Supply-Side Hydrology in India

The Last Gasp

The plan for inter-linking rivers is based on the simple and deeply flawed belief that rivers have surplus waters and that floods and droughts can be banished by technical solutions alone. This belief is grounded in the troubled legacy of hydraulic management in the sub-continent dictated by a supply-side approach, which ignores the complexities inherent in river ecosystems.

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Those who are good at controlling water give it the best opportunity to flow away, those who are good at controlling people give them plenty of chance to talk.

– Chia Jang, a great Han Engineer
(Quoted in Joseph Needham, *Science and Civilisation in China*, Vol 4, Part III, Cambridge, 1971)

Fame had already preceded Colonel Arthur Cotton in May 1858, when he submitted his *Report on the Mahanuddy River* to the colonial government of Orissa. As a hydraulic engineer, Cotton had previously experienced immense successes in the Kaveri, Godaveri and Krishna deltas. Though the report on the Mahanadi river was required to principally suggest a solution to the problem of flooding in the Orissa delta, it dramatically went beyond its modest brief. But 1858 was no ordinary year. The East India Company administration in India had just given way to Crown government and the British empire was busy setting itself up for glory and permanence. The era of high finance moreover had begun, with financiers, bankers and sundry speculators desperately steering money markets in London towards investing in the colonies.[1] It was a time for big-thinking about schemes and ventures. Driven in equal measure by unrestrained speculation about super profits and quick returns.

Colonel Cotton, with a formidable reputation to nurse, was out to seize the moment. His *Report on the Mahanuddy* authoritatively proclaimed that the Orissa delta like "all deltas require[d] essentially the same treatment".[2] The Mahanadi river, he suggested, needed to be 'regulated' by a plexus of irrigation and navigation canals and lined by a system of embankments. The entire project, he estimated, could be completed at the cost of a mere Rs 13 million and would be made to irrigate 2.25 million acres, while generating a 30 per cent return on the investment. The Orissa scheme, as it came to be known, however, was not intended to stand alone. Colonel Cotton in his inestimable confidence had earlier also drawn up a plan to connect the Indian subcontinent through a grid of navigation and irrigation canals. A peninsula system, in other words, which would link Karachi in the northwest to Madras in the south via Kanpur, Calcutta and Cuttack, with additional lines to Poona and the west coast.[3] The Orissa scheme was merely one segment in the larger and grander plan to achieve a single navigable water route across the length and breadth of the Indian subcontinent. This period of opportunity was, however, also a period of intense competition. Cotton's river inter-linking scheme was double edged; it had to draw capital investments for navigation and irrigation schemes while simultaneously starving the same for the railways, which was then being touted as the most viable mode for mass transport in India. Cotton, in effect, wanted river navigation to trump railway lines. This explains why his *Report on the Mahanuddy* contained several diatribes against the railways, which he unhesitatingly declaimed was an "inferior mode of conveyance".[4] In the subsequent years, Cotton's reputation was all but eclipsed. Not only did the proponents for the railways triumph, but the Orissa scheme and several others, whose construction Cotton had pushed for, had turned into sordid financial disasters.[5] In fact, by the time Arthur Cotton left India, he was a much defeated and broken man.

The idea for inter-linking rivers in India, however, seems to have been firmly planted. In the 1960s K L Rao, the then union minister of state for power and irrigation, spoke of linking the Ganga with the Cauvery through a 2,640 km long canal. By the 1970s, the plan was reworked as a 'national river grid' by which the surplus waters of the Ganga and Brahmaputra were to be diverted to the central and southern states. Earlier, one Captain Dastur, an air pilot, proposed that a 4,200 km long Himalayan canal and 9,300 km long southern canal be linked up at Delhi and Patna. Captain Dastur's proposal was popularly referred to as the Garland Canal.[6] The government of India subsequently set up the National Commission for Integrated Water Resources Development Plan (NCIWRDP) to assess these grand schemes. In their report, submitted in 1999, the NCIWRDP concluded that K L Rao's proposal was "very costly and lower cost alternatives were available". The commission was even more curt about Captain Dastur's proposal, which was dismissed as being "prima facie impractical".[7]

Oddly enough, the idea for inter-linking India's rivers, despite its repeated dismissal by expert opinion, seems to be merely shelved rather than killed. On October 31, 2002, the Supreme Court bench headed by Justice Kirpal 'suggested' that the government take up the plan for linking rivers. This set off an immediate chain reaction. By November, the central government claimed that feasibility studies for six of the peninsula links were ready and by December 16 of the same year appointed a Task Force under the chairmanship of Suresh Prabhu to prepare and outline an action plan for implementing the project.[8]

As it now stands, the plan, which, from a hydrologist's point of view, reads like a suicide note, advocates for 37 rivers in India to be connected through 30 links and 36 major dams. The claim is that it will generate 30,000 MW of cheap hydropower, supply drinking water to 101 districts and five metros and irrigate 34 million hectares. This idea, as stated, turns on the proposition that one has to "divert waters from surplus areas via storage dams and canals to where it is scarce."[9] This simple and deeply flawed belief that rivers have surplus waters and that floods and droughts can be banished by technical solutions in actual fact draws from a troubled legacy of hydraulic management and control in the subcontinent.

