumption of water per unit of area is a good indicator to measure the efficiency of water use in drip and non-drip crops, but water consumed to produce one tonne of sugarcane is the most appropriate method to judge the efficiency of water consumption in DMI and FMI. This is also the simplest way to understand the importance of drip irrigation in increasing the efficiency of water use. Studies have proved that water use efficiency is higher in drip irrigated crops but most of them are based on research station data (see, INCID, 1994). In order to arrive at per tonne water requirement, we have divided per hectare consumption of water with the per hectare yield of sugarcane. As mentioned by earlier studies, the results of our analysis also show that water use efficiency (WUE) is substantially higher for drip irrigated sugarcane as compared to flood method of irrigation (see, Table 5). The analysis shows that sugarcane cultivated under drip method of irrigation consumes only 12.77 HP hours of water to produce one tonne of sugarcane when compared to 28.28 HP hours of water for producing for same quantity of sugarcane output under non-drip irrigated condition. That is, to produce one tonne of sugarcane under non-drip condition about 15.50 HP hours of additional water is consumed. This trend is true in both the districts selected for survey. The fact which comes out clearly from here is that DMI not only reduces the per hectare consumption of water but also reduces the water

required to produce one tonne of sugarcane substantially when compared to flood method of irrigation.

Table 5: Water Use Efficiency of Drip and Non-Drip Irrigated Sugarcane.

| District | Yield (tonnes/ha) | | Water Consumption (HP hours/ha) | | Water Use Efficiency (HP hours/tonne) | |
|---|---|---|---|---|---|---|
| | DMI | FMI | DMI | FMI | DMI | FMI |
| Pune District | 141.32 | 116.80 | 1740.08 | 2934.08 | 12.31 | 25.12 |
| Ahmednagar District | 135.40 | 108.08 | 1793.92 | 3425.88 | 13.25 | 31.70 |
| Two Districts Avg. | 138.36 | 112.44 | 1767.00 | 3179.98 | 12.77 | 28.28 |

*Source: Calculated from field survey data.*

**6. Electricity Saving:**

It is a well-known fact that due to rapid energisation of pump-sets and widespread cultivation of water intensive crops, consumption of electricity by agricultural sector has increased many fold since independence.[7] In India, on an average, pumpsets which are used to lift water from wells consume about 70 percent of total electricity used in agriculture (Sharma, 1994). Though the increased consumption of electricity indicates better growth of agriculture, many researchers argue that electricity is not used efficiently in agriculture due to various reasons. One among the options available for increasing the efficiency of electricity use in agriculture is drip method of irrigation. Studies related to drip irrigation have shown that this micro-irrigation technology is not only useful for reducing the consumption of water but also useful in energy saving.[8] It is obvious that along with the number of working hours of pumpset the consumption of electricity also reduces in drip method of irrigation.

It is observed in the foregoing section that HP hours of water used per hectare of sugarcane crop under DMI are significantly less than FMI. Therefore, it follows candidly that the consumption of electricity also reduces significantly under DMI. In order to know the impact of drip method of irrigation on electricity saving, we have estimated electricity consumption based on the hours of pumpset operation for both the drip adopters and the non-drip adopters groups. Further, for estimating the quantum of electricity saved, we have assumed that for every hour of operation of pump-set, 0.750

kwh of power is used per HP.[9] 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 6 depicts that farmers using DMI utilise less amount of electricity as compared to FMI farmers in both the districts. Farmers who cultivate sugarcane under DMI in Pune district could save about 895.50 kwh of electricity per hectare compared to those farmers cultivated sugarcane under FMI. Similarly, in Ahmednagar district, DMI helps to save about 1223 kwh of electricity per hectare for farmers who have cultivated sugarcane under DMI as compared to flood method of irrigation. Altogether, farmers can save about 1059 Kwh of electricity per hectare by adopting drip method of irrigation in sugarcane cultivation.

