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Water drawn from small farm pond for the sprinkler system in a farm in arid Tumkur District in Karnataka, India. Image supplied by author.

Micro-irrigation is the slow application of water as discrete or continuous drips, tiny streams or miniature spray on, above, or below the soil by surface drip, subsurface drip, bubbler and micro-sprinkler systems. It is applied through emitters connected to a water delivery line through low-pressure delivery.[1]

As the agriculture sector consumes 80% of the freshwater in India,[2,,3] micro-irrigation is often promoted by central and state governments as a way to tackle the growing water crisis. This is because drip and sprinkler irrigation delivers water to farms in far lesser quantities than conventional gravity flow irrigation.[4, 5, 6] Due to recurring droughts in years 2012, 2015 and 2016, micro-irrigation has become a policy priority in India. The new catch-phrase in one of the central government's schemes, Pradhan Mantri Krishi Sinchai Yojana (PMKSY or Prime Minister's Agriculture Irrigation Programme), is "Per Drop More Crop". Apparently, the shift towards micro-irrigation is thought to "save" water and boost crop yields.

But, an investigation into the realities across India's farms, basins, and sectors linked with water resources reveals that micro-irrigation program in India is fraught with a risk of failure. This is because the program is ill-conceived, not holistic, and disintegrated from the basin/watershed perspective.

So questions arise: What are the risks associated with micro-irrigation in India? More importantly, under the current set of assumptions can micro-irrigation really "save" water and boost crop yields? – the premise over which the entire scheme is built and being promoted in India. This article therefore attempts to outline, assess, and reveal the risks and bottlenecks associated with micro-irrigation in India, so that course correction can be undertaken in future.

Energy crisis of India

First, government policies and programs such as PMKSY, National Water Policy, National Mission of Sustainable Agriculture[7] etc., have failed to consider the fact that India's energy crisis is reflected in widespread power outages and unscheduled interruptions across rural and urban India. As micro-irrigation requires pressure for water delivery in delivery lines, it requires pumps regardless of whether the source of water is surface or groundwater.[8]

The Electric Supply Monitoring Initiative (ESMI)[9] of the NGO Prayas reported that, in January 2016, out of its 160 monitoring sites across India, about 17% of its locations faced more than 30 power supply interruptions. The scenario worsened in April 2016 with 46% of its locations experiencing power cuts for more than 15 hours and 24% of locations experiencing more than 30 interruptions each greater than 15 minutes. The electricity crisis in India affects the timing and supply of water to crops because the crop water requirement in farms neither coincides nor follows India's timing of power availability or unscheduled power outages. If diesel pumps are used in place of electricity, then the cost of diesel is additional burden on the farmers.

In spite of this, as a policy, micro-irrigation in India is largely being promoted in arid and semi-arid regions where groundwater is the primary source of water. In states of Karnataka, Telangana, Andhra Pradesh, Tamil Nadu, Maharashtra, Gujarat and Rajasthan, among others, groundwater is overexploited and dependent on India's fickle power supply for its withdrawal. The persistent energy crisis affects drawal of groundwater in arid and semi-arid regions. It is therefore a disincentive for farmers to adopt technology-intensive micro-irrigation system in the regime of power outages. The persistent energy crisis of India challenges governments' grand assumptions about micro-irrigation across India's farms.

Expensive micro-irrigation

Water leakage from a sprinkler system caused by the inadequate repair of components defeats the purpose of saving water on Indian farms. Image supplied by author.

The second impediment to micro-irrigation in India is the expense of the system itself. Indian Council of Agricultural Research[10] reports that gross income of a farmer holding 3 hectares (ha) using integrated farming is $1838 (at current exchange rate $1 = Rs 68). In comparison, government data show that the micro-irrigation is expensive in terms of per hectare cost, and that it further depends on the size of farm as well as the type of crop grown.

The normative cost of installation for micro-sprinklers is $866 per ha and $12500 per ha for mini-sprinklers as per the guidelines of National Mission on Micro-Irrigation (NMMI).[11] Similarly, indicative cost of drip irrigation for closed spaced crops with 1.5m X 1.5m spacing of laterals varies from $316 per ha to $6927 per ha for a lateral spacing of 1.2m X 0.6m. Therefore, to offset the financial constraints of the farmer, governments have focused largely on financial assistance in the form of subsidies to the extent of 40-90% of the cost of micro-irrigation. But again the government policies are myopic.

A study in Maharashtra and Gujarat by Namara et.al.[12] shows that the large proportion of micro-irrigation adopters belong to a relatively wealthy group of farmers, and the poorest section of the farming population have not benefited much from innovations in micro-irrigation due to financial constraints and cropping patterns. For poorer farmers, micro-irrigation is unsustainable as the Governments' schemes and financial assistance programmes do not cover the re-procurement of drip and sprinkler system in the event of the sophisticated system becoming obsolete before the stipulated period of next assistance.

