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A Case for Pipelining Water Distribution in the Narmada Irrigation System in Gujarat, India

Tushaar Shah, Sunderrajan Krishnan, Pullabhotla Hemant, Shilp Verma, Ashish Chandra and Chillerege Sudhir

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Shah, T.; Krishnan, S.; Hemant, P.; Verma, S.; Chandra, A.; Sudhir, C. 2010. *A case for pipelining water distribution in the Narmada Irrigation System in Gujarat, India*. Colombo, Sri Lanka: International Water Management Institute. 25p. (IWMI Working Paper 141). doi: 10.5337/2010.233

/ irrigation systems / irrigation projects / canals / water distribution / pipes / river basins / water conservation / land management / India /

ISSN 2012-5763
ISBN 978-92-9090-736-7

Please direct inquiries and comments to: *IWMI-Publications@cgiar.org*

A free copy of this publication can be downloaded at
www.iwmi.org/Publications/Working_Papers/index.aspx

Acknowledgements

The authors would like to thank Dennis Wilchens, Principal Economist, and David Molden, Deputy Director General-Research, both based at the headquarters of IWMI in Colombo, Sri Lanka; Avinash Kishore, PhD Scholar, Kennedy School, Harvard University; Sam Johnson, Water Resource Consultant; and Martin Burton, a consultant based in the UK, for their useful comments.

Project

This research study is based on the IWMI-Tata Water Policy Program.

Donors

Funding for the IWMI-Tata Water Policy Program is provided by the Sir Ratan Tata Trust in Mumbai, India.

Contents

Summary

Against an ultimate potential of 1.8 million hectares (Mha), Gujarat's famous Sardar Sarovar Project (SSP) is irrigating less than 100,000 hectares (ha) by gravity flow 5 years after the dam, and the main and branch canals were completed. The key problem is that farmers who are to benefit from irrigation refuse to part with the land needed to construct a surface distribution system below the outlet. This paper argues that the government should consider a buried piped distribution system as an alternative to sub-minors and field channels. The idea, however, is strongly criticized by irrigation engineers, based on the poor track record of piped distribution under government management. In 2009, IWMI researchers proposed that if undertaken with farmer investment and management, as in Maharashtra's Upper Krishna Basin, pipelining can: (a) achieve SSP's potential quickly, at little cost to the government; (b) promote thousands of irrigation cooperatives for long-distance piped water transport distribution; (c) create approximately 150,000 to 200,000 rural jobs in water distribution; (d) dramatically raise water use efficiency and spread water from the SSP over a large area; (e) enable conjunctive management of groundwater and surface water in groundwater-stressed areas; (f) improve Gujarat's overall farm power budget in net terms; and (g) establish a new model of irrigation management partnership between farmers and the government.

There are at least ten reasons why Gujarat should seriously consider this IWMI proposal[1] for pipelining the distribution system not only in SSP but also in other canal systems. These reasons are as follows: (1) the original plan of surface distribution is not working, despite massive efforts by the government to acquire the land needed for the purpose; (2) an alternative water distribution arrangement is already emerging in the form of unregulated appropriation of water from the SSP by farmers near the main and branch canals using gravity, siphoning, lifting and conveying through earthen channels of overland rubber pipes (if this goes on, the SSP will end up in a sub-optimal state with irrigation reaching a thin strip of land along the main and branch canals); (3) contrary to C. C. Patel's (one of India's best known irrigation engineers of the 1970s) claim, retrofitting surface canals by buried pipelines is a widely used practice in the developed world, and according to the Government of India's Minor Irrigation Census III, even within India, at least 8 Mha are irrigated using buried pipeline networks that convey water from the water source to the fields (GoI 2005); (4) using land for building canals in times of growing land scarcity is proving to be an inefficient process, for every hectare that canals actually irrigate today, Gujarat has acquired 3 ha to build irrigation dams and canals (pipelining the SSP's distribution system can save more than 100,000 ha of land with a market value of INR 20,000 crore); (5) pipelining is considered too costly in comparison to constructing earthen canals, but this is true only when land is free or acquired at a fraction of the market price, and if land required for canals is valued at market price, pipelining becomes a cost-effective alternative (if this were not so, buried pipeline networks would not be the most common mode of tubewell water distribution in much of Gujarat); (6) a canal network is a vast evaporation pan, SSP may lose over 0.5-0.7 billion cubic meters (BCM) of water annually in non-beneficial evaporation in a network of open canals since Gujarat has among the highest pan evaporation rates in India (pipelining can save a large part of this loss); (7) Gujarat's reservoir irrigation systems maintain a storage of some 35,000 cubic meters per hectare (m^3/ha) of net irrigated area by canals, this is very high compared to groundwater irrigation where

[1]After International Water Management Institute which led the research.

storage needed per hectare of net irrigated area is about one-tenth (piped water delivery from SSP system can mimic tubewell irrigation and raise productivity of irrigation water applied); (8) without pipelining, there is a serious danger that SSP reservoir storage will reach a much smaller area than was originally planned, and if pipelining can enable Gujarat to spread this water over as large an area of the State as possible, it can put into place a regime of conjunctive use of groundwater and surface water that may tackle the acute problem of groundwater depletion; (9) while pipelining will certainly be more energy-intensive compared to gravity canals, if managed well, it will significantly improve the overall farm energy balance of Gujarat by spreading the water of the SSP on a larger area, reducing the need for groundwater pumping, and enhancing recharge from water of the SSP thereby reducing the energy used in groundwater pumping; and (10) pipelining opens up huge possibilities for public-private partnerships and farmer participation in irrigation management in ways that surface canals have failed to provide, and it would majorly enhance the SSP's financial, economic and environmental sustainability, spreading its benefits far and wide through thousands of irrigation cooperatives that are likely to come up if encouraged and supported, as they have been in Maharashtra.

In late 2009, a discussion paper that outlined the IWMI proposal was shared with senior policymakers of the Gujarat State. Thereupon, the Chief Minister of Gujarat appointed an Expert Group to examine various ways -- including the IWMI proposal -- to expedite the completion of the SSP distribution system. The Expert Group, consisting of eminent irrigation engineers, rejected the IWMI proposal outright based on indifferent performance of five government-managed piped distribution schemes in existing canal commands. However, the Expert Group overlooked the evidence compiled by its own members who found piped water conveyance in the SSP canal in Rajasthan working 'very well', supporting sprinkler irrigation at a third of the water allowance that was originally planned. This paper argues that notwithstanding the views of the Expert Group, the IWMI proposal deserves serious consideration.

The Expert Group's insistence on SSNNL (Sadar Sarovar Narmada Nigam Ltd.) constructing and managing the distribution system in the SSP needs to be reconsidered. Instead, the Government of Gujarat should emulate the Maharashtra example of encouraging farmer participation in investment, construction and management. To promote farmer investments in piped distribution in a planned and systematic manner, SSNNL should: (a) not only recognize and legalize but also register and incentivize lifting of water from the SSP canal system and its piped distribution; (b) make firm commitments -- during November to May each year -- of weekly water deliveries in each distributary/minor canal along a strict schedule, a la farm power scheduling under Jyotigram; (c) existing tubewell owners should be encouraged to convert their electricity connection to canal lift; (d) GUVNL (Gujarat Urja Vikas Nigam Limited) should provide new electricity connections to approved piped distribution schemes planned by farmers, cooperatives and producer companies; (e) NABARD (National Bank for Agriculture and Rural Development) and other institutional financial agencies should provide finance to support farmer cooperatives with their investments in pipelines; (f) the government should provide a 25% subsidy on capital costs of approved projects; and (g) each pipeline system should be registered with the SSNNL and be required to pay irrigation fees for all the land irrigated with water from the SSP. In sum, all that SSNNL needs to do to achieve SSP's full potential is to make a credible commitment of reliable -- even if rotational -- water availability in minor/distributary canals during October-May, and recognize, legalize and encourage private and cooperative investment in water lifting and piped distribution.

