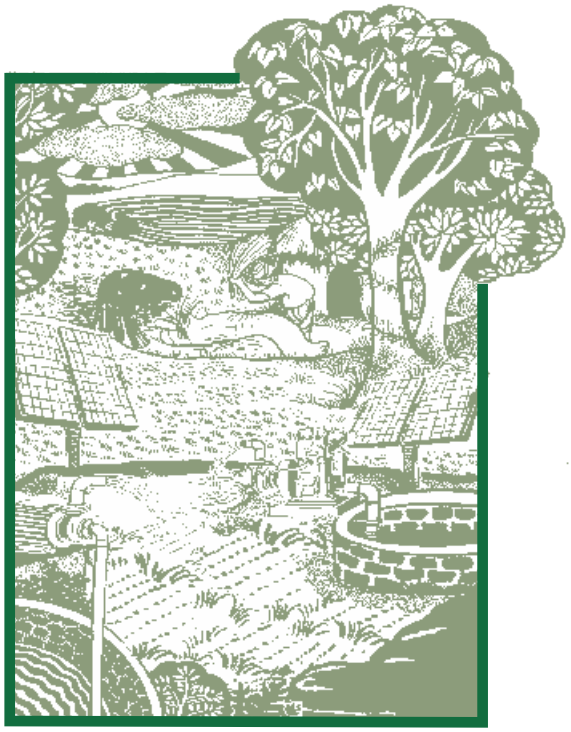
01
2016



The Prime Minister's Krishi Sinchai Yojana (PMKSY) has promised the country har khet ko pani. However, this is easier said than done. As we saw in Andhra Pradesh and Vidarbha, grand irrigation projects can guzzle up billions without delivering any benefit to farmers. PMKSY should concentrate on two low-hanging fruits. First, it should quickly utilise 20-40 million ha of unutilised irrigation potential created in major, medium and minor irrigation projects. Second, it should provide better quality power ration to farmers during peak irrigation season. Under Chauhan, Madhya Pradesh did precisely this and multiplied the state's irrigated area quickly, at small incremental cost, delivering double-digit agricultural growth.

IWMI-TATA
Water Policy Program

Water Policy Research

HIGHLIGHT

Har Khet Ko Pani?

(Water to Every Farm?)

Emulate Madhya Pradesh's Irrigation Reform

Tushaar Shah
Gourav Mishra
Pankaj Kela
Pennan Chinnasamy

Har Khet Ko Pani?
(Water to Every Farm?)
Emulate Madhya Pradesh's Irrigation Reform*

Research highlight based on Shah *et al.* (2012), Shah *et al.* (2016) and GIS mapping by Gourav Mishra and Pennan Chinnasamy

1. Introduction

The relentless spate of farmer suicides has once again drawn the nation's attention to the deepening agrarian crisis. Media is abuzz with opinions and expert advice on how to provide succour to the farming community. Oft-repeated among these is demand to increase public investment in irrigation. BJP's election manifesto promised, among other things, *har khet ko pani*. And keeping its word, the Modi government has announced Prime Minister's Krishi Sinchai Yojana (PMKSY) with a commitment to invest ₹ 50,000 crore over five years in universalizing irrigation access.

Massive irrigation initiatives have always been favourite of leaders for political grandstanding. However, we need to remember public irrigation in India has proved a bottomless pit. According to a RBI study, during 1991-2007, the country invested well over ₹ 200,000 crore (at 2007 prices) in irrigation and flood control (Balakrishnan *et al.* 2008). Yet, thanks to 'deficiencies in planning, implementation and management', the area served by government canals actually decreased by 3.8 million hectares (mha) during that period. RBI researchers viewed this, correctly, as, "a question of governance." Without tackling this 'governance deficit', public investment in irrigation is simply throwing good money after bad.

The growing gap between irrigation potential created and utilized is symptomatic of the governance deficit. According to the Ministry of Water Resources (MoWR), the utilization of potential created was 100 per cent until 1980 but fell to 58 per cent by 2007. The more we invested in canal irrigation, the less irrigation we got. The reality is likely much worse because the land use survey (LUS) data by Ministry of Agriculture shows the area irrigated by surface schemes to be below 17 mha throughout the 2000-2013 period compared to MoWR's claim of 42.70 mha and created potential of 56.40 mha (*ibid*, table 11A.8, 11A.9 and 11D.1).

PMKSY can progress towards *har khet ko pani* by focussing on two low-hanging fruits: first, quickly utilise 20-40 mha of already created canal irrigation potential that is awaiting utilisation; and second, improve the productivity of tubewell irrigation by providing farmers quality power supply, for a fixed daily ration, during peak irrigation season. Under Chauhan, Madhya Pradesh has demonstrated how to do this with great success.

