An Approach Paper

Why Drip Irrigation should be considered as Infrastructure Industry?

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** As for economics of Drip Irrigation, the Author has depended on Gokhale Institute Mimeograph Series No.47*

1.0 INTRODUCTION: HISTORICAL BACKGROUND:

1.1 Demand-Supply Gap, Growth of Irrigation Water & Water Balance:

Need for water for agriculture, industry and domestic uses has been increasing at a very fast rate in the recent years. Share of uses other than Agriculture has increased. It was 13% in 1985 and will become 27% by 2025. Such a faster growth of water need in the face of emerging supply constraints is likely to result in a supply gap for irrigation water in the near future **(Table 1)**. We are surely heading for growing water stress, if not crisis, before the year 2025. On the other hand, inspite of increase of investment on irrigation sector in the successive plans, the rate of growth of irrigated area has been declining in each plan period. In fact, the average increase of irrigated area is lower in the 1980s when compared to the position of 1970s. Most likely it would be even lower in 1990s than it was in 1980s. **(Table 2).**

Cumulative irrigation potential created by 95-96 is about 75% of the ultimate potential which has been placed at 115 million hectares for the country as a whole.

1.2 Besides these, owing to inefficient & excess use of canal water, a considerable amount of cultivated area mainly from the agriculturally advanced states are suffering from water logging and salinity problems. As per the latest (1990) estimate of the Ministry of Agriculture, the area affected by water logging alone is placed at 8.5 million hectares. This is land lost. Good agricultural land in 17 States has been rendered unproductive. According to yet another latest study, this figure is 20 million hectares - or about 23% of the irrigated area - suffers from salinity. Similarly, 33.72 million hectares of land is reported to be in advance stage of degradation for variety of reasons including waterlogging and salinity.

There has been considerable variation in the figures in regard to waste lands in the country. The CPR, Environmental Education Centre, Madras (in their publication entitled Waste Land Development 1996) has classified the waste lands in India as under :

Water Eroded	73.50 Mha
Degraded Forests	40.90 Mha
Wind Eroded	12.90 Mha
Saline/Alkaline	7.50 Mha
Affected by Sandunes	7.0 Mha
Water-logged	6.0 Mha
Shifting Cultivation	4.56 Mha
Ravines & Gullies	2.97 Mha
Riverine	2.73 Mha
Other Uncultivable Lands	2.40 Mha
Total	**160.46 Mha**

The per capita availability of land in 1950 was 0.89 hectare which got reduced to 0.38 hectare in 1990. By the year 2025, it is expected to be reduced to 0.1 hectare per person. This means only about 1/9th of land of what was available in 1950 shall be available for cultivation by the year 2025. It is, therefore, highly imperative to improve the productivity of available land resources and to save it against all degradation processes (water & wind erosion, waterlogging, salinity, alkalinity, gullies, ravines and shifting cultivation etc.) *Refer Department of Soil Conservation and Water Management, CSA University of Agriculture & Technology, Kanpur. Article by Suraj Bhan - 42/CWC/ND 1997.*

According to Ministry of Agriculture, about 53% of the total geographical area is suffering from one problem or the other and is in different stages of degradation. In quantitative terms, this means 174 million hectares are suffering by land degradation problems.

1.3 Because of these reasons, the first green revolution introduced in the mid-sixties and mainly based on creation of Storage Dams and conveyance through Canals, has lost its shine and vigour.

1.4 During pre-Independence period, cultivated land per agriculturist family was much more than what it is today. There were no cash crops except sugarcane. Because of poor response for utilisation of available water, need to improve water use efficiency was not felt much. After independence, the situation changed rapidly. On one hand because of abolition of Zamindari and implementation of Land Ceiling Laws, land holdings per family reduced in size. On the other hand, percentage of land under irrigation increased as a result of construction of large number of major, medium and minor irrigation dams. In 1970, average size of operational holdings was 2.3 hectares. It has now come down to less than 1.5 hectares.

1.5 It became remunerative to grow cash crops such as sugar cane, long staple cotton, summer ground nut, sunflower, banana, grapes, orchards, vegetables, flowers etc. Utilisation of water for agricultural irrigation improved but there was not much improvement in the water use efficiency. Likewise, requirement of water for competing demands such as urban drinking water and water for industries increased very rapidly making less water available for irrigation of farm lands. These factors successively widened Demand Supply Gap.

1.6 Importance of Irrigation for production of Agri-commodities & Economic Development:

Irrigation is a critical input for increasing the agricultural production and productivity. Without the development of irrigation, we would not have achieved the massive production of food grains. However, the growth rate of food grains productivity in majority of the agriculturally advanced states is almost stagnant in the recent years owing to the poor management of irrigation water, some of its inherent drawbacks and lack of yield increasing inputs. This stagnancy in the yield of food grains have created concern among the researchers regarding the future growth of

production of agricultural commodities and food security.

The water is not only a crucial input for the development of agriculture but also for the development of economy as a whole. To overcome the problems, the available water should be used judiciously and efficiently.

1.7 Will India become net importer of foodgrains?

Estimates show that if we are not able to increase the present rate of growth of production of agricultural commodities, the proportion of population coming below the poverty line is likely to go up which will put heavy pressure on the Indian planners. Although the rate of growth of food grains production is relatively better in the eighties (1980-81 to 1990-91) compared to the earlier decade (1970-71 to 1980-81), there is no guarantee that this growth will continue in the nineties **(Table 3)**. Even a few occasional droughts / monsoon failures may affect the production of food grains and other agricultural produces drastically as still about 68 percent of the Gross Cropped Area (GCA) is cultivated under rain-fed condition. India has been singularly lucky in having very good monsoons in past successive 9 years. However, given the population growth rate and resultant demand-supply gap, we should not be surprised if we become the victims of the Malthusian doctrine in the near future.

1.8 Govt. support for Irrigation likely to reduce:

So far the creation of Irrigation Facilities has been done by Governments on "Total Grant Basis". Even the operating and maintenance cost of these facilities are being vastly subsidized. This situation will change due to the introduction of Structural Adjustment Programme and the new economic policy under WTO. There are compulsions for reduction of Government support for seed, fertilizer, pesticide, irrigation & power. In the long-run, this will affect the domestic production of agricultural commodities adversely. Certainly, given the size of population, importing food grains will be a heavy burden for the exchequer.

1.9 How to reduce inefficiency in water-use?

Given the over-exploitation of water and the multifaceted adverse impact of the irrigation projects reducing per capita availability of land, it becomes necessary to increase the efficiency of water and land use and thereby agricultural production per unit of water and land.

One way of reducing the inefficiency in water use is to increase the resource literacy (information base about a particular natural resources, especially its use rate, pricing, cost substitute and replenishment). This is a difficult task as it has been directly related to relative short run profits and other uncontrolled variables.

For sustainable agricultural production, the run-off must be arrested at the site of occurrence. This can be achieved through different water harvesting techniques such as contour bunding, simple bunding, trenching, ridging, terracing, mulching, stripping and inter cropping. It has been observed in the field studies that these measures increase the yield even of the rain-fed crops by as much as 5 to 13% over the yields from the control plots. (*Rahmankhera studies*) It also helps arrest the run-off of rain water by as much as 10 to 30%. The soil loss was influenced favourably to the extent of 2 to 18%. Together these measures enhance infiltration and improve moisture (water) retention capacity of the soil. The excess run-off can thereafter be stored in natural ponds, dugout ponds, embankment type of storage structure for supplemental and survival irrigation. These watershed and soil conservation measures help increase cropping intensity by as much as 84% and also speeds up recharging of underground aquifers.

The third way of dealing with the inefficiency in water & land use is to bring in fundamental changes in the method of irrigation. New water saving and better land utilisation technologies have been introduced in the recent past. Among these, Sprinkler Method of Irrigation (SMI) and Drip Method of Irrigation (DMI) are the important innovations. These methods of irrigation are broadly termed as Micro Irrigation Systems (MIS). Among these, DMI has a wider acceptance in India and the world except USA.

These technologies can be used both by marginal, small, medium and/or large farmers individually and in command areas by group of farmers. Thus they can help improve water use efficiency even under dam canal system.

1.10 Israel's Example:

Just to cite an example, the effort of Israel during the last 25 years has lead to a 350-400 per cent increase in production per M3 water. They have also been able to reclaim hilly, undulated and waste & coastal lands and make them arable and productive by using DMI. In USA because of large land holdings, Sprinkler Method of Irrigation (SMI) is adopted on large scale for row as well as closely spaced crops.

2.0 DRIP METHOD OF IRRIGATION (DMI) DEFINITION, SCOPE & COVERAGE:

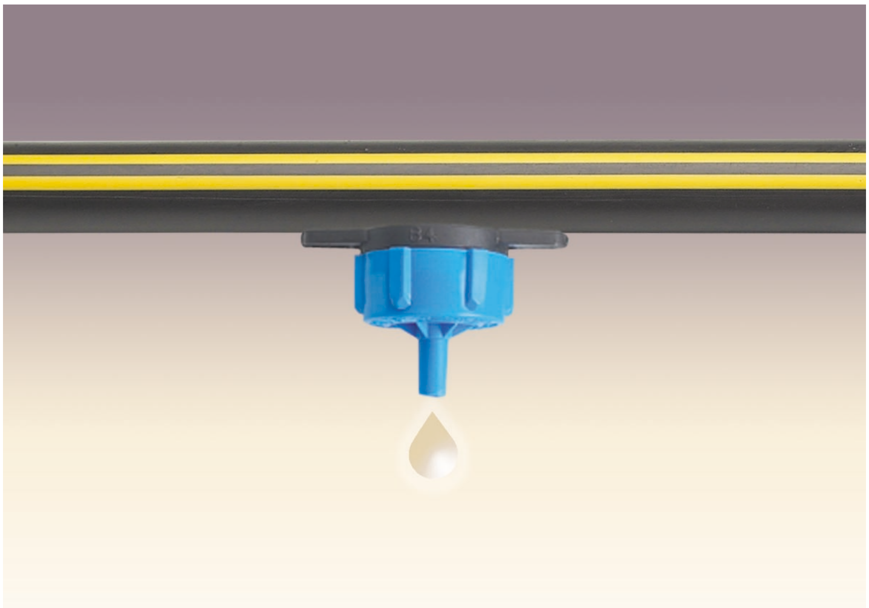
2.1 Drip Method of Irrigation (DMI) & Sprinkler Method of Irrigation (SMI) both together are termed as "Micro Irrigation Systems (MIS)" because the approach involves controlled supply of water in small quantities. Primarily DMI was used for growing vegetables in Israel and Israel could achieve the high productivity despite acute water shortages. DMI & SMI are entirely different from the Flood / Flow Method of Irrigation (FMI).