Table 6: Estimates of Electricity Consumption by Drip and Non-Drip Irrigated Sugarcane. (Kwh/ha)

| District | Electricity Consumption | | Electricity Saving over FMI | | |
|---|---|---|---|---|---|
| | DMI | FMI | In Percent | In quantity | In money value (Rs) |
| Pune District | 1305.06 (345.24) | 2200.56 (536.29) | 40.69 | 895.50 | 1343.25 |
| Ahmednagar District | 1345.44 (328.45) | 2569.41 (1150.73) | 47.64 | 1223.97 | 1835.95 |
| Two Districts Average | 1325.25 (334.12) | 2384.99 (907.83) | 44.43 | 1059.74 | 1589.61 |

Note: It is assumed Rs.1.50/Kwh to estimate electricity saving in terms of money value.
Source: Field survey data.

As in water consumption, energy used to produce one tonne of sugarcane is computed by dividing per hectare energy (electricity) consumption by yield of sugarcane per hectare. The estimate of electricity required to produce one tonne of sugarcane under DMI and FMI conditions is presented in Table 7. As expected, electricity consumed to produce one tonne of sugarcane is quite low for drip adopters in both districts of Maharashtra. For instance, on an average, sugarcane cultivators under DMI used about 9.58 kwh to produce one tonne of sugarcane whereas, the same is about 21.21 kwh for those who cultivated sugarcane under FMI. This means that for every tonne of sugarcane production about 11.63 kwh of electricity can be saved through drip method. Obviously, higher productivity

and relatively low amount of water consumption have reduced per tonne consumption of electricity significantly in drip irrigated sugarcane.

Table 7: Estimates of Electricity Use Efficiency in Drip and Non-Drip Irrigated Sugarcane.

| District | Yield (tonnes/ha) | | Electricity Use (Kwh/ha) | | Electricity Use Efficiency (Kwh/tonne) | |
|---|---|---|---|---|---|---|
| | DMI | FMI | DMI | FMI | DMI | FMI |
| Pune District | 141.32 | 116.80 | 1305.06 | 2200.56 | 9.23 | 18.84 |
| Ahmednagar District | 135.40 | 108.08 | 1345.44 | 2569.41 | 9.94 | 23.77 |
| Two Districts Average | 138.36 | 112.44 | 1325.25 | 2384.99 | 9.58 | 21.21 |

Source: Field survey data.

Farmers with drip irrigation operate less number of hours of pumpsets and therefore, consumption of electricity is also quite low. Since the saving of electricity through drip method of irrigation is very high, it also helps to reduce the total electricity bill to be paid by the farmers. In order to find out this, we have also calculated the money saved in the total electricity bill per hectare through energy saving in sugarcane crop. Since Maharashtra State Electricity Board supplies electricity on flat-rate (FR) basis for agriculture, it was not possible to get per kwh price of electricity. Therefore, we have assumed Rs. 1.50/kwh as a nominal rate to estimate the saving of electricity in monetary terms. In accordance with this, on an average, about Rs.1589/ha can be saved on electricity bill alone by cultivating sugarcane under drip method of irrigation. This amply proves that the drip irrigation technology helps to reduce the cost of cultivation enormously by reducing the cost of electricity besides helping to save the precious inputs like electricity and water.

**7. Input and Output Pattern:**

To complete the analysis of the relative economics of DMI and FMI, we have calculated the relative profit levels of sugarcane for the adopters and non-adopters of DMI. Profit of a crop is not only determined by its total quantity of output but also its quality. Market condition plays a crucial role in determining the price of agricultural commodities. A good quality product can fetch better price in the market. It has come out from earlier studies that drip method of irrigation not only helps in increasing the yield of the crops but

also improves quality of the product and fetches higher price in the market (INCID, 1994; Narayanamoorthy, 1997a, b; Sivanappan, 1994).

The impact of drip irrigation on sugarcane is measured in terms of profit per hectare. While calculating profit here, the total cost was calculated by considering only the variable costs but not the fixed cost components like interest rate and depreciation.[10] To calculate per hectare profit, we subtract the total cost of cultivation from total income for the group of adopters and the non-adopters.[11] The gross income (in rupees) is calculated by multiplying total yield with price received by the farmers from sugarcane factories. It can be seen from Table 4 that per hectare profit[12] of the adopters is significantly higher than that of the non-adopters in both the districts under consideration. In Pune district, profit of the adopters is about Rs.28509/ha higher than the profit of the non-adopters, while the same is about Rs.26341/ha in Ahmednagar district. In terms of percentage, profit of the drip adopters is higher by 67 percent and 83 percent respectively in Pune and Ahmednagar district over the profit of the non-drip farmers. This is not surprising because on the one hand drip irrigation reduces the cost of cultivation of sugarcane and it increases the yield of sugarcane on the other hand.