INTRODUCTION

The SSP on the Narmada River, arguably the lifeline of the State of Gujarat, has always been in the limelight for one reason or another (see Figure 1 for a map showing the SSP command area). Now, the project has got drawn into a new controversy. Farmers in the SSP command area have stolidly resisted the idea of giving up any land for the construction of the distribution system. As a result, while the Sardar Sarovar Dam is full, and it has enough water even with its present height to irrigate 900,000 ha, the actual area under gravity flow irrigation is only around 75,000 ha, which is just over 5% of the ultimate design command area. Given the persistent problems in land acquisition, it will take years to achieve the targeted irrigation command, if at all. Frustrated by delays in laying the 66,000 kilometers (km) of distribution canal network to achieve the targeted 1.8 Mha of irrigation, it was proposed that the government should lay an underground pipeline network 3 meters (m) below the ground level. The key advantage of underground pipelining is that it avoids having to acquire land as in the case of the surface distribution system.

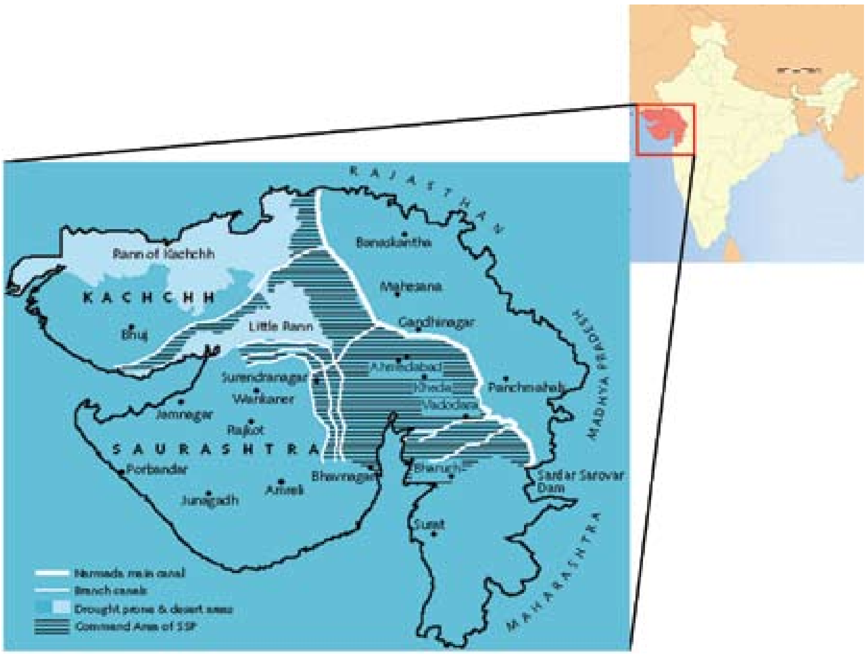

FIGURE 1. Sardar Sarovar Project (SSP) irrigation system in Gujarat, India. *Source*: www.narmada.org/maps/map.gif; http://upload.wikimedia.org/wikipedia/commons/thumb/0/01/India_Gujarat_locator_map.svg/543px-India_Gujarat_locator_map.svg.png *Note*: Shaded area in the figure shows the command area of the Sardar Sarovar Project in Gujarat.

The pipelining idea has, however, met with bitter criticism from master planners of the SSP including C. C. Patel (Times of India 2009a). Planners of the SSP admit that pipelining was considered during the late 1970s but rejected as 'unviable'.

This paper outlines an IWMI proposal that argues that pipelining will fail under government construction and management but will work very well if constructed and managed by farmers. It also argues that the critique of pipelining overlooks the vast changes that have swept Gujarat's irrigation economy since the 1970s when the SSP was planned. Many arguments against pipelining are today open to question. For example, it is argued that pipelining the SSP will mount Gujarat's farm power bill. However, if piped distribution of water from the SSP can substitute vast amounts of groundwater pumping from deep tubewells, pipelining can actually reduce Gujarat's total farm power bill. Planners of the SSP suggest that Gujarat should replicate irrigation institutions like *warabandi* (rotational water distribution) from the Punjab and Haryana experience. However, even with *warabandi* in canal irrigation, the significance of gravity irrigation has declined in Punjab and Haryana. Today, these two states depend upon groundwater pumping for over 75% of their irrigation (Dharmadhikari 2005; Singh 2006, citing a Government of Punjab 2005 document). Finally, Planners of the SSP ridicule pipelining as an impractical idea that is not practiced anywhere in the world for irrigation commands. The truth is that even within India, according to the Minor Irrigation Census of 2001-2002, well over 2 Mha of land are irrigated by buried piped distribution of surface water or groundwater (GoI 2005). Retrofitting canal systems by buried pipeline networks has also been extensively practiced as part of the modernization of irrigation systems in advanced countries such as the United States, Spain and Canada (Shah 2009).

Assessment of benefits and costs of pipelining critically depends upon the alternative it is compared with. When we compare pipelines on SSP with a surface distribution system, pipelining would naturally appear to be power-intensive. However, given its size, the SSP must be viewed against the larger canvass of the entire irrigation economy of Gujarat, which pipelining can alter in fundamental ways. The key issue is who constructs and manages the pipeline systems: if the task is performed by government departments, chances of failure are high, given the dismal record of government-managed pipeline schemes for irrigation dependent on gravity flow. But if the government encourages farmers and their cooperatives to construct and manage pump-based piped distribution, the results can be amazing as seen in the Maharashtra example.

This paper is a 'thought piece' written to generate a debate and facilitate more detailed analyses and calculation. We do not have the information needed to tie up all the loose ends of the argument, test all the assumptions implied and present a complete assessment of the cost-benefits of this proposal. However, the intention is to show that inherently the pipelining idea has many advantages and it can offer opportunities for institutional innovation and productivity gains that need to be factored into any serious analysis of this alternative.

TEN ARGUMENTS IN SUPPORT OF THE IWMI PROPOSAL

We outline at least ten reasons why Gujarat should seriously consider pipelining the SSP distribution system (as well as other canal irrigation projects), and we also briefly describe the Maharashtra example that inspired our case.

Plan A is Not Working

SSP planners advocate proceeding with Plan A of the SSP under which: (a) the SSNNL would construct the main canal, the branch canals and a pucca (lined) distribution system going up to the Village Service Area (VSA) of 250-400 ha; (b) within the VSA, the irrigators organizing themselves into a Water User Association (WUA), would voluntarily contribute land, labor and other resources (including funds) to construct the network of sub-minors and field channels to distribute water within the VSA; (c) the WUAs would assume the responsibility of ensuring the orderly distribution of irrigation water within the VSA, ensure regular maintenance and repair, and collect water fees of which around 12% would be reimbursed to the WUA as a managerial subsidy; and (d) sophisticated, computerized water control through control rooms strewn along branches and distributaries throughout the command area would ensure volumetric supply and charging for water.

Five years after the SSP reservoir first filled up, the reality turned out to be far removed from this vision that is enshrined in Plan A. One can witness buildings to house computers along the canals in a dilapidated state, and we find neither computers nor any computerized water control. Over 1,100 WUAs have been registered, but these are all WUAs which have only been registered on paper and they play none of the roles envisaged for them (Talati and Shah 2004). Nowhere in the SSP command area -- except in a handful of villages with active NGO intermediation -- have farmers agreed to provide land or mobilize other resources for constructing the surface water distribution system. Indeed, in many places, the SSNNL is facing stiff resistance from farmers in acquiring land for completing even higher level distributaries and minors. The main system is all ready, yet, 5 years after the water was first released from the dam, Gujarat utilizes only 7% of the water available in the SSP (RTI India 2008)[2] , and irrigates only around 6% of its design command by gravity flow. Ironically, farmers -- SSP's chief beneficiaries -- themselves refuse to cooperate in creating the distribution system. Most recently, the Central Government has promised funds under the Accelerated Irrigation Benefit Programme (AIBP) to compensate farmers at prevailing market prices for the land needed for the distribution system. It is still doubtful, however, whether farmers will part with their lands.