History and Hydraulic Practice

Historically, technologies for hydraulic manipulation in the Indian subcontinent has moved through three distinct, though overlapping, phases. From the earliest times, tanks, inundation canals, temporary bunds to trap drainage, wells and water-wheels made up the ensemble of water harvesting structures. These techniques were essentially directed towards either impounding precipitation, tapping river inundations or retrieving groundwater recharge.[10] At the risk of oversimplification, one could perhaps conclude that the underlying hydraulic principle was to adapt the water harvesting structure and design to micro-climates, topography and fluvial process. In the early 19th century, however, British colonialism initiated a radical break in both technique and hydraulic principle by introducing perennial canal irrigation in several parts of the south Asian subcontinent. For the first time, permanent head-works in the form of barrages and weirs were thrown across river-beds and their waters diverted through intricate and extensive canal systems. These barrages and weirs were equipped with a series of shutters to regulate flows by impounding water during lean seasons and diverting it into canals and on the reverse the former could be flipped open to release waters during periods of the river's peak discharges. In effect, by flattening the river's variable flow regime at certain points along its course, irrigation was transformed from a seasonal to a perennial possibility. This phase, often referred to as the advent of the era of modern irrigation, witnessed the construction of several large canal irrigation schemes with permanent head-works such as the Ganges Canal (1854), the Godavery (1852) and the Krishna (1855).[11] These gargantuan projects made possible a dramatic hike in cropping intensities, fuelled the growth of commercial farming and encouraged the spread of mono-cropping. By the time the great production boom from perennial irrigation began to level-off sometime in the early decades of the 20th century, the attendant problems of salinisation and waterlogging had irreversibly, in many instances, turned a fair amount of formerly fertile and cultivated lands into barren and unproductive deserts.[12] But just about the time that large-scale canal irrigation projects began to falter in their financial returns and productivity gradients, a third wave in hydraulic manipulation emerged in the 1930s, which was chiefly developed and pioneered in the US. Under the rubric of Multi-Purpose River Valley Development (MPRVD), a slew of new technologies were put into operation to effect the virtual industrialisation of river control. Now, the entire river basin instead of merely the channel became the focus for water planners and hydraulic engineers. The intention was to train the river through a sequence of interconnected dams, reservoirs and diversions from its catchment all the way to its estuary by 'harnessing' its waters simultaneously for navigation, irrigation, flood control and power generation. In this period, the experience of the Tennessee Valley Association (TVA), under whose charge the Tennessee river and its tributaries were brought under MPRVD control, became an internationally celebrated model and was aggressively advertised as worthy for global emulation. The quest to mimic the alleged success of the TVA began in earnest in India between 1943-46, when the British colonial government approved plans to build MPRVD schemes on the Damodar, Mahanadi and Kosi rivers, besides setting up the Central Water, Irrigation and Navigation Commission (CWINC) as a professional water bureaucracy for formulating and implementing other MPRVD schemes.[13]

Thus far, independent India's water strategy has essentially been a continuation and intensification of the MPRVD paradigm for industrialising river control. Close to 4,291 large dams currently impede and alter the flows of various rivers and their tributaries.[14] In 1950, while some 5,280 km of embankments hemmed in river channels, by 1993 the length and number of flood control embankments had increased to 16,200 km.[15]According to the Planning Commission in India, utilisation of irrigation facilities in India has spiked from 22.6 million hectares (mha) in 1950-51 to 75.7 mha in 1993-4.[16] The gross withdrawal of water from both surface and underground sources is estimated to have increased from 376 bn. cubic metres in 1968-69 to 549 bn cubic metres in 1990.[17] This great surge in construction and deployment of projects for extracting, harnessing and utilising water has, not unexpectedly, been made possible at a substantial cost. Between 1950 and 1997, the central and state governments together have invested nearly Rs 540 billion on various types of water schemes, while another Rs 70 billion has been disbursed by ways of loans from public sector financial institutions to agriculturists, primarily for ground water extraction through pumps.[18] In short, since independence, governments in India have pursued an aggressive supply-side solutions approach for both ascertaining and meeting water demands. Consequently, initiatives to ameliorate perceived shortages have been met either by the construction of dams and diversions or by encouraging ground water mining through electric and diesel pumps.

