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Trickle Irrigation System for Sugarcane Crops and Its Water Utilization in Tamil Nadu

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ABSTRACT
Tamil Nadu depends predominantly on ground water for irrigation purpose. The Trickle irrigation can help in saving the water. The objective of this study to knows the sagaciousness of the agriculturalist towards usage of Trickle irrigation. 250 agriculturalists from 5 different villages of Erode District were personally contacted for questionnaire survey. The reasons for Trickle irrigation usage were higher productivity, high quality, lower cost of water and labour cost. And the reasons for not using Trickle irrigation were lack of information and knowledge about usage of Trickle irrigation and the higher cost of installation.

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I. INTRODUCTION

Indian agriculture has an extensive background which goes back to more than 10 thousand years. India is one of the fastest developing economies of the world; it is the seventh largest country in the world in terms of its geographical size. Today it has a population of nearly billion out of which more than 60% people depends on agriculture. India is gifted with the largest irrigated area in the world. Agriculture is a censorious sector of the Indian economy. Tamil Nadu has around 6 percent of India's geological area (19.6 million) and is home to around 56.4 million people. The state has around 5% of the total population, contributes around 6.5 %of the all India GDP and 5.6 percent of all India Gross Domestic Product from Agriculture (GDPA).

Due to the fast turndown of irrigation water potential and increasing necessities for water from different sectors, a number of demand management strategies have been introduced to save water and increase the existing water use efficiency in Indian agriculture. One such method introduced relatively recently in agriculture sector is micro- irrigation, which includes both Trickle and sprinkler method of irrigation. Trickle method of irrigation was introduced in India during the early 1970^{s} by the Agricultural Universities and other Research Institutions.

The scientists at the Tamil Nadu Agricultural University (TNAU), Coimbatore, who are considered to be the pioneers in Trickle irrigation research in India, have managed large-scale demonstration in the agriculturalist' field for various crops, which received encouraging response from the agriculturalist (INCID, 1998). The micro-irrigation is economically viable and eco friendly but less numbers of studies seem to have attempted to study the sagaciousness of Trickle and sprinkler irrigation. This study mainly focuses on to finding out the sagaciousness of agriculturalist of Erode Districts for the Trickle irrigation.

II. OBJECTIVES

The main objective of this study is to know the sagaciousness of the agriculturalist towards usage of Trickle irrigation. The secondary objectives are

1. To substitute the flooding method/manual method of giving water by trickle irrigation system
2. To eliminate land leveling in undulating
3. To maximize utilization of available water
4. To increase the cultivable area and yield of the crops.

Though trickle irrigation technology is primarily introduced in agriculture for increasing the water use efficiency water, it also significantly increases the productivity and cultivability of crops and also reduces power consumption as well as cost of cultivation. However, unfortunately, the studies carried out using experimental data have brought out only the impact of Trickle irrigation on water saving and productivity gains. In this case study, besides focusing on productivity gains and water saving, it has also brought out the other benefits realized by the farmer due to Trickle method of irrigation.

PLANTING COST

The cost of Planting of the crops under Trickle method of irrigation is less when compared to the crops that are cultivated under surface method of irrigation. Cost reduction is generally realised more in labour intensive operations like ploughing, weeding, irrigation, etc. Since water is supplied at the root zone of the crops, the lands that are used for trickle method of irrigation do not require many ploughing as in the case of surface method of irrigation. Similarly, since water is supplied only at the root of the crops, weed problem is less and thus the cost required for weeding operation reduces significantly. Cost of irrigation is substantially less under trickle method of irrigation because of the following reasons:

First, the requirement of labour is less for managing irrigation under trickle method of irrigation. Second, since water saving is very high under trickle method, it substantially reduces the working hours of pumpset which extensively reduces the cost on electricity/diesel. The operation-wise cost of cultivation of the sample farmer presented in Table 1 clearly shows that cost reduction is very high in operations like weeding and irrigation as expected. The total cost reduction (excluding harvesting and transportation) comes to about 18 per cent (Rs. 3,450/acre) due to trickle method of irrigation when compared to flood method of irrigation. Though the farmer has used liquid form of fertilizers (only urea and phosphate), he did not reduce deliberately the consumption of fertilizer as he felt that any reduction of fertilizers might affect the yield of crop. However, after releasing the effect of liquid fertilizers in his farm, he accepted the fact that the efficiency of fertilizer increases significantly by supplying fertilizers through water. He was of the opinion that if fertilizer is used through water, the amount of fertilizers can be reduced to a considerable extent when compared to the application methods like top dressing and basal, which are commonly followed under flood method of irrigation.