Drip-Irrigation in Chikkaballapur District of Karnataka, India, where the author observed a farmer being informed that he had to replace obsolete components at his own cost in 2016. Image supplied by author.

One such situation was witnessed during my visit to a farm in Chikkaballapur District of Karnataka where the farmer, who had adopted drip irrigation, had to bear the cost of all obsolete and clogged components himself simply because the period of eligibility for the next round of financial assistance was too far in the future (about 10 years).[13] In another study in Vijayapura district of Karnataka, it has been found that factors such as the clogging of emitters, poor quality of products, damages by rodents, high cost of installment, poor component repairs, loan approval delays, delays in subsidy approvals, and inadequate technical support were all obstacles for farmers in adoption of micro-irrigation.[14]

Further, when assistance is linked with the creation of new sources of water, as in the case of Karnataka, the additional investment that a marginal farmer (1-2 hectare) has to bear is a disincentive to adopt micro-irrigation. In Punjab[15], assistance is also extended to create tanks and for installation of solar pump-sets, but not for maintenance and drilling borewells. So, even if wealthy farmers could afford micro-irrigation in the short term, considering drawbacks such as the expense of maintaining the components, the risks of a power crisis, falling groundwater levels, and fickle weather patterns, micro-irrigation is not sustainable in the long term. Hence, the governments' assumption that all categories of farmers with any landholding and cropping pattern can afford micro-irrigation and maintain the systems is not only wrong, but also unreasonable.

Declining landholdings and farm income

The third impediment to the adoption of micro-irrigation is even more alarming because the data on India's operational landholdings shows that the average size of landholdings have halved since the 1960s.[16] From 2.28ha in 1970-71, landholding size has nearly halved to 1.16ha in 2010-11. As of 2010-11, landholdings less than 1ha constituted 67% of all landholdings, and, when combined with landholdings between 1-2ha, these marginal and small landholdings constituted 85% of the operational landholdings in the country.[17]

The declining size of landholdings impacts farm incomes and farm income is closely associated with the capability of the farmer to adopt expensive micro-irrigation systems. The average net farm income from crops for all marginal, small, and large landholdings in 2003 was a mere Rs6694 or US$98 per annum. According to Sachdeva and Chahal[18], the farm business income from rice in 2006-07 was Rs12,472 or US$183 (1$ = Rs 68) and from wheat in 2007-08 was Rs25,590 or US$376. This means that the level of income from farms in India does not even cover the consumption expenditure of micro-irrigation.[18]

The meager farm income from declining landholdings challenges the sustainability of expensive micro-irrigation on Indian farms because farmers now have to invest further to replace obsolete components of drip/sprinkler systems such as filters, clogged pipe network, electrical/electronic components, pumps, silted water bodies etc., all of which are not covered in any of the governments' financial schemes.

“Per Drop More Crop” fallacy

Fifth, and most importantly, whether micro-irrigation saves water or not? Policies and programmes are clueless whether the “Drop” referred in the “Per Drop More Crop” is the “Drop” diverted (also known as withdrawn) from a water source to farms (or basins) or the drop consumed by the crops i.e. Evapotranspiration (ET). Because a reduction in ET is what constitutes real water savings, if the “Drop” referred to is assumed to be ET, then “Per Drop More Crop” is fallacious as micro-irrigation does not reduce ET.[19]

Tarantino et al.[20] compared the application of water through drip and furrow irrigation on Tomato crops (UC-82) but found no difference in the seasonal ET under similar crop canopies. In fact, the mean ET loss under daily drip irrigation actually exceeded that from furrow irrigation by about 8.9%, except for a period of three days following each furrow irrigation.[20] In such cases, crop yields are dependent not only on water alone but also on timely inputs such as nutrients and soil management.[21]

If the “Drop” referred in “Per Drop More Crop” is water diverted (or withdrawn) to farms in a watershed, then the apparent “water savings”, is an illusion to the users who adopt micro-irrigation. This is because micro-irrigation, according to Ward and Velanquez[19], merely prevents water in excess of ET from returning back to the basin/watershed via surface runoff or deep percolation.

From a basin or watershed perspective, which is the scale of focus for India’s water policies[22, 23], this prevention creates significant tradeoffs. The externality imposed on an unsuspecting farmer dependent on return flows (via surface runoff or aquifer) is “No Drop No Crop” or “Less Drop Uncertain Crop” or “Uncertain Drop No Crop”.