Collapse of Supply-Side Hydrology

In recent years, there has been a virtual avalanche of official, scholarly and popular studies and reports revealing that India's water crisis has become cancerous and fatal. The supply-side approach has quite unceremoniously careened off the bend and noisily crashed against ecological limits. Large dams, for one, have been particularly singled out for causing catastrophic environmental damage. Amongst the long list of adverse ecological impacts is the destruction of innumerable sensitive aquatic ecosystems because of changes in temperature and flow regimes. This alteration of the chemical and bio-physical properties of the river has caused not only the loss of estuarine fisheries downstream of the dam, in many instances, but has also very severely impacted water quality. In addition to the destruction of aquatic flora and fauna, reservoirs of large dams, through submergence, have been destroyers of forests. According to the World Commission on Dams, India report (henceforth WCD), the Central Water Commission in a study of 116 projects arrived at the figure of 2,400 ha as the average forest submergence per project. Assuming these figures are accurate, if the government's plans of completing 1,877 dam projects in the period 1980- 2000 have been realised, then roughly 45,04,800 ha (roughly four and half million hectares) have already been lost. This is in addition to the rather conservative figure of 5,00,000 hectares that is being currently claimed as the total loss of forest cover from the construction of large dam reservoirs till 1980.[19] In the majority of canal commands, water-logging and salinisation continue to afflict formerly productive soils. To take one example, in the Sharda Sahayak project (Uttar Pradesh), after canal irrigation, yields of paddy and wheat decreased by about 40 to 70 per cent due to water-logging in large areas of the command.[20] Similar instances, in fact, abound of post-project soil degradation caused by reckless canal irrigation; the Sriram Sagar (Andhra Pradesh) irrigation project has water-logged close to 60,000 hectares of its command and the corresponding figures for Chambal (Madhya Pradesh and Rajasthan) and Gandak (Bihar and Uttar pradesh) are ascertained at 98,700 hectares and 2,11,010 hectares respectively.[21] Salt build up has also been an equally vexing problem in irrigated tracts. By the late 1980s, India's share of salinised soils was close to 7.0 million hectares, which adds up to roughly 17 per cent of the total land that was under irrigation then.[22]

Alongside the destruction of aquatic habitats, soil degradation, forest loss and the adverse alteration of the rivers bio-chemical and physical properties, large dams have also not necessarily delivered on economic benefits vis-à-vis their costs. One need not rehearse those facts at length here, as they have been meticulously documented and argued elsewhere.[23] Nonetheless, it will be suffice to mention that steep siltation rates adversely affect most reservoirs in India and have very significantly undermined their performance. The Bhakra dam, for example, is currently calculated to have a 139.86 per cent higher siltation rate than originally assumed. The percentages for Hirakud, Maithon and Ghod are 141.67 per cent, 808.64 per cent and 426.59 per cent respectively. The high siltation rate not only reduces storage and thereby affects performance but also drastically reduces the life span of the dam; the Bhakra dam is now expected to function for merely 47 years, virtually halved from the original estimate of 88 years. The Hirakud, similarly, has been reduced to 35 years from 110 years.[24]

Ground water mining in which the rates of extraction far exceed the rates of recharge has also set off alarm bells in various parts of India. The area irrigated by tube-wells in India grew from 1,00,000 hectares in 1961 to 11.3 million hectares in 1985 and is still rapidly climbing. The recent study by the Nagpur based National Environmental Engineering Research Institute (NEERI) found that water tables across the country were sinking at an alarming rate. The situation is particularly grim in the states of Haryana and Punjab, where village surveys found that water tables in certain districts were dropping between 0.6-0.7 metres per year. In Tamil Nadu, in certain districts, water tables have fallen up to 30 metres since 1970.[25]

However, notwithstanding the exhaustion of both surface and underground water supplies through over-extraction, there continues to simultaneously occur the unchecked pollution of most of our major rivers. According to the Centre for Science and Environment (Delhi), 25 large towns and cities along the Ganga river discharge close to 1,340 million litres per day of sewage into it. This mostly untreated waste includes traces of heavy metals. Agricultural runoff loaded with fertilisers and pesticides also wind their way via drains, tributaries and streams into the main channel of several of the larger river systems. From the time the Yamuna river enters Delhi at Wazirabad, it is similarly asphyxiated with about close to 1,700 million litres per day (mld) of untreated sewage pouring through 18 notorious drains. In the east, the Damodar river has been literally soaked with toxic industrial effluents. The relentless dumping of high concentrations of oil, grease, coal dust, fly ash, chromates cyanides, phenols, ammonia, alkali, tar and tar products have rendered the waters today unfit for both human and agricultural purposes, not to mention the massive destruction of flora, fauna and aquatic ecosystems. In the south, the Noyyal tributary, which flows into the Cauvery river, has over 800 odd dyeing and bleaching units pouring a cocktail of soda ash, caustic soda, sulphuric acid, hydrochloric acid, sodium peroxide and various other dyes and chemicals into its channel.[26] The fate of these rivers is, in fact, not unique and overwhelmingly across India, rivers, streams, ponds and water sources are being polluted with abandon. Clearly, much of India's current water crisis cannot simply be explained away as a natural shortage. Alongside the strains of overuse, pollution and ecological stress, an entirely different order of hydraulic crisis has begun to intensify. The subcontinent's complex natural drainage and inundation regime has been drastically altered for over a century and large tracts are now witness to the violence of unnatural flooding and water congestion.