2. Accelerated Irrigation Expansion in MP

Post-2000, UPA and BJP Chief Ministers have pursued sharply different irrigation strategies. UPA governments in Maharashtra and Andhra Pradesh have used massive irrigation investments to create rent seeking opportunities and left the anarchy on rural electricity network totally untouched. Soon after he became Chief Minister in 2004, Raj Shekhar Reddy announced free power to farmers until 2017 and launched *Jala Yagnam*, a massive scheme to provide irrigation to over 1.20 crore acres at a cost of ₹ 1.86 lakh crore. Between 2003-04 and 2011-12, the state government invested ₹ 74,200 crore on *Jala Yagnam* (*ibid*: chart 5.4). However, a 2012 CAG audit concluded that its benefits are illusory. In Maharashtra, similarly, the Congress-NCP government got mired in an irrigation scam in drought-prone Vidarbha region that cost the exchequer over ₹ 70,000 crore but resulted in hardly any increase in irrigated area leading to accusations that half the funds spent were swindled by politicians. In both the states, farm power supply remained free but with progressive deterioration in quality and availability. Between 2000-01 and 2012-13, when massive irrigation investments were made in Andhra Pradesh and Maharashtra, their index of area irrigated by government projects, as well as by all sources, was flat or declining (figure 1 and 2). The major beneficiaries of these investments arguably were politicians and contractors. Maharashtra Chief Minister Phadnavis recently lamented that despite having 40 per cent of India's dams, 82 per cent of Maharashtra's farm lands are rainfed!

In contrast, irrigation scene in BJP ruled Gujarat and Madhya Pradesh has been different as evident in figures 1 and 2. Vaidyanathan (2007) had shown that all agricultural growth in India during 1970-2000 could be attributed to irrigation-induced productivity growth. As if on cue, Modi and Chauhan pursued agricultural growth through irrigation development as a political strategy for capturing agrarian vote-banks rather than rent-seeking. Since 2000, these states rapidly expanded areas under canal irrigation and improved farm-power supply. Neither Modi nor Chauhan nor their colleagues got accused of irrigation scams. As Gujarat's Chief Minister, Modi was the original architect of this strategy that delivered Gujarat's agricultural growth rate of 9

*This Highlight is based on research carried out under the IWMI-Tata Program (ITP) with additional support from the CGIAR Research Program on Water, Land and Ecosystems (WLE). It is not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or its funding partners.

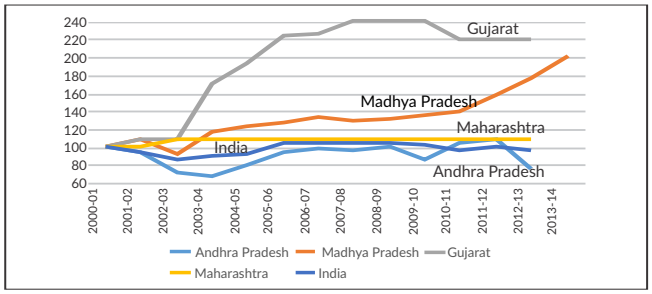


Figure 1 Index of Canal Irrigated area (2000-01=100)

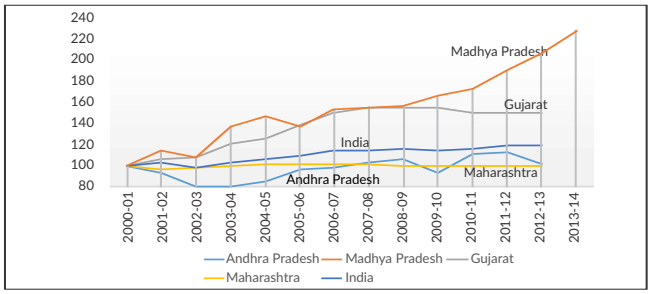


Figure 2 Index of Net Area Irrigated from all Sources (2000-01=100)

per cent/year during 2000-08 (see Shah *et al*. 2009). Modi did this *inter alia* by: [a] expediting the construction of the Sardar Sarovar project; [b] implementing a highly successful program of supporting local communities for water harvesting and groundwater recharge; [c] improving quality of farm power ration through Jyotigram scheme of feeder separation; [d] issuing over 5 lakh new electricity connections to SC/ST and small farmers. Modi's agrarian success in Gujarat was unparalleled. But Chauhan, who took over as Madhya Pradesh Chief Minister after Modi in Gujarat has outdone even Modi in accelerating irrigation benefits. Chauhan's most notable success has been in quickly improving power supply for *rabi* irrigation and rapidly expanding the utilization of created canal irrigation potential from major, medium and minor schemes.

Figures 1 and 2, irrigation index numbers by government canals and all sources in the four states using Land Use Survey (LUS) data clearly show a strong upward trend in Gujarat and Madhya Pradesh during the new millennium while these are flat in Maharashtra and Andhra Pradesh. Figures 3 (a,b,c) and 4 (a,b,c) are remote sensing maps of cropped areas of Madhya Pradesh in January, February and March 2009 and 2014 respectively. These maps have not been validated for accuracy; however, they point to unmistakable expansion of irrigated areas (reflected in peak crop signatures and higher 'greenness' of the landscape) in Madhya Pradesh by some 1.90 mha, from 7.36 mha in February 2009 to 9.26 mha in February 2014. The actual increase is likely to be around twice this figure at some 3.60 mha, thanks to a large rainfed *rabi* area coming under irrigation. One of the 10 crop signature series examined showed a low peak in 2009 February, indicating low-yielding rainfed fodder crop on some 2 mha. All of these turned into much greener irrigated area in February 2014 while that particular crop signature disappeared altogether. Figure 5 which shows the spatial distribution of the difference in NDVI (or winter cropped area) suggests that there is increase in irrigated winter cropping all over the state but there is much more in groundwater-irrigated western districts (Ujjain, Rajgarh, Dewas, Dhar, Burhanpur, Shehore, Barwani) and less so in eastern and north-eastern parts (Rewa, Satna, Sidhi, Shahdol, Sagar, Damoh, Sidhi and other districts) which have much of the state's canal command areas (shown in Figure 6).