TABLE 1. COST OF CULTIVATION IN TRICKLE AND FLOOD METHOD IRRIGATED IN SUGARCANE

(Rs./acre)

Operation	Trickle	Flood	Cost saving over flood method (per cent)
(1)	(2)	(3)	(4)
1. Ploughing and preparatory works	1,040	1,040	-
2. Furrow and bunding	400	400	-
3. Seed and seed sowing	4,440	4,440	-
4. Fertilisers	3,500	3,500	-
5. Farm yard manure	1,500	1,500	-
6. Pesticides	335	335	-
7. Weeding and interculture	1,200	2,400	50.00
8. Irrigation:			
(a) Labor cost	1,500	3,000	50.00
(b) Other cost	500	1,250	50.00
9. Harvesting and transportation	16,830	10,890	-54.60
10. Others	1,000	1,000	-
Cost of cultivation excluding harvesting and transportation	15,415	18,865	18.30
Total cost of cultivation	32,245	29,755	-8.40

Source: Sample Data.
Note: Figures are rounded off to the nearest integer.

WATER CONSUMPTION

Water use pattern under trickle method is totally different from flood method of irrigation. Unlike FMI, since water is supplied at a regular interval and at a required time for sugarcane under DMI, not only is the over irrigation avoided completely but the evaporation and distribution losses are almost absent.

Table 2 presents the water use pattern of the sample farmer. Though the number of irrigation used for trickle irrigated crop is substantially higher (240 irrigation) than flood method of irrigation (48 irrigation), the hours required to irrigate one acre of sugarcane under DMI is only one hour as against 12 hours under flood method of irrigation. The total horse power (HP) hours[3] of water used for trickle irrigated sugarcane is about 1200, while on the contrary the same comes to as much as 2880 HP hours for flood method of irrigation. That is, adopting trickle method of irrigation from each acre of sugarcane can save over 58 per cent (1,680 HP hours) of water. This indicates that with the same amount of water used for irrigating one acre of sugarcane under FMI, about 2.40 acres ofsugarcane can be irrigated using DMI. In other words, an additional area of 1.40 acres can be brought under trickle method irrigation from the saving of water realized through DMI. There are two reasons for water saving under DMI. First, since it supplies water only at the root zone of the crop, the time required for each turn of irrigation is less. Second, since water is supplied through a network of pipes, evaporation and distribution losses are completely controlled under DMI as mentioned earlier.

TABLE 2. WATER USE PATTERN UNDER TRICKLE AND FLOOD METHOD OF IRRIGATION

Particulars (1)	DMI (2)	FMI (3)
1. irrigation types	240	48
2. Hours required for each turn of irrigation	1	12
3. HP of the pump set	5	5
4. Total HP hours of water consumed (1 x 2 x 3)	1,200	2,880

Source: Sample Data.
Note: HP- horse power.

POWER CONSUMPTION

Electricity consumption is one of the important advantages of trickle method of irrigation. DMI substantially reduces the working hours of pump set by reducing the waterconsumption. As a result, electricity required for irrigating one acre of land also reduces significantly. Our estimate[4] reported in Table 3 clearly shows that about 1260 kwh (saving of about 58 %) can be saved from each acre of sugarcane cultivation by adopting trickle method.[5] Even if we assume a tariff rate of Rs. 2/kwh, the cost saving on account of electricity consumed would come to about Rs. 2,520/acre from sugarcane cultivation by adopting DMI.