Nature of Flooding and Drainage

The flood prone area in India from being calculated at 19 million hectares in 1953, is now considered to be anywhere between 40-60 million hectares. That is, approximately between one-sixth to one-eight of the total land area is classified as being flood vulnerable.[27] The average area annually affected by floods has similarly registered a startling increase from being about 2.29 million hectares in 1953 to about 7.65 million hectares in 1997.[28] This despite the fact that millions of rupees continue to be spent on both flood control and flood relief projects year after year. Historically, however, much of India had a flood dependent agrarian regime and it was only towards the second half of the 19th century that the landscape became flood vulnerable.[29] The celebrated engineer William Willcocks, in the late 1920s, delivered a series of essays in which he claimed to have uncovered a long history of 'inundation irrigation' in the Bengal delta. According to him, the muddy crest waters of the annual inundations were leached through an intricate system of channels by the cultivators in the region. These silt laden waters of the swollen rivers, furthermore, carried fish eggs. While the eggs spawned into fish, who then proceeded to voraciously devour mosquitoes, the organic silt helped nourish and fertilise the soil. Besides, the continuous deposition of sediment in time built up the delta and raised the land above the level of the river beds.[30]

By the mid-19th century, however, colonial rule in a bid to consolidate its administrative and economic imperatives in the region began to implement comprehensive strategies for flood control. Mainly through the systematic construction of embankment lines, intended to hem in the rivers within their main channels. In addition, they also constructed a large number of roads, railway lines and bridges. While in Bengal and Bihar, for example, most of the natural drainage lines dropped from north to south, the roads and railways tracks were constructed across them, running east to west. These constructions, in time, not unexpectedly, began to unsettle a complex and fragile arrangement for drainage. Colonial administrators and engineers have, in fact, left a sizable number of observations on how intricately organised village level drainage systems were. The Epidemic Commission of 1864 investigating the causes of malaria in Bengal noted that:

> The drainage of all villages …in lower Bengal is effected by the water first running into the nearest paddy-fields lying in the direction of their slope, thence it collects in the *bheels* [lakes, ponds] from which it rushes through *khals* [channels] into larger streams. Which again communicate with navigable rivers.[31]

A somewhat similar description on drainage is also available for villages in the command area of the Sone canal in South Bihar:

> … the village *aharas* [tanks]…are made so as to intercept the greatest portion of it [drainage] near the south and west boundaries of the villages; the *tal* or reservoir being above the *ahara* , and the *putsar* (irrigated rice land) below it…The water thus flows from and to *ahara* to *ahara* and from *putsar* to *ahara* or *tal*, till excess water is absorbed, or finds its way into the drainage nullas [drains] of the district.[32]

By the beginning of the 20th century, natural drainage systems survived only in pockets, as vast parts of eastern India had been transformed into a “succession of waterlogged morasses” in which “dismal swamps breeding malaria” were debilitating the population and the fertility of the soil.

The post-independence phase has been no better, with successive governments continuing to intensify embankment construction and aggravate drainage congestion. More specifically, through unrestrained and unplanned urban growth. The consequent destruction of wetlands, which are vitally important as flood cushions and breeding grounds for a variety of flora and fauna, has been most alarming. The Loktak lake situated 38 km south of Imphal in Manipur perhaps best illustrates how callous the official mind has been towards the complex interaction between natural drainage and floods. Since the construction of the Ithai barrage on the Manipur river in 1979, the Loktak wetlands have shrunk from 495 sq km in 1971 to just 289 sq km in 1990. The levels of eutrophication has increased several times over, to the detriment of fisheries and aquatic vegetation. The subsistence demands of the communities who historically depended on the Loktak now are no longer met.[33]

Northern Bihar, on the other hand, is witness to the worst post-independence drainage and flooding disaster. In 1953 the decision was taken to embank the Kosi and its surrounding rivers and by 1957 several hundred kilometres of embankments shadowed the main channels of the rivers. The length of the embankments has since jumped from 160 km in 1952 to roughly 3,465 km in 1998 and correspondingly the so-called flood-prone area has leaped from 2.5 million hectares in 1952, to approximately 6.89 million hectares. Clearly, flood control embankments have worsened the flood situation of Bihar.[34] Under the banner of the Barh Mukti Abhiyan, the Kosi region in north Bihar is, in fact, witness to a remarkable but under-reported struggle against the embankments, which has adversely impacted the lives of millions of people in the region.[35] In effect, the move from flood utilisation to flood control has given rise to unnatural flooding and has sapped the intricate connectivity between wetland, drainage and inundation.

