Irrigation in British India*

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Some readers will say that I am making altogether too easy an opposition, too facile a dichotomy between the stagnation of Indian tradition and the dynamism of the British. For all his love of India, they will say, did not Rabindranath Tagore condemn Indian poverty? Did he not create a school to help his people? And, on the other hand, didn't British officers commonly view progress skeptically? Did they not often believe that Indian peasants were as happy as the people of England?

It is all perfectly true: I have indeed exaggerated the contrast between India and the West, between the bastion of tradition and the army of progress. But that does not mean that there was no army. I mean to show now just how powerful that army was, powerful in changing the character of rural India's landscape not only through the work of individual men like Meadows Taylor but through the work of government departments and professional institutions saturated with Western notions of progress. Often enough there would be men in these institutions who appreciated Indian tradition, men whose own accomplishments were like grafts on native stock. Yet time and again the work these men did would be overwhelmed by more parochially Western solutions that were more agreeable to senior officers and which both uprooted native traditions and tried to improve upon them by starting afresh. In that sense, all the shades of gray in the world hardly matter, for India--and by extension Asia as whole--was indeed overrun, while the qualities of the pristine place were lost. The germs are there in Meadows Taylor's Shorapur, with irrigation, with better farming methods, with community development programs. All we need do is trace their institutionalization.

That's why we're back south of Madras, where this history begins. We're past the village of Eruvellipet and at a weir on the Cauvery River near Tiruchirapalli, Trichy for short. We're at the Grand Anicut, a weir that lies a half hour's drive downstream from town. In the hot weather it's a popular spot with Indians seeking some relief, for though the Grand Anicut rises scarcely fifteen feet from the bed of the Cauvery, it is several hundred yards long. Laid out in a crude semicircle, the weir is pierced by sluices through which water splashes into a dozen palmately radiating channels. Some are natural, but others are artificial.

The weir is mostly of masonry blocks, and plaques indicate that different sections of the work were built mostly in the late nineteenth century. But this

is a case where looks are deceiving: only the anicut's erratic curvature, so foreign to Western engineering design, hints at the structure's true antiquity, which goes back to the second century A.D.

The British acquired the Grand Anicut and the delta it commands in 1801. WIthin three years they realized that agriculture in the delta was in grave danger, because the Cauvery was getting ready to abandon its course and join the Coleroon River, which branches off to the left, some ten miles or so upstream from Trichy. This, they realized, would be a disaster, because the delta, with a radius of about 50 miles, was one of the most productive parts of India.

For 30 years the British temporized, chiefly by raising the level of the Grand Anicut to get as much Cauvery water as possible into the ancient canals. But this did nothing to prevent the disaster that would occur if the river changed course. That is where matters stood when a young captain named Arthur Cotton was ordered to the scene in 1827.

Cotton was then twenty-four years old, but he had already completed nearly a decade's service in India. Unlike Meadows Taylor, who was five years his junior, Cotton had been commissioned a lieutenant not in a princely service but in the Madras Engineers. His first assignment in India had been the survey of a navigation channel through the rocks and islands separating India and Ceylon. He then saw military action in Burma, where he discovered the Bible and a faith that would last him to his death.

Returning to Madras, Cotton set to work on the restoration of old irrigation tanks. I do not know if he ever read the caustic speech of Edmund Burke, who, condemning the British government, said that these tanks were "not the enterprises of your power, nor in a style of magnificence suited to the taste of your minister. These are the monuments of real kings, who were the fathers of their people." But Cotton would have agreed with every word of that, not only as it praised India's old irrigation works but as it shamed the East India Company's reluctance to rehabilitate them. Reminiscing about his work on the Grand Anicut, Cotton wrote that "in '27 I was sent to inspect it, as the people were stated to be nearly in a state of rebellion from its neglect.... Is it surprising the people thought us savages? I made a small estimate of £3,500 for some immediate repairs, but knowing what its fate would be, I proceeded to Madras, and arrived just in time to hear, as I expected, that the Government could not squander such sums as this upon the wild demands of an Engineer." Nothing was done for another six years, Cotton continued: "Such was the inconceivable state of things under that admirable middle-class government."

