Reviving india's water harvesting structures to achieve drought resilience

Results from Initiatives in Four States of India

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Abstract

It is now widely acknowledged that Indian agriculture is facing an unprecedented crisis driven primarily by adverse terms of trade and the inability of farmers to deal with adverse climatic conditions. Given that agriculture continues to be the primary source of livelihood for a majority of India's population, it is not surprising that several state governments are under pressure to find ways to help farmers. In western and peninsular India, where droughts are a common phenomenon, several state governments have vowed to make farming "drought-proof" through ambitious state-wide interventions focussing on reviving irrigation and percolation tanks. This paper reviews the experience of such flagship programs in four Indian states – Gujarat, Maharashtra, Telangana and Rajasthan and highlights observed impacts in study areas, stressing the importance of tanks as rainwater harvesting structures in management of groundwater, especially in face of recurrent droughts.

I. Background

Droughts have severe impacts on economy, society and environment- affecting crops, irrigation, livestock, wildlife, soil, health problems, public safety ultimately leading to severe loss to human life. The frequency of droughts has been increasing and India has seen five drought years in the last two decades which have been a nightmare for the country's farmers, majority of whose farms are rain-fed with output dependent largely on climate. Groundwater plays an important role to help overcome water stress during these drought periods but with annual groundwater abstraction exceeding recharge leading to depletion has undermined its role in creating drought-resilience. Wells fail to bounce back even after a good monsoon, affecting farmers, especially smallholders, by making irrigation less accessible and more expensive. In such a context, the importance of tanks in semi-arid regions for harvesting rainwater to deal with erratic monsoon cannot be stressed enough.

II. Centrality of Groundwater

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In the three decades between 1970 and 2000, India added more irrigated area through expansion of groundwater irrigation than it had through massive investments in gravity-flow surface irrigation systems in the 200 years before that (Shah 2009). Bulk of this addition came because of private investments in wells, tubewells, pumps and water distribution systems, supported by farm power subsidies in western and peninsular India. Today, India has more than 20 million groundwater based minor irrigation systems – 8.8 million dugwells, 5.9 million shallow tubewells, 3.2 million medium tubewells and 2.6 million deep tubewells[4]. These structures pump anywhere between 200 – 220 billion cubic meters of groundwater annually, making India the world's largest user of groundwater. Against their ultimate irrigation potential of 78.9 million ha, these groundwater structures irrigate 63.3 million hectares annually (GoI 2017; Rajan and Verma 2017). This compares favourably against India's medium and major surface irrigation systems that irrigate 20-25 million ha against their ultimate irrigation potential of about 40 million ha.

Groundwater irrigation is particularly appealing for smallholders since it is available widely and the investment required to access groundwater is relatively low. Groundwater not only helps smallholder farmers intensively cultivate and irrigate their small land holdings, it also provides insurance against climate-induced short and long term water scarcity – both of which affect surface water availability much more than groundwater availability. Shah and Verma (2017) define the roles that groundwater can play to safeguard against droughts as stabilization role, to cope with mid-season dry spells; buffering role, to cope with monsoon failure; and carry-over storage role, to cope with consecutive years of drought.

When annual groundwater abstraction consistently exceeds recharge, wells fail to bounce-back to pre-development levels, even after a good monsoon. Over years, the over-extraction results in depletion and lowering of groundwater levels – which make groundwater irrigation costlier and less accessible, especially for smallholder farmers. This seriously undermines groundwater's drought-resilience role and many parts of India are already suffering the consequences of this damage.

III. Tanks in Peninsular and Western India

[4] Tubewells are classified into 'shallow', 'medium' and 'deep' based on the depth from which they harvest groundwater: up to 35 m for shallow tubewells; 35 – 70 m for medium tubewells; and more than 70 m depth for deep tubewells.

Tanks are part of an ancient tradition of harvesting and preserving the local rainfall and water from streams and rivers for later use, primarily for agriculture and drinking water, but also for sacred bathing and ritual. Over the last half-century, tank irrigation has taken a back seat in peninsular India's minor irrigation landscape with tubewells revolutionizing the way farmers irrigate their land. In spite of being plagued by issues of power policies, frequent well failure and rapid groundwater depletion, pump irrigation has been able to provide 'on-demand' irrigation access to farmers and helped them grow multiple irrigated crops. Country-wide share of tank irrigated area, which accounted for more than 15% in the 1950s (Thenkabail *et al*. 2009), has shrunk to a mere 3% in 2011-12 (MoSPI 2015). Flow irrigation from tanks, used for centuries to grow rice, has declined because of increased number of wells in tank commands. Accounting for 65 per cent of the country's territory, Peninsular India sits on hard-rock formations, primarily Deccan trap basalts and granitic basement complex; yet extensive areas are irrigated with groundwater. Tamil Nadu, where tank irrigation dominated in the earlier century, saw flow-irrigated area from tanks fall by a third, from 9,40,000 ha to 6,01,000 ha (Palanisami and Ranganathan 2004), reducing irrigation tanks to percolation tanks.

