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IWMI-Tata Water Policy Program

Annual Partners' Meet 2004

The Case of Micro-Irrigation:

Does it really save Water? Evidence from Maikaal (Nimar Valley) Cotton Growers*

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* **Based on Research by IWMI-Tata Core Team**

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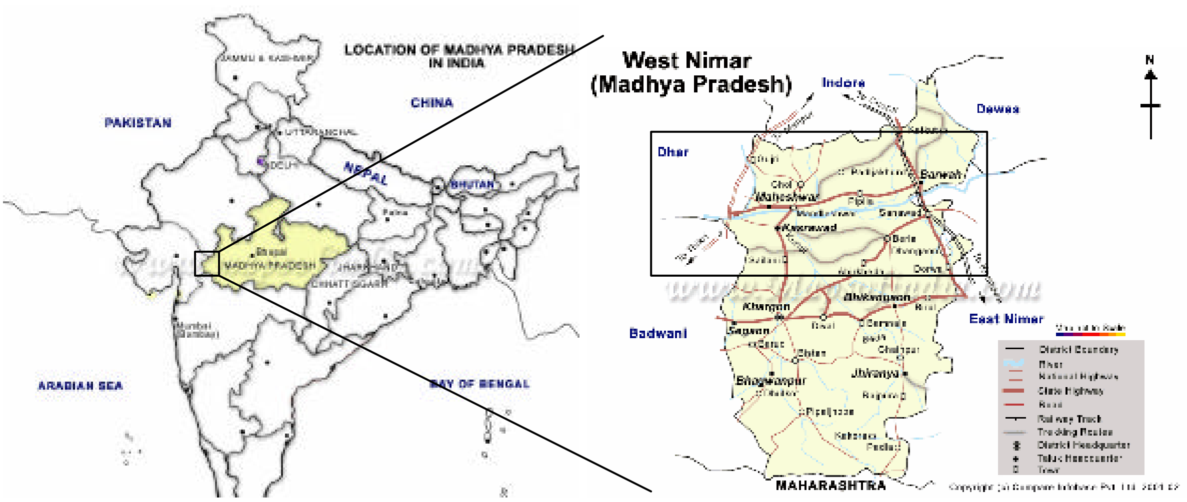
1.0 INTRODUCTION AND CLIMATE[1]

The Nimar Valley is located in the Central Indian Plateau in Madhya Pradesh and is spread on both sides of the Narmada River. To the North, the valley is bordered by the Vindhyas Range (max. altitude 881 m), and to the South by the Satpura Range (max. altitude 999 m). This region is known for its black Cotton soils and is the most productive part of the Narmada Valley. The climate is semi-arid like most of Central India with the average rainfall at 800 mm. in one monsoon season, generally lasting from June to September. Rains during monsoon are irregular, sometimes with dry periods of several weeks which constitute a major threat to the newly sown or planted crop. Very heavy rainfall events also occur, which exceed the capacity of the soils to absorb water, resulting in high surface flow off, erosion and crop damage. In addition, rainfalls are unequally distributed in the area. Rain distribution seems to follow the hill ranges on both sides of the Narmada valley, but no constant pattern was observed. The area north of the Narmada and in front of the Vindhyas Range tends to receive more rain than the region south of it. Temperatures reach a maximum of 47 °Celsius in June and drop down to 13-15° Celsius in December - January.

Figure 1: Location Map of the Nimar Valley



2.0 RAINFALL

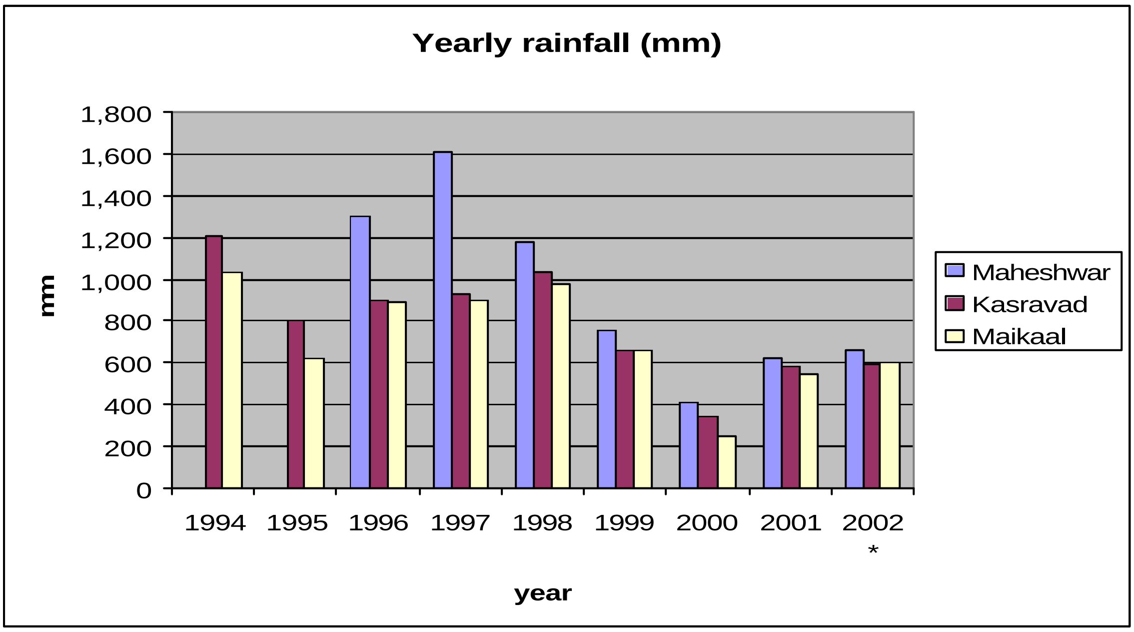
The rainfall has a high variation from 300 mm to 1100 mm in Kasravad and 400 to 1600 in Maheshwar tehsil. The area has always been affected by occasional droughts, but earlier the groundwater level used to be sufficient for irrigating parts of the fields. However, in the years 1999 to 2002, the amount of rainfall in the area was 45 % less than the average of 1994 to 1998, and groundwater levels in the wells declined. The resulting drought badly affected the entire agricultural sector of the valley as also the Central Indian states. The rainfall measured in Maheshwar, Kasravad and Maikaal factory is given in Figure 2.