Cotton was his parents' tenth son, but he had a still younger brother named Frederick, and Frederick was also an engineer working in India. They worked together closely, and it was Frederick who was given the task in 1830 of cutting

the Grand Anicut to make sluices so that more silt might drain from behind the weir. In the course of doing this work Frederick found, as he himself wrote, that "this 'Grand' anicut work was hardly more than a mass of rubbish, mud, stones, and logs of wood, the safety of which depended solely on its then plastered surface." It was an important, perhaps even a revolutionary discovery: simple inertia had been great enough to withstand 1,600 annual floods. Both Frederick and Arthur became believers in what Frederick would call the Madras, or cheap, school of engineering. Why invest in unnecessarily massive structures? "After all," Frederick would say, "what is good engineering but economy!"

Arthur was soon assigned to fix the river, and he decided to build a dam just below the point where the Coleroon leaves the Cauvery. He explained his idea in these words, written in 1834: "I have given such a height to the Annicut [sic] as will, so far as I am yet able to judge, exactly correspond with the Grand Annicut; that is, that when the water is even with the top of the one, it will be so also at the other." In this way, he hoped, the flow would be equalized in both channels.

Significantly, Cotton did not build a European-style dam on the Coleroon: you can go to the site today and see, under modern recent alterations, parts of the wall he built, 750 yards long, hardly more than seven feet high, and only six feet thick. True, the work rests on a foundation, but that foundation was sunk only three feet beneath the streambed, with periodic wells penetrating another three. True, too, the force of water pouring over the wall was broken by a masonry apron some twenty feet wide. Still, it was a daringly minimalist design. A similar dam was simultaneously built some seventy miles downstream on the Coleroon, where some 165,000 acres depended on irrigation waters that would otherwise be inaccessible when the Coleroon's flow was reduced.

(The granite for the Coleroon Anicut was not available locally. Where did it come from? Cotton explained that he took it "from the boundary wall of an ancient temple, standing in the jungle not far off, and long since disused." The priests approved, he said, and perhaps it is so.)

The Coleroon Anicut required adjustment over the next decade, primarily because the river threatened to change course farther upstream. Hence the construction in the 1840s of another simple "bar" dam across the Cauvery: it has been replaced by a modern barrage and is marked now only by a monument. Both dams were soon given sluices so that silt could flow through as well as over them. Thereafter they functioned well, immediately protecting the irrigation of some half a million acres below the Grand Anicut and, within a few years, providing water for another 86,000 acres.

It was a great success story, and there is today at the Coleroon Dam an old stone monument to it. One side says simply "The Upper Coleroon anicut was

built in A.D. 1836." Another side says that "the body and apron of this anicut for the irrigation of Tanjore were projected by Major A. T. Cotton and constructed by Major H. C. Cotton, A.D. 1836. N. W. Kindersley, Esq., Principal Collector of Tanjore."

Kindersley himself wrote later that there was "not an individual in the province who did not consider the upper anicut the greatest blessing that had ever been conferred upon it." Many similar pronouncements have been made since. "The permanent prosperity of Tanjore," in the words of one Bengal engineer, "are without question to be attributed in large measure, to that first bold step taken by Colonel Cotton, in the construction of the upper Coleroon Dam, under circumstances of great difficulty, with restricted means, against much opposition, and with heavy personal responsibilities."

And how fares the Cauvery Delta today? I went below the Grand Anicut to Thanjavur, the city that the British called Tanjore. Another 20 miles brought me to the town of Papanasam, with surprises like the Nehru Computer Training Center. From Papanasam, however, there was a quiet and good country road that ran south across the delta through a countryside of paddy irrigated by unlined irrigation ditches, from which water trickled into paddies through openings that were no more than breaks in the embankment, mudded closed or kicked open to meet crop requirements. This was January--a good time to visit this sultriest part of India--and the rice was well along, though not yet heading. At a few lagging places transplanting was still in progress: handfuls of seedlings were tied with a blade of grass.