Plan B is in Operation Anyway

The absence of distribution channels, however, has not kept farmers from irrigating wherever water from the SSP reached. Instead of providing land for surface channels, farmers in the SSP command area have invested in thousands of diesel pumps and hundreds of thousands of meters of flexible rubber pipes to siphon or lift water from the SSP system and transport it -- sometimes up to 2 km -- to irrigate their fields. If 72,000 ha were irrigated by gravity flow in 2008, over 215,000 ha were irrigated by farmers lifting/siphoning water and transporting it by private pipelines (Times of India 2009b). Pump irrigation service markets are booming. A 2008 study estimated that over 70,000 diesel pumps were purchased by farmers to pump water from the Narmada main and branch canals (Singhal and Patwari 2009). Initially, the SSNNL watched this development with concern and even tried to use force to remove the diesel pumps mounted on canal banks (Indian Express 2009). But the SSNNL was facing a dilemma: on the one hand, it was not able to achieve the irrigation targets for SSP; on the other hand, even as water was flowing away to the sea, it was preventing farmers from lifting water from the SSP for irrigation. More recently, therefore, SSNNL has begun to turn a blind eye to private lifting and siphoning of Narmada canal water.

Private lifting and piped distribution is rampant in all of Gujarat's canal irrigation systems. Now it is emerging as the dominant irrigation model in the SSP too. In the coming few years, we should expect a manifold expansion of this unruly system of irrigation rather than the orderly gravity flow irrigation that irrigation planners and managers would like to see. This apparent chaos may be better than having no irrigation at all; but it is arguably possible to do much better by formalizing piped distribution and bringing it within the SSP's regulatory framework. In view of the uncertainty about government policy regarding private pumps and also about the water availability in canals close to them, farmers are unlikely to invest to maximize full irrigation potential. Farmers make private investments only where there is an assured water supply and, therefore, invest on main and branch canals; and it is here where most private pumps are installed. As a result, under the

[2]www.rtiindia.org/forum/4391-gujarat-used-only-7-narmada-dam-water.html

prevailing regime, the area actually irrigated by pumps and pipes may well remain confined to a 0.5-1 km strip along the main, branch and distributary canals that offer water assurance. Private investments on minors would be made only when the SSP can assure water in them as and when farmers need water, even if only on reliable rotations.

Figures 2, 3, 4 and 5 provide an artist's imagery of the logic of the IWMI proposal. Figure 2 shows the original vision of the SSP command area in the 1970s in which water was to flow into the VSA through a pucca sub-minor taking off from the minor and taking water to fields through a network of field channels. Figure 3 shows the situation in early 2000 when water began flowing in the main system but the command area remained dry for want of a distribution system below the minor. Figure 4 shows the spontaneous and unruly development of pump-and-pipe irrigation all over the main system by farmers lifting water at will. Figure 5 illustrates what IWMI proposes: ban lifting of water from the main system; ensure weekly rotation of water supply in minors, which may be treated as storages; and encourage farmers, cooperatives, and service providers to invest in a buried pipe distribution system to irrigate the VSA.

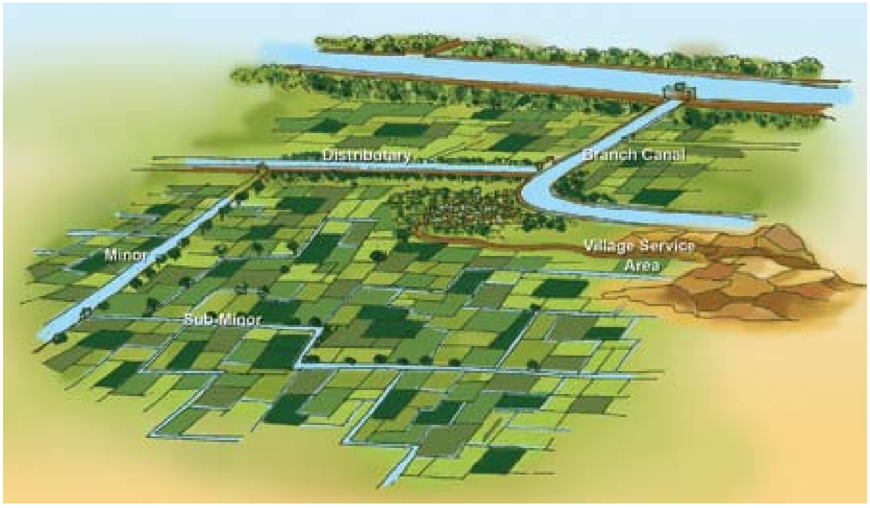

FIGURE 2. SSP Plan A: Water reaches the fields through sub-minor and open channels.

FIGURE 3. State of the command area soon after commissioning of the reservoir and the main system.

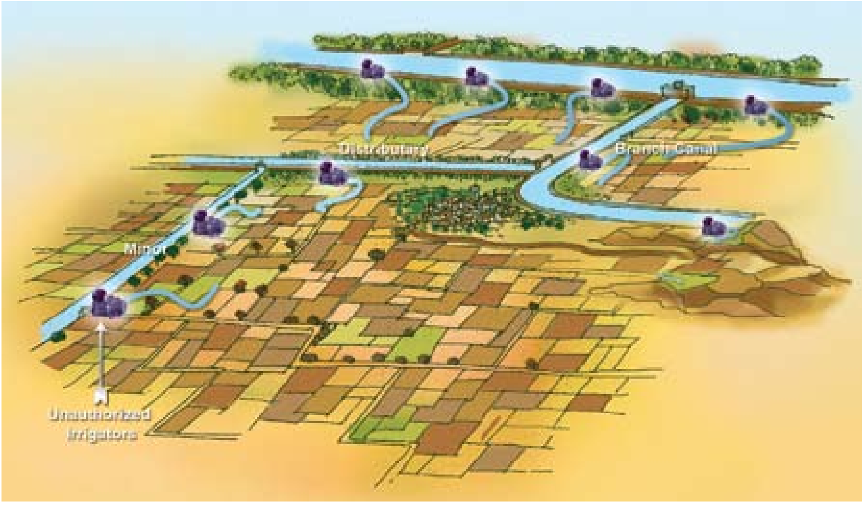

FIGURE 4. Chaotic development of the command area by illegal lifting of water along the main system.

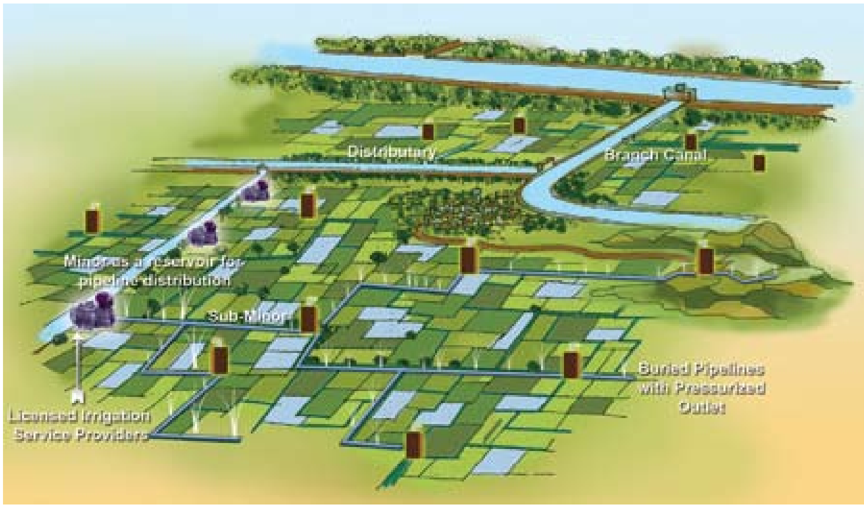

FIGURE 5. The IWMI proposal: Ban lifting of water from the main system, encourage investment in piped distribution from minor.