Global Water Crisis and Rise of Demand Management

The Indian experience with supply-side hydrology has not been exceptional. The world over, many of the once majestic, free flowing and immense river systems, have been turned into mere trickling drains. From the earliest decades of the twentieth century, the previously wild, unruly and grand Colorado river in the state of California was repeatedly drained through canals. After 1911, a series of dams began to be constructed along its course, including the (in)famous Boulder (Hoover) dam in 1935. By 1964, 19 big dams controlled, diverted and siphoned off its water and today in most years the Colorado no longer reaches the sea. The river, in the latter parts of its stretch now carries salt rather than silt and is a paltry flow of brine as it enters Mexico. Its formerly vibrant and biologically complex and rich estuaries have all been perhaps irreversibly destroyed.[36] In 1997, the Yellow, China’s second largest river, which carries close to 58 billion cubic metres of water annually, went bone dry for a record 226 days. Earlier, the river had failed to reach the sea for 133 days in 1996 and 122 days in 1995. Crop losses from the drying up of the river in 1997 were placed at $ 1.7 billion alone.[37] But, perhaps, the most notable and well known instance of a supply-side induced hydraulic catastrophe in recent times is that of the Aral Sea in Central Asia. For millennia, the Aral Sea used to be the final receptacle to the fresh water flows of the Amu Darya and Syr Darya (the Oxus and Jaxartes of classical times). In the 1960s, however, an extensive system of canals and dams diverted waters from the Amu and Syr rivers to irrigate a cotton boom. In 1995, the Aral sea was barely 30,000 square kilometres compared to some 64,500 sq km in 1960. While its volume continues to drop, a thriving fishing industry employing over 60,000 workers ground to a halt in 1982; 20 out of its 24 native fish species have gone extinct and the number of bird species in the Amu Darya delta has declined from 319 to 168. Furthermore, roving winds blowing across the salt-encrusted dried up bed of the sea (now known as the Akum desert) picks up toxins and heavy metal residues and disperses them widely around the area, causing grave health risks to the inhabitants.

Dams and diversions have, in fact, been one of the leading causes for the irreversible damage to fisheries in many parts of the world. Much like the Aral sea, fisheries have been adversely impacted in the saltwater Black, Azov, and Caspian Seas. The flows of the Volga into the Caspian sea has been reduced by almost 70 per cent; that of the Dniester, Dneiper and Don into the Black and Azov seas respectively have been halved. Not unexpectedly, with the severe attenuation of the annual flows, salinity in these estuaries has increased by up to fourfold and in their deltas up to tenfold. The most valuable commercial fisheries in the world have now been reduced by 90 to 98 per cent. Sturgeon catches in the Caspian Sea are only 1 to 2 per cent of historical levels and have been totally eradicated in the north-western Black and Azov seas.[38] The Nile delta is another striking example of a dam-induced hydraulic death. Before the commissioning of the Aswan High dam in 1964, the Nile carried an average of some 124 million tonnes of sediment to the sea each year and deposited another 9.5 million tonnes or so on its floodplain. Today more than 98 per cent of the Nile’s sediment drops in the Nasser reservoir and the delta coastline is being eaten away at an annual rate of around 5 to 8 metres. The former vibrant local sardine and shrimp fisheries that had employed over 30,000 Egyptians now also stand completely destroyed.[39]

In the recent years, however, such instances of hydraulic degradation and the collapse of aquatic webs have forced a great deal of rethink amongst water planners, governments and ordinary citizens. The entire supply-side hydrology model, chiefly supported and propped up by gargantuan water bureaucracies, engineering firms and private construction companies, has been effectively questioned and challenged by a substantial number of hydrologists, ecologists and special interest groups such as the International Rivers Network based in Berkeley, California.[40]

In sharp contrast to the construction engineer’s view that rivers are merely moving masses of water crying out to be regulated and dammed, hydrologists and ecologists have convincingly demonstrated that fluvial regimes are complex geomorphologic, chemical and biological processes in motion. Rivers are made up of habitat mosaics that support a wide variety of aquatic and riparian species. And the beating heart that keeps alive the river’s ecological health and viability is its natural-flow-regime, which organises and defines the river ecosystem itself. It is now understood that natural variable flows create and maintain particular dynamics between the channel, floodplain, wetland and the estuary. The magnitude and frequency of high and low flows, consequently regulate numerous ecological processes. While wetlands provide important nursery grounds for fish and export organic matter and organisms into the main channels, the scouring of floodplain soils by floods rejuvenates habitat for plant species within the basin. Even periods of low flow provide ecological benefits, through the recruitment of different plant species. A large body of evidence now shows that the natural flow regime of virtually all rivers is inherently variable, and that this variability is critical to ecosystem function and native biodiversity. Rivers with highly altered and regulated flows lose their ability to support natural processes.[41] In other words, dammed rivers are dead rivers.