PRODUCTIVITY GAINS

Similar to water saving, productivity gain is also very high under DMI when compared to flood method of irrigation. Our sample farmer reported that he could harvest 85 tonnes of sugarcane per acre under DMI as against 55 tonnes of sugarcane under FMI, a gain of 55 per cent (see, Table 3). The farmer attributes the higher yieldof sugarcane under DMI to the following three reasons. First, the growth of sugarcane was very good under DMI mainly due to less moisture stress. Second, the weed growth is less because of supplying of water only at the root zone of the crop. Third, since fertilizers are supplied through water (fertigation), the efficiency of fertilizers was high as losses occurring through evaporation and leaching with water is low under DMI. Because of higher production of sugarcane under DMI, the efficiency of water use along with the efficiency of cost as well as electricity is also found to be significantly higher under trickle irrigated sugarcane when compared to the same cultivated under FMI.

TABLE 3. PRODUCTIVITY GAINS, WATER SAVING AND ENERGY SAVING BY TRICKLE OVER FLOOD IRRIGATION IN SUGARCANE

(per acre)

Particulars	DMI	FMI	Gains over FMI	
			Per cent	Value
(1)	(2)	(3)	(4)	(5)
1. Productivity (tonnes)	85	55	54.55	30.00
2. Water consumption (HP hours)	1,200	2,880	58.30	1,680.00
3. Energy consumption (Kwh)	900	2,160	58.30	1,260.00
4. Water efficiency (HP hours) (water used per tonne of sugarcane)	14.10	52.40	73.00	38.20

5. Cost cuting efficiency (Rs.) (production cost per tonne of sugarcane)	379.35	541.00	29.90	161.65
6. Energy efficiency (Kwh) (electricity used per tonne of sugarcane)	10.60	39.30	73.00	28.70

Source: Sample Data.
Note: Figures are rounded off to the nearest integer.

INPUT AND OUTPUT PATTERN

In order to complete the analysis of relative economics of both methods of irrigation, we have calculated the relative profit levels of sugarcane cultivated under DMI and FMI. Here, while calculating the profit of sugarcane per acre, the total expenses was calculated by considering only the variable expenses but not fixed expenses components like interest rate and rate of deprecation. That is, the total expenses of cultivation is subtracted from the gross value of production to get profit of sugarcane cultivated under DMI and FMI. The gross income of sugarcane is calculated by multiplying total yield withthe price received (Rs. 782.70/tonne) by the farmer from Sakthi sugars factory. As perthe data provided by the farmer, the per acre profit without any discount comes to about Rs. 34,284 under DMI, whereas the same comes to only about Rs. 13,293 for flood method irrigated sugarcane. This means that the profit of trickle irrigated.

Sugarcane is about Rs. 20,991/acre higher than the crop cultivated with flood method of irrigation. This higher profit is purely because of yield effect under DMI and not because of price effect as sugarcane cultivated under both DMI and FMI fetches the same price from the sugar factory. However, the farmer argues that there is a clear case for giving higher price for sugarcane cultivated under DMI, as various scientific studies conducted using the samples collected from farmer's in the field proved that the recovery rate of sugarcane cultivated under DMI is considerably higher than the crop cultivated under FMI.[6] Obviously, the benefits of higher recovery rate of sugarcane realized due to DMI goes to the sugar factory but not to the farmers.

BENEFIT-COST ANALYSIS

Though the profit of sugarcane cultivated under trickle method of irrigation is significantly higher than the crop cultivated under flood method of irrigation, it cannot be treated as the effective profit of sugarcane cultivated under DMI because it does not account for the Investment cost of the trickle set, its depreciation and interest accrued on the fixed capital while calculating the net profit of sugarcane. The life period of trickle-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 is needed for installing trickle 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 governments subsidy are important policy issues requiring empirical answers.

Therefore, in order to find out the economic viability of trickle investment in the context of sugarcane, we have computed both the Net Present worth (NPW) and the Benefit-Cost Ratio (BCR) by utilizing the discounted cash flow technique. Since the NPW is the difference between the sum of the present value of benefits and thatof expenses for a given life period of the trickle set, it collates the total benefits with thetotal expenses covering items like capital and depreciation expenses of the trickle set. In terms of the NPW criterion, the investment on trickle set can be treated as economically viable if the present value of benefits is greater than the present value of expenses. 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 expenses 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 expenses stream (Gittinger, 1984). The NPW and BCR can be defined as follows:

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

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

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).