Some studies have indicated that since moisture stress is very less for the crops cultivated under DMI, the quality of crop produce cultivated under DMI is good which helps to fetch higher price in the market. We could not test this in our study because all the farmers have supplied sugarcane to sugar factories, where the price is same for all the farmers. However, some of the adopters have argued that if recovery testing is done separately for drip irrigated sugarcane, the real impact of DMI on recovery rate of sugarcane can be visibly seen. Therefore, it can be concluded that farmers adopting drip method of irrigation earn more profit not because of price effect but only because of yield effect. Be that as it may, the results of our study undoubtedly confirm that drip method irrigation increases the per hectare profit of sugarcane in both the districts in Maharashtra.

Table 8: Income and Expenditure Pattern of Drip and Flood Method Irrigated Sugarcane.

(Rs/ha)

| Particulars | Pune District | | | Ahmednagar District | | | Two Districts Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | DMI | FMI | % over FMI | DMI | FMI | % over FMI | DMI | FMI | % over FMI |
| Gross Income | 114536 | 91871 | 25 | 98196 | 79106 | 24 | 106366 | 85488 | 24 |
| Expenditure (Cultivation cost) | 43729 | 49572 | -12 | 40257 | 47507 | -15 | 41993 | 48540 | -13 |
| Profit | 70807 | 42298 | 67 | 57939 | 31598 | 83 | 64373 | 36948 | 74 |

Note: Figures rounded off to the nearest integer.
Source: Field survey data.

**8. Cost-Benefit Analysis:**

It is clear from the previous section that per hectare profit (farm business income) of sugarcane cultivated under drip method of irrigation is significantly higher than the crop cultivated under flood method of irrigation. However, it cannot be treated as the effective (real) profit of sugarcane cultivated under DMI, because it does not account for the capital cost of the drip set, its depreciation and interest accrued on the fixed capital while calculating the net profit of sugarcane. The life period of drip-set is one of the important variables which determine the per hectare profit. Moreover, since it is a capital-intensive technique, the huge initial investment needed for installing drip systems remains the main deterrent for the widespread adoption of DMI. 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. Past studies (e.g. INCID, 1994; Sivanappan, 1994) on the subject have either conducted benefit-cost analysis without a proper methodology or relied heavily on the experience of one or few farmers adopting DMI. Therefore, there is a need for a study to empirically evaluate the economic viability of DMI within a relatively more systematic methodological framework. Specifically, we try to address (1) how the factors like fixed investment influence economic viability on DMI and (2) how government subsidies and farmers' time preference (i.e., the differential

discount rates) influence the economic viability of DMI in sugarcane cultivation.

To evaluate the economic viability of drip investment in the context of sugarcane crop, we have computed both the Net Present Worth (NPW) and the Benefit-Cost Ratio (BCR) by utilising the 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 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 on 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 (Gittinger, 1984). 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
i = rate of interest (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 realistic assumptions so as to estimate both the cash inflows and cash outflows for drip investment. These assumptions are:

1. The life period of the drip set is considered as five years for sugarcane as followed by the INCID study (1994).
2. The cost of cultivation and income generated using drip method of irrigation is assumed constant during the entire life period of drip set.
3. Differential rates of discount (interest rates) are considered to undertake the sensitivity of investment to the change in capital cost. These are assumed at 10, 12 and 15 percent as alternatives representing various opportunity costs of capital.
4. The crop cultivation technology is assumed constant for sugarcane during the entire life period of drip set.