By thus recasting, in fundamental ways, the manner in which fluvial processes are understood, hydrologists, ecologists and popular initiatives the world over are now defining an altogether fresh paradigm for interacting with hydraulic endowments, which I would loosely term as essentially a demand-management approach. This new mood has perhaps, also helped push for the CALFED Bay-Delta Programme, which was initiated in the state of California in 1994, with the task of restoring the "ecological health and improving water management" in the region. The CALFED programme is a unique exercise in attempting to 're-store' the states' immensely stressed and degraded river system as viable natural processes.[42] Something to the tune of between $8-10 billion has been marked to be spent on the task and in turn it is breeding a whole slew of pioneers in the field of river restoration and management, who, unlike civil engineers and dam builders of a previous era, seek hydraulic integrity as their objective rather than short-term river control. River restoration is currently an expanding area of investment by public water management bodies in Australia, the USA and the EC and has been used for the enhancement of instream habitat, for reducing nutrient and sediment loads from intensively farmed agricultural land, for enhancing landscape quality and for the stabilisation of eroding stream systems.[43]

Concluding Remarks

Supply-side hydrology was the product of a certain political era. Its main proponents and beneficiaries in India turned out to be civil engineering firms, private construction companies and government water bureaucracies like the CWINC and later the Central water Commission (CWC). These interests have fundamentally ignored the complexities inherent in river ecosystems and have essentially propagated a narrow project-centric construction boom as a means to addressing water stress. In this period vast sums of money from both foreign lending agencies like the World Bank and public lending institutions have gone a long way towards sustaining not only the robber baron economics of securing plum construction contracts and tenders, but for also spawning corrupt politics through corruption and bribes.[44] The inter-linking rivers scheme is, in fact, not only more of the same but also an intensification, a last gasp effort, for these vested interests to hike their financial gains amidst a grave ecological crisis. What makes this absurd project even more banal is the ease and precision with which statistics have been coughed up overnight to claim a net gain from the river inter-linking scheme, once all the losses and costs from displacement, ecological damage and popular resistance is apparently accounted for. This tyranny or magic of official data will always remain somewhat of a mystery, especially when any casual inquiry into water resources issues in India will leave the average researcher stranded in a sea of conflicting and contradictory numbers.[45] Discrepancies abound between compilations of different departments on figures and percentages dealing with water-logging, net irrigated areas, power generation and displacement. On an average, there is usually a lack of fit between the numbers trotted out by the Planning Commission, the Central Water Commission, Land Use Statistics (assembled by village revenue officials) and the ministry of agriculture on water related issue. Take, for example, the fact that the annual recharge of groundwater was assessed at 42 m ha m in 1972, while the most recent estimates place it at 45.2 m ha m. The utilisable volume which was reckoned at 26 m ha metres in 1972 has now been revised upwards to 38-9 m ha metres.[46] These seemingly effortless revisions are being carried out even though the Central Water Commission's standards for hydraulic observation are far below the requirements set by the World Meteorological Organisation. Even to this day, there exists no comprehensive independent and credible review of the performance of the thousands of MPRVD projects in India that have been brought into operation at huge expense since independence.[47]

Consequently, assessing India's current water crisis through only a statistical and technical perspective is a deeply flawed approach. If anything, water scarcity is centrally a political issue and prime minister Vajpayee's recent statement in parliament to not 'politicise' drought is actually political opportunism at its worst. Water scarcity in India today is less a product of meteorological parsimony than it is a product of fatal and degrading land management practices and the profligate waste of water resources. In a recent well researched article, Charul Bharwada and Vinay Mahajan, meticulously describe how natural water scarcity in the Kutch region of Gujarat has been converted from the 1960s onwards into a severe water crisis. Historically, to cope with water scarcity conditions, the people in the region developed various methods to harness the scanty rainfall through techniques like 'virdas' (shallow pits in the rivers bed), 'talavs' (wells), step wells and tanks. The cropping pattern was similarly indexed to optimise water scarcity and consisted of a mix of millets, cereals and pulses. In the post independence phase, however, groundwater withdrawal was encouraged in earnest and the use of tubewells and borewells shot up from 18,000 in 1960-61 to 32,000 in 1993-94. In addition, 20 medium and 162 minor irrigation works were carried out, which included the damming of major rivers like the Khari, Saakra, Nana, Mithi, Bhukhi, Mittiyari. Suvai. The number of electric motors and engines increased form a mere 7,000 to 24,000 during the same period. Not surprisingly, the cropping pattern was dramatically altered with an emphasis on cash crops like cotton and groundnut (cultivation increased by 587 and 2,970 per cent respectively). The upshot of all these supply-side hydraulic changes has been the rapid depletion of the water table, which has declined between 30 and 60 feet during the period from 1985-95. In many villages the rate of decline is 8-10 feet annually. Serious deterioration in the quality of the water has occurred as well and there are increasing complaints of salinity.[48] Clearly, there is need for many similar studies in order for us to draw up an accurate map of the nature, extent and causes of the current water crisis in India.

Instead of the dams, diversion and groundwater mining approach, I argue, India's new water policy must be built on notions of:

(a) Reviving natural drainage by removing the massive number of obstructions and obstacles which have and continue to strangle our wetlands, lakes and streams.

(b) River restoration which involves not only cleaning up the high levels of pollution within our river but also recovering aquatic ecosystems through restoration of natural process.

(c) Achieving hydraulic Integrity through sustained efforts to ensure the ecological connectivity of floodplain, channel, wetland and estuary.

