Past, Present and the Future of Canal Irrigation in India

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Around 1800, India was the irrigation champion of the world. While the Colonial government initially neglected the maintenance and upkeep of numerous mostly small irrigation structures, it soon spotted the potential of large scale canal irrigation as an economic enterprise and took to canal building as a business on a massive scale. In those days, there was much dissatisfaction with irrigation management among observers and investors who expected much higher financial return on irrigation investments. Yet, in retrospect, around 1900, canal irrigation systems in India were arguably in a far better state than today in terms of their Operation & Maintenance (O&M), productivity impacts, and financial returns. Around 2000, while the new welfare state has kept alive the colonial tradition of big time canal construction, the management of canal irrigation had become pathetic in terms of all the criteria on which it excelled a century ago. The dominant view about the way out is that farmer management through Water User Associations can restore canal irrigation to its old glory. Not so. This paper argues that the larger socio-technical fundamentals in which canal irrigation can thrive in a small-holder agrarian setting were all mostly present around 1900 and are all mostly absent around 2000. The motives for irrigation building have changed, as have the politics around it and the nature of the Indian state and society. Most of all, the veritable and pervasive groundwater boom in Indian agriculture during recent decades raised questions about the relevance of traditional canal irrigation to Indian farmers who want on-demand irrigation, all round the year. Canal irrigation policy can chart several alternate courses in the future, of which we explore four: [a] continue in a Business-As-Usual mode, keep throwing good money after bad, and decline into irrelevance; [b] maximize the areal extent of conjunctive use of surface and groundwater by truly functioning as extensive irrigation systems as they were originally designed; [c] reform the irrigation bureaucracies for greater professionalism, accountability and performance orientation; [d] reconfigure public irrigation systems
as hybrid systems in which the Irrigation Department is responsible for reliable bulk water deliveries and private Irrigation Service Providers retail the water to irrigators. Some of [c] and [d] is already happening, but by sheer default, rather than by design. Public irrigation can serve the country far better if it pursued a considered strategy of reinventing the role of reservoirs and canal distribution in today’s changed context. For this to happen, the first step is to establish a credible information and monitoring system to assess public irrigation performance against its design and its current objectives.

1. Canal Irrigation in India circa 1900

Gravity flow irrigation has been central to Indian social history. According to Alfred Deakin, a three-time Australian prime minister and an irrigation enthusiast of early 20th century who toured India in 1890, the region had 12 million hectares (ha) of irrigated land compared with 3 million ha in the United States, 2 million ha in Egypt, 1.5 million ha in Italy and a few hundred thousand ha each in Ceylon, France, Spain, and Victoria (Australia) (The Age 1891). Although Egypt and Sri Lanka are better known as hydraulic civilizations, a century ago British India was arguably the world’s irrigation champion.

Although British irrigation initiative began in the early years of the 19th century, canal irrigation in British India experienced its most rapid expansion during the last years of that century. Between 1893 and 1903, when the first and second editions of Burton Buckley’s book “Irrigation Works of India” got published, the ‘area watered by irrigation works controlled by the Government of India increased by fifty percent’ (Burton Buckley 1905, preface). Burton Buckley proceeded in the second edition to wax eloquent about the benefits of public irrigation works [which] "cannot but tend to display the true beneficence of British rule in the great continent…".

In its big-time irrigation construction, the British irrigation enterprise revived, rehabilitated and built upon the irrigation canals that lay in disrepair in early decades of the Company rule. And the Colonial government had a lot to work on. The economic opportunity the British spotted in these
pre-existing systems was in their low-cost rehabilitation followed by their intensive management for revenue enhancement. Early rehabilitation works in the Indus and Ganges basins yielded high returns on investments (Whitcombe 2005: 683) and generated huge expectations in London. Lord Lawrence in a letter to Lord Cranborne stated that the general opinion in London held that these works would yield an average profit of 25, 50 or even 100 per cent. The subsequent experience of course belied these expectations; and colonial officials continued to bemoan poor performance of irrigation systems. Thus Col. W Greathed, Chief Engineer, Upper Ganga Canal, lamented in 1869 that “The development of irrigation has outrun its administration…”

But Colonial investment in canal irrigation consistently yielded 8-10 percent return on investment right until 1945 (Whitcombe 2005). She estimated that between 1912-13 and 1945-46, irrigation investments of the Government of British India returned a net profit increasing from 8.3 percent on productive works and 4.5 percent on all major works in 1912-13 to 12.8 percent on productive works and 7.2 percent on all major works in 1945-46. This calculation, based only on water charges collected, did not include the higher revenue assessment on irrigated land.

The key was intensive revenue management through an elaborate but low-cost irrigation administration appropriate for large irrigation systems but useless for myriad small, community based water harvesting and irrigation structures. On government schemes, to collect irrigation fees and manage water distribution at the village level and above, the Colonial government maintained a large irrigation bureaucracy. At the bottom was the Patrol (now called Lambardar in Pakistan Punjab) who wore a uniform and was a respected person among canal irrigators. His task was to keep records of areas irrigated but in many systems also oversaw water distribution. Paid Rs 5-10/month, the patrol managed 1500-3000 acres of irrigation, covering 1-3 villages. Above him was the Ameen, paid Rs 25-30/month and in charge of 7000-10,000 acres of irrigated area. The Zilladar was paid Rs 50-100/month and oversaw 30-50 thousand acres. The Dy. Collector of irrigation—often a young Englishman or a very senior native engineer—dealt with 80-120 thousand acres and was paid Rs 200-300/month (Buckley Burton 1905). The British
engineer who presided over this elaborate administration was paid some hundred times more than his lowest native subordinates. Understandably, he was under less pressure than present day senior engineers to earn on the side and could focus his time and energies on efficient O&M and water fee recovery, besides controlling corruption in the lower rungs.

Even with such an elaborate administrative apparatus, wherever possible, the Colonial government outsourced water distribution to large land holders who received water from public systems in their private distribution canals. Irrigation by private canals was a substantial part of the irrigated area in colonial north-western India. In 1943-44, nearly 500,000 acres in British Punjab were irrigated by private canals captive to one or a few farmers. In Shahpur district, where the government encouraged construction of private canals, all were owned by just two families, Noon and Tiwana (Islam 1997:36). Aside from these super-sized farm holdings, even ordinary irrigators had much larger holdings of 50 to 540 acres (Islam 1997:83). These relatively large land holdings made irrigation management below the outlet easier than it is today.

The Colonial irrigation management was thus a high-input-high-output affair. A vast authoritarian bureaucracy reaching down to the village level used forced labor to maintain canal network, managed water distribution and undertook ruthless water fee recovery on all lands deemed to be irrigated. In the canal commands the canal water “tax had to be paid regardless of whether or not use was made of the canal in a particular year or whether or not there was a reliable supply from the canal” (Hardiman 2002:114). This according to him, encouraged, even forced, farmers to grow valuable commercial crops to generate cash. This also resulted in much litigation from dissatisfied Zamindars which put pressure on canal managers to ensure water delivery and maintain canals. The amounts provided for O&M too were substantial so that deferred maintenance was minimal.

However, high water fee recovery absorbed these costs of staff as well as O&M and left a tidy surplus for the government. In 1902-3, for example, for all major irrigation projects in British India, the average water fee recovery was Rs 3.15/acre; of this, Rs 0.36 was the cost of revenue
management and Rs 0.63, the maintenance expenditure taking the total working expenses per acre to Rs 1.19 (Burton Buckley 1905). Working expenses were all of 32 percent of the water fee recovered per acre; and establishment expenses, just 11 percent (ibid). Burton-Buckely also noted that for over a dozen years previously, the average water fee recovered from canal irrigators was steadily rising, and working expenses per acre equally steadily falling.

2. **Canal Irrigation in India circa 2000**

That canal irrigation was an excellent business enterprise for the Colonial government is evident in the concluding paragraphs of Buckley Burton’s book:

> "The capital cost of the works in operation of which capital accounts are kept was about... £30,000,000 sterling at the end of the years 1902-3. In that year the value of the crops irrigated by these works was about...£26,000,000. Taking all the circumstances into consideration, it may be safely said that one-third of this sum—say, £ 9,000,000 sterling—represents the increased value of the crops due to the irrigation; for this increased value of the out-turn, people paid about £3,000,000 in water rates."

Around AD 1900, then the value of crops irrigated by canals in a single year was nearly equal to the capital cost of construction; the irrigation fee collected every year was 10-12% of the value of the output, around 9-10% of the total capital investment and 2.5 to 3 times the working expenses.