2.2 Under DMI, water is supplied only at the root zone of the crop with the help of emitters and a network of pipes. It acts as mechanical meter and ensures supply of water and other nutrients at right time, in required quantity and at appropriate place i.e. the root zone. As the water is supplied only at the root zone, the conveyance, distribution and evaporation losses are avoided. DMI is found to be ideal for horticultural plants and row crops such as Cotton. Under DMI, water use efficiency is as high as 90%.

2.3 Under SMI, crop is irrigated by overhead sprinklers which can be either stationary or mobile. This method suffers from an inherent drawback. It works under pressure and the wind direction plays a major role whereby excess irrigation in the direction of the wind seems to be occurring as against the portion which is opposite to the wind direction. In the same manner, the moving parts of SMI also pose serious maintenance problems. However, for food and cereal crops the method has been used on large scale in USA. In USA the farm holdings are as large as 1000 - 5000 acres at a stretch. Comparatively in most of the areas, the availability of water is also pretty good. They, therefore, use overhead mobile sprinkler system for irrgating the closely spaced crops such as cereals, wheat, soyabean and vegetables including onions and potatoes. As pointed out elsewhere, water use efficiency under SMI is around 75%. That apart, the Centre Pivot Systems are suitable only for large areas and are costly from small farmer's point view.

2.4 Over the past two and half decades, the hardware used in MIS has been perfected. The knowledge about the system interaction (software) - soil, plant, water and atmosphere has improved. As a result, the management of MIS including DMI has become a lot more reliable and is helping increase water use efficiency.

2.5 The experience of the countries which use drip irrigation extensively for crops, indicate that drip irrigation is economically feasible, socially acceptable and environmentally protective. It is being widely used in the countries like USA, Spain, Australia, South Africa, Israel, Italy etc. A recent worldwide survey conducted by the International Commission on Irrigation and Drainage (INCID) has identified that DMI & SMI are being practised in 35 countries. Among the countries, United States occupies the first place with about 33 per cent of the area in the world. India occupies seventh position with nearly four per cent of the world area.

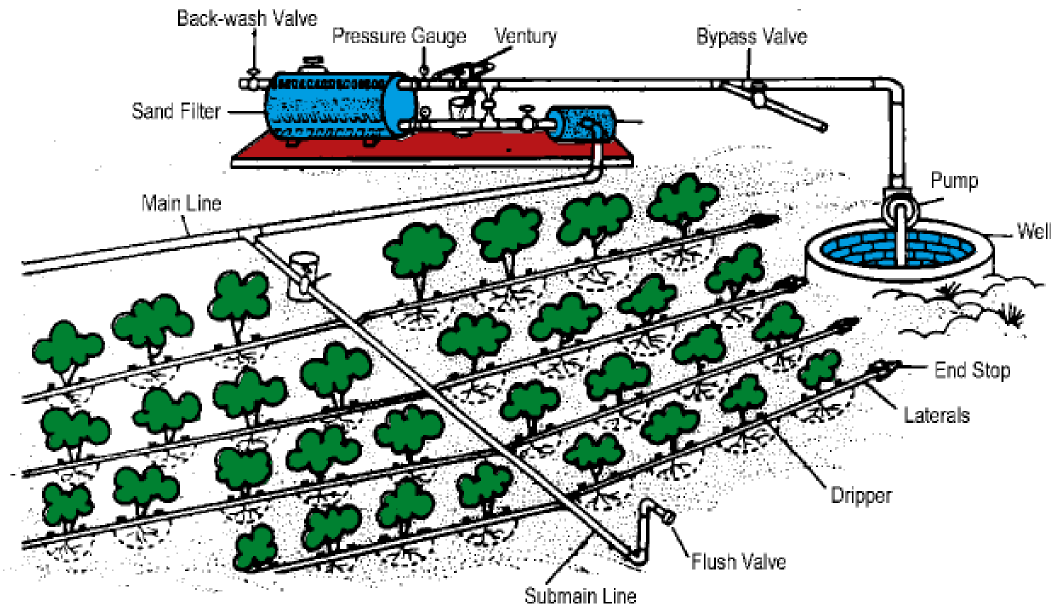


3.0 WATER USE EFFICIENCY:

(Drip Method of Irrigation v/s Flood Method of Irrigation; Cost of Water Storage v/s Water Saving:)

3.1 Traditional method of water delivery (FMI) consists of application of water to 'the field' and not to 'the crop'. Water is delivered by field channel to the field, on which crop is grown. When the concept of 'crop water requirement' came into beng, shortcomings of the conventional system were glaringly brought out. Theoretically, an efficient water delivery system would be the one which would match the quantum of water delivered, with the water requirement of crop during all stages of crop growth, from its sowing to maturity. Conventional system delivers about 8 to 10 cm. of water at one time during each rotation, even if crop requirement happens to be less or more. It means that, firstly there is wastage of water by way of deep percolation loss and secondly, the crop remains under water stress during nearly half the rotation period.

3.2 As against FMI, the on-farm water use efficiency of properly designed and managed DMI is about 90 per cent whereas it is about 75 per cent for SMI. The studies conducted in India on conventional FMI have confirmed that irrigation efficiency is only 35-45 per cent owing to enormous conveyance and distribution losses of water. Estimates show that the total water loss in unlined canals for water conveyance is as high as about 70% - about 15% in canals, 7% in distributories, 21% in water courses and 27% in farm fields (Chaudhari, 1995). One can also put land to greater intensive use with the help of MIS. DMI also can bring uncultivable land under use. Even cropping intensity can be and has been increased under MIS. In time to come, DMI will be the way to the next stage of development for water use efficiency even in India.



3.3 The largest dam in the country is Bhakra - Nangal which has maximum live storage capacity of 7190 Mn M3. If the entire quantity of water is to be used for farming purposes, the total loss of water due to conveyance will be as high as 70% i.e. 5033 Mn M3. Consequently, the net water available for plants / crops will be 2057 Mn M3 (Mcum).

It is estimated that in order to create equivalent capacity of Bhakra - Nangal, at current prices, the total cost would be over Rs.5000 crores. It is, therefore, apparent that in order to use 2057 Mn M3 of water for agricultural irrigation, investment required for creation of water resource is Rs.5000 crores.

If we adopt DMI for irrigating one million hectare of horticultural crops, we save 37.5 Mn M3 of water per day which means 37.5 Mn M3 x 270 days = 10125 Mn M3 of water per year. In other words, use of DMI will create additional irrigation potential to the extent of 10125 Mn M3 of water at a cost of Rs.4000 crores (Cost of DMI at Rs.40,000 per / ha X one Mn Ha).

The use of 2057 Mn M3 of water for agricultural irrigation will today cost the nation Rs.5000 crores. As against this, the country can save as much as 10,125 Mn M3 of water at an investment of Rs.4000 crores. This means that apart from saving capital expenditure of Rs.1000 crores, we would also generate 5 times the irrigation potential by use of DMI. Here we have not considered the cost of capital incurred during long gestation period and socio-environmental problems which are inherent in building of Dams and Canals.

3.4 Effect of introducing DMI in place of FMI on a dam-canal system is considered here to compute saving of water. This exercise can be alternatively done as follows:

We assume that 100 units of water are released at the canal head and we see how much the crop gets.

No. of Units available	At	FMI losses	Losses in unlined	DMI losses	No. of Units available	At
100	Canal head				100	Canal head
			15	Canal	15	
85	Disty head				85	Disty head
			7	Disty	7	
78	Minor head				78	Minor head
			21	Minor	21	
57	At chak head				57	At chak head (from where DMI starts)
		27	Field	6 (10%of57)		
30	At field	-		-	51	At field
				70		49

This means that because of higher efficiency of DMI (90%) out of 57 units released, 51 units are available as against only 30 units under FMI.

Let us work out saving of water for Bhakra Dam:

	By Flood Method of Irrigation (FMI)	**By Drip Method of Irrigation (DMI)**
Live storage	7190 Mcum	7190 Mcum
Losses 70%	5033 Mcum 49%	3523 Mcum
Net water available for plants	2157 Mcum	3667 Mcum

Extra water available = 3667 - 2157 = 1510 Mcum

(Gross storage of Bhakra Dam is 9620 Mcum and live storage is 7190 Mcum).

Assuming that 1 Mcum would irrigate about 100 Ha and present cost of dam & canal to irrigate about 1 Ha would be about Rs.70,000 (for major project), cost of Bhakra dam-canal system would be: 7190 x 100 x 70,000 = say Rs.5000 crores.

If we introduce DMI on entire Bhakra project, about 1510 Mcum of extra water would be available. This water can be used for extensive irrigation outside the comand. But it would require additional expenses for infrastructure and vitiate cost economics.

Alternative would be to provide intensive irrigation on the Bhakra command, by introducing higher percentage of perennial crops and/or increasing crop intensity (which is natural course with introduction of DMI) so that water saved is used entirely on Bhakra command to increase productivity.

Unde FMI, Bhakra Dam would irrigate 7190 x 100 = 7.19 lakh Ha.

Cost of providing DMI @ Rs.40,000/Ha would be:

7,19,000 x 40,000 = 2876 or say 2900 crores.

(1) So, at a cost of 5000 crores, we get 2157 Mcum of net water by FMI on Bhakra system i.e.@ 5000 / 2157 = Rs.2.3 crores /Mcum.

(2) By introducing DMI at a cost of 2900 crores, we get 1510 Mcum of net water from Bhakra system i.e. @ 2900 / 1510 = Rs.1.92 crores /Mcum.

It means that by introducing DMI, cost of water saved is less than the cost of water stored.