Fixed capital is needed for installing drip method of irrigation. The magnitude of capital requirement varies with crop as indicated earlier. Generally, wide spaced crops require relatively low fixed investment and narrow spaced crops need higher fixed investment. 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 water source (well) and the field (NABARD, 1989; Narayanamoorthy, 1996a). Let us now evaluate the empirical pattern of capital cost of the drip system, production cost of sugarcane crop and the amount of subsidy received by the sample farmers. Table 9 presents the details of capital cost, subsidy, production cost [cost of cultivation ($A_2$)] and gross value of production for sugarcane for both Pune and Ahmednagar districts. As mentioned earlier, since DMI is a capital intensive technology, governments provides nearly 50 percent of the capital cost as subsidy to encourage the adoption of drip irrigation in crop cultivation. The average capital subsidy comes to Rs. 19157/ha for Pune district and the same is about Rs. 19369/ha. for Ahmednagar district. As a proportion of the total capital cost of drip set,

subsidy amount accounts for about 35 percent for Pune district and about 37 percent for Ahmednagar district. After deducting the subsidy, the fixed capital cost of drip set comes down to about Rs. 35312/ha for Pune district and about Rs. 31782/ha for Ahmednagar district. With this background, let us analyse benefit-cost pattern of drip investment using discounted cash flow technique.

Table 9: Capital and Production Cost of Drip Irrigation for Sugarcane

(Rs/ha)

| Particulars | DMI | | FMI | |
|---|---|---|---|---|
| | Pune | Ahmednagar | Pune | Ahmednagar |
| 1. Capital cost of drip set[a] | | | | |
| (a) Without subsidy | 54470.00 (7014.24) | 51152.00 (4561.26) | – | – |
| (b) With subsidy | 35312.91 | 31782.21 | – | – |
| 2. Production cost[b] (Cost of cultivation) | 43729.40 (7729.43) | 40257.00 (3454.87) | 49572.56 (4357.57) | 47507.20 (7229.26) |
| 3. Gross value of production | 114536.00 (17057.49) | 98196.00 (12657.54) | 91870.80 (9631.02) | 79105.60 (7859.22) |
| 4. Profit without discount[c] | 70806.60 (16486.70) | 57939.00 (14418.19) | 42298.24 (9003.78) | 31598.40 (10490.56) |
| 5. Subsidy | 19157.09 (2159.01) | 19369.79 (2647.01) | – | – |

Notes: a – it does not include pump-set cost.
b - production cost ($A_2$) includes the operation and maintenance cost of drip set and pump-set.
c - This is the difference between gross value of production and production cost ($A_2$).
Figures in brackets are standard deviation.
Source: Calculated from field survey data.

Though all the sample farmers (adopters) in our survey have received subsidy for installing drip technology in sugarcane cultivation through government scheme, we have computed both the NPW and the BCR separately by including subsidy and by excluding subsidy in the total fixed capital cost of drip set. This is done to assess the potential role that subsidy plays in the adoption of DMI. 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 10 presents the results of

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 percent discount rate, the NPW of drip investment is about 190024/ha without subsidy but Rs.206692/ha with subsidy. This means that the subsidy enables the farmers to get an additional benefit of Rs. 16668/ha. It can also be observed that the difference between the NPW under 'with subsidy' and 'no subsidy' scenarios is decreasing along with each increase in discount rate. For instance, the NPW under without subsidy condition increased from Rs. 190024/ha. at 15 percent discount rate to Rs. 218859/ha. at 10 percent discount rate. Similarly, under subsidy condition, the NPW increased from Rs. 206692/ha at 15 percent discount rate to Rs. 236293/ha. at 10 percent discount rate. Similar to this, under without subsidy condition, the BCR also increased marginally from 1.98 at 15 percent discount rate to 2.02 at 10 percent discount rate.