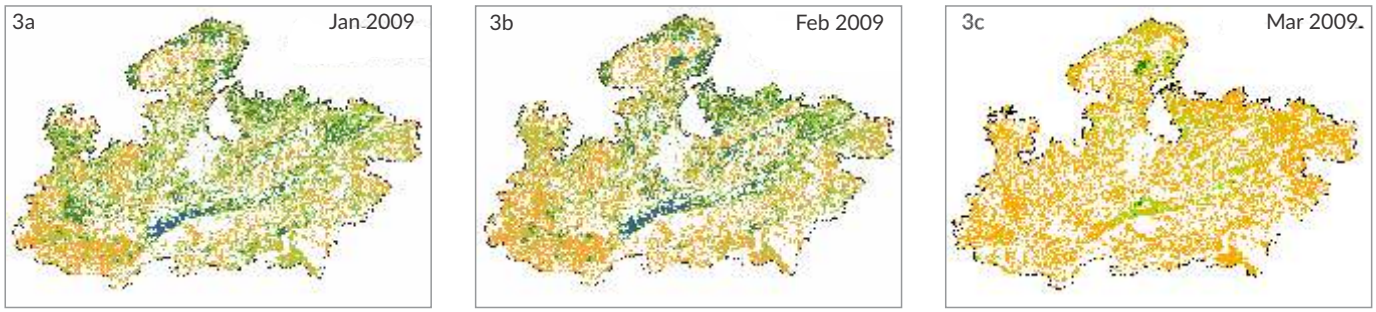


Figure 3 Cropped areas of Madhya Pradesh in January, February and March 2009

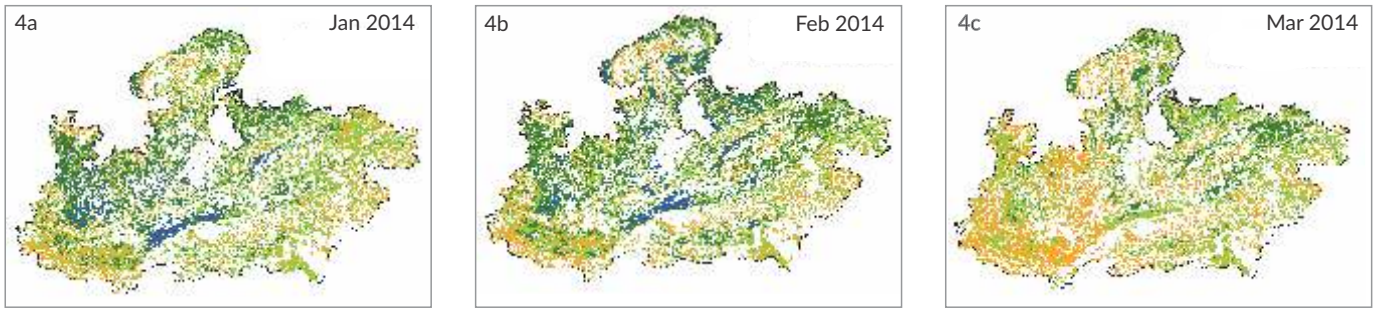


Figure 4 Cropped areas of Madhya Pradesh in January, February and March 2014

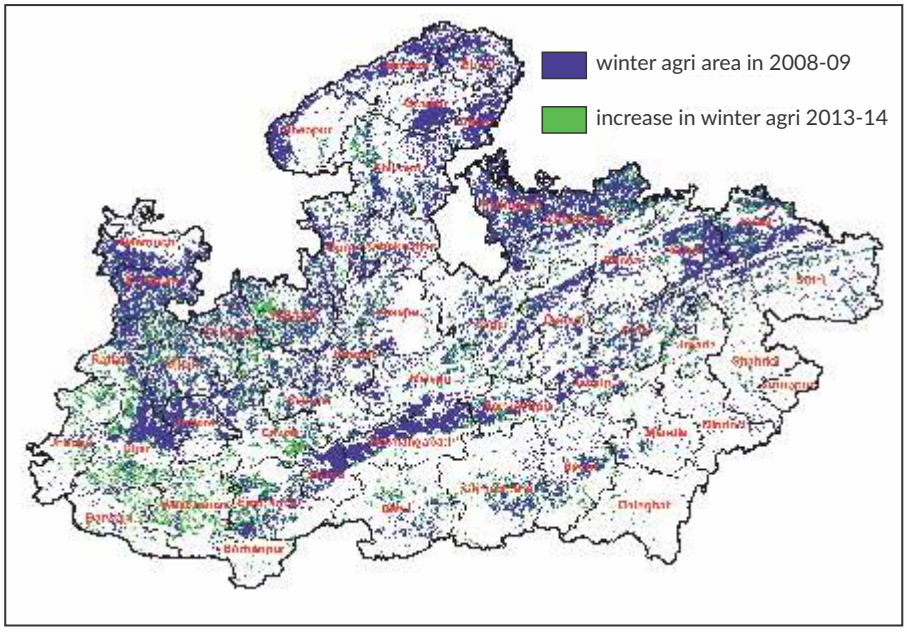


Figure 5 Increase in cropped area between 2008-09 to 2013-14

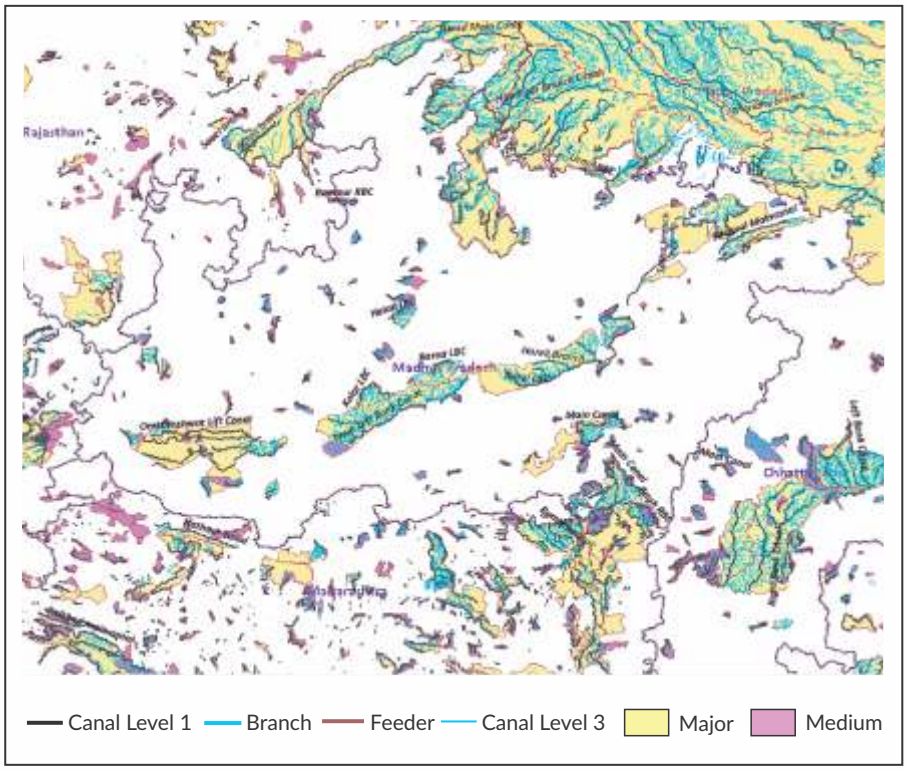


Figure 6 Map of canal command in Madhya Pradesh

3. Power Supply to Agriculture

Chauhan's agricultural growth strategy initially focused on expanding irrigation to the wheat crop by improving quality of power supply to farmers during the 110 day wheat irrigation season. But MP was critically short of power and he inherited a rural power network that was in disarray. Chauhan began attracting investments in power generation and soon thereafter, he also followed Modi's Jyotigram scheme of rural feeder separation to provide 24*7 power supply to rural households and quality power ration to farmers. Both these would however take several years to fructify. In the meanwhile, total anarchy ensued in rural power network during winter when rampant hooking on low tension lines by frustrated farmers led to low voltage, frequent black outs and transformer burnouts. Chauhan imposed a modicum of order on this anarchy by issuing temporary winter-season power connections. Irrigation demand for power during winter was so high that farmers were willing to pay ₹ 2.70-3.00/unit for reliable power. The government contracted advance power purchase for winter months, created a sense of plenty, and began liberally issuing winter-season irrigation connections. For a 5 HP winter connection, for example, the DISCOMs charged a flat rate of ₹ 13,850 of which the farmer paid ₹ 8,430 (an estimated ₹ 2.72/kWh) in advance and the government paid the DISCOM a subsidy of ₹ 5,420. DISCOMs loved the seasonal connections because advance payment by farmers solved their working capital problem. During 2010-13 period, 3.12 million winter season connections were issued resulting in 40 per cent increase in power consumption in *rabi* irrigation and expanding wheat cultivation by some 1.8-2 mha/year (Shah *et al.* 2012). In 2013-14 itself, 952,000 temporary connections and 2,13,000 permanent connections were issued. Between, 2009-10 and 2013-14, power use in groundwater irrigation, mostly during winter, soared from 6.78 billion kWh to 12.65 billion kWh. While seasonal power connections to farmers delivered large part of increased irrigation in the state, even more significant in qualitative terms were management reforms that MP irrigation department introduced in government canal projects.