Life of dam is more than 100 years whereas life of DMI infrastructure is 10 to 20 years. It requires maintenance as well. If we take these factors into consideration, following picture emerges:

	FMI		DMI
Capital cost	5000 crores		2900 crores
Interest @ 15%	750 crores		435 crores
Depreciation @ 1%	50 crores	@ 10%	290 crores
Maintenance & Repairs @ 1%	50 crores	@ 2%	58 crores
	5850 crores		3683 crores

With these values:

At 5850 crores, we get 2157 Mcum of water @ 5850 / 2157 = 2.71Cr/Mcum

At 3683 crores, we get 1510 Mcum of water @ 3683/ 1510 = 2.43 Cr/Mcum

It means that even after considering depreciation, cost of water saved by introducing DMI is less than cost of water stored.

3.5 Introducing DMI on Private Well:

For introducing DMI on private well where irrigated area ranges from about 1 ha to 5-6 ha, picture would change slightly. As the length of water conveying channels is small and they are well maintained (by the owner), conveyance losses upto field would not be more than 8-10% against 43% (15 + 7 + 21) for dam-canal systm. As the field is levelled, field losses would also be less than 15 - 20% against 27%. Following can be the saving :

No. of Units	At available	FMI	Losses in losses	DMI unlined	No. of Units losses	At available
100	Well				100	Well
		10	Watercourse			
				10		
90	Field	20	Field			
70	Crop	-		-	90	Crop
		30		10		

It means that as against 70 units by FMI, about 90 units are available to the crop by DMI. The increase in this case is about 30% because of DMI.

For a well irrigating 5 ha, losses with FMI would be more and saving with DMI would increase to at least 35 to 40%, if not more.

About 70% extra water would be available if DMI is introduced on major projects. This percentage reduces to about 30 to 40% if DMI is introduced on well irrigation. Cost economics calculations would also change accordingly.

4.0 OTHER MAJOR BENEFITS OF DRIP METHOD OF IRRIGATION

DMI has many advantages over the conventional FMI. For comparative advantage of DMI over FMI, please refer to **Table 4**.

4.1 Water Saving:

As mentioned earlier, since it supplies water through a network of pipes, conveyances, distribution, evaporation losses of water are minimal in DMI compared to FMI. Under DMI, the management of water is also very simple and one labour can easily manage up to 10 hectares of land. Available results in this regard show that water saving under drip irrigation ranges from 40 to 80 per cent compared to flood method of irrigation **(Table 5)**. As per NCPA, water saving upto 100% has been observed for certain crops cultivated under DMI.

A million hectares of horticultural crops under DMI will save water to the extent of 37.5 Mn M3 per day (Total required quantity per day per Ha is 75,000 litres and saving is assumed to be about 50% hence 37,500 litres per Ha per day). If one million hectares are brought under DMI in the country, it will result in saving of, say, 37 million M3 per day or 10,000 million M3 per year (on the basis of 270 days in the year) as explained elsewhere in this paper.

4.2 Electricity Saving:

Studies related to drip irrigation have shown that it helps save energy. By reducing the number of working hours of pumpset, it significantly reduced the consumption of electricity. A field level survey conducted in Maharashtra has shown that farmers who cultivate crops under DMI could save about 2430 Kwh/ha in banana and about 1470 Kwh/ha in grapes compared to flood method of irrigation. Further the estimate also shows that farmers can save about Rs.1217 / ha in banana and Rs.738 / ha in grapes in electricity bill alone by taking to drip irrigation **(Table 6)**.

4.3 Yield Gains:

Yield of crops cultivated under DMI is substantially higher than the crops cultivated in the same agroclimatic conditions by FMI. Under DMI the availability of water and nutrients is very close to the root zone and at required time interval in just adequate quantity. Yield increase of 20 - 100% has been noted by researchers **(Table 5)**.

There are two main reasons for higher yield for crops under DMI. Firstly, unlike FMI, DMI supplies water at regular intervals at the root zone of the crops which does not create moisture stress for crops. Likewise since it supplies water in small quantities at a time, there comes no situation wherein the crop suffers because of excess water given at one time. In FMI, too much of water is applied on the first day and moisture keeps on reducing subsequently. This is the case of overwatering or saturation more than field capacity. This also results in leaching of water or deep percolation beyond the root zone of the crop and resultantly crop growth and productivity is retarded.

Drip method does not allow much weed growth which ultimately helps increase the yield of crops. Disease and pest problems are relatively less under DMI.

4.4 Hasten or Delay Maturity:

DMI can either delay or hasten maturity of the crop. In this manner, the farmer can harvest the produce at a time the prices in the market are favourable to him. Thus DMI acts as a management tool for realising higher value for the same unit of crop.

4.5 Uniform Size & Better Shine:

It has also been observed that the horticultural fruits or row crops taken on DMI result in uniform size and improvement in colour and size of the produce. The need for grading is, thus, minimised and customer preference for such fruits increases. It has been observed that uniform size & better colour fetches at least 10% higher price compared to crops taken under FMI.

4.6 Saving in Cost of Cultivation & Inputs:

DMI reduces the cost of cultivation especially in operations like labour, tilling, weeding and also in fertiliser use compared with FMI. Studies conducted in Maharashtra and Tamil Nadu using field level data in case of certain crops have found a reduction of 50-60 per cent in weeding cost. Since fertilisers are supplied along with water (which is called fertigation) for the crops, the wastage of fertiliser through leaching is substantially reduced compared to conventional methods like basal and top dressing. As a result, fertiliser use efficiency increases significantly and DMI is known to reduce the consumption of fertiliser by 30 to 50 per cent.

4.7 Protecting and Developing Environment:

Since DMI supplies water at the root zone of the crop, it saves the soils from getting degraded or saline. It also avoids soil erosion and saves lands by not allowing top soil and neutrients to run-off.

Unlike FMI, DMI is the only technique which can bring all types of lands under use: undulating terrain, rolling topography, hilly areas, culturable waste and barren lands, old fallow lands, shallow soils, coastal & sandy soils as well as water scarcity and/or water logged areas.

DMI can also treat/ filter and use saline and even sewage water.

It has been observed that in major agricultural belts, the quality of water has changed. This has been due to over-use of fertilizers, insecticides and pesticides. DMI helps avoid the situation because it only accommodates pre-determined quantities of these inputs.

4.8 Recharging and increase in green cover:

Combined with water harvesting programme, the water savings can be used for recharging of underground aquifers. Since water saving can be attained up to 40 - 100 per cent, the water saved could be diverted to increase the green cover (agricultural, horticultural and forestry crops). DMI indeed ushers in a new more friendly and beneficial ecological regime. Use of sewage water through DMI using proper filter is perhaps the best example of minimizing of pollution of the environment.

4.9 Bringing about Greater Social Justice and Equity in Distribution:

One of the major problems of FMI & canal system is that the tail enders of command area do not get water from canal system due to over use of water by the head reach farmers. As a result, there is always a tension between head and tail end farmers. As the canal system is vast in size, there are some built-in constraints for the irrigation authorities in distributing the water equitably. Unlike this, DMI can be used to mitigate the hardships of those who are deprived of this important input, because it is not location specific. DMI thus can also be used as a tool for removing these problems which are inherent in the canal system.

DMI can be applied even for group farming or for the entire society of canal water users in an equitable manner. It is feasible under DMI to give pre-defined quantity of water. DMI ensures increased produce and higher monetary returns to the beneficiaries.

4.10 Better Benefit-Cost Ratio:

Studies relating to benefit-cost (B-C) analysis of drip irrigation has shown impressive results. The results of different crops show that the B-C ratio excluding water saving is up to 13. It goes up to 32 when water saving is considered on the income side **(Table 7)**. Moreover, DMI's relative initial capital cost is low when compared with the average capital cost of the FMI which are generally owned and operated by the Government/s. For instance, during the Seventh Plan, on average the investment requirement to create one hectare of irrigation in major and medium irrigation was over Rs.50000. In the Ninth Plan for Major Dams, it is likely to be close to Rs.70000 per hectare of land irrigated. Available figures suggest that the cost per hectare of land irrigated through Medium Dams is Rs.1,25,000 and through Minor Dams it works out to be as high as Rs.2,00,000. Thus, the cost of developing new water sources

has been growing. As against this, capital cost per hectare of DMI varies between Rs.10,000 to Rs.40,000 as on date.

4.11 DMI increases shift from conventional crops for higher value addition:

There is a noticeable shift from conventional Kharif & Rabbi cereals and such other crops to fruits & vegetables as well as perennial plantations. Over 90% of the DMI farmers adopt to horticultural crops. They are able to realise and add greater value per acre of land and per litre of water used by them. They commercialise agricultural operation with the help of DMI.

4.12 DMI ensures higher employment generation, intensive water, land & crop utilisation and improves repaying capacity:

DMI facilitates more intensive cropping pattern and more intensive use of water per acre. Thus, cropping intensity for drip adopters is found to be around 240% as against about 200% for non-drip farmers. Irrigation intensity for drip adopters is about 250% as against about 210% for non-drip farmers. The farmer who earns higher profits is also in a position to pay higher wages to the farm labourers and also improve his capacity to repay the bank loans. It has been researched that DMI improves recovery climate on account of favourable economies of the system.

4.13 DMI promotes self-sufficiency:

This technology will help for promoting self sufficiency in the production of non-food grain agricultural commodities in the long run. This is entirely different from the conventional methods where the Government support is perennially essential. As it is, the government is no longer in a position to support the conventional method of irrigation as it has done earlier due to financial and other constraints which are increasingly surfacing during past few years.

4.14 DMI ensures instant benefits:

Unlike the Government owned major and medium irrigation projects, this technology requires no gestation period. This itself is good enough a reason for which it needs to be supported wholeheartedly. It saves on cost of capital (interest) in addition to immediate returns to the beneficiary. It is therefore far more efficient to use available storage facilties with DMI, rather than plan and create new storages at huge cost and gestation period.

4.15 Export potential of crops under DMI:

Apart from increasing the production and productivity of many commercial crops, it will also increase the export earnings as most of the crops suitable for DMI have a good export potential and markets. Improvement in quality of all the horticultural and vegetable crops will promote exports. Additionally these are the crops which lend themselves to lot of value addition.

5.0 BENEFITS & COST COMPARISON OF FMI & DMI IN MONETARY TERMS

5.1 The benefits enumerated in Points 3 & 4 can be grouped under two headings:

(a) Benefits which can be quantified and converted into monetary gains.

(b) Benefits which can't be quantified in monetary terms.