A 100 years later, the finances of canal irrigation in post-Colonial India stood in stark contrast as summarized in Table 1. Around 2006, India’s Central Water Commission reported that the water fee realized by all Major and Medium irrigation projects was all of 8.8 percent of the ‘working expenses’ during 1993-7 and the ratio had declined further to 6.2 percent during 1998-2002 (CWC 2006). During 1961-2001, the capital outlay on major and medium irrigation schemes at 2000 prices was around Rs 295,000 crore (Amarasinghe and Xenarios 2009); but only Rs 2820
crore (0.1 percent of capital cost) was spent on maintaining these public irrigation assets; water fee recovered from irrigators was all of Rs 652 crore, less than 10 percent of the ‘working expenses’ of Rs 8250 crore (CWC 2006: table A1).

Table 1  Deterioaring Finances of Indian canal irrigation:  AD 1900 compared with AD 2000

<table>
<thead>
<tr>
<th></th>
<th>Major and Medium systems in British India, 1902-3</th>
<th>Major, Medium and Multi-purpose Irrigation Projects in India 1977-8</th>
<th>Major and Medium Irrigation Systems in India, 2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Source</td>
<td>Burton Buckley 1905</td>
<td>Vaidyanathan Committee report (GoI 1992)</td>
</tr>
<tr>
<td>2</td>
<td>Capital investment in major and medium projects (nominal)</td>
<td>£ 30 million</td>
<td>Rs 3004 crore</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>Area irrigated by all government schemes (m ha)</td>
<td>7.4</td>
<td>18.75</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>Water fees collected as % of capital investment</td>
<td>10%</td>
<td>1.43%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5</td>
<td>Value of crops irrigated as % of capital investment</td>
<td>87%</td>
<td>na</td>
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<tr>
<td>6</td>
<td>Water fees collected as % of value of crops irrigated</td>
<td>11%</td>
<td>Na</td>
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<tr>
<td></td>
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<tr>
<td>7</td>
<td>Water fee collected as % of Working Expenses</td>
<td>280%</td>
<td>45%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Maintenance expenditure as % of working expenditure</td>
<td>53%</td>
<td>42%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>9</td>
<td>Maintenance expenditure as % of capital investment</td>
<td>2.6%</td>
<td>na</td>
</tr>
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<td></td>
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</tbody>
</table>

As a commercial venture, then the performance of canal irrigation decidedly declined over the past 100 years as if on cue from DR Gadgil, the pioneer of Indian economic planning, who had argued that, in a poor agrarian economy like India, public irrigation investments should be judged on their social and economic returns rather than their financial returns. Soon after Independence, irrigation charges were drastically reduced; and even these remained increasingly uncollected. Around 1930, irrigation fees were the largest source of government revenue in Punjab, more than even income tax (Islam 2004); but these declined rapidly after 1950. By 1960, the scenario

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1 GoI 1992, Annexure 1.5
2 GoI 1992, Annexure 1.7-A
3 Computed using irrigation charges collected as in Table 2.6 in GoI 1992 as % of capital investment in row 3.
4 Assuming 18 million ha of canal irrigated area growing crops worth Rs 30,000/ha at 2000-1 prices.
5 GoI, 1992, 2.25 “The Irrigation Commission had suggested that water rates should be fixed at around 5 percent of gross income for food crops and 12 percent for cash crops. At present, the actual gross receipts per ha of area irrigated by major and medium projects is barely 2 percent of the estimated gross output per ha of irrigated area, and less than 4 percent of the difference between output per ha of irrigated and unirrigated areas.”
6 Computed from table 2.6 in GoI 1992
throughout the country had changed drastically for the worse. In a study of Bihar, Bhatia (1991) showed that irrigation dues in 1960 were so small that it made eminent sense to relocate the 5000-strong force deployed in collection elsewhere and abolish irrigation fees altogether. This trend continued in other states where irrigation fees remained stagnant for decades; and the proportion of total demand actually collected declined to a small fraction.

But were Gadgil’s larger expectations met? Have public irrigation investments in free India delivered the irrigation—and the socio-economic returns— they were designed to?

Not so; and there lies the heart of the problem. The financial rot was the harbinger of a much deeper crisis of stagnation and decline in public irrigation systems whose social and economic returns turned out far smaller than imagined. In one of the earliest reviews in mid-1980’s, Dains and Pawar (1987:2) noted that ‘most investments in existing large public surface irrigation systems have had rather low economic rates of return in the range of 4-12%’. Many factors explain this decline, but four are the most important: first, all-round deterioration in planning and management of public irrigation at all levels; second, failure to anticipate and adapt to the rising tide of pump irrigation from surface and groundwater, within and outside command areas; third, the resultant reorganization of India’s irrigation economy; and fourth, the challenge of performance management of public irrigation systems in the new irrigation economy.

2.1 Decline in Public Irrigation Management Performance:

Researchers writing during the 1980’s noted that surface irrigation systems tended always to be perennially underutilized, and typically only a fraction of the designed command got actually irrigated soon after the completion (Daines and Pawar 1987). The key problem, many observers noted, was poor maintenance and system management, especially below the outlet. Repetto (1986, 4) foresaw the problem when he wrote that “public irrigation systems themselves are sinking under their managerial, economic and environmental problems.” And David Seckler, another keen observer of the Indian irrigation scene, wrote: “As the rug of irrigation development
is rolled out ahead through construction of new facilities, it will roll up behind through poor maintenance and management of existing facilities” (cited in Wade 1984, 286). Without understanding the larger malaise, donors pumped in large volumes of funds in the name of ‘rehabilitation and modernization’ which led to throwing good money after bad. The Colonial irrigation’s ethos of “build–manage–generate surpluses–maintain” gave way to a “build–neglect–rebuild” syndrome.

The reality of Indian irrigation systems seems never to conform to its design. Most were overdesigned to pass the cost-benefit test; and once constructed, anarchy followed in their command areas. Everywhere, the central problem is ‘unauthorized’ over-appropriation of water by head-reach farmers for growing crops that irrigation planners had never expected them to grow. Most Indian irrigation systems were mostly designed for protective irrigation over large areas; moreover, they assumed “that farmers will stick to subsistence production of food crops, when supplementary irrigation is made available to them” (Jurriens et al 1996). But reality never conformed to this plan. Systems designed for irrigated dry crops—as in Karnataka’s Tungbhadra canal—collapsed into rice irrigation systems. As a result, the original goal of providing protective irrigation over large areas was uniformly defeated (Mollinga 2003). In the northwestern systems, as in Haryana, researchers found the much-celebrated wara bandi (rotational water supply) system—designed to minimize head-tail inequity—eroded beyond redemption; the same has been found for the Indus system in Pakistan (Jurriens et al. 1996; van Halsema 2002) and elsewhere in monsoon Asia where it has been tried (Rice 1996). Under the wara bandi, every farmer is supposed to get equal number of water turns, for equal time, per unit of land. But the study by the late Anil Shah (2003) found high levels of flow irrigation deprivation at the tail ends during monsoon as well as winter seasons in warabandi areas (Table 2). Water supplies at the periphery—away from the headworks, main and branch canals—offers the litmus test of system performance; and most South Asian public irrigation systems fail resoundingly on this criterion. As

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7 The Haryana study defined flow irrigation deprivation as 50 percent or less of the canal irrigation received by the best-off farmer in a watercourse.
a rule, they tend to collapse into a small, intensively irrigated wetland below the head-works while the periphery of the design command makes merry with pumping groundwater.

Table 2  Extent of Irrigation Deprivation levels of Tail-enders in selected Gravity Flow Irrigation Projects in India (Shah 2003)

<table>
<thead>
<tr>
<th>States</th>
<th>Names and type of systems studied</th>
<th>Extent of Flow Irrigation Deprivation (FID)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gujarat</td>
<td>Dharoi- Major; Mahi Right Bank- Major;</td>
<td>7-37 percent</td>
</tr>
<tr>
<td>Haryana</td>
<td>Western Yamuna-Major; Bhakra- Major</td>
<td>56-84</td>
</tr>
<tr>
<td>Karnataka</td>
<td>Tungabhadra system- Major; Vanivilas, Medium; Two tanks- Minor</td>
<td>40-91</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>Mula-Major; Walen tank-Minor</td>
<td>29-70</td>
</tr>
<tr>
<td>Orissa</td>
<td>Hirakud- Major</td>
<td>35-72</td>
</tr>
<tr>
<td>Tamilnadu</td>
<td>Parambikulam Aliyar-Major; Two rainfed tanks- Minor</td>
<td>24-55</td>
</tr>
</tbody>
</table>

Countless micro-level studies by independent researchers convey the same picture. Decline in the performance of irrigation administration, strong construction orientation and low O&M orientation of irrigation bureaucracy, political influence on design and management, institutional vacuum below the minor canals—all these have contributed to this decline. More important than even these is the emergence of a vast pump irrigation economy in which scavenging water from any proximate source—ground or surface—has taken precedence over orderly gravity flow irrigation.