Even this year the rainfall was unexpected. Though the total rainfall figure (894 mm.) does not convey this but this year the rainfall has been more spaced and spread over the monsoon days. Also the last rain occurred in mid October which is about a month later than normal. Also there is a lot of local variation in the rainfall received. The data used by us was recorded with a rain

[1] Detailed Concept of the Maikaal Research Project.

gauge installed on a farmer's field in village Mohana (658mm). However the recording in another village *Itawadi* (905mm) about ten kms away from Mohana is very different.

Figure 2: Annual Rainfall measured in Maheshwar, Kasravad and Maikaal factory, Nimar Valley, Madhya Pradesh



Source: Agricultural Development Offices and MBRIL records

3.0 <u>COTTON CROPPING</u>

There are three types of Cotton cropping practiced in the area. Most farmers sow the Cotton at the offset of the monsoon in June and harvest the mature balls till the plants dry up. If irrigation water is available before the monsoon starts Cotton can be sown early, in May (pre-monsoon sowing). By October, about 2/3rd of the balls reach maturation, and most farmers uproot this crop and sow Wheat. Few farmers, however, keep the Cotton crop until the end of the vegetation period i.e. till February / March.

Figure 3: Kharif and 'Pre-monsoon growing Options for Cotton

Type	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
Kharif Cotton, full length			Cotton									
Pre-monsoon, early uprooting		Cotton						Wheat				
Pre-monsoon sowing, full length		Cotton										

Source: Interviews with farmers and extension staff of MBRIL

The pattern of rainfall was so erratic this time that there were many spells in between two showers where the farmer kept vacillating between irrigating his field and waiting for a day or two for rainfall. While the clouds seemed to signal rain much irrigation was delayed. Also the last showers continued well beyond the last week of September resulting in heavy losses of the first flush of Cotton which was standing in the fields at either ball stage or the flower stage. This almost wiped out production in pre-monsoon Cotton from the first flush.

The losses in pre-monsoon Cotton have forced most of these farmers to keep the Cotton till the end of the vegetation period forgoing the Wheat crop on the fields under pre-monsoon Cotton in expectation of recovering costs from the second flush of Cotton.

Cotton is a highly uncertain crop. The yield varies on various factors. Water availability to the plant, ambient temperature, nutrient availability, rainfall pattern, wind speed etc. determines the yield. The severe drought of the past years had cast a shadow on the farmers' decisions and most farmers thought it futile to wait for the monsoon and pinned their main hopes on pre-monsoon Cotton.

4.0 MAIKAAL BIORE AND THE RESEARCH PROJECT

An organic Cotton promoting project by the name of Maikaal BioRe India limited has been functioning in the area since 1992. Remei AG of Switzerland, a promoter, is the world's largest dealer in organic Cotton. This until last year was the world's largest project of its kind. A research project was initiated to study the issues of organic agriculture and drip irrigation in the region in order to facilitate understanding of the model to replicate it elsewhere as well. It was decided to compare the organic and chemical Cotton production systems with the long term agronomic data monitoring which was constricted to three years due to the project funding constraints. The research project also aims to compare the various irrigation systems in the area as this area has seen a rapid growth in the use of pepsee systems, a locally developed and farmer-innovation micro-irrigation system.

To compare the farming systems of drip irrigated (various variants) and conventional furrow or flood irrigated farming systems of Cotton, two studies were set up. One of these was the trials at the experimental farm of the project partner, MBRIL. This was limited to organically grown Cotton. The second study on farmer's field is reported here.

There have been many experiments conducted trying to compare drip irrigated Cotton with furrow or flood irrigated Cotton that have reported multiple benefits of drip irrigated Cotton over the conventional furrow or flood irrigated Cotton. However these experiments on experimental plots have been criticized as the farmers fail to realize the same benefits and obtain similar results on their own fields under actual conditions[2]. The reasons put forward have been the difference of conditions in the farms of the farmers and experimental farms where these trials are conducted. These trials serve the purpose of highlighting the need for promoting these technologies to the policy makers. There is also the challenge to realize the results in the farmers' fields to ensure adoption and realizing the promised benefits of the technology.

The study was started as part of the Maikaal research project which concerns the problems of growing organic Cotton under groundwater stress conditions in the Nimar valley. Twelve farmers were selected but due to change in plans we finally continued with ten farmers and sixteen plots.

5.0 METHODOLOGY

The methodology adopted was simple. It was decided to compare the water application under different systems of irrigation and also when different variants of the drip irrigation system were used.

[2] Kumar, M. Dinesh; Shah, Tushaar ;Bhatt, Maulik and Kapadia, Madhu; "*Dripping Water to a Water Guzzler: a Techno-economic Evaluation of Efficiency of Drip Irrigation in Alfalfa*

It was noticed that the discharge from the tubewells would taper off with time as irrigation progressed during a single irrigation itself. However this problem was solved as farmers in this region have poor tubewell yields and hence draw water from the tubewell and store in the wells. This is then utilized for irrigation by pumping through smaller capacity pumps from the well to the fields.

During irrigation operation the discharge was measured by collecting the water discharged in a 300 liters drum and the time was observed with the help of a stopwatch. This was done many times during irrigation. Also the number of furrows irrigated and the number of plants irrigated was observed as well. This was used to calculate the amount of water applied per plant per watering. The start and end times of irrigation for each watering were also noted and the pump equipment details were collected as well. This was done to calculate the total amount of water discharged from the well and to compare the power consumption for irrigation.

6.0 COMPILED OBSERVATIONS

The observations of the study can be reported in a nutshell in the form of a table as given in table 1 which shows the compiled results of all the sixteen plots that were monitored for the flow measurement.