Trickle method of irrigation involves fixed capital and therefore, it is necessary to take into account the income stream for the whole life span of trickle investment. However, since it is difficult to generate the cash flows for the entire life span of trickle 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 trickle investment.

The assumptions followed for estimating NPW and BCR are:

(1) The life period of the trickle set is considered as ten years for sugarcane based on the experience gathered from different parts in the country.

(2) While the income generated using trickle method of irrigation is assumed constant during the entire life period of trickle set, the cost of cultivation is assumed to be less by Rs. 7,380/acre for ratoon crop, as the costs for operations like ploughing and preparatory works, furrow and bunding, seed and sowing as well as FYM are not required for ratoon crop.

(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 per cent as alternatives representing various opportunity costs of capital.

(4) The crop cultivation technology is assumed constant for sugarcane duringthe entire life period of trickle set.

The magnitude of capital requirement for DMI varies with crop depending upon the nature of the crop. Generally, wide spaced crops require relatively low fixed investment and narrow spaced crops need higher fixed investment. Table 4 presents the details of capital cost, subsidy (assumed), production cost (cost of cultivation)[7] and gross value of production for sugarcane. Since DMI is a capital-intensive technology, states like Maharashtra through a state sponsored scheme has beenproviding nearly 50 per cent of the capital cost as subsidy to encourage the adoption of trickle irrigation for different crops including sugarcane.[8] However, despite being a water-intensive crop, subsidy schemes for sugarcane crop are not available in Tamil Nadu. Therefore, the capital cost of trickle set comes to Rs. 28,000/acre for the sample farmer without subsidy. One of the important issues of trickle irrigation is the role of subsidy in increasing the viability of trickle investment. Therefore, only for the purpose of calculation, we have assumed that the farmer gets a subsidy of 30 percent of the capital cost, which comes to Rs. 8,400/acre. After deducting the subsidy, the fixed capital cost of trickle set comes down to about Rs. 19,600/acre. Now, let us analyses the benefit-cost pattern of trickle investment using discounted cash flow technique.

TABLE 4. CAPITAL COST, PRODUCTION COST AND PROFIT FOR TRICKLE AND FLOOD METHOD IRRIGATION IN SUGARCANE

(Rs./acre)

Particulars (1)	DMI (2)	FMI (3)
1. Capital cost of trickle set[a]		
(a) Without subsidy	28,000.00	-
(b) With 30 per cent subsidy	19,600.00	-
2. Production cost[b]		
(Cost of cultivation)	32,245.00	29,755.00
3. Gross value of production	66,529.50	43,048.50
4. Profit without discount[c]	34,284.50	13,293.50

Source: Calculated from Sample Data.
Notes: a - it does not include pump-set cost.
b - production cost (A_2) includes the operation and maintenance cost of trickle set and pump-set.
c - This is the difference between gross value of production and production cost (A_2).

Though the sample farmer has not received subsidy for installing trickle 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 trickle 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 would 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 5 presents the results of sensitivity analysis computed for the entire life period of trickle set by following the assumptions mentioned above. 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 trickle investment is about Rs. 164,938/acre without subsidy but Rs.172,247/acre with subsidy. This means that the subsidy enables the farmers to get an additional benefit of Rs. 7,309/acre. 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 fromRs. 164,938/acre at 15 per cent discount rate to Rs. 206,750/acre at 10 per cent discount rate. Similarly, under subsidy condition, the NPW increased from Rs. 172,247/acre at 15 per cent discount rate to Rs. 214,394/acre at 10 per cent discount rate.