2.2  Rise of the Water Scavenging Irrigation Economy

When canal irrigation first opened up in the Indo-Gangetic basin, wells fell into disuse in thousands. Dhawan (1996:537) called this ‘substitutional effect of public irrigation works which caused amongst farmers well-placed in new command areas a ‘disinclination even to maintain their own sources of irrigation of pre-canal vintage, not to mention that they drastically cut back on new investments in such means of irrigation”. Even today, in canal irrigation projects elsewhere in the world, well irrigation is uncommon (Burt and Styles 1999), as it is for non-command farmers to lift water from the canal, river or tanks and transport it several miles to irrigate their plots.
But South Asia is an exception; all these practices are rampant in Indian systems today, leaving surface irrigation systems reconfigured and their command areas redrawn. Where once gravity flow crowded out wells, the opposite is the case today; proliferation of irrigation wells in many canal commands have turned what were irrigation canals into recharge canals. In course of a field visit to Guhai irrigation system in North Gujarat, we found that most farmers irrigate 35-45 times in an year, but the canal releases are available only 3-4 times. the Guhai system meets only a small fraction of direct irrigation demand; yet it is highly valued by command area farmers because it contributes more recharge than the rainfall (Shah 2010). Flow irrigation from tanks, used for centuries to grow rice, especially in southern India, is rapidly shrinking with growing profusion of wells in tank commands. According to Selvarajan (2002), Andhra Pradesh, Tamilnadu, Karnataka, and Orissa, which together accounted for 60 percent of India’s tank-irrigated area, lost about 37 percent of their tank-irrigated area from 1965 to 2000.

Wells cannibalizing tanks and *ahar-pyne* structures was understandable. But during the 1990’s, they began to do the same to major and medium systems. In the Bhakra command in North-West India, canal irrigation at first drove out wells; however, especially since 1990, the trend has been reversed (Dharmadhikari 2005), and now, 75 percent of all irrigated areas in Indian Punjab depend upon well and tube well irrigation (Singh 2006 citing a Government of Punjab 2005 document). This is happening at the national scale too (Selvarajan 2002; Thakkar 1999:19).

Comparing land-use statistics for India, Janakarajan and Moench (2006) noted that between 1996–97 and 2002–03, the area under canal irrigation declined by 2.4 million ha (13.8 percent), the area under tank irrigation fell by 1.4 million ha (42.4 percent), and the area irrigated by all other sources declined by 1 million ha (28 percent). The only irrigation source that increased its share was groundwater wells, by 2.8 million ha (more than 9 percent). Comparing the minor irrigation census data for 1993–94 and for 2000–01 suggests that in the seven intervening years in those states common to both the censuses⁸ surface irrigation systems lost 4.6 million ha

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⁸ Andhra Pradesh, Arunachal, Bihar and Jharkhand, Goa, Himachal Pradesh, Madhya Pradesh and Chhattisgarh, Orissa, Punjab, Rajasthan, Uttar Pradesh and Uttarakhand, West Bengal, Gujarat, Maharashtra.
(29.4%) from their command, roughly at a rate of 0.65 million ha per year. Groundwater-irrigated areas grew during the same period by 4.35 million ha (Shah 2009).

To reverse the deceleration in canal irrigated areas, the government of India thought up the Accelerated Irrigation Benefits Program to step up the investment in the so-called last-mile projects. More than US$7.5 billion has been invested in these projects since 1997. However, instead of acceleration, public irrigation command areas have continued to decelerate during this period. A recent study of 210 major and medium irrigation projects by a Delhi NGO used the data supplied by the Ministry of Agriculture to show that after investing Rs 130,000 crore, these delivered 2.4 million ha less irrigation during 1990-1 to 2006-7. Similar results were obtained by comparing the data from three Minor Irrigation Censuses (Shah 2009). If anything, increasing the area served by public irrigation projects in India looks like the labors of Sisyphus, and public irrigation policy, a theater of the absurd; governments have to invest twice as fast in canal irrigation projects every year just to keep their command areas from shrinking, as figure 1 suggests.

Figure 1 Accelerating Investment and Decelerating Irrigation Benefits
2.3 Changing Organization of India’s Irrigation Economy

All this suggests that the organization of India’s irrigation economy is in the throes of a massive transformation; and public irrigation systems are losing their position of dominance in this changing playing field. As Wallach, writing about the Nagarjun Sagar project in Andhra Pradesh during 1980’s spoke of the Indian reality that ‘dams and canals are splendid monuments, but as water distribution systems they are rarely able to deliver water to more than half of their commands’.⁹

In contrast, the pump irrigation economy is spreading faster than previously imagined, especially after 1990. 50 years ago, rural India had a clear water-divide: villages within canal commands and those outside. But that is not so any longer. An all-India NSS survey of 78,990 farm households in 1998 showed hardly any difference in average gross area irrigated per sample household in villages with government canals (1.8 ha) and those without government canals (1.69 ha). It found “a marked rise in privately owned irrigation facilities...[and that a] large part of the cultivated land today is irrigated by hiring pumpsets” (NSSO 1999, Report 451, 39). A 2002–03 survey of 51,770 farm households from 6,638 villages around India showed that 69 percent of the sample area irrigated in kharif and 76.5 percent in rabi was served by wells and tube wells (NSSO 2005). Yet another large-scale NSSO (2003) survey found that in 2002, 76 percent of the 4,646 villages surveyed had irrigation facilities, but mostly in the form of tube wells. Per 1,000 villages surveyed, only 173 had water from a government canal, but wells and tube wells abounded in 762 villages per 1,000 that reported having an “irrigation facility.” The Central Water Commission claims that over 30 million ha are irrigated by canals. All other sources suggest that this number is around 15 million ha; and pump irrigation economy reaches supplemental irrigation to an undetermined area anywhere between 30 and 90 million ha, depending upon the data source (Table 3).

Table 3 Various Estimates of Area Irrigated by Canals and Wells in India: circa 2000

<table>
<thead>
<tr>
<th></th>
<th>Data for year</th>
<th>Major &amp; Medium Schemes</th>
<th>Groundwater</th>
<th>Other sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minor Irrigation Census, October 2005, Net area irrigated&lt;sup&gt;10&lt;/sup&gt;</td>
<td>2000-1</td>
<td>10.23 m Ha</td>
<td>30.5 m Ha</td>
</tr>
<tr>
<td>2</td>
<td>NSSO 59&lt;sup&gt;th&lt;/sup&gt; Round:&lt;sup&gt;11&lt;/sup&gt;</td>
<td>Jan-Dec 2003</td>
<td>7.75%</td>
<td>28.95%</td>
</tr>
<tr>
<td>2a</td>
<td>% of net area sown in kharif irrigated by:</td>
<td></td>
<td>8.37 m Ha</td>
<td>31.3 m Ha</td>
</tr>
<tr>
<td>2b</td>
<td>% of net area sown in rabi irrigated by:</td>
<td></td>
<td>7.68%</td>
<td>42.86%</td>
</tr>
<tr>
<td>3</td>
<td>Ministry of Agriculture, Govt. of India</td>
<td>Net area irrigated by different sources</td>
<td>2001-2</td>
<td>15.9 mHa</td>
</tr>
<tr>
<td>4</td>
<td>Central Water Commission</td>
<td>2001-2</td>
<td>16.2 m Ha</td>
<td>75 m Ha</td>
</tr>
<tr>
<td>5</td>
<td>IWMI’ global irrigated area map using remote sensing data (gross area irrigated)&lt;sup&gt;13&lt;/sup&gt;</td>
<td>2004-5</td>
<td>55 m Ha&lt;sup&gt;14&lt;/sup&gt;</td>
<td>91 m Ha&lt;sup&gt;15&lt;/sup&gt;</td>
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</tbody>
</table>

2.4 Parameters for Performance Management

Finally, a major driver of declining performance in public irrigation projects is the difficulty in assessing their performance. When water rates were high and vigorously collected as under colonial irrigation, total collection and financial returns offered a robust surrogate of performance. But today, irrigation fee collection tells nothing about the performance of the irrigation management. Land use survey data are challenged by irrigation managers on the pretext that farmers under-report canal irrigated area to avoid paying water charges. Remote sensing maps can help assess total irrigated area in a command but not by source. Political leaders derive

<sup>10</sup> From the Abstract of information from Village Schedule, Table 6.1, p. 321
<sup>11</sup> Table 3.4.1. This survey covered 51770 farming households from 6638 villages around India.
<sup>12</sup> Kharif cropped area in 2002-3 was 108 million ha and rabi cropped area was 102 million ha. See, http://www.mospi.gov.in/press_note_nss_31august06.htm
<sup>13</sup> Thenkabail, P.S et al 2006.
<sup>14</sup> Conjunctive use areas in command of major and medium irrigation systems
<sup>15</sup> Gross area irrigated by groundwater structures, small tanks, and other sources outside the command areas of major and medium irrigation systems
much satisfaction watching main branch canals flowing at FSL; but have no means to assess the goings-on at the outlet level and below. The difficulty of measuring the performance of public irrigation management poses a formidable obstacle in the challenge of performance improvement.