Table 10: Net Present Worth and Benefit Cost Ratio for Drip Irrigated Sugarcane under With and Without Subsidy Condition.

| Particulars | Pune district | | Ahmednagar district | |
|---|---|---|---|---|
| | Without Subsidy | With Subsidy | Without Subsidy | Without Subsidy |
| 1. Present Worth of Gross Income (Rs/ha) | | | | |
| At 15 percent discount rate | 384039.21 | 384039.21 | 329251.19 | 329251.19 |
| At 12 percent discount rate | 412902.28 | 412902.28 | 353996.58 | 353996.58 |
| At 10 percent discount rate | 434205.99 | 434205.99 | 372261.05 | 372261.05 |
| 2. Present Worth of Gross Cost (Rs/ha) | | | | |
| At 15 percent discount rate | 194014.43 | 177346.91 | 179484.83 | 162632.24 |
| At 12 percent discount rate | 206287.09 | 189178.92 | 190806.11 | 173508.00 |
| At 10 percent discount rate | 215346.76 | 197912.90 | 199163.52 | 181536.10 |
| 3. Net Present Worth (Rs/ha) | | | | |
| At 15 percent discount rate | 190024.78 | 206692.30 | 149766.36 | 166618.95 |
| At 12 percent discount rate | 206615.19 | 223723.36 | 163190.47 | 180488.56 |
| At 10 percent discount rate | 218859.23 | 236293.09 | 173097.53 | 190724.95 |
| 4. Benefit Cost Ratio: | | | | |
| At 15 percent discount rate | 1.98 | 2.16 | 1.83 | 2.02 |
| At 12 percent discount rate | 2.00 | 2.18 | 1.85 | 2.04 |
| At 10 percent discount rate | 2.02 | 2.19 | 1.87 | 2.05 |

Source: Computed using field survey data.

As observed in Pune district, the NPW of the investment under subsidy condition is marginally higher than that under 'no subsidy' condition for Ahmednagar district as well. Under without subsidy condition, the NPW increased from Rs.149766/ha at 15 percent discount to Rs.173097/ha at 10 percent discount rate. Under with subsidy condition, the NPW increased from Rs.166618/ha to Rs.190724/ha under with subsidy condition. Similarly, under subsidy option, the BCR increases from 2.02 to 2.05 when discount rate falls from 15 percent to 10 percent in Ahmednagar district. Among the two districts considered for analysis, the BCR (under different discount rates) of Pune district is relatively higher than that of Ahmednagar district. This is mainly because of higher gross income due to higher yield of sugarcane in Pune district as compared to Ahmednagar district. The higher BCR under subsidy condition suggests the positive role that subsidy plays in improving the economic viability of drip method of irrigation in sugarcane.

The important issue in the context of DMI adoption in sugarcane is the number of years needed to recover fully the capital costs involved in drip installation. Our results of the NPW for sugarcane 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 the farmers seems to be of considerably lesser importance than one might think. However, in order to have a more definite answer to the economic and social viability of DMI, we need a social rather than a private cost-benefit evaluation, which is attempted here. A comprehensive evaluation can be done by incorporating both the social benefits in the form of water saving, additional irrigation benefits, lower soil degradation and retention of soil fertility as well as the social costs in terms of the negative food and fodder implications of crop pattern shift and labour displacement. On the whole, the BCR under different discount rates indicates that drip investment in sugarcane remains economically viable even without subsidy.

## 9. Major Findings and Policy Suggestions:

An attempt is made in this study to evaluate the impact of drip irrigation on various parameters of sugarcane cultivation using field level data collected from two districts in Maharashtra. The study shows that cost of cultivation (cost $A_2$) per hectare of the adopters is much less when compared to the non-adopters of drip irrigation in both the districts – the average cost saving is nearly 14 percent. Cost saving is found mainly in operations like irrigation, ploughing and preparatory works, seed and seed sowing, weeding and inter-culture and chemical fertilisers. Productivity of sugarcane is significantly higher for the farmers who adopt drip method of irrigation when compared to the non-drip adopters. The yield difference in absolute term between the adopters and the non-adopters comes to about 23 percent. Per hectare profit (gross income minus cost $A_2$) of the drip adopters is significantly higher than that of the non-drip adopters in both the districts. Water consumption (in quantity) per hectare of sugarcane is much less under drip method of irrigation as compared to flood method of irrigation. Water saving is estimated to be about 44 percent. The additional irrigated area from the saving of water is estimated to be about 0.80 ha (1.98 acres). Due to water saving under drip method of irrigation, per hectare consumption of electricity is quite low for drip irrigated sugarcane when compared to flood irrigated sugarcane. On an average, farmers could save about 1059 kwh of electricity per hectare (about 44 percent) due to drip method of irrigation. Electricity saving from drip method of irrigation also helps to reduce electricity bill by about Rs.1589/ha. Benefit cost ratios with different discount rates indicate that drip investment in sugarcane cultivation remains economically viable even without subsidy.