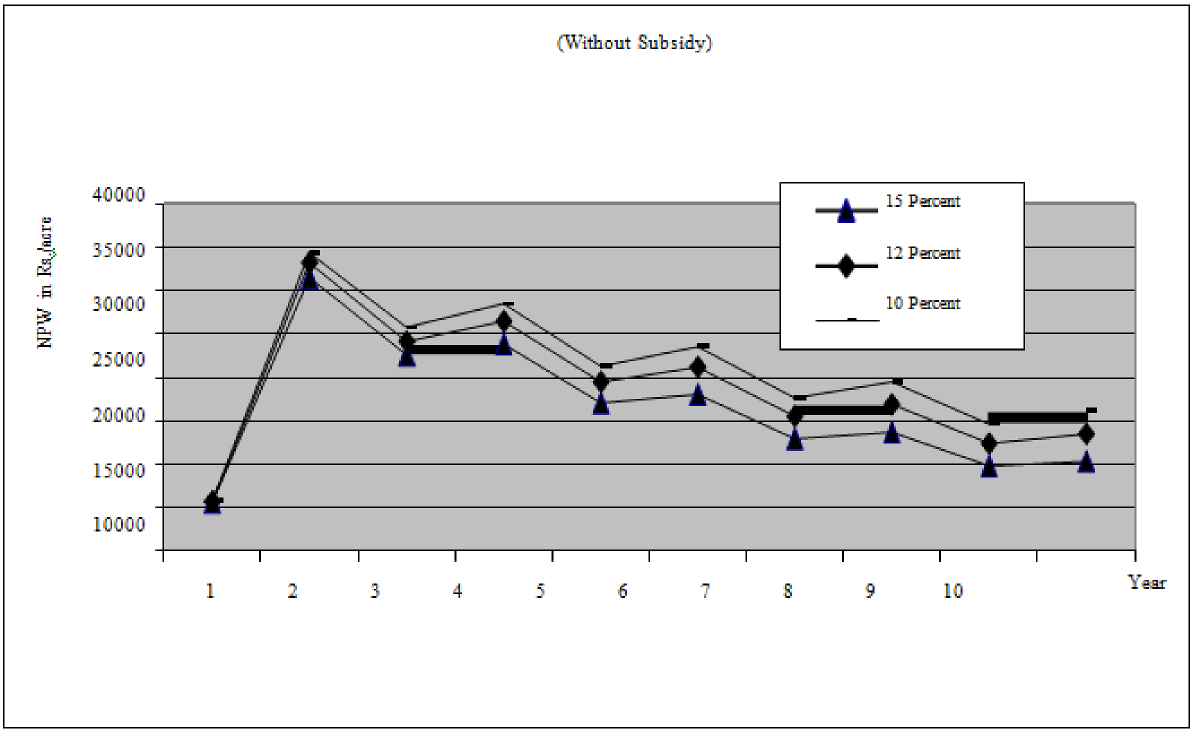
TABLE 5. NET PRESENT WORTH AND BENEFIT-COST RATIO FOR TRICKLE IRRIGATEDSUGARCANE UNDER WITH AND WITHOUT SUBSIDY

Particulars (1)	Without subsidy (2)	With subsidy (3)
1. Present Worth of Gross Income (Rs./acre)		
At 15 per cent discount rate	333,911.60	333,911.60
At 12 per cent discount rate	375,958.20	375,958.20
At 10 per cent discount rate	408,757.25	408,757.25
2. Present Worth of Gross Cost (Rs./ acre)		
At 15 per cent discount rate	168,972.70	161,664.70
At 12 per cent discount rate	187,545.40	180,044.20
At 10 per cent discount rate	202,006.80	194,362.80
3. Net Present Worth (Rs./ acre)		
At 15 per cent discount rate	164,938.30	172,246.80
At 12 per cent discount rate	188,412.80	195,914.00
At 10 per cent discount rate	206,750.50	214,394.50
4. Benefit-Cost Ratio:		
At 15 per cent discount rate	1.97	2.06
At 12 per cent discount rate	2.00	2.09
At 10 per cent discount rate	2.02	2.10

Source: Computed using discounted cash flow technique.
Note: Figures are rounded off to the nearest integer.

The BCR computed with different discount rates clearly demonstrates that trickle investment in sugarcane crop is economically viable. Under without subsidy condition, the BCR varies from 1.97 at 15 per cent discount rate to 2.02 at 10 per cent discount rate. Similarly, under with subsidy condition, the BCR varies from 2.07 to 2.10. The relatively higher BCR realized with subsidy condition indicates the important role of subsidy in increasing the economic viability of trickle irrigation. Though there are variations in BCR at different discount rates, on the whole, the BCR unequivocally authenticates that trickle investment in sugarcane remains economically viable even without subsidy.