To understand persistent poor performance of major and medium projects, the Government of India commissioned the four IIMs to undertake an in-depth exploration of issues. The question they were posed with is: why is the gap between irrigation potential and the area actually irrigated by public systems widening?\(^\text{16}\) Regrettably, the question itself was trivial and produced a trivial answer. The question is trivial because the ‘irrigation potential’ is defined simply as the ‘presumed’ volume of water expected in the reservoir divided by a ‘presumed’ irrigation delta required for a ‘presumed’ cropping pattern totally overlooking the ground reality of Indian canal irrigation. In no Indian irrigation system do real values of these variables approach their presumed values which in any case are arguably the numbers chosen to justify project investment rather than honestly considered estimates. The gap between potential created and area irrigated is thus a good indicator of poor planning of irrigation projects rather than of canal irrigation performance. Researchers really interested in the performance of public irrigation projects ask different questions and therefore get different, often more insightful answers.

From the viewpoint of irrigators, the performance of an irrigation system is judged by the level of water control it offers (Boyce 1988). After Freeman et al. (1989), water control can be defined as the capacity to apply the proper quantity and quality of water at the optimum time to the crop root zone to meet crop consumptive needs and soil leaching requirements. The performance gap

\(^{16}\) Different departments measure irrigation potential created and utilized differently. The Irrigation Department estimates the ayacut by the volume of water released and an assumed duty of water. The Revenue Department estimates area irrigated based on the water cess actually collected. It also uses the previous records of localization orders issued earlier. The Agriculture Department goes by the area in which crops are raised under irrigation. All these estimates differ widely and no attempt is made at reconciliation at any stage.
between the level of water control that command area farmers expect and the one they actually receive is the sum of three component gaps:

- **Gap I**: Gap between the area (and farmers) designed to be served by gravity irrigation and the area (and farmers) actually served after the system begins operation;
- **Gap II**: Gap between the level of ‘water control’ promised at planning stage and the level of ‘water control’ actually delivered after the beginning of the operation;
- **Gap III**: Gap between the level of ‘water control’ demanded by farmers at the present point in time and the level of ‘water control’ actually offered by the system.

Gap I arises often because irrigation systems are over-designed to make them appear more viable and beneficial than they can actually become. Irrigation delta assumed is lower than realistic so that a larger design command can be shown. Repeated experience is overlooked of the head-reach farmers irrigating water-intensive crops and the shrinking of the command area that actually gets served. Once the system gets commissioned, the gap tends to expand because of the *anarchy* endemic in a canal command which includes acts of omission and commission that subvert the objectives of system management. Acts of commission include water thefts, vandalism, violation of water distribution norms, unauthorized diversion or lifting of water from canals by head-reach farmers. Acts of omission include farmers’ own failure to cooperate in maintenance and repair, to pay irrigation charges, and so forth (Burt and Styles 1999; Pradhan 1989,18; Oorthuizen 2003,207).

Gap II generally arises because of inept system management as well as physical deterioration of the system and reengineering by farmers (Oorthuizen 2003). Also important are operating rules for reservoir and main system management. In multi-purpose projects, often the hydro-electric plants determine the protocol and schedule for releasing water from reservoirs without much regard for the irrigator’s needs.
Gap III arises from the changing pattern of irrigation demand, mostly due to diversification of farming towards high value crop. For centuries, farmers in canal and tank commands grew rice or rice/wheat rotations. With growing urbanization and rising incomes, farmers have opportunities to grow high value fruit and vegetable crops that impose a different irrigation schedule. Irrigation systems designed for rice/wheat rotations or for extensive irrigation can meet only a small fraction of the water control needs that diversified farming systems require. Depending only on public irrigation systems would thus drastically reduce the opportunity set of farmers who then turn to groundwater irrigation for providing them the high level of water control they need for their diversified cropping patterns. Crop diversification reducing the appeal of canal irrigation is an Asia-wide phenomenon. A World Bank study of rice irrigation systems in Thailand in mid-1980’s saw the forebodings when it noted that “...the emerging trend towards crop diversification... raises many questions... diversified field crops do not accommodate over-irrigation and continuous irrigation which are common practices in irrigating rice in Thailand.” (Plusquellec and Wikham 1985:7).

For long, poor performance was blamed on the physical deterioration of systems and poor maintenance, and numerous programs were launched to “rehabilitate” surface irrigation systems. But as Boyce (1988, A-9) pointed out, “The social difficulties of achieving joint water use among many irrigators may exceed the technical difficulties of constructing large-scale systems.” As a result, evaluations repeatedly found that physical rehabilitation was not a silver bullet. Typically, a visible performance jump in the immediate aftermath of physical rehabilitation enlarged the command area and improved fee collection, water flowed unimpeded to the tail-end, and users expressed satisfaction. A few years later, however, water fee collection would languish, anarchy levels rise. Maintenance would be deferred; degradation of the system would begin slowly and then accelerate, causing head-tail imbalance and prompting another round of rehabilitation. In South Indian tanks, the cycle has been so short that new rehabilitation plans are afoot even before the last plan is fully implemented. Mohanty (2005), an infrastructure expert, calls this the build-neglect-rebuild syndrome. Recent thinking about improving performance of surface systems
therefore favors modernization, defined as the “process of technical and managerial upgrading … of irrigation schemes combined with institutional reforms, with the objective to improve resource utilization … and water delivery service to farms” (Renault 1998, 8). Involving farmers in irrigation management through PIM is a key component of modernization. But can PIM help to close Performance Gaps I, II and III?

3. **Improving Public Irrigation Performance: Can PIM do it?**

Unfortunately, participatory irrigation management (PIM)—and its sibling, irrigation management transfer (IMT)—have proved surprisingly sterile as the new mantra for revitalizing canal and tank irrigation not only in India but in much of Asia (Mukherji et al 2009). The idea of PIM goes back to traditional Farmer Managed Irrigation Systems (FMIS), in whose case a distinct ‘irrigation culture’ passed over generations of irrigation communities. However, the logic of transforming traditional “irrigation communities” into PIM through water users’ associations in a government-run irrigation system itself has been questioned (Hunt 1989; Narain 2004). More than two decades ago, Coward (1983) put his finger on the problem:

> The basic point is to understand that the fundamental processes of investment now being made by the State [in large irrigation projects] fail to create property relationships among the water users, and thus are unable to support the creation of a social basis for action among local people.

What is extraordinary about PIM (and IMT, which is as yet untried in South Asia) is the sway it has continued to hold on the irrigation management discourse despite virtually no evidence of its having succeeded anywhere in the developing world except on an experimental basis, and only with facilitation of unreplicable quality and scale. That system managers want farmers to manage irrigation canals is not new; the British tried hard in late 19th century to get farmers from the Indo-Gangetic basin to participate in irrigation management but without much success, except in wara
*bandi* in the Indus canals (Whitcombe 2005). Since independence, farmers’ organizations for irrigation management have been regularly tried, with uniformly disappointing results. In the early 1960s, Uttar Pradesh tried *Sinchai Samitis* (irrigation committees) on irrigation tanks and reservoirs; later, Madhya Pradesh tried it on thousands of its minor irrigation tanks. Other states have been struggling to make *Pani Panchayats* (water assemblies) work. But the *Sinchai Samitis* of Madhya Pradesh and Uttar Pradesh have disappeared without trace, and so have *Pani Panchayats* in Gujarat and elsewhere. Gujarat introduced its Joint Irrigation Management Program in 1983, but the 17 irrigation cooperatives lost money and were disbanded. In 1991, it made another attempt, this time with assistance from local nongovernmental organizations, and 144 irrigation cooperatives were formed to cover 45,000 ha of irrigated area (Shukla 2004). However, these cooperatives never functioned, and it is difficult to see precisely how PIM areas were better off than other command areas.