These objectives are eminently possible and will essentially require political will. And instead of the troika of contractor, engineer and politician the new water strategy should be forged by hydrologists and ecologists in concert with a growing number of popular initiatives such as the Tarun Bharat Sangh (Rajasthan), the Naramada Bachao Andolan, The Barh Mukti Abhiyan (Bihar) and the National Fisherman's Union. Oddly enough the inter-linking river issue has thrown up one positive possibility, the government's willingness to spend Rs 5,600,000 million to relieve India's water stress. Reviving, restoring and achieving natural drainage, fluvial process and hydraulic integrity will perhaps cost just about that much. EPW

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Notes

[Thanks to Rammanohar Reddy, Harish Damodaran and Shellie Corman for making this article possible].

1 On British capital exports to India in this period see Leland H Jenks, *The Migration of British Capital to 1875*, New York, 1927.

2 Colonel Arthur Cotton, *Report on the Mahanuddy River*, Calcutta, May 1858, p 3.

3 Daniel Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940*, UK, 1988, p 20.

4 Colonel Arthur Cotton, *Report on the Mahanuddy River*, p 22.

5 On the failure of the Orissa scheme see Rohan D'Souza, 'Canal Irrigation and the Conundrum of Flood Protection: The Failure of the Orissa Scheme of 1863 in Eastern India', *Studies in History*, January 19, 2003, pp 41-68.

6 Aniket Alam, 'Linking Rivers: Would It Drought Proof India?' in *The Hindu: Survey of the Environment, 2003,* p 48.

7 *Dams, Rivers and People*, SANDRP, Issue One, February 2003, p 3, Available on www.narmada.org/sandrp.

8 Ibid, p 2.

9 Shankar Aiyar, 'Changing the Course', *India Today*, January 20, 2003, pp 28-32

10 For a comprehensive discussion of the various types of water harvesting structures termed traditional see Anil Agrawal and Sunita Narain (ed), *Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems*, Centre for Science and Environment, New Delhi, 1997. Also see Nirmal Sen Gupta, *User Friendly Irrigation Designs*, New Delhi, 1993.

11 Following the 'sepoy mutiny' of 1857, the Indus river system was overrun by a series of irrigation schemes. Beginning with the Bari Doab canal (1859) and the Sirhind system (1882), the drive climaxed with the 'most ambitious' irrigation project of the colonial period – the Triple Canal Project (1916). For studies on colonial irrigation history in India see Elizabeth Whitcombe, 'Irrigation' in Dharma Kumar (ed), *The Cambridge Economic History of India, C 1757 – C 1970*, Vol II, New Delhi reprint, 1984.

12 For studies on colonial irrigation history in India see Elizabeth Whitcombe, *Agrarian Conditions in Northern India,* Vol I, Berkley, 1972, Ian Stone, *Canal Irrigation in British India*, New Delhi, 1985 and Imran Ali, *The Punjab under Imperialism (1885-1947)*, New Delhi, 1988

13 For an account on the origins of MPRVD schemes in India see Rohan D'Souza 'Damming the Mahanadi River: The Emergence of Multi-Purpose River Valley Development in India (1943-46)', *Indian Economic and Social History Review,* 40,1, 2003, pp 81-105.

14 WCD, *Dams and Development,* Earthscan, London, 2000. p 6. According to the International Commission on Large Dams (ICOLD), a large dam is 15 metres or more high (from the foundation). If dams are between 5-15 metres and have a reservoir volume of more than 3 million cubic metres they are also classified as large dams.

15 See Anil Agarwal and Sunita Narain (eds), *Floods, Flood Plains and Environmental Myths,* State of India's Environment, A Citizen's Report, Centre for Science and Environment, New Delhi, 1991, p 9, and R Rangachari, 'Some Disturbing Questions' in *Seminar*, 478 June 1999, pp 62-67.

16 A Vaidyanathan, *Water Resource Management*. Oxford University Press, New Delhi, 1999, p 58. Over the same period under major and medium irrigation is estimated to have risen from 9.7 m ha to 29 m ha, while the area irrigated by minor irrigation rose from 12.9 m ha to 55 m ha; much of it from groundwater extraction.

17 A Vaidyanathan, *Water Resource Management,* p 67.

18 A Vaidyanathan, *Water Resource Management*, p 56.

19 *WCD, India Report,* Earthscan Publications, London, November 2000, p 23. Also see www.dams.org and www.earthscan.co.uk

20 Satyajit Singh, *Taming the Waters: The Political Economy of Large Dams in India*, OUP, New Delhi, 1997, p 146. Satyajit details the ecological consequences of large dam between pp 133-63.

21 *WCD, India Report,* p 34.

22 Sandra Postel, *Pillars of Sand: Can the irrigation Miracle Last?,* W W Norton, New York, 1999, p 93.

23 For an exhaustive critique of large dams , their economic performance and their ecological impacts see Patrick McCully, *Silenced Rivers*: *The Ecology and Politics of Large Dams*, Zed Books, London, (reprint) 2001.