Availability of cheap pumping technology and the provision of highly subsidised or free farm power catalysed a shift in farmers' irrigation preferences towards pumping water accumulated in wells recharged from tanks instead of using flow irrigation even in tank commands. In this context, tanks are playing a vital role in semi-arid areas by recharging groundwater and providing a safety net to farmers to irrigate crops around the year by harvesting rainwater in monsoon. Policymakers are now focussing on their revival to mitigate effects of groundwater overexploitation on rural economy, especially as a drought-resilience measure. This paper captures efforts by four state governments – in the Indian states of Gujarat, Maharashtra, Rajasthan and Telangana – to use groundwater recharge through water harvesting as a strategy for helping rural communities deal with droughts.

IV. Methodology for data collection and analysis

This paper is based on multiple studies conducted over last five years by IWMI-Tata Water Policy Program- each using different methods for sampling and tools for data collection. Table 1 below lists details of each of these studies.

Table 1: Details of the studies done in four states

State/ Program	Sample	Tool for data collection	Study Year
Gujarat - Sujalam Sufalam	26 villages	Village questionnaire	2015
Maharashtra – Gaalmukt Dharan Gaalyukt Shivar	30 villages	FGD, Interviews	2017-2018
Telangana – Mission Kakatiya	25+37+15 tanks (3 studies)	FGD, Questionnaire survey, Interviews	2015-2017
Rajasthan – Mukhyamantri Jal Swavlamban Abhiyan	87 villages	Village level questionnaire, FGD	2018

Each of these studies collected data to quantify impacts of these programs on:

- Groundwater levels;
- Irrigated area, cropping patterns, cropping intensity, productivity, cost of cultivation, and;
- Local governance and institutions.

The studies also tried to gather insights on role of community in the program, major stakeholders, and process of implementation and monitoring.

V. Groundwater Management in Gujarat

Harvesting rainwater for groundwater recharge extends beyond tanks in Gujarat, foundation of which was laid through a mass movement in the late 1980s, following three successive years of drought (1986-87-88). In their desperation to save their crops under unfavourable conditions, some farmers in hard-rock Saurashtra started diverting rainwater and water from nearby canals and streams into their wells. During this Saurashtra recharge movement, within a short span, thousands of farmers from across the seven districts of Saurashtra were converting their wells into recharge structures. Over time, farmers evolved different ways to deal with silt and also expanded the repertoire of activities undertaken to enhance groundwater recharge. Besides recharging dugwells, farmers de-silted village water bodies and built check dams and sand-dams on a large scale. Besides farmers, a large number of community organizations contributed. Scientists have debated on the impact of such large-scale decentralized water harvesting for groundwater recharge. While most studies agree that the local, village level impacts have been positive, some have pointed to upstream-downstream conflicts at the river basin scale. Studies have noted improvement in well productivity (Joshi 2002; Raval 2002);

increased cropping intensity (Bhammar 2002); higher crop output (Joshi 2002; Bhammar 2002) and easier availability of wage labour (Raval 2002).

In 2004, the *Sujalam Sufalam Yojana* was launched with the objective of using the surplus water available in Narmada and Mahi rivers to fill reservoirs and recharge aquifers in 10 water-scarce districts of north Gujarat. The scheme was designed with 3 key components: [a] pumping water from Narmada canal through pipelines to fill-up 9 surface reservoirs in north Gujarat; [b] a 337 km long unlined "spreading canal" linking Kadana dam on Mahi river to Banas river; and [c] construction of 200,000 farm ponds along the spreading canal to enhance groundwater recharge. Preliminary studies on the impact of *Sujalam Sufalam* have reported: [a] rise in groundwater levels (by 2 to 4 meters near recharge structures); [b] revival of dry dugwells (0.5 to 2.0 km from the spreading canal); [c] expansion of irrigated area and increase in cropping intensity; and [d] reduction in energy use for pumping groundwater (CGWB 2009; ACT 2012; Prathapar *et al*. 2015).
Based on surveys in 26 villages all along the spreading canal, Rai *et al*. (2015) found significant reduction in depth of tubewells[5], especially in villages along the first half of the canal (