4. Canal Irrigation Reforms

During Chauhan's first decade, Madhya Pradesh government spent a total of ₹ 36,689 crore on irrigation, far less than AP and Maharashtra had done; yet, MP tripled its irrigated area in canal commands (from all sources) from 0.80 mha in 2006 to 2.50 mha in 2012-13. One might suspect that large increase in canal irrigation resulted from new projects commissioned on Narmada. However, as figure 7 shows, canal irrigated area increased in all of MP's river basins rather than just Narmada. Figures from MP irrigation department would be expected to show rapid increase; but even LUS

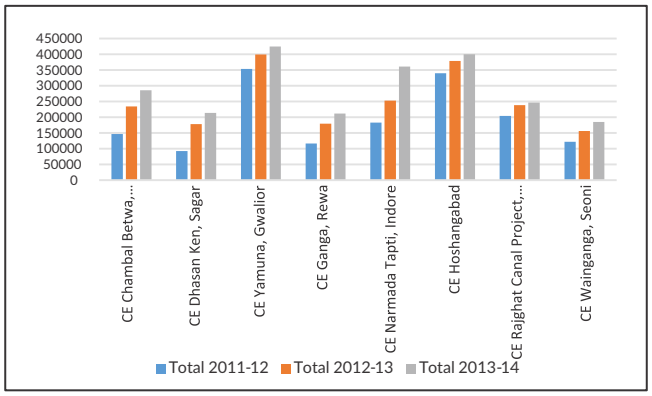


Figure 7 Area reported to be irrigated by public canals in different river basins of Madhya Pradesh: 2011-12 to 2013-14

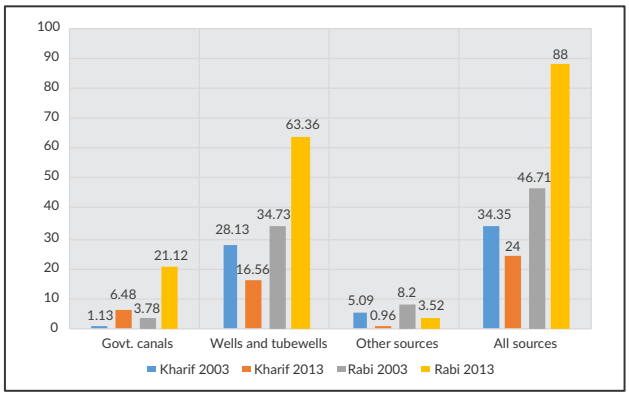


Figure 8 Increase in % of cultivated area under irrigation by different sources in Madhya Pradesh: Comparing NSSO Round 59 (2002-03) with NSSO Round 70 (2012-13)

figures show the rapidly increasing trend in canal irrigation (Figure 1). Figure 8 compares the irrigation data for Madhya Pradesh compiled by NSSO round #59 for 2002-03 and round #70 for 2012-13. These too show near doubling of *rabi* irrigated area from all sources and a near 6-fold increase in canal irrigation for the farmers sampled.

In 2003, government canals in MP irrigated around 0.65 mha. Under Chauhan's prodding, irrigation inched up. In 2008 assembly elections, Chauhan reaped rich electoral dividends from farmers for his irrigation policies. So in 2010, after sacking a corrupt irrigation secretary, Chauhan brought Julaniya, a dynamic, upright and pushy officer to run the irrigation department, with promise of stable tenure and total support in stamping out political interference in running canals. This move delivered. The area irrigated by government canals jumped from less than 1.0 mha in 2010 to 1.56 mha in 2011, to 2.02 mha in 2012, and 2.33 mha in 2013. In 2014, despite being a poor monsoon year, Julaniya expects the state will have 3.0 mha irrigated in canal commands (by all sources), more than even the potential created of 2.83 mha.

How did Madhya Pradesh achieve such miraculous expansion in canal irrigated area? We undertook an open-ended field investigation to understand key elements of MP's irrigation management reform campaign. We visited several major, medium and minor systems, interviewed farmers and their leaders, met irrigation staff from Principal Secretary and Superintending Engineers down to *'chawkidars'*. The top political and administrative leadership implemented reforms by making performance-linked demands (PLD) on the bureaucracy and offered performance-linked supports (PLS) so that the department could rise to the challenge. The PLD-PLS strategy involved six components:

a. **Restoring canal management protocol:** Four rules of effective canal system operation-viz., rationalized irrigation schedules, tail-to-head irrigation, osarabandi (operating canals by strict rotation) and operating canals at full-supply level (FSL) have eroded in all Indian systems. MP restored their primacy and insisted on full enforcement of all these principles. Obsolete irrigation schedules were revised; water allowances were adjusted to reflect new cropping patterns; areas served by lift irrigation from surface and groundwater in command areas began to get counted as canal irrigated areas. Irrigating tail-end first removed the head-tail inequity endemic to canal irrigation; FSL canal operation meant that water reached tail-ends and could be distributed in an orderly manner; enforcing osarabandi ensured that distributaries could be operated at FSL during their rotations. The most difficult of all in early years was enforcing the 'tail-end first' rule because it challenged the long-entrenched power relations. In some projects, tail-end farmers were asked to complete land preparation a week or so in advance so that water could be released in advance when head-end farmers were not ready. Restoring the primacy of 'tail-end-first' required a massive thrust first; but once it got accepted, things began to fall in place; farmers adjusted planting schedules; water demand in head began lagging that in tail. Earlier, when canals ran non-stop at low-supply, it was a winner-take all game for head-end farmers who were under no pressure to time planting or save water. Now, osarabandi delivers full-supply for specific pre-determined time slots that drives farmers to manage water better. Over time, there is greater appreciation among farmers for the discipline of 'tail-end-first' irrigation and osarabandi since with greater discharge of water, the fields are irrigated faster saving the farmer time and labour.