The important issue in the context of DMI adoption in sugarcane is the number of years needed to fully recover the capital costs involved in trickle installation. The results of the NPW for sugarcane clearly shows that farmers can recover the entire capital cost of the trickle set from the income of the very first year itself even without any subsidy from the schemes operated by the government. For the purpose of ready reference, we have presented the year-wise trends in net present worth estimated under without subsidy condition using different discount rates in Figure 1. The findings of NPW clearly discards the common misapprehension that the capital cost recovery for trickle investment takes more time. More importantly, if the farmer 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 to carry out a social cost-benefit analysis rather than the private cost-benefit analysis, which is attempted here. A comprehensive evaluation can be done by incorporating the social benefits in the form of water saving, additional irrigation benefits, higher recovery rate of sugarcane, 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.



III. CONCLUSION

Though trickle method of irrigation is highly suitable for water-intensive crops like sugarcane, not many studies have brought out its economic viability using data collected from the farmers' field. In this case study, therefore, an attempt has been made to study the various economic advantages of trickle method of irrigation insugarcane cultivation by selecting a model farmer from Erode district in Tamil Nadu. The data collected from the sample farmer clearly show that trickle method of irrigation has many advantages over flood method of irrigation in sugarcane cultivation. While the productivity gains due to trickle method of irrigation is about 54 per cent (30 tonnes/acre), water saving due to DMI comes to about 58 per cent over flood method of irrigation. Owing to less consumption of well water, the farmer is able to save about 1260 kwh/acre of electricity, which is used for lifting water from wells. Besides these advantages, the farmer could reduce the cost of cultivation to the tune of Rs. 3,450/acre particularly in operations like weeding, interculture and irrigation cost (both labour and other costs). Discounted cash flow analysis employedfor studying the economic viability of trickle investment in sugarcane cultivation clearly suggests that trickle investment in sugarcane cultivation is economically viable even without subsidy. The benefit-cost ratio varies from 1.98 to 2.02 under without subsidy condition and the same varies from 2.07 to 2.10 with subsidy (30 per cent) at different discount rates. Further, the results of net present worth indicate that the farmer can recover the entire capital cost of trickle set from the income of the very first year itself even without subsidy.

Though the investment on trickle method of irrigation in sugarcane cultivation is economically viable without subsidy, one cannot say that the adoption of trickle method of irrigation can be increased without subsidy. The sample farmer suggests that since many farmers are reluctant to adopt trickle method of irrigation because of the high fixed capital, a nominal subsidy is perquisite to increase the widespread adoption of trickle method of irrigation especially among the resource poor farmers. Besides advocating for a nominal subsidy, the sample farmer suggests four important points to increase the area under trickle method of irrigation in crops like sugarcane. First, the importance about the trickle method of irrigation has not reached among majority of the farmers so far and therefore, its water saving capacity and productivity gains has to be demonstrated clearly and effectively through a quality extension network. Second, credit facility provided by the banks by following the norms of NABARD is not enough for installing trickle set and therefore, the amount of credit should be revised periodically based on the cost of trickle set. Third, per acre/hectare capital cost required for trickle set appears to be very high for all those farmers who want to adopt DMI and therefore, it is essential to find out ways and means to reduce the capital cost of trickle set. The cost of trickle set can be brought down by introducing measures such as zero sales tax or Goods and Services tax (GST), removal of excise and other duties imposed on raw materials used for manufacturing the trickle system. Fourth, as service facilities (technical and agronomic advises) with quality (timely as well as regularly) are essential for the successful operation of trickle irrigation system in any crop cultivation, farmers should purchase the trickle system from those companies/agencies which can provide necessary services whenever needed.

Though the results of the study amply suggest that trickle method of irrigation is economically viable even without subsidy in water-intensive crops like sugarcane, one cannot generalise the results of the study, as it is a case of one farmer. Case study has its own limitations, despite the fact that it allows an in-depth understanding of the issues and solutions for trickle irrigation development. Therefore, the results and evidences presented here are to be taken with extra care, not to be generalised too much. Studies using data from relatively large sample survey need to be carried out to corroborate the advantages (both economic and non-economic) of trickle method of irrigation in water-intensive crops like sugarcane.