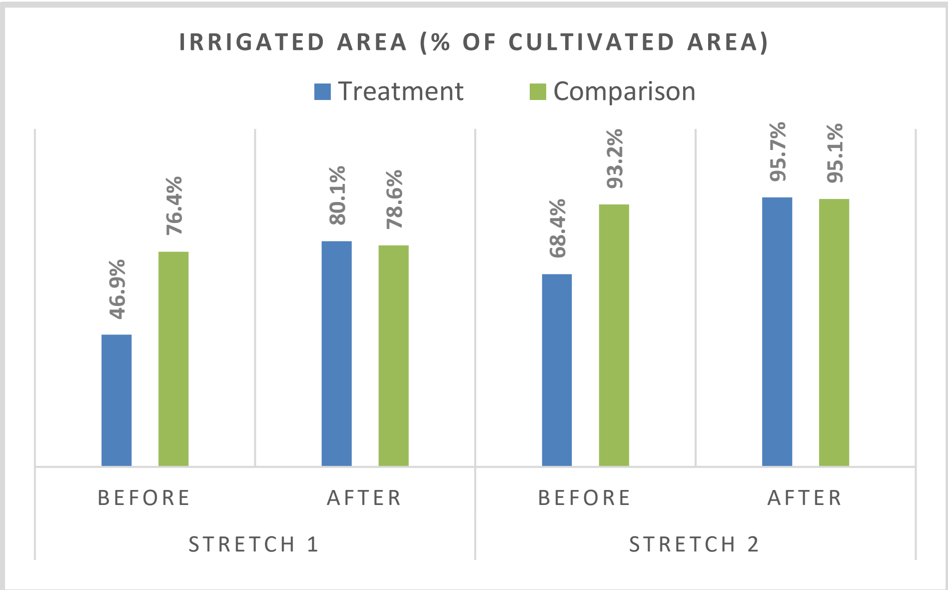
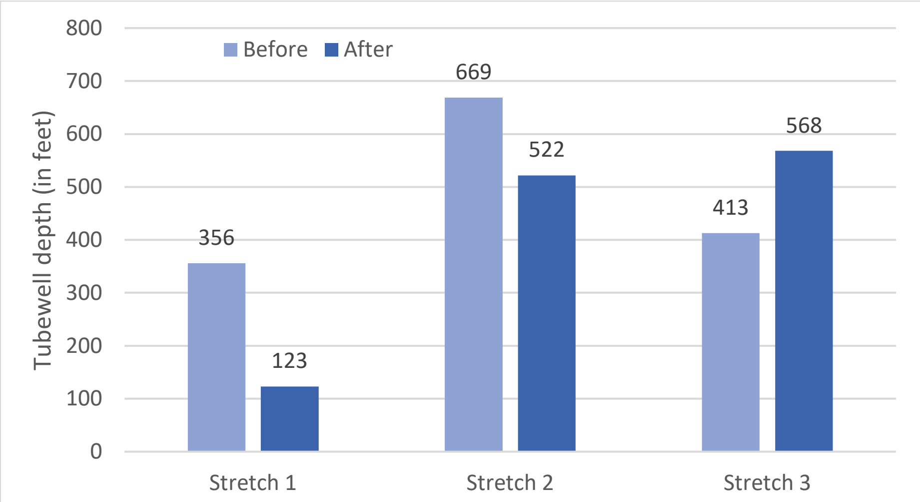


Figure 1: Depth of tubewells in villages along the *Sujalam Sufalam* spreading canal (Source: Rai *et al*. 2015)

[5] Typically in the region when groundwater levels decline, farmers add "*columns*" to their tubewells to shift the submersible pump downward a few feet and when groundwater levels rise, the farmers remove columns to lift the submersible pump closer to the ground to save energy and improve discharge. Reduction in tubewell depth here indicates the level at which the submersible pumps were located.



). They estimated an average 12% rise in water tables; leading to near doubling of irrigated area (Figure 2) and an incremental 31% increase in gross value of crop output (

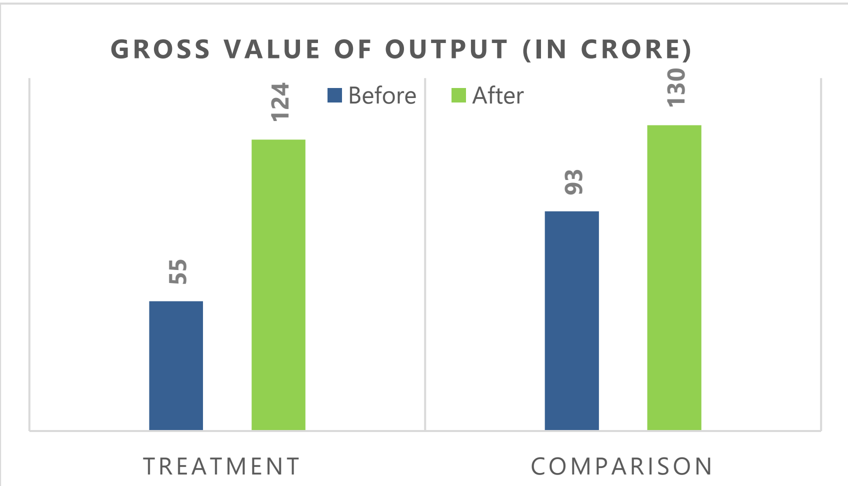
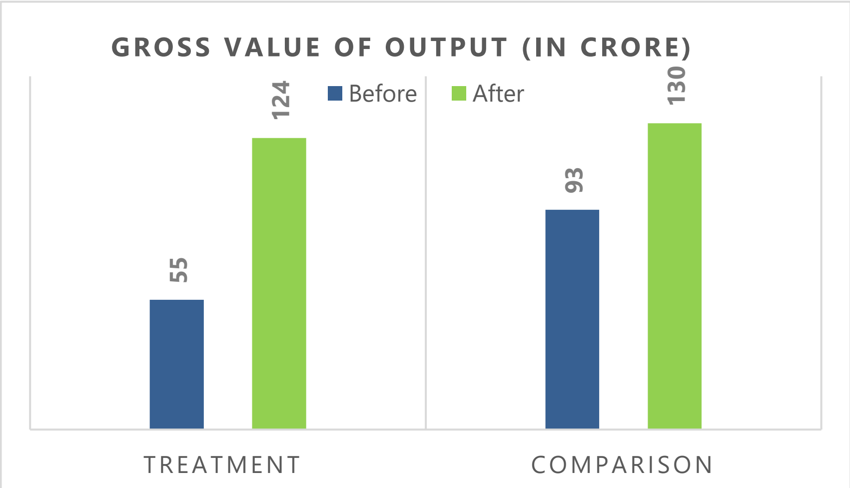