Piped Distribution from Canals is a Widely Used Technology in India and Abroad

Planners of the SSP claim that piped distribution of canal water is advised only in saline areas or areas prone to waterlogging. The fact is that canal irrigation systems are getting retrofitted with piped transport and distribution in many advanced countries for water and energy savings, besides other advantages (see Shah 2009). Several irrigation systems in southern USA, Canada and Spain are converting water transport from surface canals to rubber-gasketed jointed reinforced concrete pipes (BECC 2003)[3] . The 20,000-ha irrigation system in Hidalgo County, Texas, has proven viable, with water and energy savings, reduced health risks and improved vector control. Spain has similarly retrofitted its 1,000-year-old Mula system (Plusquellec 2002)[4] , and so has Alberta

[3]See www.cocef.org/aproyectos/ExComHidalgo2003_05ing.htm

[4]See www.fao.org/docrep/004/ac799e/ac799e03.htm

in Canada (Government of Alberta 2003)[5] with buried pipes in place of open canals. The motive for pipelining in these countries is to improve irrigation service, save water from evaporation and seepage, and provide pressurized irrigation. Many of these countries are land-abundant and have no need to save land. But in the Indian context where population pressure on farmland is high, pipelining can reduce the need for much of the productive land that surface canal networks require. In India, too, while governments have shied away from piped conveyance in canal irrigation, farmers have aggressively been using lifts and pipes to irrigate upland areas that have been written off as 'non-command'. In the Upper Krishna Basin in Maharashtra, some 350,000 ha (gross) are irrigated by buried pipe distribution in lift irrigation systems established by individual farmers, farmer cooperatives and sugar cooperatives over several distributaries of the Krishna River (GoI 2005). In Madhya Pradesh, the area that is irrigated in a similar way is even larger (GoI 2005).

Land Saving

The most important benefit of pipelining in the Indian context may be saving land. The managers of the SSP often claim that the main obstacle to land acquisition is created by powerful and well-off farmers. However, the ground reality is much more complex, as researchers have discovered (Talati and Liebrand 2003). Farmer resistance would be less if all farmers were required to contribute land in some equitable manner. However, only some farmers are required to sacrifice land and not all on equal terms. Even if a few farmers with large landholdings agreed, farmers with small or marginal holdings tend to be far more reluctant to give land from their already small parcels, especially now that irrigation by lifting or siphoning has made their land more valuable than ever before. Owners of private tubewells too tend to be reluctant because they have already invested in a secure irrigation source. There is also the right-of-the-way issue. Unless farmers nearest to the outlet agree, it does not help even if most farmers in a VSA agree to sacrifice some land. And it is commonly the farmers near the outlet or at the head who are most unwilling to give any part of their land, because an unlined sub-minor passing by their fields would threaten their land with waterlogging and flooding (Talati and Liebrand 2003). Finally, the need felt by farmers for surface channels is less acute than was the case in the past when neither flexible pipes nor diesel pumps were as easily and cheaply available as they are today. Failure of public irrigation systems to meet farmer expectations also plays a role. There was a time when farmers happily gave a part of their land for canal construction because it would ensure water availability. But rural Gujarat, today, has thousands of command area farmers whose land was acquired for canals but were never provided with any canal water.

In today's context, in land-starved India, the use of land for transporting water, even at the societal level, makes little sense. Creating irrigation potential would be worthwhile if productive land used to create an irrigation system is a small fraction -- say 5 to7% of the land ultimately irrigated by it. If an irrigation system uses more land than it irrigates, there is a need to ask why build it at all? This is pretty much the situation in Gujarat. A recent study by Lobo and Kumar (2009, 67) showed, using government data, that between 1961 and 2004, the Government of Gujarat acquired 1.921 Mha of land -- affecting 254,044 families -- for constructing 21 major and 130 medium irrigation systems to create an irrigation potential of 3.06 Mha (ibid). However, the Government of Gujarat's own data suggests that in 2004, the actual area irrigated by gravity

[5]See http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/irr7197/$FILE/irrigationinalta-part2.pdf

canals from major and medium irrigation systems in the State was just 0.68 Mha -- 22% of what was planned (GoG 2009). Moreover, the land benefited by canal irrigation is less than one-third of the land acquired to build the irrigation dams and canal networks. It is ironic to remove 3 ha of land from productive uses to make 1 ha more productive. Thus, it is not surprising that farmers are unwilling to part with their land for canals.

Cost-effectiveness

A strong argument against pipelines is that they are costlier to lay than digging canals, especially earthen ones. But most of such back-of-the-envelope calculus of cost-effectiveness does not factor in the market value of the land that canals use and pipelines save because, in the past, the government never paid the market value of the land acquired. In the SSP, if all the 66,000 km of branch, distributaries, minors and sub-minors were to be laid, the market value of the land needed would make pipelining appear cheap. According to Lobo and Kumar (2009, 72), the Government of Gujarat has already acquired 425,000 ha of land for the SSP dam, main and branch canals. The government now claims that only 15,000 ha more is needed to build over 60,000 km of distribution network. However, this seems to be a serious underestimate since under most branches, the development of distributaries and minor canals too are held up for the lack of land. A more realistic estimate is that the completion of the entire network will likely need around 100,000 ha to cover the design command. At a market price of INR[6] 2 million/ha, this land would be worth INR 200 billion (US$4.4 billion at US$1 = INR 45). The pipelining project would save most of this land by replacing surface canals with underground pipelines for water transport. The investment required in pipelining would, in all likelihood, be less than the investment needed in constructing canals below the outlets *plus* the market value of land needed for open canals. If pipelines were not more attractive compared to surface channels, we would find most Gujarati farmers using surface channels for conveying water from their wells to their fields. However, today, in large parts of rural Gujarat, most farmers use buried pipeline networks to convey water from wells to their fields; even poor tribal farmers use overland pipes in place of earthen channels to convey water. In central and north Gujarat, tubewell owners invest in elaborate buried pipeline networks to irrigate their own lands as well as the lands of scores of other farmers (Shah and Bhattacharya 1993). In Navli, a small village in the Anand District, it was estimated that private farmers had invested in 65 km of buried pipeline networks in a single village to irrigate 1,200 ha of land by tubewells (Shah 1993). In Gandhinagar, Mehsana, Patan, Kheda, Anand and Vadodara districts, private investments of this order in pipelines are common in most villages. This would not have happened had the cost-benefits of piped irrigation been as adverse as they are made out to be.

Water Saving Impact

In a semi-arid climate with high wind speeds, which is the case in much of Gujarat, surface storages and canal networks suffer high non-beneficial evaporation from open surfaces. Annual pan evaporation rates in Gujarat as a whole are well over 200 centimeters (cm)/year, but in Kachchh and North Gujarat, these can be over 300 cm/year (Krishiworld 2010)[7]. This implies that a body of standing water exposed to the sun loses at least 200 cm/year just to evaporation. A surface irrigation

[6]INR = Indian Rupees. Throughout this paper, US$1 = INR 45

[7]http://www.krishiworld.com/html/water_resources2.html

system in western India is thus a vast evaporation pan. SSP's 37,000-ha reservoir and some 20,000 ha of canal network -- much of which is exposed to the sun throughout the year because the canals provide drinking water year-round -- is likely to lose around 0.5-0.6 BCM of water annually to non-beneficial evaporation. An equivalent amount of groundwater provides supplemental irrigation to over 100,000 ha of land. Indeed, minimizing non-beneficial evaporation of water in storage and transport can be a major pathway to improved water productivity at the basin level. The minors, sub-minors and field channels lose most of the water they carry to evaporation as their ratio of surface area to depth is much higher than it is for the reservoir and main and branch canals. In so far as the pipelines will replace the most-evaporating tertiary canal network, it can potentially save anywhere up to 0.5 BCM annually of the water that the SSP would lose to evaporation under surface distribution system. There would be a similar volume of water removed through seepage; however, much of this ends up as highly valuable groundwater recharge which Gujarat badly needs and, therefore, cannot be viewed as a loss.