But there is a darker side to the picture, a side that has nothing to do with water distribution or paddy production. In 1958 an enterprising journalist named Kusum Nair spent a year touring rural India. Her journal was published in 1961 as *Blossoms in the Dust,* a confusing title until you realize that she is talking about India's children. Nair begins with a chapter on the Cauvery Deltak where she says that both landowner and cultivator are basically content. Her chapter title expresses their acceptance of a life dominated by agriculture: she calls it "Rice-girdled Horizons." She herself, however, is less content. Local society is so highly stratified, she says, that, although land is held in ownerships usually smaller than a single acre, landowners never till their own fields but rely instead on sharecropping tenants or salaried laborers.

These observations will not be welcome to irrigation engineers, whose own horizons are usually girdled by engineering works as ends in themselves--or, at a stretch, by admiration for the green landscapes those engineering works create. Provoked, engineers will respond that it is not within their power to eradicate social inequality: one has done well enough to raise the prosperity of rich and poor alike. Perhaps it is so, but the social inequalities of the Cauvery Delta are so great that they are visible to even a casual observer, and we ought

not to be blinded to them simply because no one has been able to eradicate or even ameliorate them.

It is no accident, therefore, that out in the countryside beyond Papanasam I saw transplanting being done by men darker than the people in Papanasam. The laborers wore only breechclouts, so that in profile they appeared almost naked; some were entertained by radios, broadcasting over the countryside and always playing at a volume so loud that the sound was breaking up into noise. For miles south of Papanasam the road was lined with the homes of these men, which were no more than shacks. No wonder that on the way from Thanjavur there was a large Christian church. No wonder, I say, because it was from the ranks of agricultural laborers such as these that Christian converts were most easily made. The church was painted with alternating vertical bands of fuchsia and ocher, and it contained a tomb from the 1930s: "Hic jacet expectans resurrectionem Rev. Gabriel Playoust." That is what the converts, too, might have hoped for. Nowadays, there are few missionaries in India, at least few openly evangelizing ones, and in this great delta there are no forests to offer shelter, like those of the wild Godavary, to revolutionaries. There is only and terribly the status quo, represented in the delta towns by tile-roofed houses of plastered brick and steel-barred windows.

After his work on the Cauvery, Cotton turned to building India's first railway, a short line in Madras. He built a church on the coast farther north, at Vizagapatnam. He made plans for developing that city's port, but he also began examining the Godavary Delta, which then lay within the Rajahmundry District. (The district no longer exists; roughly, it has been replaced by two districts, East and West Godavary.) In his characteristic voice, he wrote of this surveying work to his brother Frederick: "I made a run through Rajahmundry, and could not help seeing what it wanted, which was simply everything. So magnificent a country in such a state of ruin was the greatest disgrace to a civilized Government." Here was the germ of Cotton's greatest achievement: bringing to the Godavary Delta the intense cultivation that had traditionally existed on the Cauvery.

The Godavary Delta had been devastated by a famine in 1832. One Walter Campbell, then a lieutenant stationed 100 miles to the south at the mouth of the Krishna, left a powerful account of that same famine, where "a strong body of police… [werel constantly employed in collecting the dead and throwing them into a huge pit prepared for the purpose. They could not manage to keep the ground clear," Campbell wrote: "numbers of bodies … [were] left to be devoured by dogs and vultures." But the delta's problems went beyond drought and famine. Land in both the Godavary and Krishna deltas was held by big landlords, who were gradually driven into bankruptcy not only by the famine and their own profligacy but by the government's closing down of its cloth-purchasing establishments and by its neglect of the existing small irrigation

works. No longer able to pay their taxes, the landlords lost their estates to the government.