In sum, it is rare circumstance in which WUAs have improved public irrigation systems’ performance on a large scale in South Asia. And that too only when a mid-sized NGO invests years of effort and resources in organizing WUAs and using means to reduce transaction costs that farmers on their own would normally not possess. Some of the best known examples of successful PIM/IMT on large government-run surface irrigation systems in India are Ozar on Waghad project in Nashik, Maharashtra, Dharoi in North Gujarat, Pingot and a few more medium schemes in Bharuch district. The success of farmer management in all these—and its beneficial impact— is undisputed. In each of these, however, there was a level of investment of motivation, skill, time, effort and money which is unlikely to be replicated on a large scale. In catalyzing Ozar co-operatives, Bapu Upadhye, Bharat Kawale, two popular local leaders and their NGO Samaj Pragati Kendra, and senior researchers of SOPPEKOM, a local research group, invested years of effort to make PIM work (Paranjapye et al. 2003). In Gujarat, between them, Aga Khan Rural Support Program and Development Support Centre invested at least 30 professional field staff for over 10-15 years to organize say 20-30 thousand flow irrigators in to functional WUAs. My intent is not to undermine this exceptional work but to suggest that no government agency in South Asia
has the quality and scale of human and other resources, nay the motivation levels, needed to implement an institutional intervention that can sustainably raise the productivity of the 35-40 million ha of flow irrigated area in India over say 15 years.

Nevertheless, the fascination with the idea continues as governments and donors seek to rejuvenate irrigation systems with the magic wand of PIM. And the recent fad is to do it with a “big bang.” Orissa recently passed a law that transferred all its minor irrigation systems to instantly created Pani Panchayats. And Andhra Pradesh created more than 10,000 water users’ associations by a stroke of its chief minister’s pen. The Andhra Pradesh reform is lauded by some observers as great example, even though dozens of institutional big bangs of this genre have quietly ended as whimpers. And if the 250,000-ha decline in surface irrigated area in Andhra Pradesh between the 1993–94 and 2000–01 minor irrigation censuses is any indication, Andhra Pradesh’s reforms are already a whimper. The World Bank loan spent, field researchers in Andhra Pradesh too are beginning to wonder precisely what the water users’ associations are doing better than before (Jairath 2001; Reddy 2003; Madhav 2007).

Indeed, a primary purpose of the command area development agencies (CADAs) formed by the Government of India in early 1980s was to involve farmers’ organizations in the management of irrigation projects. But we see no trace of CADAs or their “beneficiary farmers’ associations.” In Kerala, thousands of such organizations were formed during 1986. An assessment by Joseph (2001) in late 1990s suggested that, even in this land of strong traditions of local governance, high education, and high levels of participation in public affairs, the beneficiary farmers’ associations were a damp squib. Some random excerpts from Joseph (2001) based on his study of Malampuzha Project:

“It is the CADA officials who took the initiative in their formation and not the farmer groups. In most cases, membership fee of Rs 5 was not paid by the farmers concerned; payment was made on their behalf by prospective office bearers, or the potential
contractors of field channel lining or the large farmers in the ayacut. .86 percent (of the BFAs) were formed in these two years (1986 and 1987)... for making possible the utilization of funds....Only 57 meetings were held by the 8 Canal Committees during a span of 10 years..43 of them were held without quorum and 35 with zero attendance of non-official members... The level of knowledge... about Canal Committees... and there structure and functions is very low…”

For some researchers, PIM interventions are laboratories in democratic governance; to them, whether PIM improves irrigation performance or not matters little. Most PIM protagonists would be happy with far less. Indeed, PIM action the world over is driven by the idea that water users’ associations can manage irrigation systems better than remote bureaucracies and would be better at controlling anarchy, improving water service, collecting fees, and maintaining the system. That would raise water and land productivity and improve the fortunes of the farmers. Democratic governance aside, PIM programs have belied many of these lesser expectations even where they are widely considered successful, in Turkey, Mexico (Kloezen 2002; Rap 2004), and the Philippines (Oorthuizen 2003). As a result, expectations have been increasingly moderated and participatory management is now considered successful even if it just “saves the government money, improves cost effectiveness of operation and maintenance while improving, or at least not weakening, the productivity of irrigated agriculture” (Vermillion 1996, 153). The discussion, in recent times, has been more about shifting responsibility away from governments than about improving the lot of farmers—the original goal to which much public irrigation investment has been directed over the past 50 years.

The lesson learnt is that benefits of rehabilitation and upgradation are transitory without the capacity to control anarchy. And when it comes to controlling anarchy, the idea of gravity flow irrigation itself is up against some hard questions in India.

4. Socio-technical Pre-conditions for Canal Irrigation
One of these questions most interesting to ask but seldom explored is: can India’s publicly managed canal irrigation systems reproduce some of the productivity, socio-economic and financial outcomes in 21st century that they demonstrated at the end of the 19th? A likely answer is ‘no’ because the socio-technical conditions in which canal irrigation can thrive were all present then and are all absent now. Table 4 summarizes a broad-brush selection of socio-technical conditions that prevailed during pre-colonial, colonial and post-colonial eras in many Asian countries including Mughal and British India. Our hypothesis is that particular forms of irrigation organization we find in these eras were in sync with the socio-technical fundamentals of those times. Irrigation communities thrived during pre-colonial times when: [a] there was no alternative to sustained collective action in developing irrigation; [b] strong local authority structures, such as Zamindars in Mughal India, promoted—even coerced—collective action to enhance land revenue through irrigation; [c] exit from farming was difficult; and [d] irrigating with wells, where possible, was highly laborious, costly and time-consuming.

Similarly, large-scale irrigation systems during colonial times kept the three Performance-Gaps (discussed in the previous section) under control because: [a] land revenue was the chief source of income for an authoritarian government, and enhancing it was the chief motive behind irrigation investments17; as a result, irrigation managers had strong stake in ensuring that the main-systems were well managed and maintained; [b] state had a deep agrarian presence and used its authority to extract ‘irrigation surplus’ and impose discipline in irrigation commands; [c] the farmers in canal commands had no practical alternatives to either subsistence farming livelihoods or to gravity flow irrigation since well irrigation remained costly and laborious; and [d] population pressure on farm lands was nowhere as severe as found today. These socio-technical conditions created an ‘institutional lock-in’ that ensured that public irrigation systems performed in terms of criteria relevant to their managers at those times.

17 Land revenue constituted 60% of East India Company’s total income in 1840’s (Banerjee and Iyer 2002); though its share declined somewhat, it stayed at around 50 percent through the 19th century.
Post-colonial India is confronted with a wholly new array of socio-technical conditions in which neither irrigation communities nor disciplined command areas are able to thrive. The welfare state’s revenue interests in agriculture are minimal; the prime motive for irrigation investments is food security and poverty reduction, and not maximizing government income. Governments have neither the presence and authority nor the will to even collect minimal irrigation fees needed to maintain systems. Then, agrarian economies are in the throes of massive change. Farmers can—and do—exit agriculture with greater ease than ever before. Growing population pressure has made small-holder farming unviable except when they can intensify land use and diversify to high-value crops for a growing urban and export markets. In any case, to sustain, surface irrigation seems to require an ‘optimal’ population density; at very low population density, it is not worthwhile; but beyond a threshold, land becomes so valuable that using it for water storage and transport comes under severe pressure (von Oppen and Subba Rao 1987:36).

Finally, gravity flow irrigation systems are hit by the mass-availability of small pumps, pipes and boring technologies that have made ‘irrigation community’ redundant; these have also made the irrigator impervious to the progressive widening of the three performance gaps, and reduced her stake in their performance. But for the rise of pump irrigation, canal irrigators would have protested non-performance by voice; now they have the easier option of exit (Hirschman 1965).

Table 4 Socio-technical context of surface irrigation in different eras

<table>
<thead>
<tr>
<th></th>
<th>Pre-Colonial (Adaptive Irrigation)</th>
<th>Colonial (Constructive Imperialism)</th>
<th>Post-Colonial (Atomistic Irrigation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit of irrigation organization</td>
<td>Irrigation Community</td>
<td>Centrally managed irrigation system</td>
<td>Individual farmer</td>
</tr>
<tr>
<td>Nature of the state</td>
<td>Strong local authority; state and people lived off the land; forced</td>
<td>Strong local authority; land taxes key source of state income; forced</td>
<td>Weak state and weaker local authority; land taxes insignificant; poverty reduction, food security and</td>
</tr>
</tbody>
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18 As Wallach says of Nagarjunsagar project: “The problem is partly engineering one.; more fundamentally, however, the problem is political, for the government is unable to prevent farmers at the upper or head ends…from taking so much water that the tail ends run dry… Little has been published on the subject, perhaps because India has put so much money, professional pride, and dreams of prosperity invested in the projects. Yet, many irrigation engineers in India will admit privately that the waste of development finds is staggering.” [http://ags.ou.edu/~bwallach/documents/Krishna%20Basin.pdf](http://ags.ou.edu/~bwallach/documents/Krishna%20Basin.pdf) visited on October 30, 2009.
labor; maximizing land revenue chief motive for irrigation investments
labor; maximizing land revenue and export to home-markets chief motive for irrigation investments; state used irrigation for exportable crops
donor funding key motive for irrigation investments; forced labor impossible; electoral politics interfere with orderly management

| Nature of Agrarian Society | No private property in land. Subsistence farming, high taxes and poor access to capital and market key constraints to growth; escape from farming difficult; most command area farmers grow rice. | No property rights in land. Subsistence farming and high taxes; access to capital and market key constraints to growth; escape from farming difficult; tenurial insecurity; most command area farmers grow uniform crops, majorly rice. | Ownership or secure land use rights for farmers; subsistence plus high value crops for markets; growing opportunities for off-farm livelihoods; intensive diversification of land use; command areas witness a wide variety of crops grown, with different irrigation scheduling requirements |
| Demographics | abundant land going abegging for cultivation; irrigable land used by feudal lords to attract tenants | abundant land going abegging for cultivation; irrigable land used by feudal lords to attract tenants | Population explosion after 1950 and slow pace of industrialization promoted ghettoization of agriculture in South and South-east Asia and China. |
| State of Irrigation Technology | Lifting of water as well as its transport highly labor intensive and costly 19, | Lifting of water as well as its transport highly labor intensive and costly; | Small mechanical pumps, cheap boring rigs, and low cost rubber/PVC pipes drastically reduce cost and difficulty of lifting and transporting water from surface and groundwater. |