5.2 Benefits which can be quantified and converted into monetary gains :

In the table below, it is assumed that the total cultivable farming land available is one million hectare. In absence of adequate source/s of irrigation, half of the land is under FMI for horticultural crops while other half is Rainfed. However, given the same quantity of water under DMI, one can irrigate total one million hectares under horticultural crops.

Assumption :

Area Irrigated	Under FMI	Water	Under DMI Requirement	Water Requirement
Rain-fed Crops	0.5 Mn Ha	NA	NA	NA
Horti. & Cash Crops	0.5 Mn Ha	*37.5 Mn M^3/day	1.0 Mn Ha	*37.5 Mn M^3/day

* For horticultural crops under FMI, the water requirement is assumed to be 75 M^3 per day per hectare. Water saving under DMI is assumed at 50% i.e. 37.5 M^3 per day per hectare.

The Table 'A' appearing in next page is an exercise which vividly brings out the monetary gains that can be ascribed to DMI as compared with FMI for one hectare of land. The net incremental income to the one hectare farmer is Rs.49,250, say Rs.49000. If one million hectares of land is brought under DMI, it adds net amount of Rs.4900 crores to the GDP of the country as shown in the Table 'B'.

Table 'C' compares per Hectare Cost of construction of New Major Dams as against saving water through DMI. This approach also concludes that cost of saving water through DMI is just about 50% of cost of creation of new storages.

Table `D' compares 2 projects with closed pipe conveyance cost with or without drip cost. Cost of introducing pipe conveyance for M.I. project would be at least Rs.75,000 per hectare as against introduction of drip system at Rs.48,000 per hectare.

Two of the Tables deal with the same subject but represent 2 points of you : conservative & optimistic.

Table 'A'

Cultivation Cost, Gross & Net Income for one hectare of land under FMI v/s DMI

Fig. in Rs.

Sr.	Particulars	FMI	DMI
01	**Area Considered**		
	(i) Under Rainfed Crops	0.5 Ha	N.A.
	(ii) Under Horticultural & Other Cash Crops	0.5 Ha	1.0 Ha
02	**Cultivation Cost**		
	(i) Rainfed Crops		
	(a) Seeds	700	
	(b) Fertilizers	875	N.A.
	(c) Crop Protection	550	
	(d) Labour & Others	875	
	Sub Total	**3,000**	
	(ii) Horticultural & Other Cash Crops		
	(a) Planting Material (Rs.30,000/Ha amortised over 20 years)	750	1,500
	(b) Fertilizer (25% saving)	6,250	9,375
	(c) Crop Protection (50% saving)	1,750	1,750
	(d) Labour & Others (50% saving)	7,125	7,000
	(e) Electricity (50% saving)	1,875	1,875
	(f) Interest on capital investment of Rs.40,000 @ 15%	N.A.	6,000
	(g) Depreciation on capital investment of Rs.40,000 @ 10%	N.A.	4,000
	Sub Total	**17,750**	**31,500**
	Total Cultivation Cost	**20,750**	**31,500**
03	**Gross Income**		
	(i) From Rainfed Crops	7,500	N.A.
	(ii) From Horticultural & Other Cash Crops	37,500	1,05,000
	Total Gross Income	**45,000**	**1,05,000**
04	**Net Income [(3) - (2)]**	**24,500**	**73,500**
05	**Net Incremental Income**	-	**49,000**

Table 'B'

Cost Comparison of FMI v/s DMI in Monetary Terms For One Million Hectares of Land.

Figs. in Crores of Rs.

Sr.	Particulars	FMI Horti.	FMI Rainfed	FMI Total	DMI Horti. Total
01	Gross Income	3750	750	4500	10500
02	Less Cost of Cultivation including Interest and Depreciation.	1750	300	2050	3150
03	Net Income	2000	450	2450	7350
04	Incremental Income under DMI v/s FMI / Per Yr (7350 less 2450 = 4900)	NA	NA	NA	4900
05	Total Capital Investment (1 Mn Ha x 40000 Per Ha)	NA	NA	NA	4000
06	Therefore Payback Period (Investment 4000 Cr. Net Income 4900 in one year)	NA	NA	NA	Less than One Year
07	Total Subsidy (at 60% of 4000 Crores spread over 10 years)	NA	NA	NA	2400
08	Per Year Subsidy Required. (2400 ÷ 10)	NA	NA	NA	240
09	Therefore Addition to GDP (4900 ÷ 240)	NA	NA	NA	20 Times

Table 'C'

Cost Economics of Major Dam Project V/s DMI - An Example

Assume a typical major proejct having live storage of 500 MCum irrigation of 50,000 Ha and @ Rs. 80,000/Ha cost of the project would be Rs. 400 crores.

If we assume construction period of 12 years actual cost of the project with 5% escalation and 15% interest would be as below:

Year	Balance cost at the start of year	%age of expenses during the year	Actual expenses in crores	Updated expenses @ 15% interest each year in crores	Balance cost in crores	Escalation @ 5% at end of the year in crores	Balance escalated cost in crores
1	2	3 (Col. 8)	4 (2x3/100)	5	6 (Col.2-4)	7 (5% of Col.6)	8 (Col. 6+7)
1	400	2	8	21	392	20	412
2	412	6	25	63	387	19	406
3	406	10	41	96	365	18	383
4	383	15	57	125	326	16	342
5	342	20	69	141	273	14	287
6	287	25	72	137	215	11	226
7	226	33	75	131	151	8	159
8	159	40	64	102	95	5	100
9	100	40	40	58	60	3	63
10	63	50	31	40	32	2	34
11	34	60	20	23	14	1	15
12	15	100	15	15	-	-	-
Total			**517**	**952**		**117**	

Updated expenditure in Col. 5 is computed as below :

For example year 4 - Col.4 (1 + [12-year No.] x 0.15) = 57 x (1+[12-4]x0.15)

= 57 x 2.2 = say 125

Observations :

A. Calculations as above show that present cost of the project (Rs.400 crores) if escalated @ 5% and with interest @ 15% on investment each year works out to Rs.952 crores. Hence cost/Ha of irrigation on completion of the project would be Rs.952 crores/50,000 = say Rs.1,90,000.

Project cost of introducing DMI is Rs.40,000/Ha.

At an escalation of 5%, probable cost of introducing DMI would be :

Rs. 40,000 x (1+[12-1] x0.05) = Rs.40,000 x 1.55 = Rs.62,200/Ha.

B. Because DMI would save 70% water after its introduction, comparable cost which would save 100% water would be : Rs.62,200/0.70 = say Rs.90,000/Ha.

C. As against cost of Rs.1,90,000/Ha for major dam unlined canal system, cost of introducing DMI system would be Rs.90,000/Ha.

D. Even if we add 11% (10% for depreciation and 1% for extra maintenance cost) to this rate because life of DMI is 10-20 years as against 80-100 years from irrigation project, we get DMI cost/Ha as Rs.90,000+9,900 = say Rs.1,00,000.

Still it is nearly half that of dam-canal cost/Ha.

Conclusion:

The construction of Dams and development of DMI are not substitutes or alternatives. They are complementary to each other. DMI pre-supposes availability of water sotrage in the form of Dam or Well. Given the limited financial resources, if we are to compare the cost of introduction of DMI on the existing water source as against creation of new water storages, DMI without doubt is a far better and beneficial method of achieving the same purpose. Moreover, if cost of creation of water storages & irrigation through Minor Dams is considered, the difference will become far more glaring. Irrigation through DMI as compared to irrigation through Minor Dam will cost almost one fourth/Ha.

Table "D"

Closed Piping for Conveyance v/s Drip Irrigation

Sr. No.	Particulars	Pipardi MI Project Tq. Sihor Dist. Bhavnagar	Madkhol MI Project Tq. Sihor Dist Bhavnagar
1.	Gross storage	74.88 Mcft	79.50 Mcft
2.	Live storage	66.85 Mcft	59.86 Mcft
3.	Irrigable area	280 Ha	110 Ha
4.	Cost of complete pipe distribution (incl.10% contingencies)	211.00 lakhs (DSR 88.89)	77.45 lakhs (DSR 94.95)
5.	Escalated cost @ 5% ex. each year (97 - 98)	211 x 1.45 = 306 lakhs	77.45 x 1.15 = 89 lakhs
6.	Cost / Ha	= 69,000	= 81,000
7.	Cost of drip system including storage ponds.	= 92 lakhs	*
8.	Escalated cost (97-98)	= 133 lakhs (92 x 1.45)	*
9.	Drip cost / Ha (97-98) (with storage ponds)	= 48,000	*

* Drip system not proposed for Madkhol MI Project.

Water Saving in the above Model

Sr.	Particulars	M.I. Conventional FMI	M.I. with drip DMI	M.I. with pipe distribution without drip FMI	M.I. with pipe distribution & drip DMI
		Losses	Losses	Losses	Losses
1.	Water released at	100 Units	100	100	100
	canal head	40	40	5	5
2.	Water at field	60	60	95	95
		30 (50%)	6 (10%)	47 (50%)	10 (10%)
3.	Water to crop	30	54	48	85
4.	Percent increase with ref. to (1)	80%	60%	183%	

Cost of water saved by drip alone = 48000 / (54-30) = Rs.2000 / Unit of water

Cost of water saved by pipe distribution alone = 75000 / (48-30) = Rs.4170 / Unit of water

Cost of water saved by pipe distribution and drip system = (48000 + 75000) / (85-30) = 123000 / 55 = Rs.2240 / Unit of water

Hence introducing pipe line distribution system without drip is not an economical proposal.

Observation:

Cost of drip alone and pipe distribution with drip is fairly comparable. Pipe line distribution has the added advantage that no land is required for the conveyance system and the same can be brought under irrigation. The advantage is sizeable because of high cost of land under irrigated agriculture. It is partly offset by the land required for constructing storage ponds for the drip sytem.

5.3 Benefits which do not easily lend themselves for quantification or conversion into monetary terms:

(i) Culturable waste lands and old fallow lands can be made cultivable. Hilly & undulated lands can be made arable. Saline lands can be made productive. Saline & sewer water use for irrigation is possible:

But for DMI it would be very difficult if not impossible to convert waste, hilly, undulated and saline lands into productive and cultivable fields. Similarly, saline and sewer water cannot be used for irrigation in FMI but can be gainfully used on partial treatment for irrigation through DMI.