Despite enormous benefits from drip method of irrigation, the area under sugarcane with DMI accounts for only a small fraction as of today. The total area under sugarcane in Maharashtra is 229800 ha as of 1998-99, of which only about 3.80 percent (20323 ha) has been brought under DMI. In order to increase the area under DMI, many policy changes need to be introduced. Some specific policy recommendations are presented below:

- *First*, though drip method of irrigation is economically viable for sugarcane crop, majority of the farmers in our study have expressed that capital cost required to install drip irrigation is very high for sugarcane crop. Therefore, measures can primarily be taken to reduce the fixed cost of drip irrigation by promoting research and development activities.
- *Second*, the centrally sponsored scheme of drip irrigation does not provide subsidy for sugarcane crop. This restriction should be removed to increase the drip-irrigated area at a faster rate. The rate of subsidy is fixed uniformly for both water-intensive as well as less water intensive crops. This needs to be restructured. 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 rate of consumption of water.
- *Third*, though there was no delay in sanctioning subsidy, farmers had to wait at least six months to get the amount of subsidy. This increases farmers' debt burden as majority of the farmers have used bank loan for installing drip system. Adequate arrangements should be made to distribute the amount of subsidy within one or two months. While there was no serious problem in getting subsidy from government, almost all the farmers have paid some amount of money (varied from Rs.500 to Rs.1500/ha) to the drip set dealers in order to get subsidy amount quickly. Since the adopters of DMI get nearly Rs.20000/ha as subsidy for sugarcane, farmers feel that they are not going to lose anything by giving this token of bribe. However, if appropriate action is not taken to stop this practice immediately, this may hamper the diffusion of this technology.
- *Fourth*, inadequate information about the operation, maintenance and usefulness of drip irrigation is the main reason for its uneven spread across regions. Even the adopters do not know how much of subsidy is available per hectare for different crops. In fact, many

farmers do not know the fact that drip irrigation can also be used efficiently and economically for crops like sugarcane, cotton, vegetables etc. These problems can be removed through quality extension network.

- *Fifth,* sugar industries always try to increase the area under sugarcane in order to increase their capacity utilisation in almost all the states including Maharashtra. They are least bothered about the method of cultivation of sugarcane. Since sugar industries have close contact with sugarcane cultivators, some kind of target should be fixed for each sugar industry to bring cultivation of sugarcane under drip method of irrigation.
- *Sixth,* drip sets manufacturers should be asked to involve intensively in promoting drip irrigation by introducing frequent demonstration at farmers' field. Since the use of drip method of irrigation is in the initial stage in crops like sugarcane, the role of drip manufacturers is essential for promoting and developing confidence among the farmers. Large-scale adoption of drip method of irrigation will not only help to increase the production of different crops but also help to avoid water scarcity in the future.

**Notes:**

1. During 1998-99, sugarcane accounted for about 2.39 percent (about 5.30 lakh hectares) in the gross cropped area of the state. This is relatively higher than the national level average of area under sugarcane. Not only this, the growth rate of area under sugarcane in Maharashtra is also very high (4.63 percent per annum) as compared to the national average growth rate (2.07 percent) between TE 1972-73 to TE 1996-97.

2. Application of fertilisers through water is called fertigation. It substantially reduces consumption of fertilisers and wastage compared to methods like basal and top dressing. As a result, efficiency of input increases in drip method of irrigation.

3. Water use pattern, water saving and water use efficiency due to drip method of irrigation in sugarcane cultivation are elaborately analysed in chapter seven in Narayanamoorthy (2001).

4. See, Narayanamoorthy (1992) and Alstorm (1990) for more details in this regard.

5. Results of different research stations for different crops are available in INCID (1994; NCPA (1990).

6. In our survey, none of the farmers reported that they could increase area under irrigation after installing drip technology in their field. However, it is reported that they could irrigate the crop at required interval even under the condition of water scarcity because of drip technology.