Adapting system design and management to phenomenal expansion in pump irrigation is arguably by far the most formidable challenge to government canal irrigation systems and their managers. Private businesses respond to such ‘creative destruction’ either by reinventing themselves or by fading away. When IBM refused to recognize the threat posed to its mainframe by the arrival of cheaper and widely accessible PC technology, it lost its market leadership and was eventually obliged to enter the PC business as the only way to survive. In India, the Hindi film industry, which was organized around cinema halls, has reinvented itself in the era of television and DVDs as the only way to survive. Public irrigation management faces much too similar threat from pump irrigation from canals and groundwater—as mainframes did from PCs and Bollywood

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19 Assuming that a pair of bullocks pulling a 100 liter leather bucket do 100 turns a day for say 100 days per year, lifting 5 km³ of water from wells would require 10 million bullocks working on wells. This work is done today in the Ganga basin by around 300,000 5- horse power diesel pumps doing 8 hours/day for 100 days. In Gorakhpur, James Buchanan estimated that 10 men could water from a ditch 3 to 5 thousand square feet/day using swing-baskets. A 1 hp pump can do this work now in less than an hour. Besides the drudgery, the financial cost was an issue, too. The cost figures for those days given by the Agriculture Commission were Rs 7-20 per ha for canal irrigation and Rs 54 per ha from a well. “In view of such a large difference in cost, it was not surprising that wells were superseded by canals as the source of water supply in areas supplied by canals.” (Randhawa 1983, vol. 3:291).
did from DVDs. It refused to adapt because it does not have to earn to survive; but the only way it can remain relevant is by reinventing itself in the changed irrigation scenario.

One way to adapt, many argue, is by modernizing Indian irrigation systems to make them more demand-oriented, as in Australia or commercial farming sector of South Africa where they cater to a small number of large users and provides each a level of water control that the Indian small farmer seeks from his own borehole and pump. But this will be a vain hope. Moreover, such modernization will work only to the extent that it addresses the rapidly changing socio-technical fundamentals of the canal irrigation context of India. Rather than improving canal irrigation performance by ‘reforms’—institutional reform (like PIM/IMT), bureaucratic reform, reform of main system management (Wade and Chambers 1980)—India may be better off ‘morphing’ its canal systems to fit the changing socio-technical context of its agrarian economy in transition.

5. Future of Canal Irrigation: Reform or Morph

What is the path that canal irrigation will—or can--follow in the future, over say 25 year time horizon? Many scenarios are possible; but I will explore here three in particular.

a. Business-As-Usual Scenario: This is most likely and assumes that construction and management of canal irrigation projects will continue over the coming 25 years pretty much as they have done in the past 25. This will imply, among other things, that [1] Governments at central and state governments will continue to construct large public irrigation projects despite their poor track record of performance and without understanding how to improve their performance; [2] similarly, multi-lateral lenders will continue to find new irrigation projects as well as rehabilitation/ modernization projects that are attractive for making large loans that governments are happy to receive regardless of the past experience with the performance of such loans or future prospects; [3] poor performance of irrigation systems will continue to be blamed on the anarchy below the outlet; and despite lack of evidence of large-scale success, PIM/IMT will continue to be peddled as blanket solutions to improving system performance; [4]
Since best sites are already used up, new projects will be increasingly costly and unviable, like the massive lift irrigation projects under construction on Godavari in Andhra Pradesh whose energy cost of pumping the water itself is estimated at Rs 17500/ha; [5] to justify unviable projects, planners will continue to over-estimate the command area\(^2\) and assume unrealistic irrigation duty; once commissioned, the head reach farmers will make a habit of irrigating water loving crops ensuring that the actual area commanded is a half or a third of the original plan; [6] Political leaders will continue to score electoral brownie points in initiating and constructing grandiose projects, without paying much attention to the stringent institutional and management requirements to achieve the performance goals of these systems; irrigation projects will also be attractive to politicians for the opportunities these provide in favoring supporters with construction contracts; [7] Irrigation departments will continue to remain construction-oriented with engineers having little interest or incentive or capacity in efficient management of systems so that they achieve their full performance potential; [8] Even if bureaucracies were motivated and capacitated, canal irrigation performance is difficult to measure and monitor when land revenue and water fee collection have been trivialized; [9] in some states, irrigation departments will continue to stagnate or even shrink in size; states like Gujarat have not hired an irrigation engineer in 20 years, and by 2015, all engineers are expected to have retired; this will leave little organization to manage these large irrigation capital assets; [10] where irrigation departments are growing, with rising government salaries and stagnant irrigation fee collection, establishment costs will increase as the share of working expenses with little left to repair and maintain the systems; [11] in overall terms, the low-level equilibrium in which public irrigation in India is comfortably ensconced today will continue; governments will keep throwing good money after bad; multi-lateral lenders will keep financing unviable rehabilitation projects; and overall, more and more money invested will keep giving India less and less canal irrigation as has happened since 1991; [12] The key socio-economic benefits of such projects—often more than gravity fed

\(^2\) For example, the Sardar Sarovar Project is planned to irrigate 1.8 million ha on the assumption that the project will ration canal water at a delta of 53 cm/year. If we take the total water circulating in Indian canal systems a 300 BCM and divide it by the 17 m ha this irrigates, the storage per net ha irrigated comes to 17640 m\(^3\). As a project representative of Indian canal irrigation sector, then SSP can not command more than 0.55 million ha.
irrigated areas—will be in terms of recharging the aquifers in the areas where they can reach water by gravity flow and feeding urban water supply schemes.

b. **Expanding the area under conjunctive management of surface and groundwater**

The simplest step that canal irrigation management in India can take to significantly enhance its impacts is to maximize areas under conjunctive use of ground and surface water. This is not happening because India’s irrigation systems irrigate only a fraction of the area they were designed to and they can with tighter management of the main system. India’s canal systems are designed to mobilize and move around some 300 BCM of water in a normal year. According to the Central Water Commission, these irrigate some 30 million out of a total of 37 million ha that can be potentially irrigated. According to the land-use survey data as well as the Minor Irrigation Census data, however, some 14-15 million ha are irrigated by major and medium public irrigation projects. With CWC figures, the volume of storage needed to irrigate a ha is around 10,000 m³/ha; with LUS data, the volume increases to 20,000 m³/ha, a good deal of which either creates water-logging or evaporates without producing any benefit. In comparison, 230 BCM of groundwater storage gives India a gross irrigated area of 35.2 m ha according to LUS and 53 mha according to the Minor Irrigation Census. Thus, the groundwater storage India needs to support an irrigated ha is between 4300 to 6600 m³/ha.

A potentially gigantic opportunity of unlocking value out of India’s canal systems is of spreading their waters on much larger areas to expand the areas under conjunctive management of surface and groundwater. Around the world, a key problem in achieving such conjunctive use is reluctance of command area farmers to invest in groundwater irrigation structures. In Pakistan during the 1950’s, the World Bank had to invest a large sum in the so called SCARP tubewell program to stimulate such conjunctive use. In India of today, this is no longer a problem since irrigation wells dot the entire land scape of the country. Farmers have thus done their bit; it is the canal managers who have to play their part. Many Indian systems were designed as extensive (or protective) irrigation systems to support irrigated dry crops that can be matured with relatively
low delta. However, entirely due to poor system management and political intransigence, most systems have degenerated into intensive irrigation systems where a fraction of the design command uses up 10-15,000 m$^3$ of water/ha to grow water-loving crops.