(ii) Speedier use of Bio-fertilizers is achieved. Use of DMI along with hi-tech agro inputs alone can create exportable surpluses of quality produce acceptable in the overseas markets:

The use of Bio-fertilizers and genetically superior planting materials including organic manure produced through vermiculture can be speeded up only with the help of DMI. It is observed that creation of manure through existing compost method takes as much as nine months to a year before it is fit to be used in the farms. Under the latest technique of vermiculture, agricultural waste including grass, weeds etc. when mixed with cowdung and processed by certain types of earthworms, can produce a far better quality organic manure within less than 60 days. Thus the possibility of speedier use of Bio-fertilizers can be achieved only with the help of DMI. In short, the intake and use of hi-tech agro inputs is vastly facilitated by DMI. Under FMI, it is simply not possible to use hi-tech agro inputs. And without the use of hi-tech agro inputs, it is difficult to create exportable surpluses of quality produce acceptable in the international markets.

(iii) Higher employment generation:

Use of DMI on one million hectares would create 3.5 million jobs per year by way of Direct Employment and 1 million jobs by way of Indirect Employment. Direct Employment includes plantation, fertigation, pest control, inter cultivation, weeding, harvesting, grading, packing, loading etc. It also includes excavation and back filling. The semi and skilled workers are required for pipeline fittings, drip installation and maintenance. Professional services of electricians, mechanics, agronomists, engineers and technicians are also required for the purposes of preparation of seed beds, operation and maintenance of DMI.

Indirect Employment includes manufacturing companies, other conventional agro input companies, hi-tech agro input companies, tractor and machinery companies and transporters, brokers, traders & other related people.

This being reality, it is experienced and researched that DMI does not reduce employment but instead generates higher employment and also adds value and skill to the available working people. It makes them knowledge workers rather than use them only as manual workers.

In short, it may be noted that DMI encourages far more intensive utilisation of land/crop as well as water per unit. It is, for example, possible to take 2 or even 3 crops in a year by rotation. It is also easy to inter-cultivate other crops. In addition, it leads to higher productivity / yield per unit of water, land and other resources used.

(iv) Protection and improvement of environment is guaranteed :

The polluted saline and sewage water, when left without treatment and uncovered, create enormous amount of air pollution as well as other water-borne diseases and also spoil the lands through which such waters travel. In the same manner, the chemical fertilizers when applied by conventional methods also leach out beyond the root zone of the crops and pollute underground water sources. Under DMI, the fertigation is restricted to the root zone and consequently fertilizers do not get leached and do not pollute the water sources. It also avoids degradation of soil. This helps in avoiding pollution of sub-surface water. DMI creates its own micro climate and reduces the surrounding temperature and it can create, when required, the desired degree of humidity. In short, it creates an improved overall environment and also protects the air as well as water resources.

6.0 PRESENT STATUS OF DMI TECHNOLOGY IN INDIA:

6.1 Competition will ensure quality supply:

It is also possible that by giving the status of infrastructure to MIS, many new companies will enter into MIS industry which will lead to healthy competition among the companies and ensure better quality and continuous improvement so vital for growth of any industry.

6.2 Present Quality is Good & Cost Effective:

In the 3500 sample farmer study, 85% of the farmers considered that indigenous technology compared favourably with the best in the international technology. All of them considered that the indigenous technology was more cost effective in the given situations. However, larger size of the industry will ensure greater exposure to advanced technology and provide impetus to indigenous industry for improvement.

6.3 High Market Share of few Manufacturers:

Presently there are 5 manufacturing firms which contribute 78% of DMI hardware. Even among them, one single firm contributes 59%. Of late, there has been mushrooming growth of small manufacturers / suppliers. As many as 25 such units operate in Maharashtra while 12 in Karnataka and 4 in Tamil Nadu. 35% of the sample farmers in the above study stated that quality of the products supplied by these small manufacturers / suppliers is not upto the mark and nor are their after sale services satisfactory..

6.4 Regional Imbalance in Coverage:

As far as regional coverage under the technology is concerned, it is highly lop-sided and is confined mostly to 4 states viz. Maharashtra, Karnataka, Tamil Nadu & Andhra Pradesh. They account for 85% of the coverage under Drip irrigation in India. Maharashtra alone accounts for over 50% of the total area under DMI in the country. Either as a cause or consequence, major manufacturing firms are also concentrated in these very states.

6.5 Perception of Manufacturers & Farmers:

DMI manufacturers complain of inordinate delays in subsidy disbursement, profound confusion in its valuation and extraordinary questionable practices in its sanctioning process and procedures. Farmers complain of lack of demonstration farms, operation & maintenance, training facilities, after sale services and availability of spares from the manufacturers.

6.6 The Central Government has recognised the significance of promoting DMI. Some of the States mentioned above have also joined the Central Government for boosting DMI. They perceive DMI as a technique for saving water. However, DMI should be considered as the management tool and technology for improvement of yield & quality. Notwithstanding the perception at the macro level, in practice it is observed that for lack of proper training & extension, not only of the farmers but also that of the concerned official, the DMI has not caught on. The yet another hindrance in promotion of DMI is administration of subsidy schemes by the Govt. Thus, there is a wide gap between policy perception and practice. In the same manner, the banking industry which plays a pivotal role in supporting new technologies, has also not taken up the matter very seriously. Credit delivery for DMI is difficult and cumbersome.

7.0 WHY DMI HAS NOT CAUGHT ON, ON LARGE SCALE, IN INDIA?

7.1 No Demonstration:

It has been researched that 86% of the beneficiary farmers installed the systems only after witnessing a functioning system in the field of some other farmer. The farmer is a practical individual with high common sense. He, therefore, does not go by any theory or lectures or sales talk. He wants to see the demonstration. The progress made for establishment of demonstration centres by PDCs, State & Central Government Agencies as well as the Industry has been less than satisfactory. The dissemination of information, therefore, has been slow resulting in slow acceptability of the system.

7.2 Low Bank Credit Support:

Inadequate credit support by banks has been yet another problem faced by the farmers. For example, the banks need a "No Due Certificate" from other banks. The farmer is not in a position to provide the same because for his other needs, he would have already borrowed funds from other co-operative societies, scheduled or nationalised banks.

The banks also insist on making the loans available only as per the scale of per hectare cost specified by NABARD. The actual cost is always higher than the NABARD norms which are not revised on annual basis. The subsidy amount is linked to the per hectare cost of the system as determined by the implementing government department or agency. The NABARD unit cost and departmental unit cost are not always the same. This, therefore, creates lot of confusion. To complicate the matter further, the banks do not finance the subsidy portion and insist that subsidy amount should be deducted from the loan amount even if it is not received by the farmer.

The whole approach and lengthy procedure have disuaded farmers from availing loans from the banks. Consequently, DMI has not received required credit support and suffer for want of easier credit delivery mechanism from the financial institutions. In a major study covering over 3,500 farmer beneficiaries, 58% of the sample considered that financial constraint was responsible for the low level of coverage of DMI.

7.3 Scale & Administration of Subsidy:

The largest single constraint, however, is the problem related to the scale and administration of Drip Subsidy Scheme/s by the concerned government agencies.

It begins with Central Government not making the funds and/or guidelines available in time to the State Government. The State Governments in turn take their own time to formulate guidelines on year to year and crop to crop basis. These guidelines along with Central Government funds and matching contribution by the concerned State Government are then transferred to the implementing agency which is different in each of the State. In some States, it is Department of Agriculture, in others it is Department of Horticulture, in few cases this is done by State Agro Corporations and so on. There is, therefore, no uniformity or time limit fixed for all the steps to be completed.

The subsidy proposal requires minimum of 26 documents to be submitted before it can be considered by the concerned authorities. The transfer of the papers from gram level to the designated level is treacherous, time consuming and involves payment of speed money at most of these stages.

The State Governments sometimes operate their own scheme/s in addition to the Central scheme. The states may choose to give subsidy for a given crop while the same is not admissible under the Central subsidy guidelines. This also creates lot of confusion and many times different departments are assigned the implementing role for such different subsidy schemes.

Above all, it has been noted that subsidy payment by the States to the farmer/s or their nominee/s such as the manufacturers / suppliers is inordinately delayed by as much as 6 to 15 months. The States are found to either divert the Central subsidy for some other use or is not in a position to provide matching contribution or is simply unable to fund the schemes.

Similarly, as per the usual practice, the pressure for disposal of the subsidy amount comes only during the last quarter of the year. The manufacturers, however, are not able to cope-up with matching supplies to the subsidy amount being released at such a short notice. The haste also creates problems in half-finished installations and / or no installation and procuring only certificates from the concerned authorities.

The entire work relating to documentation is, in most cases, being completed by the manufacturers on behalf of the farmers. The manufacturer obtains a lien from the farmer and the subsidy amount thus gets disbursed, in the ultimate analysis, to the manufacturer rather than the beneficiary farmer. The manufacturers have to, therefore, invest for the subsidy amount in each case. These amounts when delayed for reimbursement for periods such as 6 to 15 months total upto huge numbers which most of the manufacturers are not in a position to provide or stand upto. In this manner, it is not quality of the product, nor the choice of the farmer but the capacity of the manufacturer to extend such credit which becomes the determining factor whether a given drip installation would be done or not. Once the manufacturer reaches his finance limit, he simply refuses to supply any new sets.

In many cases, it has been found that the concerned agency which is implementing the subsidy scheme does not even issue acknowledgement for such proposals which are eligible for subsidy. They also do not accept the bills or invoices covering such a supply till such time they are in a position to pay the said amount of subsidy after it is received from the State government.

In short, but for the malfunctioning, scale and administration of subsidy, the physical achievement of the targets could have been of a higher order. The coverage under DMI during first four years of the Eighth Plan was 56% of the planned target. The progress picked up substantially in 1996-97 because of increase in the scale of subsidy from 50% to 70% in case of general category farmers and from 70% to 90% in case of SC/ST, small/marginal and women farmers. Indeed, the annual target for 1996-97 was achieved to the extent of 172%. Thus, the scale & administration of subsidy and credit support mechanism are the two major factors which can influence adoption of DMI.