What should be done with the land? The matter was first taken up in the Godavary Delta, where Henry Montgomery was appointed special commissioner for that purpose. Montgomery had formerly been the collector of Tanjore and had taken a large enough role in the irrigation works there that his name, too, appears on the Coleroon Anicut monument. Here, however, Montgomery's first task was to assign the lands in the forfeited estates to peasant cultivators. His second task was to call for an investigation of the delta's irrigation potential. Montgomery wrote: 'My own impression leads to the opinion that much may be done with the Godavary..... The presence ... of Captain A. Cotton, whose acquaintance with the management of river irrigation on an extended scale has been successfully applied to the southern districts, seems to afford an opportunity deserving of being embraced by the Government."

Cotton was pithier. He reported to the government six months later that "surely it is time to take decided steps to restore to prosperity a district which has so sunk under our management." A year later, after Cotton's initial cost estimates had been received with some alarm, Cotton stamped his foot and wrote: "If it be asked how is this great sum of money to be obtained, the answer is simply, by converting the water of the Godavery into money instead of letting it run into the sea." The governor-general, Lord Dalhousie, came to view Cotton as "perfectly insufferable."

Cotton's own plans for the Godavary weir evolved, but the essential and unchanging point of them was that the work should be of the Madras or cheap school of engineering. He wanted to build a weir would consist of four sections separated by islands but totaling 12,0000 feet in length. "The principal part of the work," Cotton wrote, "will thus consist of loose stone, of which there is an unbounded supply.... This is the mode of construction originally used at the ancient native work called the Grand annicut, which has stood for so many centuries."

The Godavary weir was to rise only 12 feet above the river's pre-monsoon water level: in the monsoon it would be completely overtopped. Yet the foundation would reach only six feet beneath the sandy bed of the river. Cotton’s main concern was, therefore, to keep the water that poured over the top of the weir from scouring under its downstream face and then penetrating the sand. To prevent that, he designed a 19-foot section of horizontal masonry flooring that would be placed downstream from the weir. This flooring would be followed by an inclined plane of clamped masonry 28-feet wide and then by a rough stone apron about 75 feet wide, for a total weir breadth of 130 feet or more. Or more, I say, because Cotton wrote in 1852, "I think it will be advisable to continue to throw in 20,000 tons a year for some years to come." Indeed, over

the next forty years some half million tons of rock was thrown in below the weir.

The work was authorized in 1846 and executed with a work force of about 10,000 men between 1847 and 1852. Cotton was assisted by his brother Frederick and by Charles Ort, who a few years later would supervise construction of the Cottonian weir built across the delta of the third of the great Madras rivers, the Krishna. Apart from a medical furlough, Cotton spent the construction years on the Godavary with his wife and daughter in a weir-side house of palm logs and thatch. His daughter, who as Lady Hope wrote a biography of Cotton, recalled "we seldom went to bed without a provision of boots or brushes to throw at snakes." And Cotton's wife? A child was born to Elizabeth Cotton here on the Godavary. The child soon died, and Elizabeth wrote with religious acceptance: "Except for periodical attacks of jungle Fever, God was very gracious to us in respect of health,--another dear little daughter was born to us in our rough house,--a sweet babe, who was her father's delight, and whose loving looks and ways, when he came in tired from his work, were always a refteshment to him. It pleased God to take her from us after about twelve months, and we buried her at Rajahmundry in a little graveyard looking down upon the river."

Cotton kept working. Lady Hope, a daughter who survived, would later write that "for days together on his long expeditions… [he] would live on milk and bananas." She recalls his telling her to "do something, my girl; do something. Never be idle for a single moment. Remember, Time is short, Eternity is near!" He himself, she says, "was never really happy unless he was in some manner promoting what he believed to be the furtherance of the kingdom of God in the world." And that, of course, is how Arthur Cotton saw his work on the Godavary. "In a country," he wrote, "where, within living memory, men had died of famine by tens of thousands, and population has been checked by contingent consequences of famine, we now see a teeming population of stout, cheerful, well-proportioned men, women and children that will compare with any in the world for intelligence."