Figure 3). The survey differentiated between "*treatment*" and "*comparison*" villages, classifying villages within 2.0 km of the spreading canal as "treatment" and more distant villages as "comparison". The gross value of output increased from ₹55 crore[6] to ₹124 crore in

"treatment" villages while the same grew from ₹93 crore to ₹130 crore in "comparison"



villages (Figure 3).

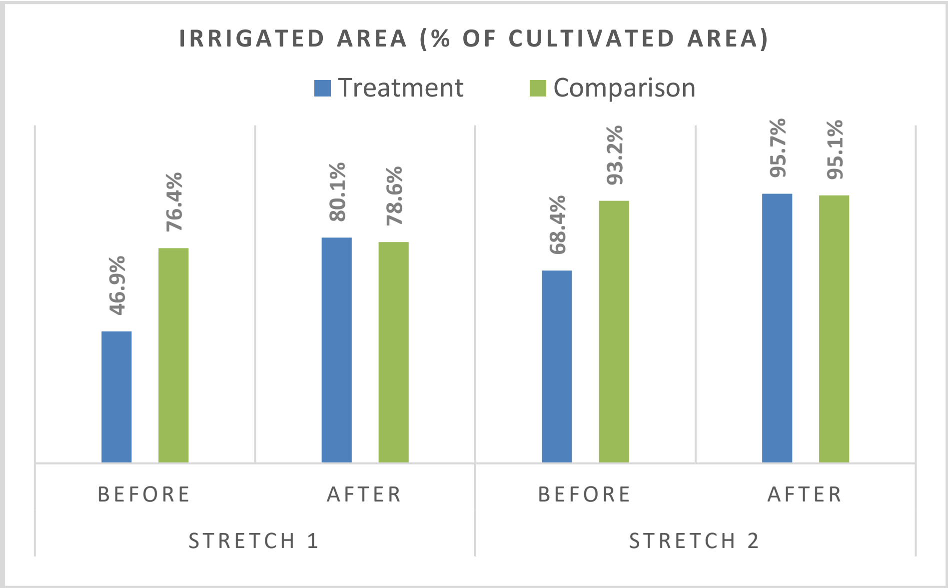


Figure 1: Depth of tubewells in villages along the *Sujalam Sufalam* spreading canal (Source: Rai *et al*. 2015)

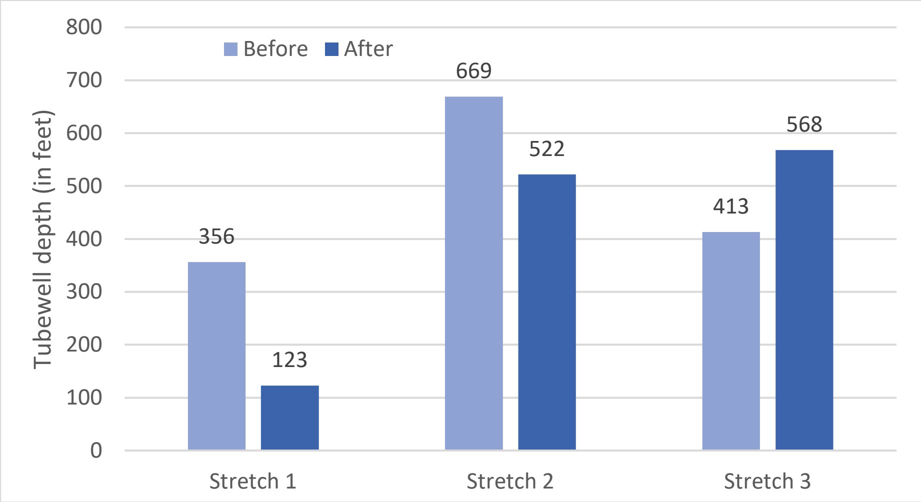


Figure 2: Irrigated area in treatment and comparison villages along the *Sujalam Sufalam* spreading canal (Source: Rai *et al*. 2015)