Water Productivity Impact

Reducing evaporation from open surfaces can be a big boost to basin water productivity in the State. However, pipelining can also contribute greatly to the irrigation productivity of water applied. Surface irrigation systems in Gujarat, as indeed in India as a whole, are highly inefficient when compared to groundwater irrigation by private wells and tubewells. Table 1 shows data for Gujarat (GoG 2009) to illustrate this point.

For a net hectare actually irrigated by canals, Gujarat maintains reservoir storage of nearly 35,000 m^3, whereas for a hectare irrigated by wells and tubewells, the State uses all of 3,300 m^3 of groundwater storage. It is sometimes argued that reservoir storage is used not only for irrigation but also for drinking water and industrial needs. The counter-argument is that this is even truer of groundwater. Farmers tend to use groundwater more carefully because a rationed electricity supply imposes a quantity constraint, and the high cost of diesel imposes a surrogate price constraint. Piped distribution of water from the SSP will encourage farmers to use canal water as efficiently as groundwater.

TABLE 1. Surface water and groundwater development and use in Gujarat.

Sr. No.	Details	Surface water	Groundwater	Total
1	Total rainfall precipitation in a normal year (MCM)			196,000
2	Water resources (MCM/year)	37,400	15,800	53,200
3	Water resources available for utilization or utilized (MCM/year)	27,485	11,500	33,695
4	% of domestic water requirements met	18	82	100
5	% of industrial water requirements met	35	65	100
6	Storage available for irrigation (80%) (assumed) (MCM)	21,988	9,200	26,956
7	Net irrigated area (Mha)	0.63	2.76	3.39
8	Storage volume/ha (m^3)	34,900	3,300	7,952

Note: * Surface water storage in major, medium and minor irrigation projects plus recharge structures (check dams, percolation tanks, etc.)

Conjunctive Use Impact

One big opportunity that canal irrigation offers is conjunctive management of groundwater and surface water to avoid problems arising from excessive use of either surface water or groundwater in irrigation. But this requires the available surface water to be spread over as large an area as possible. As we saw earlier, the water in Gujarat's surface storages reaches and wets only a fifth of the area it is designed to irrigate. As a result, large swathes of Gujarat's agricultural lands are exclusively dependent on groundwater irrigation without any benefit of canal recharge, resulting in severe groundwater depletion. Spreading canal water over as large an area as possible can alleviate Gujarat's groundwater depletion problem. A pipeline-based distribution system can spread a given volume of water in surface storages over a larger area through pumping. This could in theory bring much of Gujarat's groundwater irrigated farm lands under a conjunctive management regime. If the 27.5 BCM of Gujarat's surface storage (including the SSP) were to be spread over 3.5 Mha of the State's net irrigated area through a total pipeline-based system (i.e., without significant non-beneficial evaporation) at a rate of 7,800 m^3/ha, it would nearly eliminate the need for pumping groundwater to that extent; and moreover, a portion of that surface water would end up recharging the aquifers.

Energy Impact

Against all these advantages of pipelining, its chief disadvantage is its energy requirement. As C. C. Patel has argued, in the absence of hydraulic head in flatlands, it needs energy to push water to counter the friction loss in pipes, even if pipelines are laid such that they use the head that the distribution canals were to use for gravity flow. Shah (2009) has suggested that pipes may have to transport water on average 10-15 km from branch canals and that an additional 1,500 megawatts (MW) of energy will be needed to reach 9.8 BCM of water to 1.8 Mha. This is a serious overestimate; however, even if we take it as correct, we need to compare this with the 6,300 MW of electricity farmers are currently using to operate Gujarat's 800,000 tubewells[8] (GoG 2009).

For a gigantic project such as the SSP, the real issue is whether a pipelined SSP can have a favorable influence on Gujarat's overall irrigation energy balance sheet. Gujarat's 800,000 farmers owning electrified tubewells today use around 12 billion kilowatt-hours (kWh) of electricity (valued at some INR 60 billion or US$1.33 billion/year at generation stations) to lift some 7 to 8 BCM of groundwater. Another 480,000 diesel pump owners use around 200 million liters of diesel/year (valued at INR 7.2 billion or US$160 million) to lift 1-1.5 BCM of shallow groundwater and some surface water. Gujarat's groundwater-based agriculture is extremely energy-intensive anyway. The only way to curtail this energy intensity is to spread available surface water over large areas of North Gujarat, Saurashtra and Kachchh which would produce a double-effect: (a) availability of surface water would reduce the need to pump groundwater; and (b) irrigation return flows would enhance groundwater recharge and thereby reduce the pumping head in tubewells. This can be done only by pipelining not just the SSP but also other canal systems. An indication of energy savings that such a strategy can produce is that all the power needed by a pipelined SSP would be recovered if it could decommission around 25,000 tubewells in North Gujarat and Kachchh.

Finally, a major new objective SSNNL is working towards is promoting micro-irrigation in the SSP command area to maximize water use efficiency. If the command area farmers were to use

[8]Assuming an average load of 10.6 horsepower (hp)/tubewell (GoG 2009).

micro-irrigation, they would have to use pumps to create the pressure needed to operate drips or sprinklers even if water was delivered to their fields by gravity. Micro-irrigation can be integrated far more easily in a piped distribution system than in a gravity flow distribution system.

Public-Private Partnership

By far the most important advantage of pipelining water distribution in the SSP is that, given encouragement and a supportive policy environment, farmers and their cooperatives will take over the entire responsibility of investing in pipeline projects and managing them. The best proof that this will happen is offered by the experience of irrigation development in Kolhapur, Solapur, Sangli, Satara, Nanded, Nasik and Ahmednagar districts in the Upper Krishna Basin in Maharashtra. We describe this experience in some detail in the paragraphs below.

In 1976, the Bachawat Award[9] allocated 560 thousand million cubic feet (TMC ft) of water to Maharashtra, which the State had to develop by 2000. Maharashtra was not in a position to build the reservoirs and canal networks needed to use this water; by 1996, it had constructed only 385 TMC ft of storage and little by way of canal network in the Krishna Basin. Therefore, the government first began allowing farmers to lift water from the Krishna River and its tributaries. But this only encouraged small-scale private lift schemes, most of which could not convey water beyond a distance of 1-1.5 km. In 1972, only 200 private and cooperative lift schemes were operating in Maharashtra. As pressure to utilize the water mounted, the government adopted a far more proactive approach towards lift irrigation schemes. It introduced a capital cost subsidy for irrigation cooperatives and also facilitated bank finance from nationalized and cooperative banks. Most importantly, the Irrigation Department (ID) constructed a series of Kolhapur Type (KT) weirs across many tributaries of the Krishna River to use them as storages for lift irrigation schemes. Each scheme has to be approved by the ID, whereupon it qualifies for an electricity connection and bank finance. Each scheme also has to pay irrigation fees to the ID for the actual area irrigated and pay the electricity charges to the State Electricity Board at the prevailing rates for agricultural use. Between December and June each year, the ID implements a fortnightly schedule of water releases to fill up the dykes, starting with the last dyke first. This ensures that lift schemes will have access to a reliable water supply during the irrigation season.