Another externality witnessed during my visit to the arid South Karnataka region of Doddaballapur district was that micro-irrigation had enabled better-off farmers/farming companies to divert groundwater towards agriculture on fallow or wastelands despite a falling groundwater table. “Per Drop More Crop” is meaningless here as there has not previously been any irrigated agriculture practiced on the wastelands. Instead, this diversion has intensified the domestic water crisis during the dry season, undermining the objectives of the “Per Drop More Crop” initiative.

Hence, the policies and programmes that promote micro-irrigation as a game-changer in India’s water management lack conclusive research to show that micro-irrigation reduces crop consumptive use or ET for any crop thereby bettering the current studies conducted by Tarantino et al. and Ward and Velanquez.

Looking at alternatives

Considering the vigour with which micro-irrigation is being promoted in India, questions arise as to whether micro-irrigation is the only *miracle* left for planners and policy makers to transform water management in India? If not, then what other alternatives are available for governments?

A glance at India's chaotic cropping pattern brings into focus the rampant cultivation of water intensive crops (high ET) such as sugarcane, paddy, cotton, banana etc., across water stressed regions of India. Maharashtra is one of the worst water stressed states of India but government data suggests that Maharashtra state is also the largest state with sugarcane cultivation in the tropical region.[24] Similarly, sugarcane and paddy are commonly cultivated in highly water stressed regions of the Cauvery basin, which spreads over the conflicting states of Karnataka and Tamil Nadu. Table.1 shows water requirement of various crops.

Crop	Water Requirement (mm)	Crop	Water Requirement (mm)
Rice	900-2500	Chillies	500
Wheat	450-650	Sunflower	350-500
Sorghum	450-650	Castor	500
Maize	500-800	Bean	300-500
Sugarcane	1500-2500	Cabbage	380-500
Groundnut	500-700	Pea	350-500
Cotton	700-1300	Banana	1200-2200
Soybean	450-700	Citrus	900-1200
Tobacco	400-600	Pineapple	700-1000
Tomato	600-800	Gingelly	350-400
Potato	500-700	Ragi	400-450
Onion	350-550	Grape	500-1200

Table 1. Water Requirement of various crops (Agropedia 2017).

As agriculture is the largest consumer of freshwater in India, the shift from water intensive sugarcane, paddy, cotton, banana etc., to less water intensive but high value crops such as pulses, millets, vegetables, legumes, oilseeds, medicinal plants etc., will spare large quantities of freshwater in India with less cost than what accrues through micro-irrigation. In places where this has occurred, this is the real water savings caused due to a reduction in ET. It is a paradox and absurd to promote micro-irrigation with slogans to "save" water, while governments overlook stringent legislation, robust institutions, incentives, mass awareness, stronger administrative capacity to monitor and restrict water intensive crops across water stressed regions such as Maharashtra, Karnataka, Telangana, Andhra Pradesh, and Tamil Nadu.[25, 26, 27]

Water footprints, virtual water trades and formal water markets are other alternatives for saving water.[28] However, these measures are yet to emerge from policy papers. The virtual water imported from water abundant regions of India such as Indo-Gangetic, Brahmaputra plains, coastal India etc., to water stressed regions of peninsular India will bring real savings in freshwater with hardly any capital costs of the magnitude seen with the implementation of micro-irrigation.

Captive solar plants can replace grid electricity or function in tandem during power outages in the short term or at least till such time India's energy crisis is overcome in future. But it possesses drawbacks in being capital intensive and with a scope to exploit more groundwater.

Conclusion

Micro-irrigation in India is fraught with risks. This is because there is no guarantee in the near future that India's energy crisis could be overcome or there could be consolidation of landholdings with concomitant elevation of farmer's income so as to afford expensive micro-irrigation. Though micro-irrigation in India is being promoted by vested interests with sporadic success stories, it is not backed by conclusive research showing any reduction in ET of crops – the point ignored by policies and schemes. Hence, governments should initiate basin-wide studies which take a holistic approach to verify whether micro-irrigation reduces crop ET before promoting micro-irrigation as a saviour of water.

In fact, alternatives such as the cultivation of low ET crops in place of water intensive crops across arid and semi-arid regions of India, virtual water trades, and water markets cause real water savings with little cost. In comparison, micro-irrigation is no substitute for these alternatives in terms of freshwater saved. Hence, governments have to prioritize planned cropping patterns backed by stringent laws and administrative capacity to monitor cultivation of less water intensive crops. In light of the risks, bottlenecks and alternatives identified in this article, governments in India have to review the current micro-irrigation strategy to avoid chaos in India's water management. Instead, if the *status quo* is persisted with, then India's micro-irrigation strategy will falter with severe consequences not only to the exchequer but also exacerbate the worsening water crisis across India.

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