b. **Last mile investments:** To enforce the three core-rules requires that systems are well-maintained and in good repair. A World Bank loan and internal resources were found to prioritise and quickly complete last-mile projects with high potential. Lining big earthen canals on old systems helped reach water to tail ends quickly. Small investments in rehabilitating over 4,000 minor irrigation schemes doubled the area served by them in just two years from 3,67,000 ha to 7,60,000 ha.

c. **Reducing deferred maintenance:** Canals can be operated at FSL only if they are regularly maintained and will not breach. In most states, after salaries are paid, irrigation departments are left with no resources for Management, Operation and Maintenance (MO&M). In MP, the

department was provided resources to undertake proper MO&M. Two months ahead of every irrigation season, the department would be mobilized to desilt and clean all main canals while Water User Associations cleaned sub-minors and field channels. Even then, in older systems, risks of canal breach remained. Engineers were enjoined to run canals at FSL and, if they occurred, fix the breaches within a stringent time limit; in doing so, they were backed by the department bosses.

d. **Constant Monitoring:** The hallmark of new management was relentless monitoring. Potential created was taken as the target for irrigation. Regular weekly video-conferences taken by the Secretary and newly introduced ICT systems created pressure for performance. The long abandoned practice of engineers overseeing irrigation operations in the field got revived with the Secretary and Chief engineer themselves frequently heading out to the field. Irrigating tail-end areas became an obsession and from the Secretary down, the key variable monitored was whether tail-end fields were watered. In a masterful innovation, the Engineer-in-Chief would randomly call any of the 4000 odd mobile numbers of tail end farmers to enquire if water reached her/his field.

e. **Animating the irrigation bureaucracy:** Unstinted support of the Chief Minister empowered the irrigation bureaucracy to establish order and rule of law in canal commands. Local political interference was firmly crushed, when needed, with direct intervention from the Chief Minister. This had magical effect on the department's morale which was further enhanced by a new system that recognized and felicitated high performing staff. The Chief Minister's backing also made coordination with agriculture, forest, revenue departments and district collectors easier, quicker and result-oriented. Time-consuming peripheral issues were decluttered. An invigorated irrigation bureaucracy was focused on the core task of delivering water to as many farmers as possible especially in the tail-ends.

f. **Vitalizing farmer organisations:** Under a new law made in 1999, some 2000 Water User Associations were formed but mostly lay defunct. WUAs had little role when poorly managed main system failed to deliver water to many parts of the command for years. Now that the MO&M of the main system improved, water began reaching the tail-ends and defunct WUAs sprung to life. By involving them in pre-*rabi* desilting of minors and sub-minors, the department enhanced its outreach and WUAs became critical partners in irrigation scheduling, maintenance below outlets and orderly water distribution.

5. Sustaining Gains from Irrigation Management Reform: Unfreeze, Change, Refreeze

Impacts of bureaucratic reforms are hard to assess in a short timeframe. In Madhya Pradesh irrigation department, there are some signs of these working because of significant political and administrative energy behind them. But are these sustainable?

Management Guru Kurt Levin argued 75 years ago that changing a system succeeds only if the change sustains after its driving-impulse peters out. In his popular model, managing change involves three stages: unfreezing, changing and refreezing. Unfreezing involves making a compelling case for changing the current order and preparing the stakeholders for embarking on a change program. This is followed by actually implementing the change program, overcoming the uncertainties, anxieties and fears about the new reality, and preparing stakeholders to embrace new behaviours, processes and ways of thinking. Madhya Pradesh Irrigation Department (ID) has completed these two steps in its irrigation reforms; but it needs to reinforce and solidify the new order by refreezing it through supporting policies, mechanisms, structures and norms. It is very likely that irrigation gains will gradually fizzle out if, for example, the present Secretary is replaced by someone less zealous or Chauhan makes way for another politician. So far, Chief Minister and Secretary (irrigation) have been the sole source of Performance-linked-demands (PLD) and Performance linked supports (PLS) that have driven change; refreezing requires that farmers become the providers of PLD and PLS. This can happen only by building a strong relationship of mutuality between ID and farmers through aggressive recovery of Irrigation Service Fee (ISF). In this sense, MP's irrigation reforms are incomplete. While the area irrigated has increased four-fold, ISF recovered has increased only 60 per cent, from ₹ 10.50 crores in 2005-06 to ₹ 16.45 crore in 2013-14. ID staff in other states are loathe to recover ISF because IDs do not offer reliable service. MP ID offers reliable irrigation; and therefore, is best placed to vigorously recover a rationalized ISF.