7.4 Poor Quality Products & Inadequate Testing/QA Facilities with DMI Manufacturers:

Many times the manufacturers do not have facilities for water and soil testing or even for testing of the various components of the system. The BIS mark has been found to be given even to these units which cannot carry out the simple test/s. In fact, in order to determine the life of the laterals, one is supposed to have Accelerating Weathering Apparatus. Most of the manufacturers do not possess such sophisticated quality assurance equipments. This leads to supply of poor quality products. The State Government or the implementing agency is not equipped to supervise or control such lapses. The administrative and political compulsions do not allow the implementing agency to be strict about the quality aspect. It has been found that even if some units are blacklisted, they soon get reinstated with certain amount of pressure from the influential quarters.

It may be noted that a properly designed Drip system can comprise of as many as 75 individual components. These components act in unison with each other and therefore each one has to be of good quality if the total system is to function in an efficient manner for optimum results. There are very few manufacturers who make all these components under one roof. Most of the manufacturers purchase many of the important components from the market sources and assemble them together to produce a system. The mismatch and hotch-potch results in poor performance and short life of the system, leaving alone high maintenance cost and non-supply of spare components at short notice. The lack of effective dealer network and/or service centres of the manufacturers has also been one of the constraints for popularizing the DMI.

7.5 Inadequate designing facilities can lead to high cost of over-designed systems:

Many times alternatives and options are not quite obvious and/or easy. For example, higher variations in discharge than are usually acceptable along a lateral may be more than justified, if there is a significant cost saving. Similarly, innovative farmers may tend to use DMI as miniature dragline sprinkler like system for inter cropping of vegetables in between fruit trees. Thus there are many practices which prima facie & theoretically seem unacceptable or

ineffective but , in fact, make a significant contribution to management, higher yields and production for the farmers. We must learn and adopt these into design to provide flexibility and versatility.

7.6 Lack of Farmer's Matching Contribution:

In some of the cases, the farmers are unable to raise matching contribution. The small area of operational holding also does not allow the farmer to go for DMI. Few of the farmers are yet not convinced of the economics of this technology. Some of them find the maintenance of the system rather difficult for their farm operators and as such do not want to adopt the same.

7.7 No Training & after Sale Service:

Neither the manufacturers nor the implementing agencies are found to have organised short term training courses in operation and / or maintenance of DMI. Wide applicability of DMI is feasible only if its vulnerability is reduced for farmers who are without adequate access to extension, technical support & training services from manufacturers and hardware dealers. Extension services should include:

(a) The orientation of engineers, planners and agricultural professionals in the realities and requirements for appropriate small farmer irrigation technology.

(b) Practical on-the-job training for farmers, extensionists and pump operators.

(c) Technicians for adequate and appropriate support services.

The after sale service of the manufacturer / dealer is yet another reason for reservations in the minds of the farmers.

7.8 Non-dependable Power Supply:

Erratic power supply is yet another reason for slow adoption of DMI. Not only the power supply is erratic, it also lacks in required voltage. It has also been found that most of the farmers like to use the available pump sets which are not found to generate required pressure for the system to function well and deliver required quantity of water.

7.9 Small Land Holdings

The Land Ceiling Laws, fragmented and small land holdings, ceiling on the subsidy amount are also some of the factors which discourage wide adoption of DMI.

7.10 Non-availability of required water quantity

It has also been researched that 95% of the users depended on ground water resources and only the balance 5% used surface / canal water. The ground water resources are depleting very rapidly and as such even required small quantity of water is also not available for DMI to operate. The canal water is normally found to be of poor quality leading to clogging of filters and/or emitters.

Summary :

It is for the above reasons / constraints / hurdles that DMI has not caught on in India on large scale. Even the modest target of covering 1.25 lac hectares under Drip in the Eighth Plan period was not met. The scale and administration of subsidy, quality of the product and after sales service from the manufacturers, lack of training and demonstration on the part of implementing agencies and inordinate gap in installation of the sets and payment of subsidy, poor bank finance support are some of the main reasons for low development of the otherwise advanced technology so vital to the national interest.

8.0 POTENTIAL OF DMI IF INFRASTRUCTURE STATUS IS GRANTED AND ALSO IF "SUBSIDY" BEING GIVEN IS CONSIDERED AS THE "INVESTMENT IN AGRICULTURAL INFRASTRUCTURE" BY THE GOVERNMENT/S.

8.1 Concenssional & long term Bank Finance:

If the status of infrastructure is granted to DMI, the banks and other financial institutions will provide financial assistance as a priority sector to the DMI manufacturers and farmers at concessional rates and for longer duration. The world financial bodies will also make long term finance at concessional rates and consider DMI as forward integration of the Irrigation Industry which is already considered as Infrastructure Industry. DMI helps achieve better utilisation from completed irrigation projects.

8.2 Easy Availability of Finance:

Presently Irrigation Industry is construed to be and is limited to creation of water storages such as dams & reservoirs and water conveyance systems including canals, distributories and water courses. Once DMI is taken to be an integral part of the Irrigation Industry, the very availability of finance will become relatively easy.

8.3 Farmers Acceptance Made Easy:

The measure will help reduce the capital cost of DMI and also the longer period will reduce farmer's burden in respect of payment of annual instalment. This will encourage him to go for DMI.

8.4 Large competing firms' entry facilitated:

The infrastructure status to DMI will also result in fiscal and tax benefits to the manufacturers and the Industry will eventually attract even the large corporations to become DMI manufacturers.

8.5 Present Slow Coverage:

It may be noted that at presently DMI industry has a turnover of about 400 crores and its growth in past several years has been less than impressive. In India, row crops are cultivated on more than 18 million hectares. The techno-economic feasibility across a spectrum of these row and horticultural crops has been fully established. This picture will dramatically change.

8.6 What is feasible to be achieved:

It is quite possible and feasible to cover at least a million hectare in a medium term period of about 5 years. This will represent a mere 1% of the total irrigated area in the country. The broad order of the cost involved in this can be put at Rs.4000 crores (Rs.40,000 per hectare x one million hectares). Thus the 400 crore DMI industry has the potential of becoming Rs.4000 crore Industry.

8.7 Future Outlook:

In time to come, by providing infrastructure status to the MIS industry, the fixed cost required for installing per hectare of drip irrigation can be reduced. This will pave the way for bringing at least 12 - 15 million hectares under drip irrigation in foreseeable future and the DMI will rise to be a 48 to 60,000 crore industry in due course of time.

8.8 DMI 'Subsidy' is not a subsidy but an 'Investment':

We may instead suggest that extension of subsidy to DIS should not be viewed as "Subsidy" at all. It is an investment for utilisation of already created irrigation infrastructure which is so vital for a sustainable agriculture and which alone can ultimately lead to exportable surplus. If these are the national objectives, in that case, DIS subsidy cannot be in real terms described as "Subsidy".

Irrigation facilities including dams, canals, waterways and distributories for conveyance of water are being provided on "Grant" basis, both for capital cost as well as for operating cost by the Government. In this situation, there is absolutely no justification for considering subsidy for DIS as subsidy.

Irrigation technology creates and distributes water upto the field. DIS helps save the water and bring additional area under cultivation by network of pipes laid throughout the field.

DIS is merely a forward integration of the irrigation technology. Atleast under DIS Subsidy Scheme, the operating cost is being borne by the farmer in addition to his share in the initial capital cost. It should be, therefore, preferable to utilise already created irrigation potential thorugh DIS rather than make fresh investments for creating additional storages / dams particularly when available funds are limited and getting scarce.

9.0 WHY INFRASTRUCTURE STATUS TO DMI:

9.1 Other hi-tech agro inputs can only be used in conjunction with DMI:

Development of sound infrastructure is essential for introducing as well as for adoption of any high-tech inputs in agriculture. This has been in discussion among the eminent agricultural economists and scientists all over the world. In India, in the recent times, the first green revolution benefits both in terms of production and productivity have stagnated. Keeping in view the declining trends of investment in agriculture and the future requirement of agricultural produces and increased demand for water, there is an urgent need to develop a good infrastructure which can promote the adoption of high-tech agricultural inputs as well as more conducive environment for promoting Second Green Revolution. None of the hi-tech agro inputs such as Tissue Culture, use of Liquid Fertilisers, use of Genetically Superior and Aggressive Planting materials, can be gainfully adopted without the help of drip irrigation system.

9.2 Presently No exportable surpluses despite First Green Revolution:

For creating better environment for the Second Green Revolution, as a first step, drip irrigation should be treated as infrastructure industry. There is no doubt that the green revolution introduced in the mid-sixties has helped in increasing the foodgrain production. However, it has not been able to sustain itself for creating exportable agricultural surpluses. DMI can help fulfill the need.

9.3 Creation of irrigation potential is the same as saving of water through DMI:

As the creation of irrigation facilities including storage and conveyance has been acknowledged as infrastructure projects, there should not be any second thought for considering introduction of micro irrigation facilities as infrastructural development. After all, creation of irrigation potential and saving of water both serve the same purpose. Studies have undoubtedly confirmed that through MIS water can be saved from 80 to 100 per cent.

9.4 Surface and underground water resources over exploited - DMI can help correct the situation:

It must be remembered that the available water for the future use of irrigation has been declining drastically. Most of the states have already exploited their easily available surface water resources for irrigation purpose. Further exploitation of surface water by constructing new dams / reservoirs will take more investment and time and may cause adverse environmental problems. By providing the status of infrastructure to the MIS industry, a congenial atmosphere can be created to use the available irrigation water in a more efficient manner.

9.5 Shortcomings of conventional irrigation storage & application & solution thereto:

Flood or gravity method of irrigation is largely in practice in India. It has many economic and environmental externalities. After the independence, the Government has spent about Rs.691.75 billion (upto 1994-95) on irrigation sector alone, however, it could irrigate only about 33 per cent of Gross Cropped Area. For instance, as stated above, expenditure incurred to create one hectare of irrigation under Major and Medium Irrigation (MMI) projects has increased from Rs. 1526 in the First Plan to over Rs.50000 in the Seventh Plan and Rs.70000 in the Ninth Plan.

Problems like cost escalation, long gestation, inefficiency in use of water, low recovery rate, poor participation of farmers and widening gap between potential created and utilised are going beyond the control and have plagued irrigation management in majority of the surface irrigation systems in India.

The adverse effects and impact of conventional irrigation projects and methods include :

(a) Submergence of cultivable / forest land.

(b) Problems connected with resettlement of the affected people.

(c) Pollution of regenerated water.

(d) Higher incidence of water-borne diseases.

(e) Water logging & salinity of the soils. The degradation of the environment, even in the catchment areas, has been causing concern.