A good example of the kind of partnership between the ID and irrigation cooperatives that Maharashtra's policies have spontaneously promoted is seen in the Radhanagari Project (constructed by Shahuji Maharaj in 1916) that serves 91 villages in the Kolhapur District -- studied by Choudhury and Kher (2006), Padhiari (2005) and Chandra and Sudhir (2010). The dam never had any canals; water is released from the dam into the Bhogavati River on which the ID has constructed a series of KT weirs. The ID has three roles: (a) approve proposals for new schemes; (b) release water into the Bhogavati River every 15 days to fill all the KT weirs; and (c) collect irrigation fees from all lift schemes based on crop and area irrigated. Water lifting, conveyance and distribution are done by some 500 'Irrigation Service Providers (ISP)' in private and cooperative sectors.

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[9]In 1969, the Government of India constituted the Krishna Water Disputes Tribunal to adjudicate the dispute between the states of Karnataka, Maharashtra and Andhra Pradesh regarding the sharing of water in the Krishna River. This tribunal was headed by R. S. Bachawat, a former judge of the Supreme Court. The Krishna Water Disputes Tribunal is sometimes also referred to as the Bachawat Commission. The Krishna Water Disputes Tribunal Award is referred to as the Bachawat Award.

The Radhanagari Project's performance over the past two decades has been very good compared to surface irrigation systems elsewhere in India. Against a design command of 26,560 ha, the average area irrigated by ISPs during 2001-2006 was 30,341 ha. However, the ID managed to collect only 58% of the irrigation charges that fell due. Against the annual operation and maintenance (O&M) cost of INR 7.9 million (US$0.18 million), irrigation charges collected in 2005-2006 was INR 17.9 million (US$0.4 million). In terms of the area irrigated as well as irrigation charges recovered, tail-end areas were found no worse off compared to areas at the head; the practice of filling up KT weirs last to first seems to address the head-tail inequity. An informal survey suggested that the number of irrigations the project provides is 80 to 90% of the number needed and that over 80% of the farmers interviewed were happy with irrigation provided by the ISPs (Choudhury and Kher 2006). In terms of offering irrigation-on-demand, Radhanagari comes close to tubewell irrigation.

Choudhury and Kher (2006) interviewed eight private and nine cooperative ISPs that irrigate a little over 1,000 ha in the Radhanagari Project. These ISPs had altogether invested nearly INR 220 million (US$4.9 million) in systems that included 2,280 hp of pumps, 41 km of buried pipe network and employed 92 staff to manage water distribution. Typically, every system has a rising main -- sometimes, multi-stage -- to a chamber from where water is conveyed by buried pipes to fields. These ISPs having invested INR 220,000/ha in the system, use 2.3 hp/ha of power load, employ a water manager for every 12 ha irrigated and collect an irrigation charge that is high enough to pay off debt, pay electricity charges to the Electricity Board, irrigation charges to the ID and salaries to employees, and still save enough for prompt repair and maintenance work.

The Radhanagari Project may appear an exception, but it is not. According to the Government of India's Minor Irrigation Census III, in 2000-2001, Maharashtra had some 100,000 such schemes in operation for lifting and piped distribution of surface water, mostly in the Upper Krishna Basin (GoI 2005). Over 20,000 of these were owned and operated by farmer groups and cooperatives. These lifted water from rivers and streams and transported it mostly by buried pipelines up to 30 km from the source. Remarkably, none of these was operated by a government agency. Over 90% of Maharashtra's lift schemes were constructed by farmers from their own funds and bank finance, and the present value of aggregate investment is around INR 50 billion (US$1.1 billion). Over 90% of the schemes used electric pumps to lift water and 70% had buried pipeline network for water distribution. Total horsepower of pumps installed in these schemes was around 590,000, equivalent to 440 MW, even though all the schemes involved a sizeable lift ranging from 20 to 185 m. These irrigated a gross area of around 350,000 ha (including a sugarcane area of over 100,000 ha). Maharashtra's lift irrigation schemes employed a likely number of over 100,000 workers as pankhyas (water managers), if we count the fact that of the 80,000 families operating private lift schemes, each had at least one family member devoted full-time to work on the scheme operation.

EXPERT GROUP'S REJECTION OF IWMI PROPOSAL

A discussion paper outlining the arguments above (which we may call the 'IWMI Proposal' for convenience) was shared with technocrats and political leaders of the Government of Gujarat, whereupon the Chief Minister constituted an 'Expert Group for Strategy for the Accelerated Development of Sardar Sarovar Project Command Area'. An 'Expert Group' with a broad cross section of experts in agriculture, groundwater, economics, planning, and irrigation engineering would have been required to do justice to the IWMI Proposal. However, the seven members of the 'Expert Group', including the chairman, were all highly experienced irrigation engineers best known for their knowledge and experience in design, construction and management of government canals[10]. The 'Expert Group' met three times. In the intervening period, sub-groups made brief field visits to several government-operated irrigation pipeline schemes. The results of these visits were reflected in the minutes of the meetings. Based on this work, the 'Expert Group' rejected the IWMI Pipelining Proposal by recommending that "in the SSP command area the conventional open channel should be adopted for construction of sub-minors" and buried pipelines should be used only when the open channel is not feasible. Two more recommendations were made but were with regards to measures to expedite land acquisition and construction of the open channel distributary system below the outlet.

The rejection of the 'IWMI Proposal' was based on the experience of Vatrak, Karjan and Ukai Right Bank systems, three large irrigation projects where underground pipelines were used under gravity flow in portions of the command area. Poor performance here was attributed by the 'Expert Group' to poor O&M, siltation, insufficient ground slope and available head, and farmer vandalism. However, the 'Expert Group' also considered evidence from the Narmada Canal System in the neighboring Rajasthan State, where water is delivered by canals into *diggis* (ponds) from which water is pumped and carried through buried pipes for sprinkler irrigation. The pumps and buried pipelines are installed by the government but will soon be handed over to WUAs for management. Farmers buy these sprinkler sets with the government subsidy. The original motive of the scheme was to reduce canal irrigation supply to a third of the originally planned allowance and encourage farmers to use it conjunctively with groundwater, an aim that is valid for the entire command area of the SSP since the entire system is planned on a water allowance of just 21 inches per hectare during the irrigation season. Visits to the Rajasthan projects by the Expert Group's committee members showed that these worked 'very well', and that the farmers paid the full electricity cost. "The team members were entirely satisfied with the innovative system put into operation by the Rajasthan Government and congratulated the engineers, farmers and stakeholders for boldly implementing the scheme" (GoG 2010, 129). Based on this field visit, one of the 'Expert Group' members developed a 'public-private partnership model' for water distribution, where canal managers deliver regular water supply at the outlet on a roster of weekly *warabandi* (rotation), the private service provider ensures regular volumetric water supply to each field from *diggis* (ponds) and keeps the pipeline system well-maintained, and the farmers or their groups pay for energy and water to the service provider (GoG 2010, 149-151). This model in essence is very similar to the IWMI Proposal.

In our assessment, the 'Expert Group's' report did not satisfactorily address any of the ten arguments in the IWMI proposal (see Table 2). Moreover, its rejection of the 'IWMI Pipelining Proposal' does not follow from the evidence its members gathered. All the cases of poor performance of buried pipelines it found were under government management and depended on gravity flow. It did not consider the evidence within Gujarat of some half a million kilometers of private, farmer-managed pipeline networks which have, for decades, overcome all the problems of O&M, siltation and clogging, obtaining right-of-the-way from other farmers, and of farmer vandalism, all of which make government-managed pipeline systems perform poorly. The 'Expert Group' discarded the experience of piped distribution in the Narmada Canal in Rajasthan by casting doubts about

[10]The 'Expert Group' was chaired by Mr. B. N. Navalawala, former Secretary, Water Resources, Government of India and presently Water Advisor to Gujarat's Chief Minister, a well-known water resource planner who played a key role in not only planning the SSP but also shaping India's irrigation policy during the 1990s. Other members included A. S. Kapoor, N. B. Desai, R. G. Kulkarni., B. J. Parmar and K. S. Srinivas. All except K. S. Srinivas were canal irrigation experts. The 'Expert Group' also invited inputs from distinguished irrigation engineers like Messrs C. C. Patel, V. B. Patel, M. U. Purohit and M. R. Goswami, all very well known for their experience and expertise in canal irrigation.