Like MP's ID, its DISCOM's also undertook change management but their dealings with farmers are more likely to sustain at new higher plane because they have completed the refreezing process. Until 2008, the anarchy on MP's rural electricity feeders was as bad as in its canal commands. Power theft by farmers was rampant. Unable to offer reliable service, DISCOM's were reluctant to recover tariff and stop theft. Once order was established and DISCOMs had reliable power to offer, they began selling seasonal connections to farmers at a fairly high price of ₹ 2.70/kWh collected in advance; and because farmers paid a high price, DISCOMs felt pressure to offer matching service. A vicious cycle was replaced by a virtuous one; farmers morphed from being beneficiaries to customers. The same process needs to be replicated in irrigation commands.

It is by no means necessary that farmers pay the full MO&M cost of irrigation service provision; but ISF needs to be rationalized and vigorously collected, if only to ensure that farmers begin to make PLDs and offer PLS to irrigation department. Madhya Pradesh needs to launch its own version of the National Irrigation Management Fund (NIMF) that was included in the 12th Five Year Plan which offered to match ISF collected by each irrigation system on a 1:1 basis to augment MO&M resources available with irrigation managers. In addition, to strengthen WUAs, the government

should offer a 50 per cent bonus on all ISF collected by WUAs. Unless irrigation management reform is taken to its logical end by rationalization and vigorous recovery of ISF, the gains of irrigation management reform will peter out as soon as the leadership changes or takes the pressure off.

Post-script

Much of the analysis presented in this paper used data up to 2013-14 which was a normal monsoon year. Since then, however, Madhya Pradesh has experienced two back-to-back droughts. The average rainfall was 845 mm in 2014-15 and 840 mm in 2015-16, way less than 1472 mm in 2013 and above normal-rainfall in 5 previous years in a row. Many parts of the state, especially Bundelkhand and other rainfed areas, were under deep distress, especially in 2015-16 where irrigation wells dried up. Rainfed soyabean crop in kharif 2014 got nearly wiped out; however, *rabi* wheat, which is irrigated, thrived in 2014-15. Published final figures are still not available; however, Julaniya (2016), the state's water resources secretary claimed in a recent workshop at Asian Development Bank, Manila that irrigation by all sources in Madhya Pradesh's canal commands increased to 2.69 mha in 2014-15 and 2.81 mha in 2015-16, higher than 2.53 mha irrigated in 2013-14. He claimed this contributed to increase in state-wide food grain production from 30.07 mmt in 2013-14 to 34.09 mmt in 2014-15 and to (expected) 37 mmt in 2015-16. Irrigated wheat production increased from 1.71 mmt in 2013-14 to 1.78 mmt in 2014-15. However, in 2015-16, wheat production is expected to suffer a decline thanks to the second drought in a row. Irrigation reforms have clearly not prepared Madhya Pradesh agriculture for two successive drought years. However, the strategy of spreading canal water over larger areas has promoted conjunctive management of surface and groundwater. While groundwater wells in rainfed areas dried up in the second successive drought, in canal commands, many still offered supplemental irrigation to 2015 *rabi* wheat crop. A clear lesson is the need for demand-side management of groundwater in hard-rock areas. Had the five successive years of normal monsoon during 2009-2013 been used to maximise groundwater recharge, and had effective mechanisms been put in place for judicious use of this recharge, Madhya Pradesh could well have sailed through even two successive drought years. Effective demand management of water must be the next priority of irrigation reforms.

References

Balakrishnan, P., Golait, R. and Kumar, P. (2008): "Agricultural Growth in India since 1991," Reserve Bank of India, Mumbai, Development Research Group Study No.27, https://rbidocs.rbi.org.in/rdocs/content/pdfs/85240.pdf (accessed on August 30, 2015).

Julaniya, R.S. (2016): "India-Experiences in Modernization of Irrigation", presentation at Asia Irrigation Forum II, Manila, http://www.k-learn.org/system/files/materials/2016/01/india-experiences-modernization-irrigation-management.pdf (accessed on February 1, 2016).

Shah, T., Banerjee, P.S., Roy, A. and Singhania, S. (2012): "Coping with Seasonal Peak in Power Demand for Irrigation: Pros and Cons of Temporary Farm Power Connections in Madhya Pradesh and West Bengal", Highlight # 4, IWMI-Tata Water Policy Program.

Shah, T., Gulati, A., Pullabhotla, H., Shreedhar, G. and Jain, R.C. (2009): "The Secret of Gujarat's Agrarian Miracle after 2000", *Economic & Political Weekly*, 44(52): 45-55.

Shah, T., Mishra, G., Kela, P. and Pennan, C. (2016). *"Har Khet Ko Pani?* Madhya Pradesh's Irrigation Reform as a Model", *Economic & Political Weekly*, 50(6): 19-24.

Vaidyanathan. A (2007): "Water Policy in India: A Brief Overview", Occasional Paper # 6, Center for Public Policy, Indian Institute of Management, Bangalore.