(f) After construction of the dam, there is considerable weed growth in the river bed in many reaches of the river.

(g) Unequal distribution of water and non-reliability in distribution.

(h) Non-utilisation of combined use of surface and underground water.

Out of these various adverse effects, water logging is the problem which defies solution except DMI.

9.6 Investment on irrigation projects generates low revenue:

According to Vaidyanathan "Committee Report on Pricing of Irrigation Water", the revenue which was collected from MMI is not even enough to meet the operation and maintenance cost of irrigation system. While the revenue was covering about 25 per cent of the operation and maintenance cost ion 1977-78, declined to a meagre 9 per cent by 1986-87 and the decline continues unabated. This has brought tremendous pressure on the investment in irrigation and a large part of this investment even does not yield minimum conceivable return.

9.7 DMI reduces Government's financial burden and ensures user participation:

Unlike the Government owned and managed major and medium, and minor irrigation projects, micro irrigation facilities as stated above create uniform social and economic benefits in addition to improving environment. The gestation period of the investment is low and the benefits can be harvested instantly. Importantly, it will also reduce the burden of the Government in the long-run by reducing the capital, operational & maintenance cost of the surface irrigation and storage systems. This also ensures user participation and help him become self-sufficient.

9.8 Not the size of DMI industry but its benefits that are important:

It may be argued that micro irrigation is not an Industry which has assumed sufficiently large proportion so as to be termed as "infrastructure". This may be true in the past because MIS was not proven and was in its infancy. But now the condition has changed significantly and today a considerable amount of area has been cultivated under DMI. Moreover, proportion of area or condition of industry should not be taken as a test for considering the status of infrastructure. Therefore, keeping in view the long-term benefits and the present advance stage of DMI, there is an urgent need for a review of this proposition. It is not the size of the industry, it is the economic & social objective it achieves which is more important. Presently, water use efficiency has become critical for the very viability and sustainability of Agriculture as a National Asset of value par excellence.

9.9 Greater value addition to GDP:

DMI technology is modern and quite advance. It is designed for conservation of natural resources and greater value addition to the country's economy / GDP. The hardware has been perfected in past over 30 years and each country has also developed its own software in better understanding of the relationship between plant, water and climate under DMI. Leaving alone high profitability and favourable B-C ratio for each farmer, the value addition at the National Level (GDP), is what matters in the ultimate analysis.

Summary:

It is with the help of DMI that other hi-tech agro inputs can be used and thereby exportable surpluses generated. Saving of water through DMI costs much less than creation of fresh irrigation potential. Underground water resources have been over exploited. DMI, along with water harvesting structures, can help change this situation. The conventional irrigation storage and distribution is riddled with many socio-economic problems and, when completed, these projects generate low revenue. DMI ensures user participation and reduces Government's financial burden apart from adding significant value (GDP at national level). In view of the favourable and established reliable research data, DMI not only saves water but increases yield and production per unit of water, land and crop. As such, the subsidy being advanced needs to be treated as Investment in Agricultural Infrastructure. In any case, DMI is merely a forward integration of conventional irrigation projects. Since Irrigation is already an Infrastructure Industry, it would be logical to add DMI for the same status.

In short, an integrated and holistic approach is the only ultimate solution to problems in agricultural irrigation, water storage and water scarcity, low crop intensity and low land use intensity. DMI is the technology which can ensure cost efficient and sustainable agricultural irrigation development in the country.

10.0 CONCLUSIONS:

10.1 Not the Size but the Purpose is Important:

The subject of DMI needs to be viewed and reviewed in proper perspective and from long term national point of view. The DMI has enormous advantages and it is going to be the only viable option for future development of irrigation. It is not the size of the Industry which should be considered for the purpose of giving it the status of Infrastructure Industry. The potential of the Industry and the purpose it serves are two touch stones to decide the status of the Industry. DMI can help promote self-sufficiency and avoid imports of agricultural commodities. Indeed, it can provide food, safety and security for the very survival. Additionally, it protects environment and ensures equity and social justice for the concerned beneficiaries. DMI is an advance and upcoming technology whose economic benefits have been otherwise and undoubtedly confirmed by numerous research studies and field tests during past over a decade.

10.2 Irrigation Potential & Utilization can be doubled:

Keeping in view the rapid decline of available potential of irrigation water and the growth of population, concerted programmes should be formulated to utilise / distribute the already created irrigation potential with the help of DMI. By doing this, the existing irrigation potential can be doubled without affecting the environment and without undertaking further investment on any major projects. Completion of the project at various stages of development will be sufficient for taking care of our requirements in the foreseeable future.

10.3 Returns in Irrigation are declining, need for diverting funds for DMI:

Despite a significant increase of investment on the surface irrigation, the returns from this sector have been declining continuously over the period. If a significant portion of Irrigation allocation is diverted for propagation and coverage of DMI, immediate and substantial benefits can be harvested. This will also help bring more area under irrigation which will further increase the production and productivity.

For a sustained growth of drip and other similar technologies, the Government should immediately give the status of infrastructure to the DMI. Such a policy initiative would act as catalyst for bringing about needed change in the basic social values regarding use of natural resources especially land and water.

10.4 Urgent need for Training, Demonstration & Extension:

Many field based studies revealed that one of the reasons for the slow growth of DMI is the lack of awareness among the farmers about the real economic and resource-related advantages of DMI. This means that apart from provision of capital subsidy there is also an urgent need for an awareness campaign through an effective extension, demonstration and training network.

It is noteworthy that in the sample study of 3,500 farmers, the awareness about the technology basically became available to the farmers from the Industry and the fellow farmers. Other sources of awareness were Government Agencies (20%), Media (5%) and PDCs (1%). The role of NCPA and PDCs and all others in spreading the awareness did not exceed 26%. 86% of the beneficiary farmers installed the systems only after witnessing a functioning system. The Government extension agencies including Department of Horticulture organised only about 7% of the total demonstration visits. The farmers and the Industry together have provided initiative for such demonstrations and visits.

There is, therefore, an urgent need for an awareness campaign through the effective extension network in the targeted areas.

To work out a tailormade, scientifically designed, cost efficient, versatile, modest but affordable DMI is quite a complex exercise. In order to do that, one has to take into consideration the following factors:

- Soil and water analysis.
- Availability of water & power.
- Crops, their age, water requirements and agronomic practices.
- Topography.
- Climatology.
- Hydrology.
- Some time, when required, aerial photography.

10.5 Functioning & Integration of Subsidy Administration:

The scale, administration and lack of uniformity and one single Agency for subsidy is yet another constraint which needs to be removed urgently. We need to evolve an integrated approach wherein the Central / State Governments, their implementing agencies, the industry and users can and should frequently and freely interact with each other. It is observed that even the Central & State Governments, leave alone the implementing agencies, do not always pull in the same direction. In fact, the Ministries / Departments of Water Resources, Agriculture, Irrigation, Petroleum, Rural Employment and Planning Commission must get together and evolve a strategy for implementation of DMI technology. It may be appropriate to hand over the subsidy administration to Water Resources / Rural Employment Ministry / Department as a combined body for resource allocation. Agriculture Department / Ministry may be used for extension work because they already have the network to do the job. The Ministry of Petroleum can probably keep an eye on the quality of the hardware and support the promotion of liquid water soluble fertilizers through DMI (fertigation).

10.6 When to Substitute Subsidy?

Determination of time table for continuation and discontinuation of the subsidy should not be time based but based on achievement of given percentage of area under DMI compared with area under conventional irrigation. Once about 12 to 15 million hectares are brought under DMI, Government may consider withdrawal of support / subsidy or substitute it with concessional Bank Finance or greater investment in Agriculture Sector. It can be argued with force whether assistance being rendered in the form of subsidy to DMI is a subsidy or an investment from the national perspective.

10.7 By Definition DMI is Infrastructure Industry:

Above all, considering the definition of infrastructure given by various economists and followed by Government of India and other world institutions for various purposes and also looking at the current and future benefits, it is imperative to give infrastructure status to DMI industry.

The Infrastructure Industry is the one which generates a cascading effect. This is the primary industry upon which so many other industries depend for their development & growth. DMI is the Industry on which the growth and productivity of the entire agriculture industry depends. Moreover, growth of DMI will help utilise the excess capacity of the Indian PVC Industry and accelerate growth of Polyethylene Industry. It will also generate higher employment at all levels and add value to human resources.

10.8 In the National Interest, it must get Infrastructure Status:

The need of the hour is to accord this technology the status of Infrastructure so as enable it reach its ultimate potential in terms of addition to GDP, value added exports, greater social justice, improvement in environment and conservation and better utilisation of our precious and scarce natural resources : Water & Land. Indeed, DMI can transform agriculture and allow it to become equal partner with Industry and also act as an engine for alround growth. From a national perspective, there is no alternative to adoptionof DMI. As pointed out in Table `A' appearing on Page 12, a farmer using FMI for half an hectare and putting another half an hectare under FMI for the horticultural crops can have a net income of Rs.24,250 as against a farmer who puts his total hectare under DMI for horticultural crops and gains net income of Rs.73,500. Thus, the incremental income to the one hectare farmer using DMI is Rs.49,000 per hectare.

From the national perspective, if we bring one million hectares under DMI as compared with FMI, the nation has to invest by way of capital investment about Rs.4000 crores (1 Mn Ha X Rs.40,000 per Ha). For this investment, the incremental income through DMI shall be Rs.4900 crores. Thus, the pay-back period could be less than one year.

Assuming that the Government will have to subsidise at least 60% of Rs.4000 Crores to be invested as capital expense, the Government will have to provide for Rs.2400 Crores over a time period of 10 years and the subsidy per year will be hardly Rs.240 Crores per year. However, the net addition to the GDP as pointed out above will be over 20 times (4900 divided by 240).

It may be noted that DMI has historically evolved and has essentially remained a Small Farmer Irrigation System. For exmple : In Maharashtra the average size of the land holding of Drip farmer is less than 1.2 hectares. Thus, the small farmers will stand to benefit substantially. This certainly is the national priority.

10.9 Prioritization of Usage of Water for Agricultural Irrigation:

If we are to take a macro view of the subject of irrigation for agriculture and fix priorities, we would strongly recommend the following schedule of implementation:

(i) Water Harvesting Structures (Watersheds, Village & Farm Ponds etc. etc.) and increasing Green Cover will represent a lasting solution for the problems of depletion and recharging of Ground Water Resources. This must be considered and taken up while planning and completion of point (ii) below. It should form as an integral part of the Project Planning.