Table 1: Compiled Results of Monitored Plots

Plot no.	Type of Irrigation Distribution	HP of pump	Number of Waterings	no. of days of pre monsoon season	Area	Total Discharge (Volume of Water Applied)	Volume of water applied per plant per watering	Number of hours of Pump Run for each day	Number of hours of pump run for the season	HP-Hours for the season
1	drip	3	41	46	4.50	1009474	2.25	0.77	35.53	106.60
2	drip	3	24	37	4.00	456997	2.5	0.52	19.37	58.10
3	drip	3	33	34	6.00	955266	2.26	0.89	30.20	90.60
4	drip	3	39	43	9.00	514043	1.54	0.66	28.45	85.35
5	drip	3	39	42	10.00	2408644	4.21	2.65	111.40	334.20
6	drip	3	27	27	4,2.4	436321	2.3	0.78	21.10	63.30
7	drip	10.5	38	40	6.00	1752789	3.5	1.86	74.33	780.50
8	easy drip	1	24	24	2.00	188808	3.5	0.53	12.68	12.68
9	easy drip	5	15	17	1.50	117856	2.77	0.22	3.78	18.92
10	furrow	3	37	38	1.50	603251	15.27	0.71	27.10	81.30
11	furrow	3	6	11	2.00	390215	10.31	1.12	12.33	37.00
12	furrow	5	16	23	3.00	900692	21.77	1.24	28.58	142.92
13	furrow	5	23	23	6,1.5	2216588	18.13	4.97	114.33	571.67
14	furrow	8	21	35	4.00	1526503	11.72	1.50	52.33	418.67
15	furrow	10.5	21	33	3,3	581749	4.27	1.17	38.73	406.70
16	pepcee	5	17	17	0.50	101197	6.03	0.19	3.23	16.17

This table clearly shows that the drip irrigating farmers were able to sow their Cotton earlier than the furrow irrigating farmers. It enabled them to prepone the Cotton sowing by about thirty to forty days which means that they can harness the benefits of pre-monsoon Cotton and then prepone the Wheat crop. Ability to prepone the Wheat crop gives substantial benefit as it leads to higher yields which translates to higher income and also higher bio mass produced which serves as fodder for the livestock owned by the farmer.

The questions that this study takes on are:

a) Can micro irrigation result in water saving? If yes, at what level?
b) What benefits does it really offer for the farmers at their field level?

7.0 LIMITATIONS

The study came across certain serious limitations as it had to deal with a special rainfall year. In a normal year, in the pre-monsoon sown crops, the flowering starts around the last week of august and ball formation starts by first week of September when the rains cease. In a case like the present year, if either the rains after 20th august come in heavy bursts with big drop size, or if the showers extend well beyond the mid of September to the mid of October then a heavy loss occurs by loss of flowers, Cotton-balls and also standing Cotton ready for picking. This happened this year and the farmers have lost heavily in pre-monsoon Cotton. Thus this year's yield data for pre-monsoon Cotton is not valid for generalization as this is a rare occurrence and not a general phenomenon. It is for the same reason that comparisons have not been made based on the yield of pre-monsoon Cotton.

8.0 DECLINE IN PROSPERITY

Till a decade or so ago the farmers of this region received excellent benefits from the Cotton crop and there was a prosperity boom in the region favored by climate, rainfall and more importantly green revolution technology. However various problems have beset agriculture in this region in the past 15-20 years. This has led to falling yields, deteriorated environment, more marginalized communities and demotivated farmers. The last and worst to hit has been the increasingly unfavorable rainfall and its pattern which has not only taken the sheen away from farming as an occupation but also pushed many households into debt and poverty.

The shallow soils have been sucked and little was given back leading to the degraded state of many pockets. The farmers have responded to two problems threatening unsustainiability of agriculture – deteriorating soil quality and increased water shortage and the high requirement of capital to overcome these with conventional solutions. Organic agriculture and use of drip irrigation are seen as innovative and effective solutions of these problems and are being tried out and adopted by farmers.

A recent survey by the Maikaal[3] research project shows that 34% of the households have a child studying in a hostel outside the village. Also 65% of the households have some outstanding debt liability other than the annual crop loans. About 60% of the households use pucca toilets or closed pucca spaces for toilets. This reflects the conflict within the society as we see signs of prosperity and indebtedness together. This reflects the recent downward trend that lie and life quality have taken in this region.

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[3] Unpublished Document *Socio-Economic Photo of Nimar Valley Cotton Growers*: Shah, T., Verma, Shilp and Bhamoriya, Vaibhav, 2004.

9.0 BENEFITS OF PRE-MONSOON SOWING OF COTTON

Pre-monsoon sowing means multiple benefits for the farmers. We have to understand the Cotton crop in some detail to appreciate these benefits. Cotton is a long duration crop and usually lasts 190 days or more than six months on the field. A few more days are added for field preparation and cleaning of the fields after removal from the field. This means that only summer crop is possible apart from Cotton if Cotton is monsoon-sown. In a place like the Nimar valley most farmers do not have water availability round the year and so summer crop is not possible. The farmers have water availability for a Rabi crop but most of their most productive fields are under Cotton waiting for the second "flush" to be harvested. The farmers in this region are able to get good returns from the Wheat crop but are unable to do so because of the standing Cotton in the fields. Also they cannot uproot the Cotton and sow Wheat as the amount of capital pumped into Cotton is very high and often the yields of the first flush are not enough to give profitable return.

Pre-monsoon sowing solves this complex issue. By sowing early, we shift all operations of the plant early and it also leaves the plant stronger and more mature during periods of pest attacks and disease incidences. All this translates in better yield and early harvesting of the Cotton crop. This changes the economics at times to an extent that many farmers get profitable returns from the first "flush" itself and do not wait for the second "flush" but uproot the Cotton and sow Wheat which adds to their hedge of risk for bad years and maximizes profits for good years. This provides the chance to sow Wheat and also allow it to stand for a longer time in the field increasing the Wheat yield as well.

10.0 OBSERVATIONS

The study has come out with some interesting observations.

Graph 1 represents the details of the pre-monsoon season for the fields arranged by different types of irrigation. It is clearly evident that the pre-monsoon sowing enabled preponement of the whole Cotton crop calendar by a higher number of days than did furrow or any other type of irrigation. The average figures are given in the table.