Few people have chosen to disagree with this assessment. Some 18,000 acres had been irrigated with river water in the years before construction of the weir; the figure rose by another 364,000 within a few years and to 640,000 by the end of the century. A visitor from Australia at that time concluded that "taking all things into consideration, it may be questioned if there is a more beneficent or more profitable public work in the world." Arthur Cotton's reward for the work was to be appointed chief engineer of Madras; brother Frederick was put in charge of completing the delta canals and operating the system.

And today? The Godavary's sanctity is second only to that of the Ganges, but Rajahmundry at the delta’s apex is a place dominated by practical matters. Perhaps I am biased: I wound up in a hotel with some kind of bug in the

bedding. The bites, originally on the small of my back, grew infected and spread, and the irritation took several months to clear. Still, I remember the nearby Evangelical Lutheran boys' school, opened in 1905 and dark as any Wagnerian fantasy. I remember outside of town and upstream some tobacco-drying barns, crudely fueled with coal and wood. I remember villages where men made cart wheels, where they splashed water on heated iron tires that would shrink tight on a carefully shaped wooden rim.

Most of all I remember a night visit to the banks of the Godavary in the town itself, at a place where there is a typically Indian set of bathing steps. Just upstream from those steps there is a great railway trestle; in the British era, at least, it was the second longest railway bridge in India. A small boat loaded with sand took off and disappeared into the still waters of the river. Then, thinking at first it was my imagination, I heard a rumbling. I looked up at the old trestle and thought I saw movement. Indeed. A train was approaching; it looked as though it might go wrong and plunge over the unguarded rails. The engine had no headlight, but clouds of cinders flew out from the firebox every few seconds and drifted down through the boxwork of the bridge. It was the first steam engine I had seen along this coast, and the bridge structure magnified the sound of the steam chests and pistons and axles. The train might have been crossing a gulf of decades.

The next day I drove the few miles downstream from Rajahmundry to Dowleshwaram, the site of the weir. Unfortunately for anyone seeking Cotton's handiwork, the popularity of irrigation prompted the government of Madras almost immediately after the weir's completion to raise the curtain wall two feet with steel shutters; at the turn of the century the work was raised another two feet. The apron was not enlarged proportionately, however, and by 1960 hydraulic action had undermined the weir. Engineers feared a catastrophic failure. Just upstream from the old weir, therefore, a concrete barrage has been built, and all but a few bits of Cotton's structure are now obscured.

Nearby, there is a Victorian brick building once used as housing for an officer of the public works department. (I hazard the guess that Frederick Cotton may have lived in it.) Now it is the Arthur Cotton museum. The collection includes an abundance of statues: some busts, some full-length, others equestrian. There are portraits, too, including one in which Cotton is literally beatified: white robes, a halo between his head and a dark background, his arms opened to the viewer. In the lower foreground, looking up at him, stand a mass of worshipful Indians. Lady Hope, Cotton's daughter, is memorialized, too, in her case by a crude statue in which she appears in a garment that is part sari and part European dress. It is a good thing she is dead, for having spent a life filled with evangelical activity, she is shown with breasts as subtle as baseballs under a T-shirt. Still, the intention is respectful: the caption reads "Lady Hope in her teens with her pet dog. The anonymous sculptor might have been, in one of the museum's captions, "one of the many million fans of Cotton." The rest of the

museum is of a more sober character, with maps and models of the weir and delta works, well done.

There is a two-lane road across the new barrage, and I crossed as far as one of the islands, then turned downstream. Eventually I got lost. I had gone too far and crossed too many junctions to want to even try retracing my steps. Yet it was a remarkable drive. For one thing, the canals were full of boats. Cotton would have wanted it this way: despite having built India's first railway, he was always an ardent believer in inland navigation. And the boats were of a sort that he himself must have seen: poled vessels, with steering oars, and often filled so high, usually with sand, that the gunwales were within an inch of being overtopped. Swamping must be rare, however, for the main canals are wide, often 100 feet, and straight as an engineer can make them. Periodically the water passes over drops, but the boats pass through manually operated locks.