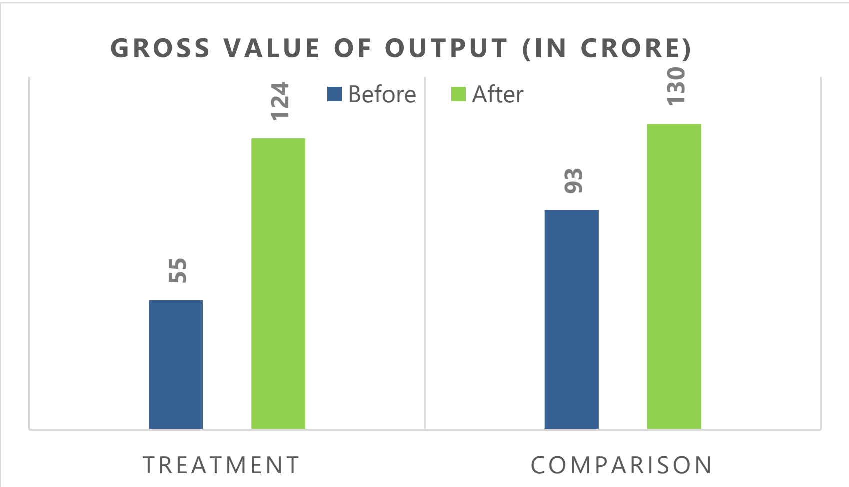


Figure 3: Gross Value of Output in treatment and comparison villages along the spreading canal (Source: Rai *et al*. 2015)

Gujarat has also been able to promote micro-irrigation to encourage efficient utilization of irrigation water alongside *Jyotigram Yojana* for intelligent rationing of farm power to control the amount of water pumped by farmers. In 2008, the state government constituted a Taskforce to develop an integrated 'Managed Aquifer Recharge' (MAR) strategy for Gujarat, which recommended a four-pronged strategy for managing groundwater in the state: [a] recharging with surface water; [b] recharging with rainwater; [c] incentivizing accelerated recharge by communities; and [d] introducing policies for groundwater demand management. It also outlined an implementation plan for the construction of 21,200 percolation tanks, 22,400 recharge wells, 23,600 check dams and modification of 42,000 existing wells through a budgetary allocation of US$ 700 million.

Gujarat added another feather in its cap just weeks before the expected onset of 2018 monsoon when the Gujarat Chief Minister announced a month-long campaign to create additional water storages at more than 8,000 sites across the state with the objective of capturing rainwater and catalysing groundwater recharge. Through a campaign implemented on a war-footing by several government departments with the help of local communities, private players and civil society organizations, the state set out to desilt 13,000 ponds, 200 large reservoirs and 1,500 check dams; and clean more than 3,400 km of riverbeds to capture 11,000 million cubic feet (~31.15 million cubic meters) of rainfall. This mission mode program is expected to increase availability of surface water, recharge aquifers and mobilize community to participate in such activities periodically.

VI. Gaalmukt Dharan Gaalyukt Shivar (GDGS) in Maharashtra

The Marathwada and Vidarbha regions of Maharashtra are among the most drought-prone regions of India. The 1972-73 drought, which affected more than 20 million people (at that time, 57% of Maharshtra's rural population), led to large-scale crop failure and widespread farmer distress. The total loss to the economy was estimated to be in excess of ₹333 crores (~US$ 450 million). Some media reports claimed that consecutive years of drought leading up to 2014-15 have been even worse (Anvesha et al. 2017). Incidentally, Maharashtra has also witnessed an alarming number of farmer suicides in recent years and while the reasons behind these incidents might be varied, there is a growing awareness that worsening water situation, in particular declining groundwater levels, have put farmers under severe distress.

In response, the Government of Maharashtra in 2014 launched a five-year mission to make the state "drought-proof" by 2019. The state government intends to achieve this through its program for improving village-level water security (Jal Yukt Shivar – JYS) and a parallel program for tank rejuvenation (Galmukt Dharan and Galyukt Shivar – GDGS). While JYS prioritizes in decentralized water harvesting for maximizing irrigated area, GDGS focusses on desilting tanks and spreading the silt on farmlands to improve agricultural productivity.

De-siltation of tanks involves extraction of silt accumulated at tank beds, resulting in restoration of tank storage capacity and augmentation of groundwater recharge. Under GDGS, the extracted silt is then transported by farmers and spread on their fields to replenish soil nutrients and improve agricultural productivity. The ITP study on tank de-siltation in Maharashtra (Solanki *et al*. 2018) focused on three things: [a] understanding the processes followed in carrying out tank de-siltation; [b] understanding farmers' perceptions about the program; and [c] quantifying the impact on village water security and agrarian livelihoods. The study covered 30 villages in five districts – Nashik, Jalna, Aurangabad, Latur and Beed.

Our field studies found significant benefits of tank desilting. Solanki *et al*. (2018) report increased irrigated area, improved drinking water availability, reduction in cost of cultivation, higher crop productivity and perceptible improvement in groundwater levels. However, the study also raises doubts about sustaining momentum once the four-year program is over. The study noted limited participation of village communities in planning and implementing the desilting works. In a few years when the tanks and reservoirs need another round of de-silting to sustain the groundwater recharge and farm productivity benefits, the authors wonder whether the village communities will be willing and able to undertake such works on their own.