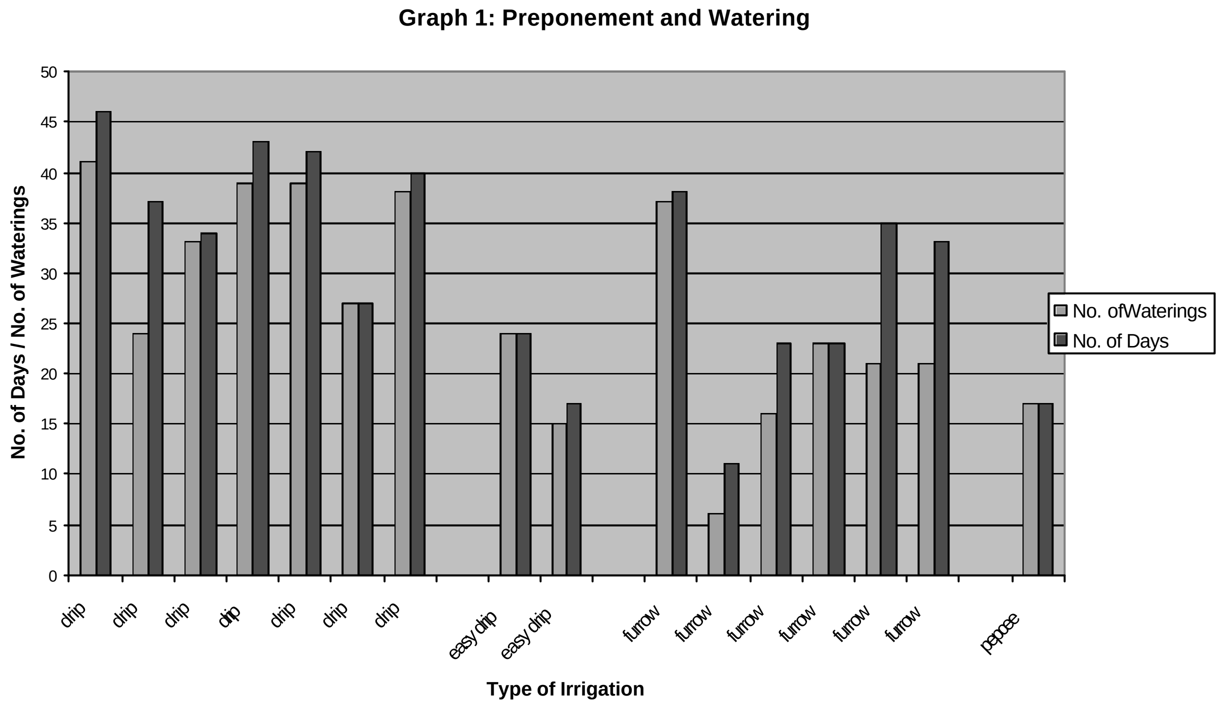
Table 2: Preponement of Cotton Crop using Different Irrigation for Pre-monsoon Irrigation

Type of irrigation	No. of days preponed
Furrow	27
Drip	38
Easy Drip	20
Pepsee	17

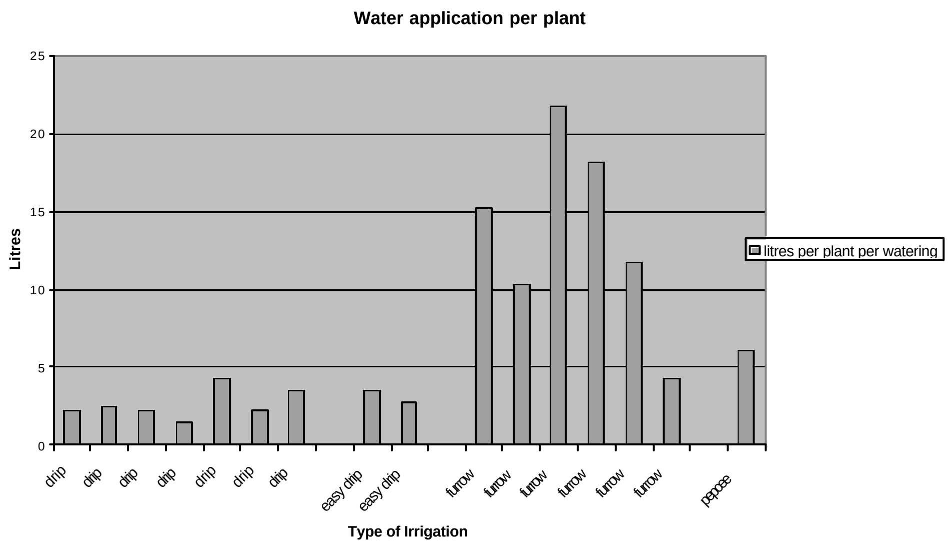
This offers many benefits to the farmers as discussed earlier. From a macro-perspective it can create a few concerns too as by increasing the number of days we also increase the number of irrigations required as also the frequency to daily while in furrow irrigation the watering is given every alternate day. This can push up the total water application figure for the pre-monsoon season.

The intra variation that exists here depicts that there are other variables which influence the number of days by which the Cotton sowing can be preponed. Most important of these is the water availability in the wells as few farmers have water available in the well. Some farmers do not have single drop of water for irrigation or not enough water for irrigating even with a drip system.

Graph 2 shows that there is a huge difference in the amount of water applied to a plant in a single irrigation by drip irrigation and by furrow irrigation. It is evident despite the intra-variation that the use of drip irrigation systems results in astronomical savings of water per plant per irrigation. This is due to increased irrigation efficiency achieved through the reduction of conveyance losses and seepage losses when furrow irrigation is done at a high temperature of 47 degrees Celsius with no humidity leading to very high evaporation losses.