It is possible to argue that canal systems can be transformed into extensive systems as they were planned without investing much simply by improving the management of the main system. Most rehabilitation and modernization projects aimed at doing precisely this, 'restoring derelict systems to their original potential'. Most however ended spending huge sums on construction and little on management improvement and capacity building, in which neither engineers nor their bosses show much interest. Improving the management of main systems holds the key to unlocking value in India’s public irrigation (Wade and Chambers 1980). But doing this requires reform and revitalization of irrigation bureaucracies more than PIM/IMT and spending billions on reconstruction.

c. **Irrigation Agencies Reinvent Themselves:** When pushed against the wall, bureaucracies sometimes reinvent themselves provided there exist certain prerequisites in their internal and external task environment. Turn around of such strategic utilities can not only change their own fortunes but also the fortunes of the economy they dominate. As a recent example of such turn-around, I will cite the Gujarat Electricity Board (GEB) which, in a span of 10 years, has transformed itself from a poorly performing, loss-making, dreaded parastatal utility into a high-performing, viable, customer-oriented public utility. That it is making profit today is important but even more important it that its turn-around has given Gujarat—rural and urban—unparalleled energy supply environment that has spurred all-round development of the state. GEB turn-around is a subject of extensive study as an example of successful 'change management' (Shankar and Mondal 2010; Hansen and Bower 2003; Joshi 2008; Shah and Verma 2008). Around 2002, GEB was all but bankrupt and a constant drain on the state’s budget; huge subsidy bill for agriculture meant high tariff for commercial and industrial users; quality of power supply was poor; the vast organization was lethargic and corrupt; customer satisfaction was low. Today, a profitable
GUVNL (GEB reincarnate) is a key vehicle for Gujarat’s multi-faceted development. The process of turn-around involved: [a] unbundling the monolith into seven independent companies—five autonomous regional distribution companies, one generation company, one transmission company and a holding company, of which the other six are subsidiaries; [b] the new companies were allowed professional boards and technocrats as chairmen and managing directors; politicians heading GEB became a matter of the past and the new structure was insulated from political interference; [c] government of Gujarat infused one-time equity of over US $ 6 billion to complete the transition to the new structure and for efficiency improvements; [d] an independent Electricity Tariff Commission was constituted to determine power tariffs for different consumer classes; [e] in tandem with these structural changes was set into motion organizational culture change process; smaller companies now promoted decentralization of decision making, and empowerment of ground-level employees; [e] performance based rewards and penalties—on reducing Transmission and Distribution losses, improving customer service, ISO certification, and national and international awards, etc—generated healthy competition among distribution companies; [f] agricultural feeders were separated from other rural feeders to cap farm power subsidies and provide 3-phase 24*7 power supply to villages; moreover, farm power subsidies were reimbursed by the government so that companies could focus on commercial viability; [g] with government support, the new structure came down heavily on power-thefts; administrative measures were used to penalize theft; and technological innovations were evolved to make theft difficult as also to minimize technical losses. In sum, this ‘turn around’ process put Gujarat’s electricity utility on a performance ascent unimaginined before. Gujarat cut farm power subsidies; yet its agriculture grew at unprecedented 9.6%/year during this period (Shah et al 2010); T&D losses, the litmus test of power industry performance, dropped from 30.9% in 2003-4 to 21.8% in 2007-8. In 2003-4, the average cost to serve a unit of power was Rs 4.15 and average realization, Rs 3.94; in 2007-8, the realization was Rs 3.96, 2 paise higher than the cost to serve a unit. In sum, in a span of five years of ‘copybook turn around’, GEB morphed from a ‘benefit provider’ to a ‘service provider’. In 2001, GEB was subject of all-round scorn; in 2010, GUVNL became a target of public adulation and Gujarati pride.
Can Gujarat’s irrigation department achieve such a feat? After all, there are striking similarities between the business of power supply and of irrigation water supply. Both are valuable and scarce. Agencies involved are both monopoly suppliers supplying to hundreds of thousands of customers through transmission and distribution networks. Farmers are a special interest group for both; and ‘T&D losses’, thefts, non-recovery of fees, poor maintenance of distribution systems are all as serious problems for the irrigation agency as they were for the GEB in 2000. If Gujarat could fix its power industry by turning around GEB, why can it not improve its irrigation economy by turning around its irrigation agency?

There are no easy answers to this question. The idea of unbundling has already been tried in Sardar Sarovar Narmada Nigam Limited (SSNNL), a special purpose vehicle created outside the Irrigation Department to construct and manage the Sardar Sarovar Project. However, there seems little evidence to suggest that SSNNL has done better than the Irrigation Department as either a ‘profit center’ or a ‘responsibility center’. A pre-condition to any management turn-around is reliable information about organizational performance. In case of the power industry, reliable information about key performance variables—T&D losses, cost to serve versus realization per kWh, etc—is easily available. In canal irrigation, it is not; even on basic variables—the area wetted by canals in a system—different government sources provide vastly different numbers. Because irrigation charges are hardly collected, even water fee realization is a poor indicator of area irrigated. Finally, unlike during Colonial times when irrigation fees commanded 1/3rd crop share, canal irrigation is inherently unviable as a business today. Despite these, I think that irrigation agencies would improve if: [a] a reliable and transparent Management Information System were established to monitor the performance of each irrigation system; [b] the monolithic department was unbundled into independent management units for each system with operational autonomy, freedom from political influences, agreed management goals, and performance-based reward system; [c] a transfer pricing scheme were evolved to translate system performance into a performance management system for the agency.
d. **Morphing into hybrid systems with Public Private Partnerships:**

A third scenario of where Indian canal irrigation might go in future is for the irrigation agencies to enlist the ‘water scavenging anarchy’ as a partner and leverage it to enhance their reach and performance. A good example is provided by developments in the upper-Krishna basin in Maharashtra. In 1976, the Bachhawat Award allocated 560 TMC of water to Maharashtra which the state had to develop by 2000. Maharashtra was not in a position to build reservoirs and canal networks needed to use this water; by 1996, it had constructed only 385 TMC of storage and little by way of canal network in the Krishna basin. Therefore the government first began allowing farmers to lift water from Krishna and its tributaries. But this only encouraged small-scale private lift schemes most of which could not convey water to longer than 1-1.5 km distance. In 1972, only 200 private and co-operative lift schemes were operating in Maharashtra. As pressure to utilize the water mounted, the government adopted a far more proactive posture towards lift irrigation schemes. It introduced a capital cost subsidy for irrigation co-operatives and also facilitated bank finance from nationalized and co-operative banks. Most importantly, the Irrigation Department (ID) constructed a series of Kolhapur Type (KT) weirs across many tributaries of Krishna to use them as storages for lift irrigation schemes. Each scheme has to be approved by the ID, where upon 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; it also has to pay the electricity charges to the State Electricity Board at 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 reliable water supply during the irrigation season.

A good example of the kind of partnership between irrigation department and irrigation co-operatives Maharashtra’s policies have spontaneously promoted is the Radhanagari project (constructed by Shahuji Maharaj in 1916) that serves 91 villages in Kolhapur district studied by Chouchury and Kher (2006), PadhiYari (2006) and Chandra and Sudhir (2010). The dam never had any canals; water is released from the dam into 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 Bhogavati river every 15 days to fill up 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 all done by some 500 ‘Irrigation Service Providers (ISP)’ in private and co-operative sectors.

Radhanagari’s performance over the past two decades has been very good compared to surface irrigation systems anywhere in India. Against a design command of 26,560 ha, the average area irrigated by ISPs during 2001-2006 was 30,341 ha. The ID managed to collect only 58% of the irrigation charges that fell due; however, against the annual O&M cost of Rs 79 lakh, irrigation charges collected in 2005-06 was Rs 179 lakh. In terms of the area irrigated as well as irrigation charges recovered, tail end areas were found no worse off compared to 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 service providers (ISPs) (Choudhury and Kher 2006). In terms of offering irrigation-on-demand, Radhanagari comes close to tubewell irrigation. Choudhury and Kher (2006) interviewed 8 private and 9 co-operative ISPs that irrigate a little over 1,000 ha in Radhanagari project. These have together invested nearly Rs 22 crore in systems that include 2,280 hp of pumps and 41 km of buried pipe network and employ 92 staff to manage water. 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 thus invested Rs 2.2 lakh/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 salary to employees, and save enough for prompt repair and maintenance.