VII. Revival of Kakatiya Tanks in Telangana

In 2014, India's youngest state Telangana launched '*Mission Kakatiya*' to revive and harvest the benefits of tank irrigation by increasing command area, water available for irrigation and opportunities for agriculture. One of the major slogans of the movement for a separate Telangana state was "*Mana Ooru, Mana Cheruvu*" (our village, our tank), which later became the punchline for Mission Kakatiya. The five-year program intends to uphold the vision of *Kakatiyas* through revival and restoration of minor irrigation tanks to their original glory by effectively utilizing 265 billion cubic feet (7.5 BCM) of water allocated for minor irrigation in the Godavari and Krishna River basins to irrigate twenty lakh acres.

The main objective of Mission Kakatiya is to revive minor irrigation in the region by increasing water storage capacity of tanks through de-siltation and repair of sluices, weirs, and irrigation canals. The project has also impacted groundwater irrigation through increased recharge of groundwater. Field data shows a positive change in tank irrigated area for all tank sizes. IWMI-led field studies in 2015, 2016 and 2017 consistently reported increase in irrigated area and cropping intensity. Figure 4 shows the change in area under paddy in study districts after implementation of the program compared to previous year in study villages of Nirmal and Warangal districts. Field surveys also suggest reduction in cost of cultivation and improvement in yields as a result of silt application. Farmers also reported increased availability of water in the wells. A survey by the state groundwater department also found groundwater levels increased in 22 of the 31 districts (The Hindu 2017). IWMI field studies also reported positive impacts on non-crop incomes including fishing, cattle herding and toddy making (Shah *et al*. 2017). A NABCONS (2017) assessment shows 62 per cent increase in fish production in Telangana tanks.

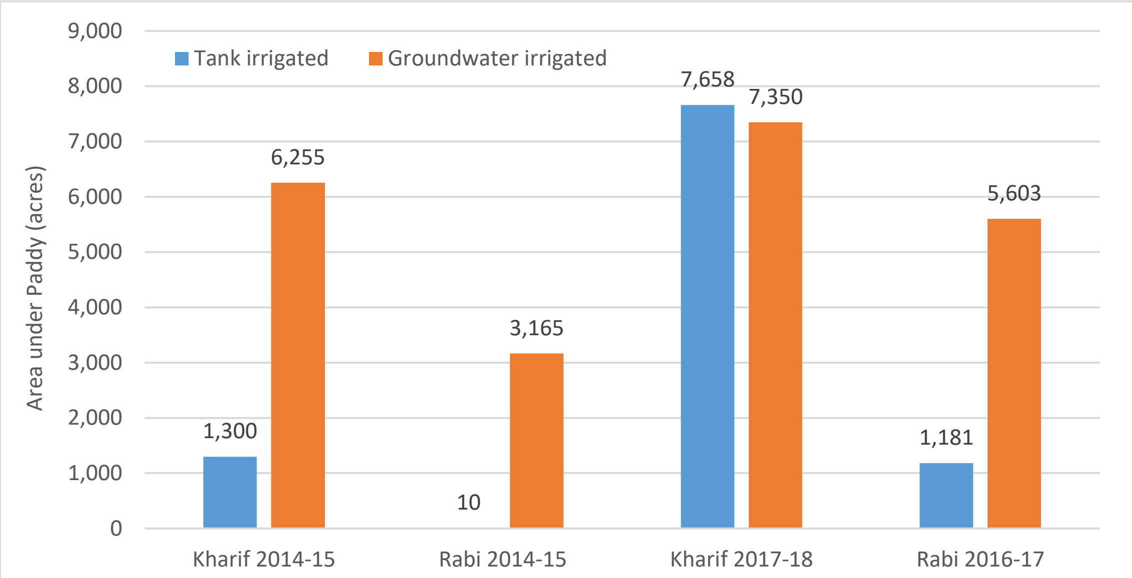


Figure 4: Change in area under tank and GW irrigated paddy before and after the mission in study villages

The positive impacts of tanks on agriculture are evident, especially in villages where they have been rehabilitated and desilted. However, like in Maharashtra, Mission Telangana also seems to have missed out on the opportunity to invest in lasting village institutions or empowering local village institutions to sustain the positive impacts at the end of the 5-year program. The traditional *Neerghati* – tank manager – in villages that vanished with the decline in importance of tanks is still missing and it is not clear who will be responsible for maintaining and managing the tank systems after the work undertaken under Mission Kakatiya. By the time the last of the 45,000-odd tanks are desilted, the tanks covered in Phase I of the program will probably be in need of another round of desilting. As things are, the communities will again have to wait for a state-sponsored program to desilt their tanks. Should the government plan for a perpetual tank rehabilitation program to sustain benefits or can communities take back ownership and responsibility of managing and maintaining tanks – that is the central question groundwater and tank policy makers will have to address. Nonetheless, the initiative deserves credit for highlighting the importance of tanks and groundwater and deservedly has been receiving a lot of positive media and policy attention.