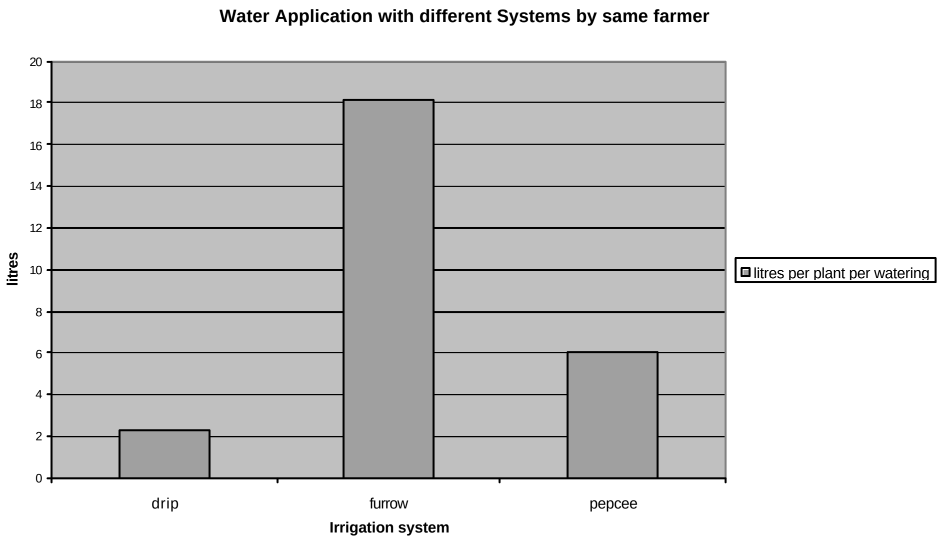
Graph 1: Details of Preponement of Sowing and Irrigations for Pre-monsoon Cotton



Graph 2: Water Application per Plant per Watering

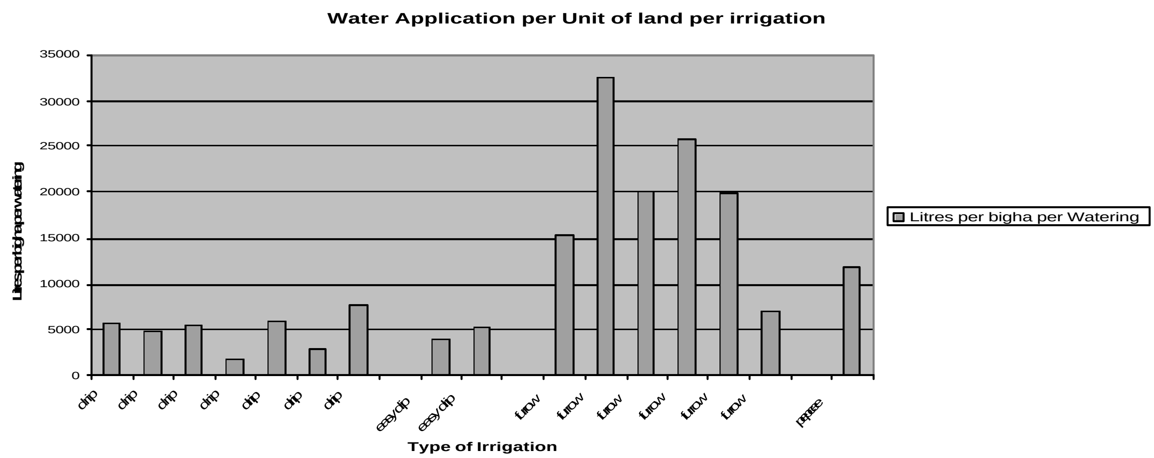
The intra variation can be a result of two conditions: lack of availability of water or the perceived requirement of water of the plant by the farmer. Also with poor power quality and irregular supply as was the case during last year, it could be due to improper irrigation due to intermittent and limited power supply.

By comparing the plots of same farmer under different types of irrigation systems, we neutralize the irrigation attitude[4] or perception of farmer leading to higher application in furrow irrigation. This clearly shows that the contention that perception apart, drip irrigation does save water inherently due to direct application is strongly shown here. We are amazed to find that this calculates to a water saving of 80% if the drip system is used over the furrow system of irrigation (from the figures averaged across the studied fields).



Graph 3: Water Application per Plant per Irrigation by Same Farmer with Different Irrigation Systems

The graph depicting the water application per unit of land irrigated is not very different from the graph 2 and the intra variations have increased due to the varying plant densities in the fields. Plant density is decided by the shape and slope of the land as well. However it is clear that irrespective of this the water applied for irrigating unit land area is very low for the drip system than for furrow irrigation and results in a saving of 75 % water. The wide variation between different fields using the same system of irrigation can be due to the perception of water requirement for the crop and the limited water availability as well.



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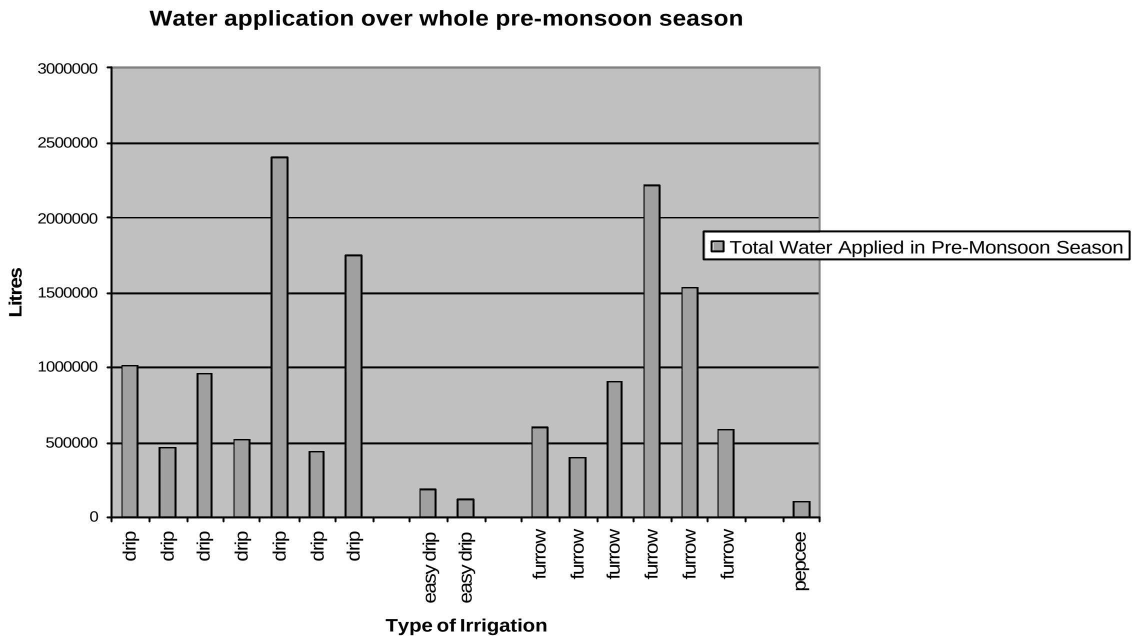
4 Irrigation attitude referred here is the perception of the farmer that the plants cannot survive unless there is standing moisture and flooding around them which results in over-irrigating even with a drip system.