7. For more details regarding the trends and determinants of electricity consumption in Indian agriculture see, Narayanamoorthy (1999b).

8. In an earlier study related to banana and grapes, we have found saving of electricity through drip method of irrigation is about 2430 kwh/ha for banana and about 1470 kwh/ha for grapes. See, Narayanamoorthy (1996a) for details in this regard.

9. For more details in this regard, see Shah (1993).

10. Our cost of cultivation refers to cost $A_2$, which includes all actual expenses in cash and kind incurred in production by owner plus rent paid for leased-in land. See, CACP (1998) for more details about different cost concepts.

11. Benefit cost analysis using discount rate technique for the entire life period of drip investment is presented separately in section seven of this paper.

12. Our profit refers to gross income minus cost $A_2$. This can be appropriately called as farm business income.

**References:**

AFC (1998) *Evaluation of Drip Irrigation System.* Mumbai, India: Agricultural Finance Corporation (AFC) Limited.

Alstorm, Styrbjorn (1980) *Fundamentals of Weed Management in Hot Climate Peasant Agriculture.* Crop Science, Department of Crop Production Science, Uppasala, Sweden: Swedish University of Agricultural Sciences.

Batta, R.K. and S.R. Singh (1998) 'Adoption of Drip Irrigation in Sugarcane in India', in Varma and Rao (Eds.), *Proceedings: Workshop on Micro Irrigation and Sprinkler Irrigation Systems,* pp. VII 27 – VII 45. New Delhi: Central Board of Irrigation and Power

Dash, N.K. (1998) 'Drip Irrigation and Micro-Irrigation Potential and Prosperity for Sugarcane Cultivation with Reference to Orissa', in Vasantdada Sugar

Institute, *Proceedings of the National Seminar on Irrigation Water Management for Sugarcane*, pp. III 7 – III 12, Pune, India.

Deshmukh, A.S.; P.P. Shinde and S.S. Katake (1998) 'Role of Drip Irrigation in Increasing Water Use Efficiency for Sugarcane Crop', in Vasantdada Sugar Institute, *Proceedings of the National Seminar on Irrigation Water Management for Sugarcane*, pp. III 34 – III 46, Pune, India.

Deshpande, R.S. and A. Narayanamoorthy (2001) 'Issues Before Second Irrigation Commission of Maharashtra', *Economic and Political Weekly* 36 (12): 1034-1043.

Dhonde, R.M. and A.R. Banger (1998) 'Peoples Participation in Drip Irrigation System for Suru Sugarcane in Kukadi and Krishna Commands of Maharashtra: An Overview', in Vasantdada Sugar Institute (VSI) (1998), *Proceedings of the National Seminar on Irrigation Water Management for Sugarcane*, pp. III 25 – III 33, Pune, India.

Gittinger J, Price (1984) *Economic Analysis of Agricultural Projects*, Second Edition. London: The Johns Hopkins University Press.

Government of India (2000) *Agricultural Statistics at a Glance: 2000.* New Delhi: Directorate of Economics and Statistics, Ministry of Agriculture.

INCID (1994) *Drip Irrigation in India.* New Delhi: Indian National Committee on Irrigation and Drainage.

Mollinga, P. Peter (ed.) (2000) *Water for Food and Rural Development: Approaches and Initiatives in South Asia.* New Delhi: Sage Publications.

Narayanamoorthy, A. (1992) 'Impact of Tractors and Weedicides on Yield and Employment in Sugarcane Cultivation', *Journal of Rural Development* 11 (3): 351-362.

Narayanamoorthy, A. (1996a) *Evaluation of Drip Irrigation System in Maharashtra.* Gokhale Institute Mimeograph Series No.42, Agro-Economic Research Centre, Pune, India: Gokhale Institute of Politics and Economics.

Narayanamoorthy, A. (1996b) 'Electric Pumpset and Groundwater Management: Macro and Micro Evidence of India', *Water Resources Journal* 189: 24-33.