VIII. Water Self-reliance in Rajasthan

With a view to help rural communities cope with droughts, the Government of Rajasthan is focusing on making villages self-reliant for meeting their water needs. Launched in 2016, the *Mukhyamantri Jal Swavlamban Abhiyan* (MJSA) (Chief Minister's Water Self-Reliance Campaign) is the government's flagship program designed to implement 'Four Waters Concept'[7] in the state's drought-prone geography. MJSA is implemented in four annual phases with first phase completed in July 2016 in all 295 blocks of 33 districts. The activities taken up under the program include construction of minor irrigation tanks, anicuts, checkdams, field bunds, farm ponds, rooftop water harvesting structures, staggered trenches, continuous contour trenches (CCTs), deep CCTs and others to capture runoff. With a view to leverage similar programs administered by other line departments, MJSA also focusses on tree plantation, afforestation of wastelands, pasture development, horticulture expansion and promotion of micro irrigation. The program aims to create a movement on water conservation with participation of people and manifold departments. While the program focusses on increasing irrigated and cultivable areas, it has also given equal importance to drinking water. One of its objectives is to bring at least 40% rain-fed area under irrigation to increase production.

An internal impact assessment was conducted at district level by all district teams to study the impacts of the program after two monsoons. Using piezometers installed across the state, it was recorded that out of 21 non-desert districts, 16 districts showed rise in groundwater levels with average rise being 4.66 ft. The program claims to have intercepted 6,653 MCFt (188.39 MCM) of water through watershed development and an additional 4,516 MCFt (127.88 MCM) storage capacity was created through tanks, anicuts, check dams etc. (GoR 2018). A comparison of villages covered under MJSA phase 1 was done with villages not covered under MJSA and a 56 per cent decrease in transportation of water (through water tankers) was found in MJSA first phase villages implying additional months of water availability in wells in villages. 64% defunct hand pumps and 20% tube wells were reported rejuvenated in 2017 compared to 2015, latter pointing towards improved irrigation for farmers in dry months. A total 44,409 ha of crop

[7] Four Waters concept revolves around harvesting of available runoff from rain water, groundwater, underground water and in-situ soil moisture.

area increase in *rabi* and *zaid* seasons was recorded and an additional 2,470 ha increase was reported owing to improvisation of water distribution system. Being a major animal rearing state, MJSA has also helped bovine population in villages by ensuring water in surface structures for longer period. 28 lakh trees have been planted in vicinity of micro water bodies under the program which has enhanced green cover by 3,678 ha which has controlled soil erosion in various terrains.

IWMI-Tata program conducted an impact assessment study in 87 villages of six districts of Rajasthan (Ajmer, Tonk, Dungarpur, Pali, Jalore and Sirohi) covering all categories of drought frequency. Figure 5 shows the average pre and post-monsoon ground water levels across these villages.

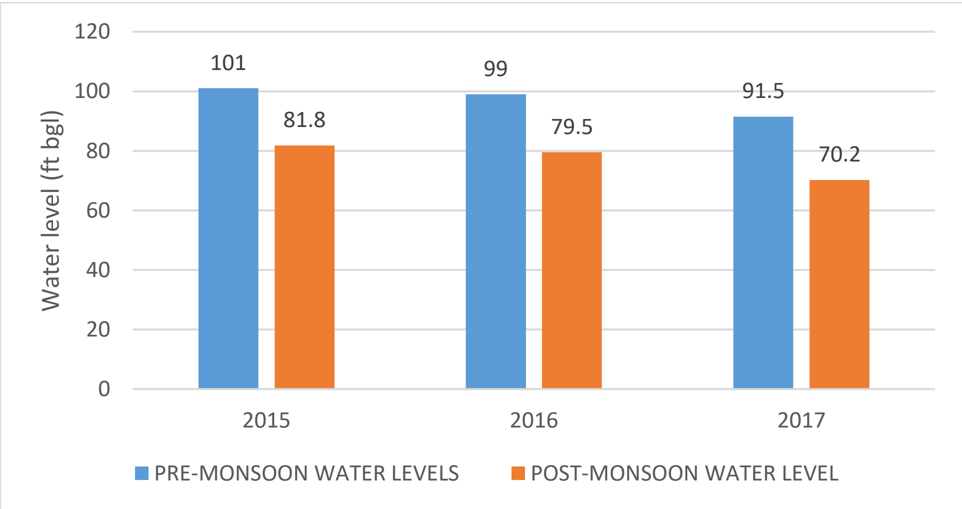


Figure 5: Comparison of groundwater levels in base and study years

A net increase of 11.6 feet was observed in post monsoon water levels with better rainfall reported in years following the program compared to base year. The study also revealed a substantial reduction in number of defunct hand pumps and tubewells (see Figure 6). The study also reported an 18% increase in rabi area in 2018 compared to 2016. Figure 7 shows the overall change in irrigated and cultivated area in the study villages.