Graph 4: Water Application per Unit of Land per Irrigation

Graph 5 shows the total water used in the whole pre-monsoon season. It poses more questions than it gave answers. As can be seen the total water application is erratic for all irrigation systems and no significant water saving is visible here.



Graph 5: Total Water Application in the Season by the Farmer

The reason for this is explained by the model itself as given below

N
Total Water Application = ? (liters per bigha x land area irrigated in bigha)
I=1

Where,

The summation is over the number of irrigations given to the crop.

Thus we see that the total water application can be affected on three accounts: Firstly, the farmers' perception of water requirement of the plants which would change the value of liters per bigha from watering to watering or from irrigation system to system ,Secondly, the change in area under irrigation and lastly, the difference in the number of waterings.

Due to preponement by higher number of days, the drip irrigating farmers give higher number of irrigations than the farmers irrigating through any other system. This is evident from the table 1.The average area under drip irrigation is much higher than that under any other irrigation system. On probing further an interesting phenomenon was observed. Most of the drip irrigating farmers do pre-monsoon sowing of Cotton in their most preferred plot and irrigate the Cotton plants regularly till the plants are "stable" and able enough to withstand moderate shock of water scarcity. Now if there is water available then the farmer shifts the same drip system or employs another drip system, if available, to sow more area under Cotton. This might be termed as late pre-monsoon Cotton sowing. This increase in area under irrigation by the farmer ultimately leads to an increase in water application at the aggregate level.

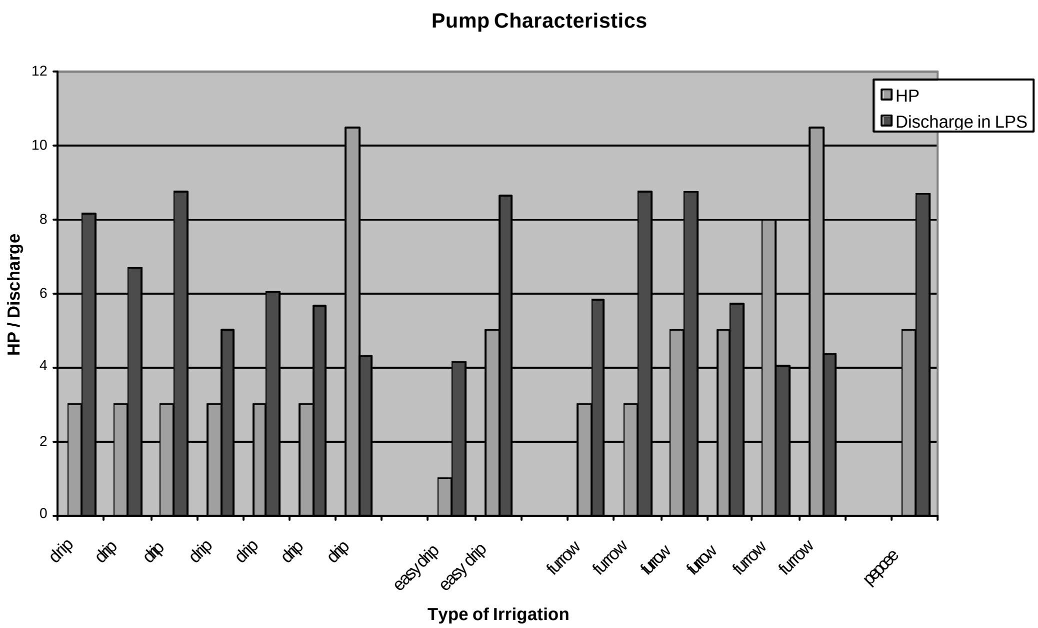
In a nutshell, drip irrigation results in massive water saving increasing irrigation efficiency by reducing the irrigation loss of water in conveyance and seepage. The saved water is used to irrigate and bring more land under irrigated pre-monsoon sowing by increasing the area of sowing. Some farmers sow Cotton in three batches with two sowings separated by fifteen days by which time the earlier sown plants are somewhat "stable"[5].

11.0 POWER CONSUMPTION

An elementary look into the energy aspects of the irrigation issue compared the HP of pumps used; the average discharges (though the figures of average discharge often have little expression in hard rock conditions), average pumping hours per day, pumping hours for full season and HP-hours for the season.

The capacity of pumps installed on the wells for drip irrigated fields was lower than that for the furrow irrigated fields. Most farmers collect irrigation water from different sources in a main well and then pump it to the field for irrigation. We have considered only the final pump on the main well used to pump water into the field in our calculations.

Graph 6 clearly shows that the HP for the pumps on drip irrigated fields is lower and the average discharge figure is also higher. This could be because of two reasons – higher pump and machine efficiency and / or due to varying water availability.