TABLE 2. Expert group's critique and our responses on ten reasons in support of pipelines.

#	IWMI argument	Expert Committee response	IWMI response
1	Plan A is not working because farmers are reluctant to part with the land	Not true; it is working in Phase I; in other five phases, distribution network construction is delayed	The plain fact is that 7 years after the dam and the main and branch canals were ready, less than 10% of the design command of the SSP is irrigated
2	Plan B is in operation anyway with tens of thousands of farmers lifting water and conveying it by pipelines	Only in certain places and in some areas where water is not flowing properly up to the tail-end	Our surveys found that private lifting and piped distribution of water of the SSP is rampant. Numerous newspaper reports too confirm this. If this were not so, the government would not have deployed mounted police on Narmada canal to check such 'unauthorized' lifting
3	Piped distribution is a widely used technology in India and abroad	Pipelines are used where no gravity flow irrigation is available. Pipelines are useful for tubewells but not relevant for a vast project like the SSP	Thousands of kilometers of pipelines are used by farmers on canal systems as well as on tubewells in Gujarat's canal command areas. Diesel pump dealers affirm that some 70,000 pumps were purchased in recent years for use on the SSP system
4	Piped distribution can save land	The land required for creating a surface distribution system is insignificant	If so, why is such a large, prestigious project delayed due to inability to acquire land for building sub-minors?
5	Piped distribution can be relatively cost- effective if the land cost is factored into surface canals	Pipelines too require land under the right-of-use act; farmers will demand compensation for crops lost during O&M	Thousands of kilometers of private irrigation pipelines neither pay for right-of-use nor crop compensation. These are demanded only when the government installs pipelines; doing this should be left to private service providers
6	Piped water distribution can save evaporation losses at sub-minors where the surface area to depth ratio is the highest	Water from the SSP is to be provided only during ambient temperatures that do not permit high evaporation	Canal network is carrying water during the past five summers. Moreover, evaporation losses from a sub-minor network of over 50,000 km would mean a shallow exposed water body of 10,000 ha. Replacing them with pipes will save on evaporation
7	Piped distribution can raise water productivity by spreading canal water over a larger area	Groundwater distributed through pipelines has high productivity because farmers have to 'pay through their nose' for it	Piped distribution of water of the SSP too will attract a volumetric charge as is common with all private service providers; it will, therefore, be more productive than gravity flow irrigation which will not be charged for on a volumetric basis
8	Pipes can promote conjunctive use of groundwater and surface water over large areas; surface canal command shrinks over time	This is not true; surface channels will take water to every field in the design command; moreover, groundwater is used only in small pockets where available in abundance	No canal irrigation project in Gujarat today is able to irrigate more than 40-50% of its design command; groundwater irrigation is pervasive throughout the State and can benefit from conjunctive management with surface water
9	Piped distribution is energy intensive but can also save energy by reducing groundwater pumping and promoting conjunctive use	Gravity is the cheapest form of irrigation and a huge gift from God	The report ignores the argument that spreading surface water over large areas in North Gujarat can raise groundwater levels and reduce energy costs of pumping. It also ignores the potential to link tubewell pumps to SSP minors for dual source irrigation
10	Piped distribution can promote public-private partnerships in ways that gravity flow has not done	The argument is based on 'some isolated cases quoted to impress'. Surface canals are the 'easiest, cheapest and most effective' mode to transport water	The Maharashtra private pipeline schemes are in tens of thousands; in North Gujarat, pipeline schemes operated by tubewell cooperatives too are in tens of thousands (Shah and Bhattacharya 1993). These have evolved their own institutional models for sustainable management of piped water distribution

future O&M issues once the pumps and pipelines are handed over to WUAs. In our thinking, such doubts are bound to arise when the government installs pumps and constructs pipeline networks. However, if this is done by farmers themselves, they will ensure efficient O&M as they have done for decades in the past (Shah 1993). The 'Expert Group' suggests pipelines are energy-intensive; we agree, but the 'Expert Group' totally ignored the aggregate energy saving from conjunctive use of rationed canal water supplies and deep groundwater. Above all, the 'Expert Group's' report remains blind to the profoundly changing nature of Gujarat's irrigation economy and the deteriorating performance of canal irrigation systems; and the contribution that such innovative hybrid systems (as found in Rajasthan) can make to reversing the trend. Indeed the principal ground on which the 'IWMI Pipelining Proposal' is rejected is that "The entire Narmada Project has been conceived on the premise that water would be delivered through flow irrigation only." It mattered little to the 'Expert Group' that Gujarat's irrigation economy has vastly changed from the time when the SSP was conceived during the 1970s. It also mattered little that the Rajasthan pilot, which departed from 'the premise' is, in their own assessment, doing 'very well'.

CONCLUSION

In this paper, we have argued that there are at least ten strong reasons why Gujarat should seriously consider the 'IWMI Proposal' for pipelining the water distribution system below the minors in the SSP command area. The 'IWMI Proposal', in brief, argues that: (a) SSNNL should abandon the construction of sub-minors below the outlet; (b) instead, encourage, facilitate and incentivize private or cooperative service providers to invest in water distribution systems based on buried pipelines; (c) SSNNL should focus its management effort on delivering the bulk of the water at the minor level on a volumetric basis in a strictly enforced, predictable rotational schedule rather than delivering water to each field. Doing this will develop the SSP command area faster and better. Moreover, besides saving land, water, energy and public funds, pipelining opens up huge possibilities for public-private partnerships and farmer participation in irrigation management in ways that surface canals have failed to provide. For farmers and cooperatives to become ISPs, four conditions are necessary: (i) there is potential for economic value creation through irrigation service provision; (ii) there is assurance of reliable water supply over the economic life of their investments; (iii) water supply need not be perennial, but it should match the irrigation demand pattern of a potential clientele that ISPs can serve in a viable manner; and (iv) for ISPs to operate as economic players, they should be able to market or share 'irrigation service' as a private good. These conditions prevail under piped water delivery and not under gravity flow through open channels. The proposal that the Government of Gujarat's Expert Committee has appraised and rejected outright involved the SSNNL constructing and managing a pipeline system for gravity flow distribution -- something inimical to the IWMI Proposal. Pipeline-based lift irrigation systems need intensive management; as a result, government-managed piped lift irrigation schemes have met with resounding failure in Gujarat and elsewhere in India. If the SSNNL installed and managed piped distribution, the chances that the project would fail, are high. Instead, it should emulate the Maharashtra example to invite farmers and their cooperatives to invest in and manage piped distribution systems. To promote farmer investments in piped distribution in a planned and systematic manner, the SSNNL should: (1) not only recognize and legalize but also incentivize lifting of water from SSP minors and its piped distribution; (2) ban water lifting from the entire system except at the minor level; (3) register all ISPs, private, cooperative and others, and bring them under a formal regulatory ambit; (4) make firm commitments of weekly water deliveries in each distributary/minor along a strict schedule, *a la* farm power scheduling under *Jyotigram*[11] ; farmers would invest, for example, if they felt assured that their minor will have plenty of water for at least one full day each week of the irrigation season; (5) encourage existing tubewell owners to use their connection to lift water from SSP minors; (6) persuade the state electricity utility to provide new electricity connections to approved piped distribution schemes planned by farmers, cooperatives and producer companies; (7) invite NABARD[12] and other institutional financial agencies to finance and support farmer cooperatives for their investments in pipelines; (8) offer a subsidy (we suggest 25%) on capital costs of approved projects in a way that minimizes perverse incentives; (9) register each pipeline with the SSNNL and require it to pay an irrigation fee -- preferably volumetric -- for all the land irrigated with water of the SSP; and (10) revise the traditional idea of 'irrigation command' to include all areas where farmers are willing to invest in a piped distribution system and pay volumetric water charges.