24 Satyajit Singh, *Taming the Waters*, p 139.

25 Sandra Postel, *Pillars of Sand,* pp 72-74.

26 Anil Agarwal, Sunita Narain and Srabani Sen, *The Citizen's Fifth Report*, Centre for Science and Environment, New Delhi, 1999, p 57-108.

27 See *Floods, Flood Plains and Environmental Myths*, State of India's Environment (3), A Citizen's Report, Centre for Science and Environment, New Delhi 1991, pp 1-8.

28 B S Ahuja, Theme paper on Non-Structural Measures of Flood Control prepared by the River Management Wing of the Central Water Commission, Ministry of Water Resources, Government of India. Paper presented at a Workshop held at the Indian Institute for Public Administration (IIPA), October 8, 1997.

29 Rohan D'Souza 'Colonialism, Capitalism and Nature: Debating the Origins of the Mahanadi Delta's Hydraulic Crisis (1803-1928)', *Economic and Political Weekly*, Vol 37, No 13, March 30, 2002.

30 Sir William Willcocks, *Ancient System of Irrigation in Bengal,* New Delhi, (reprint) 1984. Also see, *Note by C Addams Williams on the Lectures of Sir William Willcocks on Irrigation in Bengal together with a Reply by Sir William Willcocks*, Calcutta, 1931.

31 *Report of the Drainage Committee, Bengal (Presidency Division),* Calcutta, 1907, pp 20-21.

32 *Report of the Committee Appointed to Enquire into the Administration of the Sone Canals*, Vol I, Calcutta, 1888, p 18.

33 See the excellent discussion on the Loktak by Ramananda Wangkheirakpam, "Lessons from Loktak" in the special issue 'Large Dams in Northeast India: Rivers, Forests, People and Power', *The Ecologist (Asia),* Vol 11, No 1, January-March 2003, pp 19-24. This issue of the *Ecologist* has a comprehensive critique of the Indian government's efforts to add another 168 large dams in the north-east region.

34 Dineah Kumar Mishra, 'The Embankment Trap' in special issue on Floods in *Seminar*, 478, 1999, pp 46-51.

35 See D K Mishra,, 'The Bihar Flood Story', *Economic and Political Weekly*, Vol 32, 1997; 'Proceedings of the Second Delegates Conference (April 5, 6 1997)', *Barh Mukti Abhiyan,* Patna*;* 'Proceedings of the Seminar on River Crises in South Asia (June 21-22, 1998*)', Barh Mukti Abhiyan*, Patna; R Krishnakumar, 'The Kosi Untamed', *Frontline,* Vol 16, September 20-October 8, 1999.

36 J R McNeill, *An Environmental History of the Twentieth Century World*, Norton paperback, New York, 2001, pp 177-79.

37 Sandra Postel, *Pillars of Sand*, pp 68-69.

38 Patrick McCully, *Silenced Rivers,* pp 44-45.

39 J R McNeill, *An Environmental History*, pp 165-72.

40 See their newsletter *World Rivers Review* and their website www.irn.org.

41 N LeRoy Poff et al, 'The Natural Flow Regime: A Paradigm for River Conservation and Restoration', *BioScience*, Vol 47, No 11, 1996, pp 769-84. Also see J V Ward and J A Stanford, 'Ecological Connectivity in Alluvial River Ecosystems and Its Disruption by Flow Regulation', *Regulated Rivers, Research and Management* (RRR), 335, GR, 1995, pp 1-15.

42 See G Mathias Kondolf, 'Lessons Learned from River Restoration Projects in California', *Aquatic Conservation: Marine and Freshwater Ecosystems*, Vol 8, 1998, 39-52.

43 D A Sear, River Restoration and Geomorphology, *Aquatic Conservation, Marine and Freshwater Ecosystems*, Vol 4, 1994, pp 169-77.

44 See the excellent essay by Sanjay Kapoor on flood control embankments and politics in Uttar Pradesh. Notably the rise of Amar Singh as a politician from the humble beginnings of a flood control contractor, 'Flooding Corruption', *Seminar*, 478, 1999, pp 71-72.

45 Arundhati Roy brilliantly brings this out in her essay 'Towards the Common Good' in *The Cost of Living,* Random House, New York, 1999. Also see Sanjay Sangvai, on how the data on the costs and so-called benefits of the Narmada project have been constantly revised over the years. Sanjay Sangvai, *The River and Life: People's Struggle in the Narmada Valley*, Earthcare Books, Mumbai, July 2000, pp 85-110.

46 A Vaidyanathan, *Water Resource Management,* p 106.

47 R D'Souza, Pranab Mukhopadhyay and A.Kothari, 'Re-Evaluating Multi-purpose River Valley Projects; A Case Study of Hirakud, Ukai and IGNP', *Economic and Political Weekly*, February 7, 1998, pp 297-302.

48 Charul Bharwada and Vinay Mahajan, 'Drinking Water Crisis in Kutch: A Natural Phenomenon?', *Economic and Political Weekly*, November 30, 2002.