The air was heavy and hazy, and paddies on either side were bounded by bananas or coconuts. Even the Cauvery Delta had not seemed so opulent, and certainly farmers in the Godavary Delta will tell you that their soil is less sandy and therefore allows greater crop diversification. Most of all I remember the huge stacks of rice straw, fully 25 feet high and 100 feet long. The men building them waved like men who had just finished framing a Pennsylvania barn.

Eventually the road, without warning, intersected the main highway between Madras and Calcutta. I crossed and headed another 20 miles into the delta. The road was paved but phenomenally rough for a district as rich as this: two hours and twenty miles later I came to Amalapuram. The town has a much better hotel than the one where I had stayed in Rajahmundry; simple, next door to a movie theater, but mercifully clean.

The canals the next morning were bathed in the heaviest dew, but sunshine struggled through the fog and created reflections of palms, coconuts, and bananas. The canals were technically in poor shape, with many concrete outlets into branch channels long ago deliberately broken to increase the water supply passing through them. Still, the delta's water supply is so abundant there is little reason to rehabilitate the system, especially since new control gates, like such structures throughout Asia, would be promptly vandalized by farmers unwilling to have anyone tell them when to take water.

Amalapuram is as cluttered as the Indian conception of cities demands, but the villages surrounding it were scrupulously clean, with palm-thatch roofs and the same kind of fresh wall mudding that Nirad Chaudhuri remembered in Kishorganj. Porches and grounds were swept immaculate, almost as if to enhance the six-foot-high clay granaries fixed to the porch floor. During the

harvest festival with which my visit coincided, even the simplest huts were decorated with white and precisely geometric bands of color.

One afternoon I parked a few miles from Amalapuram just so I could walk down an unpaved side road that led through a perfectly maintained coconut grove- the grounds plowed absolutely clean to maximize soil aeration and retention of rain and irrigation water. I passed a barn housing a dozen European-crossbred dairy animals, and I thought for a while that it must be a dairy herd for Amalapuram.

I discovered how wrong I was when I continued into a village which, at one end, had a cluster of two- and three-story houses, mostly of plastered and painted brick. All were built in the most modern architectural designs, and one boasted a satellite dish. Before I had time to think through what I was looking at, a man asked if he could help me, and so it was that I met Narayana Raju of Kodurupadu.

He, two brothers, and a surviving uncle owned 400 acres of farmland, almost exactly a third of the village lands; the rest of the village's 3,000 people shared the remaining thousand acres. Many of them worked for the Raju family, and Narayana was quietly proud of the fact that he served as banker for many, lending money, sometimes without interest. It was a family tradition, he explained in fluent English. But there was a limit to community intimacy: his own son, for example, did not play with village children. "He has no time," was Narayana's explanation, though when I pressed him he said that playing on holidays was restricted to family members.

Narayana had a barn with tractors, which he used for preparing his immense rice fields, covering more than two hundred acres. Harvesting was still done by hand, certainly a good thing for the villagers who depended upon the family for their cash income. But the opportunity to work in the rice paddies hinged upon the relative prices of paddy and coconut. For the time being, work seemed a sure thing, because converting a field to coconuts requires a costly raising of the land surface to keep the coconut roots dry. If the price of paddy and coconut diverges sufficiently in coconut's favor, however, the case for conversion will grow stronger. The villagers may well be pleased that a banana disease had recently put an end to the especially profitable intercropping of bananas and coconuts.

Narayana took canal water 11 months of the year, but when the canals were shut down for desilting he turned on his own tube-well pumps. Good water lay only ten feet below the surface, he said, though there was saline water twenty feet farther down. The village pond had now been converted to a family fishpond, from which fish were taken every eight months; villagers took their water from "filter points," shallow pumps recently installed to tap the same fresh-water zone used by his irrigation pumps.

I did not ask about income, but the family's housing told the essential story. The new houses had been designed by architects in Hyderabad, Narayana said, and the satellite dish perched on one of them meant that the family no longer bothered with Indian television; they relied on Hong Kong's STAR satellite for BBC news and the American soaps they liked. Narayana himself had no outside income, though at least one of his brothers did; the uncle ran the village rice mill.