Fortunately, the SSP is designed as a network of Constant Volume Canals (CVC) up to minors; as a result, as water gets withdrawn from any minor, upstream gates automatically open to replenish the water released. Every minor, distributary, branch and main canal of the SSP is in a dynamic hydraulic equilibrium with the reservoir. This implies that SSP minors can be used as excellent storage canals, needing little modification to support piped distribution. If, therefore, undertaken with farmer investment and management, pipelining can: (a) achieve SSP's potential quickly, at little cost to the government; (b) promote large-scale ISPs that would invest in long distance pipeline networks; (c) create some 150,000-200,000 rural jobs in water distribution; (d) spread water of the SSP over a large area; (e) enable conjunctive management of groundwater and surface water; (f) improve Gujarat's overall farm power budget in net terms; and (g) establish a new model of irrigation management partnership between farmers and the government. This would also be the best way to encourage and facilitate the spread of pressurized micro-irrigation in the SSP command area. Above all else, this can achieve SSP goals without additional investments of public funds. All that SSNNL needs to do is to make a credible commitment of reliable -- even if it is rotational -- water availability in minor/distributary canals and recognize, legalize and encourage private lifting and piped distribution.

[11]Jyotigram is an innovative program implemented by the Government of Gujarat to ration electricity supply to tubewell irrigators to curtail electricity subsidy burden and groundwater overdraft without adversely affecting groundwater irrigated agriculture. Under this program, the electricity utility rations power supply to tubewells up to 8 hours/day; however, power supply is provided on a pre-announced roster, with minimal interruptions and at 440 voltage. Improved quality and reliability of power supply has helped tubewell owners accept the stringent rationing on supply (Shah and Verma 2008; Shah et al. 2008).

[12]National Bank for Agriculture and Rural Development, which provides institutional finance to such undertakings.

REFERENCES

BECC (Border Environment Cooperation Commission). 2003. Hidalgo County Irrigation District No. 1, Texas Canal Lining and Pipeline Installation Project. Available at www.cocef.org/aproyectos/ExComHidalgo2003_05ing.htm (accessed on December 28, 2009).

Chandra, A.; Sudhir, C. 2010. A study of Kolhapur lift irrigation co-operatives, MTS Report. Anand, India: Institute of Rural Management.

Choudhury, N.; Kher, V. 2006. Public-private partnership in surface water irrigation: A case of Kolhapur, IWMI-Tata Water Policy Program, Anand, India (Unpublished).

Dharmadhikari, S. 2005. Unravelling Bhakra: Assessing the Temple of Resurgent India, Manthan Adhyayan Kendra, Bhopal.

Government of Alberta. 2003. Alberta's irrigation infrastructure. Available at http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/irr7197/$FILE/irrigationinalta-part2.pdf (accessed on November 11, 2009).

GoG (Government of Gujarat). 2009. First approximation report to increase groundwater resources through artificial recharge in Gujarat State. Narmada, Water Resources, Water Supply and Kalpsar Department, Gandhinagar.

GoG. 2010. Report of the expert group for strategy for the accelerated development of Sardar Sarovar Project command area. Sardar Sarovar Narmada Nigam Ltd., Gandhinagar (Unpublished).

GoI (Government of India). 2005. Report on third census of minor irrigation schemes. Ministry of Water Resources, Minor Irrigation Division, New Delhi, India.

Indian Express. 2009. Government orders removal of diesel pumps installed along Narmada Canal. *Ahmedabad edition June* 20, 2009.

Krishiworld. 2010. Krishiworld.com. Available at www.krishiworld.com/html/water_resources2.html (accessed on April 28, 2010).

Lobo, L.; Kumar, S. 2009. Land acquisition, displacement and resettlement in Gujarat, 1947-2004. New Delhi, India: SAGE Publications.

Padhiari, H. 2005. Water service markets in surface irrigation systems: Institutions and socio-economic impacts. IWMI-Tata Water Policy Program, paper presented in Third ITP Annual Partners' Meet, Anand, India (Unpublished).

Plusquellec, H. 2002. How design, management and policy affect the performance of irrigation projects: Emerging modernization procedures and design standards. Food and Agriculture Organization of the United Nations, Bangkok. Available at ftp://ftp.fao.org/docrep/fao/004/ac799e/ac799e00.pdf (accessed on February 3, 2010).

RTI India. 2008. Gujarat used only 7% Narmada Dam water. As reported in *Yahoo News* May 29, 2008. Available at www.rtiindia.org/forum/4391-gujarat-used-only-7-narmada-dam-water.html (accessed on January 3, 2010).

Shah, H. 2009. Narmada Yojana: Nehro ne badle pipeline ketli vyajabi? (Gujarati) Arthbodh.

Shah, T. 1993. Groundwater markets and irrigation development: Political economy and practical policy. Bombay, India: Oxford University Press.

Shah, T. 2009. *Taming the Anarchy: Groundwater governance in South Asia*. Washington DC, USA: RFF Press.

Shah, T.; Bhatt, S.; Shah, R. K.; Talati, J. 2008. Groundwater governance through electricity supply management: Assessing an innovative intervention in Gujarat, Western India. *Agricultural Water Management* 95(11): 1233-1242.

Shah, T.; Bhattacharya, S. 1993. *Farmer organizations for lift irrigation: Irrigation companies and tubewell cooperatives of Gujarat*. Network Paper 26. London, UK: Overseas Development Institute.

Shah, T.; Verma, S. 2008. Co-management of electricity and groundwater: An assessment of Gujarat's Jyotigram Scheme. *Economic and Political Weekly* 43(7): 59-66.

Singh, S. 2006. Credit, indebtedness and farmer suicides in Punjab: Some missing links. *Economic and Political Weekly* 41(3): 330–31.

Singhal, N.; Patwari, V. 2009. *Evolving arrangements for local water diversion-delivery in SSP*. Management Traineeship Segment Report. Anand, India: Institute of Rural Management.

Talati, J.; Liebrand, J. 2003. Evolving institutions for irrigation management in Sardar Sarovar Project command, IWMI-Tata Water Policy Program, Anand, India. (Unpublished).

Talati, J.; Shah, T. 2004. Institutional vacuum in Sardar Sarovar Project: Framing 'Rules-of-the-Game'. *Economic and Political Weekly* 39(31): 3504–509.

Times of India. 2009a. Shelve Narmada Pipeline Plan: Expert. *Ahmedabad edition*, September 12, 2009.

Times of India. 2009b. Narmada Pipeline Project scaled down. *Ahmedabad edition*, November 13, 2009.

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Hirway, I.; Goswami, S. 2005. ***Performance of Narmada-based drinking water supply in Gujarat: Second round results from ITP-PRAVAH-CFDA Citizens' Monitoring System***. IWMI-Tata Water Policy Research Highlight, 10. 7p.

www.iwmi.org/iwmi-tata/FILES/zip/H05/10.zip

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Shah, T.; Hussain, I.; Saeed ur Rehman. 2000. ***Irrigation management in Pakistan and India: Comparing notes on institutions and policies***. Colombo, Sri Lanka: International Water Management Institute (IWMI). 20p. (IWMI Working Paper 004).

www.iwmi.org/Publications/Working_Papers/working/WOR4.pdf

van Koppen, B.; Parthasarathy, R.; Safiliou, C. 2002. ***Poverty dimensions of irrigation management transfer in large-scale canal irrigation in Andhra Pradesh and Gujarat, India***. Colombo, Sri Lanka: International Water Management Institute (IWMI). 31p. (IWMI Research Report 061).

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ISSN 2012-5763
ISBN 978-92-9090-736-7