Notes

I Tushaar Shah and Pennan Chinnasamy are with Colombo based International Water Management Institute (IWMI). Gourav Mishra is a doctoral candidate at Technische Universität München (TUM), and Pankaj Kela is a consultant with IWMI.

ii http://mospi.nic.in/Mospi_New/upload/Infra_stat_2010/11.ch_irrigation.pdf (table 11D.1), (accessed on August 30, 2015).

iii Ministry of Agriculture, Government of India. (On802). http://www.indiastat.com/table/agriculture/2/irrigationbysource19502013/449345/9484/data.aspx

iv Government of Andhra Pradesh, 2012, Report of the Comptroller and Auditor General of India on Jal Yagnam, Hyderabad, http://gssaap-cag.nic.in/sites/all/themes/marinelli/Reports/2011-12/Jalayagnam/English/Jalayagnam_Complete_Report_2011-12.pdf (accessed on August 5, 2015).

v http://indianexpress.com/article/india/india-others/explained-flush-with-funds-little-work-to-show/

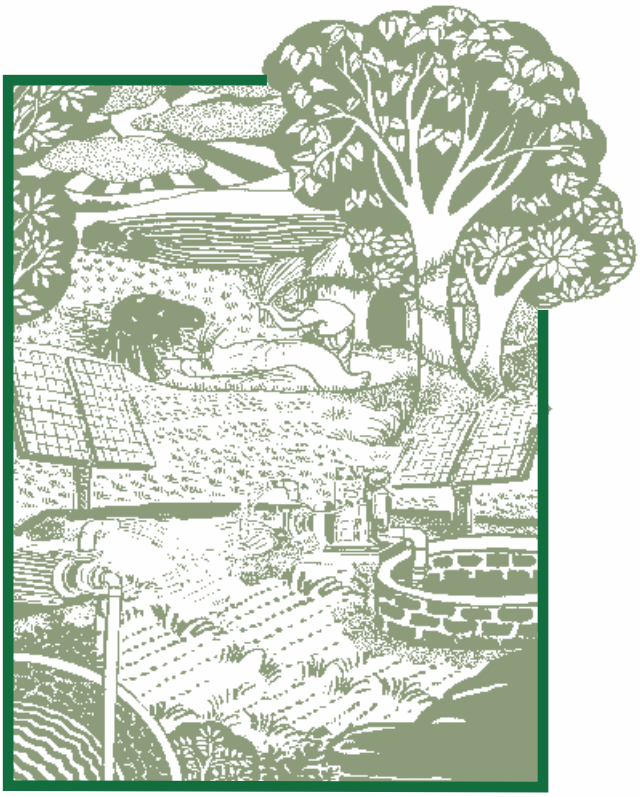
vi In absence of ground coordinates, these maps were produced from unsupervised classification of temporal MODIS NDVI images for a quick assessment of winter crop area.

vii The maps were generated from unsupervised classification of NDVI time series data. The remote sensing data (NDVI) is from MODIS (resolution- 250* 250 sq.m). The maps were made assuming a maximum of 10 possible classes on land labelled non-forest in the Global Land Cover Map of year 2000.

viii Normalized Difference Vegetation Index(NDVI) is an equation that takes into account the amount of infrared reflected by plants.

ix agricoop.nic.in/kharif2014/GroupI/MP.ppt (consulted on August 16, 2015).

x nfsm.gov.in/Presentations/2014-15/KKA(2013-14)/MP.ppt (consulted on December 23, 2015).



About the IWMI-Tata Program and Water Policy Highlights

The IWMI-Tata Water Policy Program (ITP) was launched in 2000 as a co-equal partnership between the International Water Management Institute (IWMI), Colombo and Sir Ratan Tata Trust (SRTT), 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, analyze and document relevant water management approaches and current practices. These practices are assessed and synthesized for maximum policy impact in the series on Water Policy Highlights and IWMI-Tata Comments.

Water Policy Highlights are pre-publication discussion papers developed primarily as the basis for discussion during ITP's Annual Partners' Meet. The research underlying these Highlights was funded with support from International Water Management Institute (IWMI), Tata Trusts, CGIAR Research Program on Water, Land and Ecosystems (WLE) and CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). However, the Highlights are not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or any of its funding partners.

IWMI Headquarters
127 Sunil Mawatha
Pelawatte, Battaramulla
Colombo, Sri Lanka
Mailing Address
P. O. Box 2075, Colombo, Sri Lanka
Tel: +94 11 2880000, 2784080 **Fax:** +94 11 2786854
Email: iwmi@cgiar.org **Website:** www.iwmi.org

IWMI-Tata Water Policy Program
"Jal Tarang"
Near Smruti Apartments, Behind IRMA Gate
Mangalpura, Anand 388001, Gujarat, India
Tel: +91 2692 263816, 263817
Email: iwmi-tata@cgiar.org

IWMI
International Water Management Institute

IWMI is a member of the CGIAR Consortium and leads the:

CGIAR
RESEARCH PROGRAM ON
Water, Land and Ecosystems