Perhaps that is why Narayana lived in the family's only old house. It had a U-shaped floor plan around a covered courtyard of several thousand square feet, tiled. The supporting pillars were of sal, a cherished Indian hardwood; the doors into the house were of teak intricately inlaid with rosewood; the plastering on the house was actually a coating of cement imported long ago from Britain. The house had been built a hundred and fifty years ago, Narayana said, which dates it nearly to the completion of the Godavary weir, and throughout that time the family had maintained its dominating position in Kodurupadu. When I asked Narayana for the name of the president of the village council, he laughed quietly and said "me." His whole manner was quiet to the edge of shyness--understated, cordial, and absolutely confident about the family's position.

Perhaps Narayana presents an extreme case of farmers in the Godavary Delta. When I asked him if he had had other foreign visitors, he said yes and to my surprise remembered not only that it was during the 1960s but that his visitor had been a Mr. Freeman from the Ford Foundation. The Foundation at that time was seeking out the most progressive farmers in the district, and the choice of Narayana would have been an obvious one.

Yet if Narayana is an extreme case, there are plenty of other rich farmers in the Godavary Delta. Ten miles to the other side of Amalapuram, I visited an aqueduct which takes one of the main delta canals across a branch of the Godavary. This is the Gunnavaram Aqueduct (in British times known as the Gunnaram Aqueduct), the most massive work in the delta; modified, it is still recognizable as the structure opened in 1852 to bring canal water to Gunnavaram Island.

The aqueduct consists of 49 arches, each 40 feet long, and the most remarkable thing about it is that the whole structure was built in four months. The engineer in charge, Lieutenant E T. Haig, got into trouble for spending 170,000 rupees on the job: only 70,000 had been allotted. Haig explained in his defense that the work required 10,000,000 bricks and that the local clay required more fuel in its baking than expected. "I had not much time for trying experiments," he said further, explaining that he had to fire all 10,000,000 bricks in three months. He went on to say that "the coolies are grossly idle, the bricklayers worse, and the peons worse still. It is not too much to say that there was scarcely a native employed on the work who, if unwatched, would

not have sat still half the day and done nothing." Eventually Haig was exonerated--indeed, he became a general in the Royal Engineers--and when the Madras government in 1896 published a semiofficial history of the Godavary works, Haig received high praise: "The aqueduct in any part of the world ... would have been a noteworthy achievement; in an out-of-the-way part of the Madras Presidency, where machinery was almost unobtainable and most of the skilled labour required had to be trained as the work went on, it was an extraordinary feat."

I drove across the aqueduct, parked, began walking, and within ten minutes was hailed in excellent English. This time it was by a Mr. D. S. Dikshitulu, a Brahmin retired here after a career in Delhi and Bombay. We walked for a while through the village of Gunnavaram, most of whose houses were of mud brick and thatch, often laid out like an American saddlebag house, with two rooms separated by an alley. The village lanes were unpaved but heavily shaded by palms, and coconuts were piled up in many front yards; their meat was for export. Here was a stall selling eggplants, tomatoes, potatoes, string beans, plantains, and other vegetables unrecognizable to me. And here were some huts on ground reserved for the poorest residents of the village.

Nearby was Mr. Dikshitulu's 20-acre coconut garden, fenced with thorns and irrigated by a pump lifting water directly from the Godavary; near the pump he had a patch of maize, which he was growing for commercial seed. His father, he said, had bought all this land about 1930, when it was useless sand. But diesel pumps had just become available: that was the secret. And with composting and fifty years of pumping directly from the river, the soil looked as black and rich as the soil anywhere on the island.

I cannot say how much of Mr. Dikshitulu's wealth came directly from this land, but his eldest son was preparing for graduate school at Calcutta's Indian Statistical Institute, which suggests assets exceeding the income from 20 acres. The family almost certainly lacked the agricultural wealth of Narayana's, yet it was still unquestionably dominant in the village: that much was plain just from the deference with which Mr. Dikshitulu was treated. He hired between five and 25 employees, paid the men less than a dollar a day and the women about half that. He himself wore a snow-white shirt, a snow-white wraparound, and white sandals; a man at work in his coconut garden worked naked except for khaki shorts.