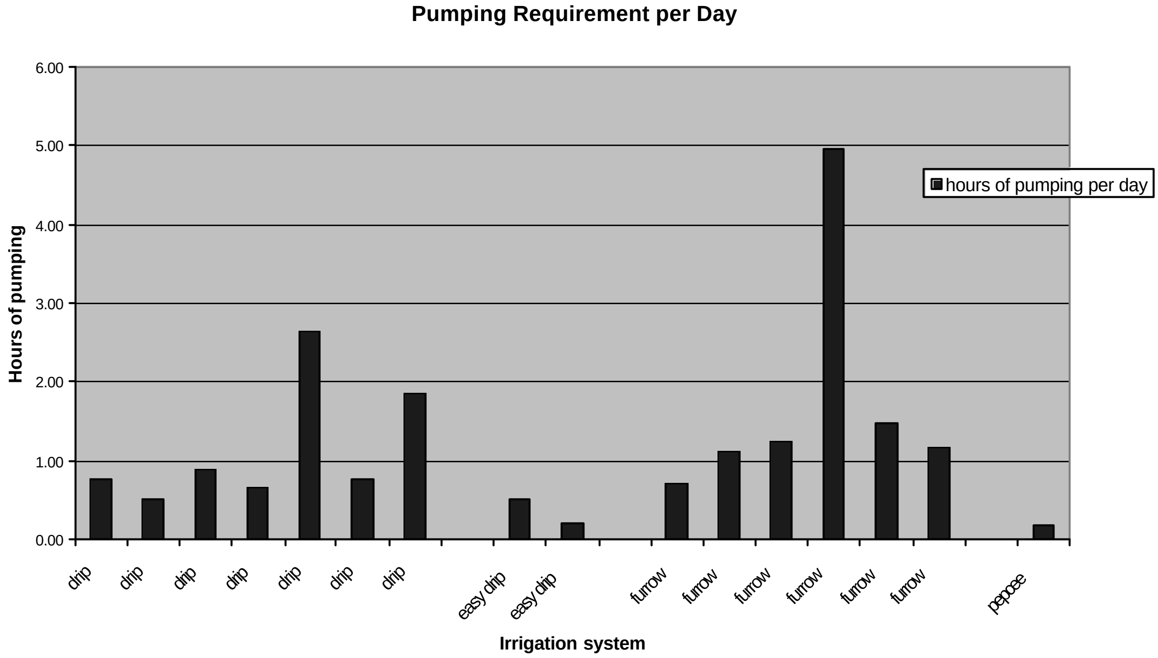


Graph 6: Pump Characteristics – Capacity (HP) and Discharge (LPS)

Despite the larger area of pre-monsoon sowing under drip irrigation the number of hours needed per day for irrigation is lower than that required for furrow irrigation. The number of hours per day requirements with easy drip and pepsee appear as even smaller but this is due to very small areas under irrigation. This shows that the farmers can irrigate their fields with smaller quanta of electricity with drip irrigation as compared to furrow irrigation wherein the electricity supply required was manifold in time terms. Good quality electricity has been a problem in this

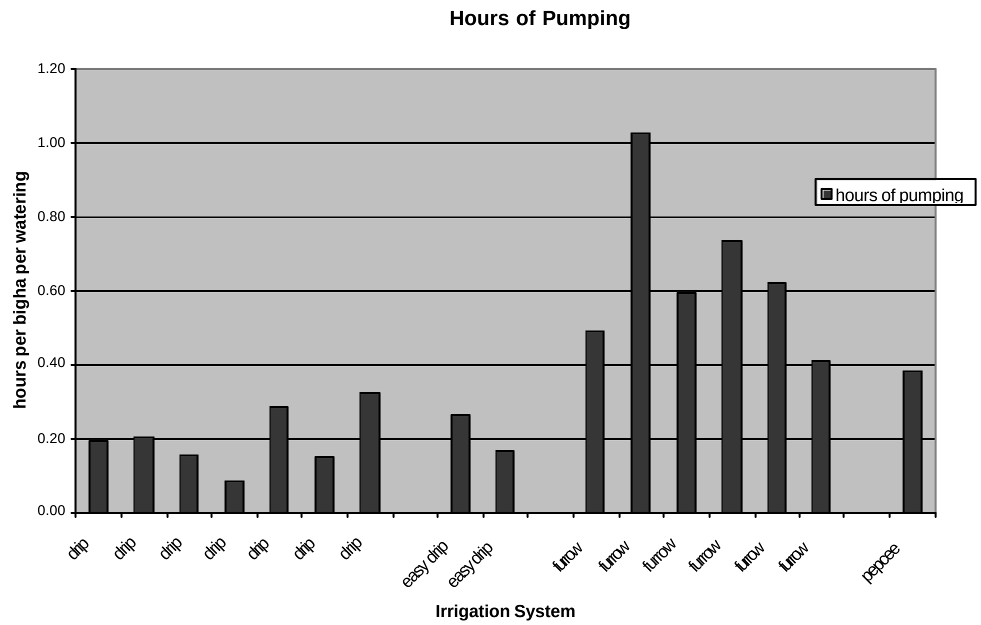
5 This refers to the ability to withstand the shock of water scarcity provided there is not enough water at a future date to irrigate the whole of the expanded area under cotton.

region of late. This can be frustrating as one of the farmers put it. The intermittent and scarce supply led to over irrigating the head reaches of the farm while leaving the tail reaches dry after hours of irrigation. This also led to consuming more electricity than required with regular supply.



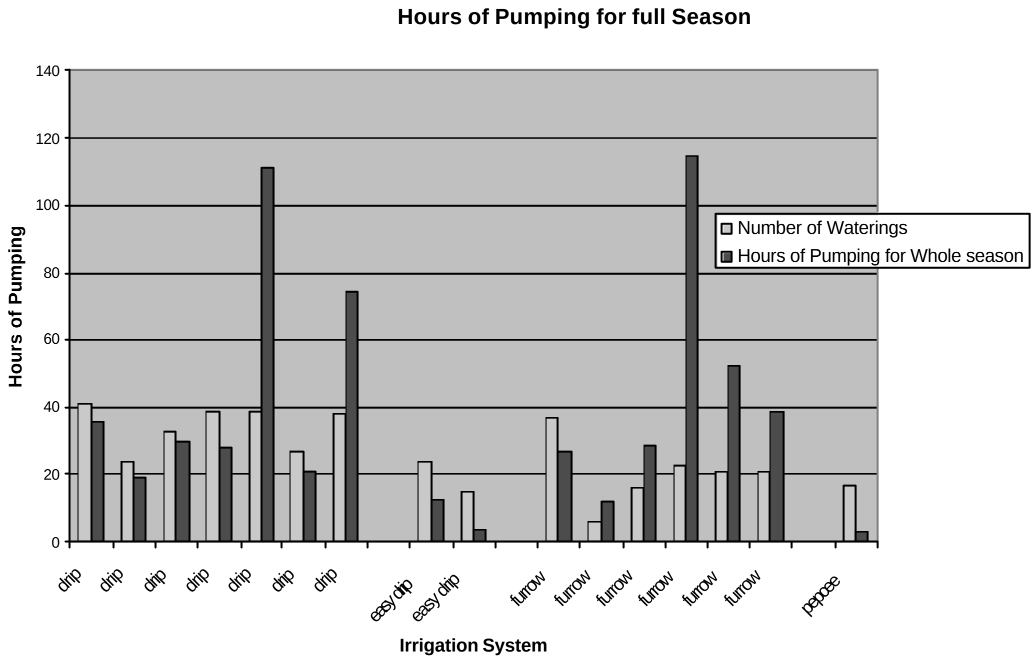
Graph 7: Hours of Pumping Required per Day

Graph 8 compares the hours of pumping required to irrigate unit land area. This shows that the electricity supply needed to irrigate unit area of land varies widely across the carious irrigation systems.