Narayanamoorthy, A. (1997a) 'Drip Irrigation: A Viable Option for Future Irrigation Development', *Productivity* 38 (3): 504-511.

Narayanamoorthy, A. (1997b) 'Economic Viability of Drip Irrigation: An Empirical Analysis from Maharashtra', *Indian Journal of Agricultural Economics* 52 (4): 728-739.

Narayanamoorthy, A. (1997c) 'Beneficial Impact of Drip Irrigation: A Study Based on Western India', *Water Resource Journal* 195: 17-25.

Narayanamoorthy, A. and R. S. Deshpande (1997) *Economics of Drip Irrigation: A Comparative Study of Maharashtra and Tamil Nadu,* Mimeograph Series No.47, Agro-Economic Research Centre. Pune, India: Gokhale Institute of Politics and Economics.

Narayanamoorthy, A. (1999) 'Drip Irrigation for Sustainable Agriculture', *Productivity* 39 (4): 672-680.

Narayanamoorthy, A. (1999b), 'Changing Scenario of Electricity Consumption in Indian Agriculture', *Productivity* 40 (1): 128-138.

Narayanamoorthy, A. (2001) Irrigation and Rural Poverty Nexus: A Statewise Analysis', *Indian Journal of Agricultural Economics* 56 (1): 40-56.

NCPA (1987) *Proceedings of the National Seminar on Use of Plastics in Agriculture.* Organised jointly by the Directorate of Extension (Ministry of Agriculture) and the National Committee on the Use of Plastics in Agriculture. New Delhi: Ministry of Industry, Government of India.

Rath, N. and A.K. Mitra (1989) 'Economics of Irrigation in Water-Scarce Region: A Study of Maharashtra', *Artha Vijnana* 31(1): 1-129.

Rosegrant, W. Mark (1997) *Water Resources in the Twenty-First Century: Challenges and Implications for Action.* Food and Agriculture, and the Environment Discussion Paper 20. Washington D.C., U.S.A.: International Food Policy Research Institute.

Saleth, R. Maria (1996) *Water Institutions in India: Economics, Law and Policy.* New Delhi: Commonwealth Publishers.

Sankpal, V.Y.; N.J. Danawale; K.K. Khade and D.S. Bhoite (1998) 'Response of Sugarcane Varieties to Drip Irrigation During Suru Season', in Vasantdada Sugar Institute, *Proceedings of the National Seminar on Irrigation Water Management for Sugarcane,* pp. III 13-III 24, Pune, India.

Shreshta, R.B. and C. Gopalakrishnan (1993) 'Adoption and Diffusion of Drip Irrigation Technology: An Econometric Analysis', *Economic Development and Cultural Change* 41 (2): 407-418.

Sharma, Anil (1994) 'Electricity for Minor Irrigation', *Seminar* 418: 21-24.

Shah, Tushaar (1993) *Groundwater Markets and Irrigation Development: Political Economy and Practical Policy.* Delhi, India: Oxford University Press.

Shah, Tushaar (1998) 'Water Against Poverty: Livelihood Oriented Water Resource Management', *Water Nepal* 6 (1): 117-143.

Sivanappan, R. K. (1994) 'Prospects of Micro-Irrigation in India', *Irrigation and Drainage System* 8 (1): 49-58.

Vaidyanathan, A. (1994) *Food, Agriculture and Water: Second India Studies Revisited.* Madras, India: Madras Institute of Development Studies.

Varma, C.V.J. and A.R.G. Rao (Eds.) (1998) *Proceedings: Workshop on Micro Irrigation and Sprinkler Irrigation Systems.* New Delhi, India: Central Board of Irrigation and Power.

VSI (1998) *Proceedings of the National Seminar on Irrigation Water Management for Sugarcane.* Pune, India: Vasantdada Sugar Institute.

Venugopal, R. and M. Rajkumar (1998), 'Drip Irrigation System – New Concept in Sugarcane Culture at Baramba of Orissa state', in Vasantdada Sugar Institute, *Proceedings of the National Seminar on 'Irrigation Water Management for Sugarcane*, pp. III 7 – III 12. Pune, India.