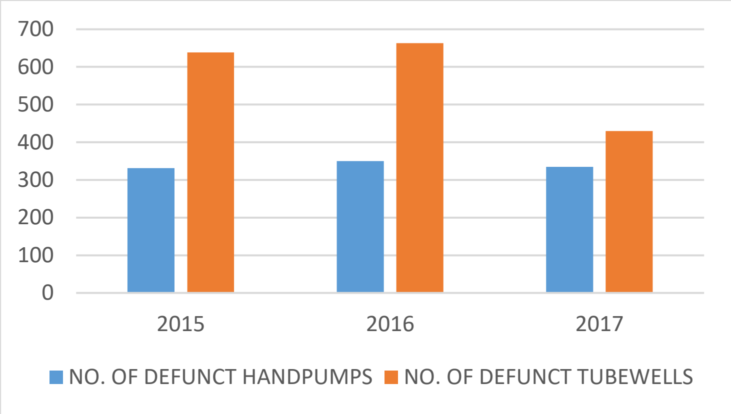


Figure 6: No. of defunct tube wells and hand pumps

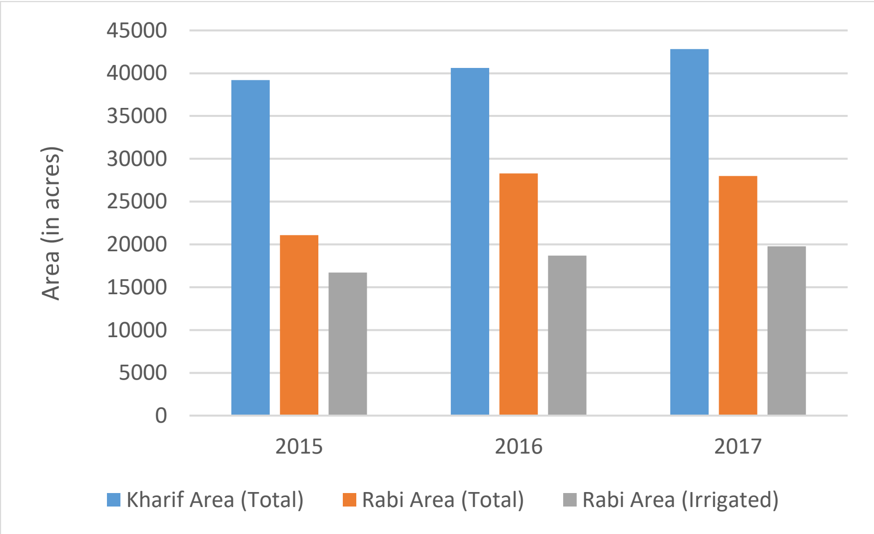


Figure 7: Change in cultivated and irrigated area

Farmers moving to higher value crops was also observed in some villages where water assurance increased. Villagers also reported reduced dependence on tanker water for drinking, although the peak season demand for tanker did not see any decline. 61% villages also reported an increase in green cover in the area directly affecting the pastures and cattle productivity.

IX. Discussion and Conclusion

All the programs studied demonstrated positive impacts of varying degree on agrarian economy and village water security. Results from these studies emphasize the importance of such programs to increase water harvesting capacity in rural areas to make villages drought-resilient as well as to increase farm income, create drinking water security, promote water-efficient cropping patterns and increase cropping intensity. Each program, however, also demonstrated gaps and weaknesses. The problem of sustaining these benefits through local institutions appear to be the biggest challenge of the time. Focus on resource augmentation and insufficient focus on capacity building of communities seem common to interventions in all four states. The recharge movement in Saurashtra saw a lot of community participation; in fact, the movement was led from the grassroots and supported by a government program – quite contrary to similar groundwater recharge interventions elsewhere. There are no specific programs in Gujarat for catalysing village-level community institutions to manage groundwater but as highlighted in 2018 through the pre-monsoon *Sujalam Sufalam Jal Sanchay Abhiyan* campaign, the government is keen to catalyse and harvest social energy for groundwater augmentation. In Maharashtra, the design GDGS calls for active community participation but field studies suggest that the response of village communities has been mixed. Further, these interventions too focus largely on resource augmentation and treat tank desiltation as a one-shot exercise, which is unlikely the case. Telangana's Mission Kakatiya highlights the important relationship between irrigation tanks and groundwater agro-ecosystems; it also illustrates the benefits of a campaign / mission mode, state-wide implementation for quick results. However, the program too suffers from a lack of long-term strategy and misses out on reviving traditional systems of community management and ownership of grassroots assets. Rajasthan's MJSA is perhaps the most nascent of the lot and its impact on the ground are yet to be fully felt. Unlike interventions in Telangana and Maharashtra, MJSA focuses on low-cost watershed-type interventions which, by the nature of their public returns, will struggle to find community ownership except where strong village-level institutions already exist to absorb the costs of and responsibility for such works. Finally, all programs illustrate that unless governments intend to support resource augmentation efforts perpetually, they will need to invest in reviving old or catalysing new village-level institutions to take over local water management even though positive impacts are clearly felt by the community.

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