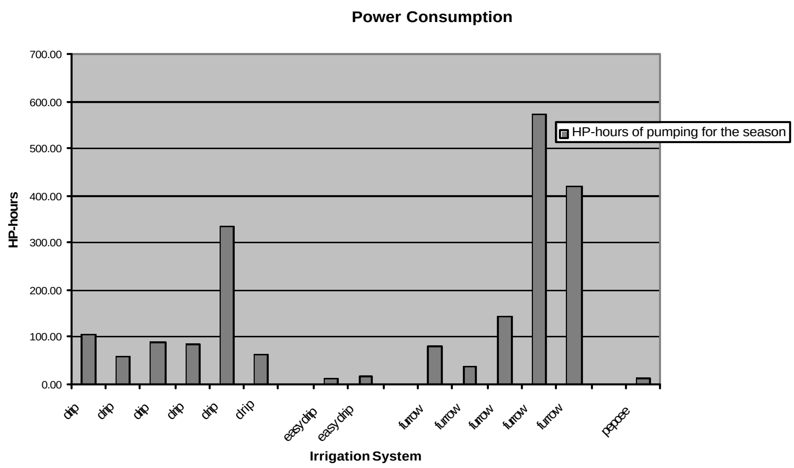
Graph 8: Hours of Pumping to Irrigate Unit Land in Single Irrigation

Graph 8 is very interesting as it shows that despite higher area of the land and also higher number of waterings the total hours of pumping required for the whole season is almost same for the drip irrigating farmers as compared to the furrow irrigating farmers. This means that by using the same amount of electricity with the help of drip irrigation a farmer can grow much more and multiply his benefits significantly.



Graph 9: Total Hours of Pumping required for the Season

Looking at graph 10, it is evident that though the total hours of pumping might be similar for different types of irrigation, the total power consumed is different as the capacities of the pumps installed on the wells are different. However under the current regime of power tariffs with flat rate charges, there is no incentive to reduce the number of hours of usage. There is little incentive to reduce the capacity of the pump as charges are paid on the basis of the installed capacities.



Graph 10: Total Power Consumption (Hp-Hours) for the season

12.0 <u>OTHER BENEFITS OF DRIP IRRIGATION</u>

One of the significant benefits that farmers obtain from the use of drips is the improved germination rate. Most farmers claimed that the use of drip irrigation increases the germination rate from 60-65 % in the case of conventional furrow irrigation to 90-100%. This is mainly due to the ability to sow in dry soil with the use of drip irrigation while pre-irrigation is required for sowing with furrow irrigation. Pre-irrigation makes sowing work more tedious and effort intensive. The higher germination rate translates into benefits of saving on labor costs incurred for the gap filling sowing process (in the spots of failed sowing) with conventional furrow irrigation and also on cost of seeds required for gap filling.

13.0 RESULTS AND CONCLUSIONS

There are significant benefits to be gained by preponement of the cropping calendar for Cotton as it helps in increasing the net returns from Cotton crop and also gives the opportunity to access and increase returns from the Wheat crop. Drip irrigation is the best way to do so as it enables summer irrigation with use of minimum amount of water and electricity. In the summer months the supply is irregular and often in short supply. Drip helps in adequate irrigation despite irregular supply as it requires smaller quanta of electricity supply to irrigate even larger areas than furrow irrigation.

The maximum benefit that accrues to a farmer from the use of drip irrigation results from the opportunity to increase the area under summer sowing. Most of the farmers using drips are able to sustain plants till they stabilize and then shift the drip to sow another part of their fields in the summer. This increases the benefits sighted till now by many folds.

Drip irrigation does result in saving of water if the area and number of days in summer season are kept constant. The adoption of drip irrigation is limited so that no effective saving of water takes place at the area or meso-level at present.

It is clear that saving of water as a result of micro-irrigation can result at a meso-level only if
a) Adopting farmers do not have land to increase irrigated area, and
b) A large number of farmers turn adopters in the area concerned.

The saved water is being diverted to other uses – to expand area under irrigated cultivation in summers in the Nimar Valley. Thus there is a need to take a relook at the proposition of using drip irrigation to effect water saving at a basin or meso-level or how to achieve the scale required for it.

At the farm level adopting to drip irrigation means a number of benefits - more irrigation with same quantity of water or lesser water for same number of plants as compared to conventional furrow irrigation. It also helps in better irrigation with irregular and lesser power supply. There are significant gains from the increased germination rate that the drip offers to farmers.

However the variation within the drip irrigating farmers with respect to water use in the field for Cotton crop clearly indicates that there are perceptional barriers to drip irrigation as a water saving medium for the farmers. There is also a need to educate the farmer that the plant can do with less water than provided to the plant in conventional furrow irrigation. This spells out the need for two types of extension activity

a) Promotion at the grassroots to change perceptions and educate farmers on how the drip can benefit them apart from water saving.
b) After sales service to the farmers to enable them to derive the maximum benefits that drip irrigation technology can offer to them.

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IWMI-Tata Water Policy Program

The IWMI-Tata Water Policy Program was launched in 2000 with the support of Sir Ratan Tata Trust, Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations.

Through this program, IWMI collaborates with a range of partners across India to identify, analyse, and document relevant water-management approaches and current practices.

The policy program's website promotes the exchange of knowledge on water- resources management within the research community and between researchers and policy makers in India.

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