(ii) Action Plan for completion of ongoing major, medium and minor dams on war-footing with deadlines for completion. Not taking up any Major or Medium Dams in near future.

(iii) Mandatory introduction and application of DMI and/or SMI even in the command area for the cash and horticultural crops.

(iv) Usage of the water so saved (because of DMI & SMI) for increasing the production of foodgrains, cereals, pulses and oil seeds. Even here, as far as feasible, gradually the maximum area should be brought under MIS. Recent studies in Egypt have demonstrated that MIS can be gainfully utilised even for improving yields of crop like Rice.

It is quite possible to take up these stages simultaneously.

10.10 Waste Land Development Via DMI:

DMI is the technology which can convert most of the waste lands and other similar degraded lands into cultivable productive lands. If culturable waste lands are developed, it will mean income to the rural poor and agriculturists, ensure supply of fuel, fodder and timber, make the soils fertile by preventing erosion, maintain ecological balance, increase forest cover and help bring out conventional rain fall. The increased green cover will reduce pests and finally help recharging of ground water. Thus, the waste land development provides solution to many problems apart from adding huge net amount to GDP.

Most of the waste/degraded lands which are currently under utilised or which are deteriorating for lack of appropriate water and soil management, can be brought under vegetative cover with the help of DMI. Moreover productivity of the Horticultural and Agroforestry crops can be doubled if survival and supplemental irrigation is provided through DMI.

10.11 Broad Summary:

(i) One has to begin with Micro water harvesting structures, then proceed with completion of irrigation projects and make it mandatory to use DMI for extisting as well as future available water resources for most of the crops across the board in the country. Indeed, the planning of Irrigation should not consist only of creation of water storages.

(ii) The planning Irrigation Dams, Conveyance and Distribution of Water for application to the crops in the field must be viewed as one integrated chain preceded by proper soil conservation and water recharging techniques. When it comes to Agri Irrigation, it is impossible to separate land and water management. We must focus not merely on "Irrigation", but extend & integrate our horizon to Land and Water Management.

(iii) Financing or/and subsidizing of DMI can be organized through bifercation of funds from the Central & State Budgetary allocations for Irrigation..

(iv) The approach is all pervasive and ensures self-sufficiency in foodgrains, availability of surpluses of horticultural vegetable crops for exports and meeting the requirements of larger number of farmers to achieve the aims of justice. Cultivation of Culturable Waste Lands can further augment GDP.

(v) The approach is economically feasible, socially acceptable and environmentally friendly. It will have a salutary effect on the socio-economic as well as socio-political climate in the country and generate employment.

(vi) Viewed in this perspective, there is no substitute for DMI. Such an integrated & holistic approach alone will ensure prosperity and prevent looming water crisis.

TABLE 1 : PROJECTION OF ANNUAL FRESH WATER DEMAND FOR VARIOUS USES

(in cubic Kilometers)

Sr.	Purpose	1985 AD			2000AD			2025AD		
		Surface Water	Ground Water	Both	Surface Water	Ground Water	Both	Surface Water	Ground Water	Both
1.	Irrigation	320	150	470.00	420	210	630.00	510	260	770.00
2.	Other uses	40	130	70.00	80	40	120.00	190	90	280.00
	(a) Domestic & Livestock			16.70			32.85			46.0
	(b) Industries			10.00			30.00			120.00
	(c) Thermal Power			2.70			3.30			4.00
	(d) Miscellaneous			40.60			53.85			110.00

Sources: CWC.(1995), Water and Related Statistics, Central Water Commission, New Delhi.

TABLE 2 : GROWTH RATES (PERCENT / ANNUM) IN NET AND GROSS IRRIGATED AREA

Periods	Net Irrigated Area				Gross Irrigated Area
	Canal	Tank	Wells	Total	
1950-51 to 1990-91	1.89*	-1.14*	3.95*	2.21*	2.62*
1950-51 to 1967-68	1.88*	-1.16*	2.33*	1.73*	2.23*
1967-68 to 1990-91	1.69*	-1.84*	3.83*	2.23*	2.42*
1950-51 to 1960-61	1.96*	3.34	1.10*	1.68*	2.17*
1960-61 to 1970-71	1.96*	-1.70*	5.18*	2.21*	3.12*
1970-71 to 1980-81	1.93*	0.90	4.31*	2.66*	3.03*
1980-81 to 1990-91	0.79*	1.35	2.82*	1.43*	1.53*

Note: * Statistically significant at one per cent level.

Growth rates are computed based on Triennium Average.

Sources: Computed from GOI. (various issues), Indian Agricultural Statistics, Ministry of Agriculture, Government of India, New Delhi.

TABLE 3 : GROWTH RATES (PERCENT/ ANNUM) IN NET AND GROSS IRRIGATED AREA

Crop	1951-52 to 1965-66	1965-66 to 1990-91	1960-61 to 1970-71	1970-71 to 1980-81	1980-81 to 1990-91
Paddy	1.86*	2.80*	0.69	1.39	3.20*
Wheat	1.16*	3.44*	0.46	2.09*	3.04*
Jawar	1.15	2.09*	0.11	5.19*	1.62*
Bajara	1.16*	1.55*	4.47*	-0.69*	2.09*
Maize	2.94*	1.39*	1.62*	0.07	2.33*
Total Cereals	1.79*	2.80*	1.95*	2.09*	3.23*
Total Pulses	-0.05	0.69	0.44	-0.79	1.62*
Total Foodgrains	1.39*	3.28*	1.91*	1.84*	3.04*
Sugarcane	3.20*	1.09*	2.09*	0.93	1.62*
Production of Total Foodgrain	2.59*	2.97*	2.33*	2.09*	2.92*

Note : * Indicates Statistically significant

Sources : Computed from GOI. (1996), Indian Agricultural Statistics at a Glance, Ministry of Agriculture, New Delhi.

TABLE 4 : COMPARATIVE ADVANTAGES OF DRIP IRRIGATION OVER THE METHOD OF FLOOD IRRIGATION.

		Drip Method	Flood Method
1.	Water saving	Varies with crop 40-100 percent	Less due to conveyance and evaporation losses
2.	Irrigation efficiency	80-90 percent	35-45 percent
3.	Inputs cost	Lower especially in labour, fertiliser, pesticides and tilling	Comparative higher due to inefficient use.
4.	Weed problem	Almost nil	Higher and reduce the yield
5.	Suitable water	Even saline water can be used efficiently	Normal water can only be used.
6.	Diseases and pest problem	Relatively less	Damages are more
7.	Water logging	No room for water logging	About 8.5 m.ha. of area is suffering with this problem in India.
8.	Water management	Very simple, one labour can easily manage upto 10 ha.	Less controllability and requires more labour
9.	Evaporation and	Completely nil	Seepages, leakages, etc. are very high.
10.	Suitable land	Any type of land (undulating area, hilly land, barren etc.)	Suitable only for the normal slope land
11.	Soil erosion and other Related problems.	Completely nil	These problems are more
12.	Efficiency in fertiliser use	Very high and constant supply	Heavy losses due to leaching and evaporation
13.	Requirement of capital cost/ha.	Rs. 15000-40000. Varies with crop and space	At the end of 7th plan, the requirement of cost was Rs. 7028 for MI and nearly Rs. 50000 for MMI projects.
14.	Yield increase	About 20-100 percent more than flood method	Yield is lower compared to drip irrigation.
15.	BC ratio	1.3-13.3 : Excluding water Saving 2.8-30.0 : Including water saving	Varies only from 1.8-3.9

Source : Narayanamoorthy, A. (1997), "Drip Irrigation : A Viable Option for Future Irrigation Development", Productivity. Vol 38, No. 3, October - December (forth coming).

TABLE 5 : YIELD GAINS AND WATER SAVING IN DRIP IRRIGATION OVER CONVENTIONAL IRRIGATION METHODS.

(Per Cent)

Crop	Yeild Gains	Water Saving
Banana	52	45
Grapes	23	48
Mosambi	50	61
Pomegranate	98	45
Sugarcane	33	65
Tomato	50	39
Watermelon	88	36
Cotton	27	53
Ladies Finger	16	40
Brinjal	14	53
Bitter Gourd	39	53
Ridge Gourd	17	59
Cabbage	02	60
Papaya	75	68
Radish	02	77
Beer Root	07	79
Chilies	44	62
Sweet Potato	39	60

Source : Compiled from INCID. (1994), Drip Irrigation in India, Indian National Committee on Irrigation and Drainage, New Delhi.

TABLE 6 : CONSUMPTION OF ELECTRICITY IN KWH BY DRIP AND NON-DRIP IRRIGATED CROPS

Farmer's Category	Banana (Jalgaon)	Grapes (Nasik)
Drip Adopters	5915.53	2482.77
Non-Drip Adopters	8347.75	3958.78
Electricity Saving by Drip Irrigation :		
In percentage	41.16	59.45
In KWH	2434.00	1476.01
In terms of Rs.	1217.00	738.00

Note : It is assumed 0.50 paise/kwh to estimate electricity cost in terms of rupees.

Source : Narayanamoorthy, A. (1996), Evaluation of Drip Irrigation System in Maharashtra. Mimeograph No. 42, Agro-Economic Research Cemre, Gokhale Institute of Polities and Economics, Pune, March.

Table 7 : Estimated Capital Cost and Benefit-Cost Ratio of Drip Irrigation for Different Crops.

Sr.	Crop	Capital Cost/ha.	Benefit-Cost Ratio	
			Excluding Water Saving	Including Water Saving
1.	Coconut	11053	1.41	5.14
2.	Grapes	19019	13.35	32.32
3.	Banana	33765	1.52	3.02
4.	Orange	19859	2.60	11.05
5.	Acid Lime	19859	1.76	6.01
6.	Pomegranate	19919	1.31	4.04
7.	Mango	11053	1.35	8.02
8.	Papaya	23465	1.54	4.01
9.	Sugarcane	31492	1.31	2.78
10.	Vegetables	31492	1.35	3.09

Note : B-C ratio is computed without incorporating the amount received as subsidy.

Sources : INCID(1994). Drip Irrigation, Indian National Committee on Irrigation and Drainage, New Delhi.