Radhanagari may appear an exception; not so. According to Government of India’s Minor Irrigation Census III, in 2000-01, Maharashtra had some 100,000 such schemes in operation for
lifting and piped distribution of surface water mostly in Upper Krishna basin. Over 20,000 of these were owned and operated by farmer groups and co-ops. These lifted water from rivers and streams and transported it mostly by buried pipelines to up to 30 km from source. Remarkably, none of these was operated by a government agency. Over 90 percent of Maharashtra’s lift schemes were constructed by farmers from their own funds and bank finance, with the present value of aggregate investment of around Rs 5,000 crore. Over 90% schemes used electric pumps to lift water and 70% had buried pipeline network for water distribution. Total horse power 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 meters to 185 meters. These irrigated a gross area of some 350,000 ha (including sugar cane area of over 100,000 ha). Maharashtra’s lift irrigation schemes likely employed over 100,000 workers as pankhya’s (water managers), if we count the fact that the 80,000 families operating private lift schemes had at least one family member each devoted fulltime to work on the scheme operation.

Table 5  Farmer modifications and adaptations of canal systems to serve their needs.

<table>
<thead>
<tr>
<th>#</th>
<th>System modification and adaptation</th>
<th>Examples</th>
<th>How widespread is this in India?</th>
<th>Extent of farmer enterprise and investment</th>
<th>Precondition for farmer enterprise and investment</th>
<th>Presence of Irrigation Service institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Classical Canal Irrigation: The System operates as designed; wells are driven out by gravity flow irrigation.</td>
<td>Mahi command in early 1970’s, Bhakra command in the 1950’s</td>
<td>Not at all</td>
<td>Negative</td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Main system delivers water in farm ponds (diggí’s) fortnightly</td>
<td>Indira Gandhi canal, Rajasthan</td>
<td>Not very</td>
<td>Low; individual</td>
<td>Regular water supply to farm ponds</td>
<td>Nil</td>
</tr>
<tr>
<td>3</td>
<td>Main system delivers water in village ponds as intermediate storages; farmers irrigate by gravity or lift</td>
<td>Sardar Sarovar; System tanks in South India</td>
<td>Some</td>
<td>Low; individual</td>
<td>Tanks replenished regularly</td>
<td>Some presence of Irrigation Service Markets (ISMs)</td>
</tr>
<tr>
<td>4</td>
<td>Main system delivers water into canals; farmers/groups</td>
<td>Mahi system, Upper Krishna</td>
<td>Very widespread</td>
<td>Substantial; private and</td>
<td>Perennial or full season</td>
<td>High to very high</td>
</tr>
</tbody>
</table>

21 Shah 1993  
22 Amarasinghe et al. 2008  
23 Choudhury and Shah 2005  
24 Patil et al. 2006; Birari et al. 2003; Choudhury and Kher 2006; Padhiyari 2006
Where ever canals offer reliable water supplies, private investors have invested in turning water into ‘irrigation service’ that mimics on-demand groundwater irrigation. A sample of the many ways in which farmers have modified and adapted canal systems to their needs is listed in table 5. If we were to learn from this experience, a variety of management models emerge in which the irrigation agency has a new, more limited role of delivering bulk water at pre-designated points in the command area and a variety of private arrangements are allowed to provide an ‘irrigation service’.

Regardless of whether governments support these or not, these are emerging and playing a major role in water distribution in many systems. This is the closest that canal irrigation can come to mimicking the flexible, on-demand groundwater irrigation.

At present, such private pump and pipe systems on canals are considered illegal, and their owners, water thieves. But these can also be viewed as partners in redesigning canal systems as hybrid

<table>
<thead>
<tr>
<th>lift and irrigate</th>
<th>Sardar Sarovar command</th>
<th>throughout India</th>
<th>co-operative</th>
<th>canals at run at FSL</th>
<th>presence of ISMs</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Main system delivers water to a village contractor on volumetric basis and he allocates water to farmers and collects water fees</td>
<td>Several systems in China</td>
<td>This model is spreading in China</td>
<td>Substantial, private</td>
<td>Perennial or full season canals at run at FSL</td>
<td>High presence of ISMs</td>
</tr>
<tr>
<td>5 Main system recharges the aquifers in the command; much irrigation surplus results from tubewell irrigation</td>
<td>Bhakra, Mahi, Upper Krishna basin, Tamilnadu</td>
<td>Very, very widespread</td>
<td>Substantial, mostly private</td>
<td>None; alluvial aquifers, unlined canals help</td>
<td>High to very high presence of ISMs</td>
</tr>
<tr>
<td>6 Irrigation tanks support well irrigation in their command</td>
<td>Tamilnadu; AP, Karnataka, Eastern Rajasthan</td>
<td>Very, very widespread</td>
<td>Substantial, mostly private</td>
<td>None</td>
<td>Some presence of ISMs</td>
</tr>
<tr>
<td>7 Irrigation tanks converted into percolation tanks</td>
<td>Much of Tamilnadu; Rayalaseema in Andhra Pradesh</td>
<td>Not very, but gaining</td>
<td>Substantial, mostly private</td>
<td>Consensus among tank irrigators</td>
<td>Some to high presence of ISMs</td>
</tr>
</tbody>
</table>

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25 Talati and Shah 2005; Talati and Pandya 2007; Singhal and Patwari 2009
26 Shah et al. 2003; Wang et al 2003
27 Dharmadhikari 2005; Down to Earth 2005.
28 Shah 1993; Shah 2009; Kolavalli 1986
29 Venot 2008; Biggs et al 2008
30 Sivasubramaniyan 2008
31 Palanisami and Easter, 1991; Palanisami and Balasubramanian 1998
32 Rao 2003
33 Shah and Raju 2001
34 Palanisami 1995; Palanisami 2005.
35 Rao 2003
systems in which the agency promises to deliver bulk-water at, say, minor-level along a predetermined schedule and licensed ISPs, paying a volumetric water charge assume the responsibility of distributing water to their farmer-customers through a buried pipe network. Such hybrid systems involving piped distribution can have several advantages over the conventional gravity flow systems: [1] Private partners take up a large part of the capital investment of a canal system by constructing the distribution system; [2] Buried pipe distribution system faces much less 'right-of-the-way' problem that canals face; [3] piped distribution saves land used up for sub-minors and field-channels; [4] it minimizes water-logging that is rampant in canal-based distribution system; [5] piped distribution is considered too costly in comparison to earthen canals but is actually cost-effective if land required for canals is valued at market price; [6] a canal network is a vast evaporation pan especially at the level of the distribution system where surface area to depth ratio of channels is low; piped distribution can save some of this non-beneficial evaporation loss; [7] piped water delivery from canals mimics tubewell irrigation and raises productivity of irrigation water applied even more so because users pay a high price for the irrigation service; [8] done right, piped distribution can help spread canal water over a much larger area than surface canals can; [9] it can put into a place a regime of conjunctive use of ground and surface water that may tackle the acute problem of groundwater depletion; [10] While pipelining is more energy-intensive compared to gravity canals, if managed well, it can significantly improve the overall farm energy balance of the country by spreading surface water on a larger area, reducing the need for groundwater pumping, by integrating micro-irrigation technologies, and enhancing recharge from canal water thereby reducing the energy used in groundwater pumping; [11] Lastly, while farmer participation in canal irrigation management has found hard to come by, under such a hybrid PPP model, farmer participation in irrigation management begins at the construction stage itself.

If the Maharashtra experience is any guide, inviting farmers to participate in creating such hybrid systems is not difficult. To promote farmer investments in piped distribution in a planned and systematic manner, all that Agencies need to do is: [a] not only recognize and legalize but also register and incentivize lifting of water from canal systems and its piped distribution; [b] make firm
commitments—during the irrigation season each year—of weekly water deliveries in each distributary/minor along a strict schedule, as in Radhanagari system described above; [c] Existing tubewell owners should be encouraged to convert their electricity connections to canal lift; [d] electricity connections should be provided to approved piped distribution schemes planned by farmers, co-operatives and producer companies; [d] institutional financial agencies should be involved in providing finance to support farmer co-operatives for their investments in pumps and pipeline systems; [d] government should provide 25% subsidy on capital costs of approved projects; [e] each pipeline system should be registered with the Agency and be required to pay irrigation fee for all the land irrigated with canal water; [f] the idea of ‘irrigation command’ should be modified to include any farming community that is willing to invest in piped distribution and pay a volumetric water charge.

6. Conclusion

According to Kurt Levin’s force-field analysis, India’s public irrigation management will begin to change for the better when drivers of change will outweigh the forces that restrain change. For the moment, the latter far outweigh the former and will make ‘Business-as-Usual’ (outlined in 6.a) the most likely option. Indeed, one can find hardly any notable ‘driver’ that would create pressure for a major change program in public irrigation sector. Governments and donors have kept throwing good money after bad; and they will keep doing so regardless of what past investments delivered or failed to deliver. If a battery of ‘change drivers’ were to be created, the work would need to begin by creating a credible information and monitoring system about how public irrigation systems are performing against their original designs, their current objectives and vis-à-vis each other. In business, measuring performance is generally considered essential to managing it. This seems nowhere more true than in public irrigation business in India today.

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