Mr. Dikshitulu lived in a house unlike any other in the village. It was a walled compound shared with several brothers, each family with a house separated from the others by what looked like a village lane. Behind iron gates, the houses were all of white-painted brick, trimmed with diamond- shaped blocks of primary colors. The roofs were hipped and either tiled or covered with heavy-gauge and darkly painted corrugated steel. They had a central portion

that was flat and which drained through a hole in the ceiling into a living-room pool, which in turn was drained by a pipe to the outside. This central room was austere: it was furnished with only a television on a table and white walls with a few framed photographs. But opening off it was a kitchen with a three-burner gas stove and with cupboards and racks filled with shining utensils; adjoining the kitchen was a prayer room ablaze with a jumble of prints perched atop a low table painted bright red and yellow. Mr. Dikshitulu was explaining to me that people here prayed to Arthur Cotton as a god when, interrupting us, his teenaged daughter appeared. My visit was completely unannounced, but she was wearing a blouse and skirt that would have been perfectly acceptable in an American high-school classroom.

All this--from the giant haystacks to the satellite dish, from the crossbred cattle to the coconut garden safely reclaimed from sand--all this, of course, was the result of the work of Arthur Cotton. And Rajabmundry itself is inevitably flourishing from the wealth downstream: in the main shopping street a new store had recently opened with six floors of suitings and saries. Billboards in English advertised the place far out on country roads, where passersby could read only the name of the establishment and infer its prestige from the unintelligible Roman letters. The only thing Cotton could not take credit for was the social hierarchy. Rooted in antiquity, it had accommodated itself handsomely to the irrigation economy.

But Cotton did not rest with the Godavary. Before it was finished he was involved with plans to reclaim the neighboring Krishna Delta.

It's a three-hour drive from Rajabmundry to the city at the head of the Krishna Delta. This is Vijayawada, now with a million people. A new hotel had just opened when I arrived; the Krishna Residency had excellent food, comfortable rooms with air conditioning, and satellite TV; there was even an elevator, though after getting stuck in it the first day I relied on the stairs. A block away the post office had international phone lines; along the streets between the hotel and the post office, many stores were selling color televisions; outside town, a World War II airfield had daily commercial flights west to Hyderabad and north to Rajahmundry.

Vijayawada's main bazaar was so crowded in the evening that the bicycle I had borrowed was impractical. One merchant had 600-meter coils of coir rope for sale at 240 rupees, which comes to about a penny a foot for rope nearly an inch thick. There were wedding chapels nearby, with electric signs identifying the nuptial partners, and there were portable public-address systems mounted on cycle rickshaws and playing music through megaphone-speakers powered by truck batteries.

Vijayawada has made poor use of its riverside location: the dikes along the Krishna are lined with the worst kind of slum. But there is a good view of the

delta control works, which stretch in a single uninterrupted line between the two hills confining the river. As on the Godavary--and for the same reason--there is now a modern barrage just upstream of the original weir, which is now used only for bathing and laundry since it was imprudently raised. But there are still old navigation locks on either side of the dam, and I saw a canal inspection boat, the *Alexandra*, tied up at an Irrigation Department resthouse on the left bank of the river. On the grounds there was a bust of Arthur Cotton.

Amazingly, the Krishna weir was envisaged as early as 1792 by a Lieutenant Beatson. He had seen the Grand Anicut of the Cauvery; we know it because in recommending a low dam he wrote that "works of this nature I have seen at Seringapatam, where there are three dams across the Cauvery." The government responded to Beatson by sending an astronomer to survey the site, but the astronomer complained of his "want of proper instruments for the indispensable process (where water is concerned) of taking levels." A century later, in 1899, the government of Madras published a history of the Krishna works by George Walch, then the province's chief engineer. Walch reviewed the reports of 1792 and commented dryly: "And there the matter ended, as far as can be traced, for nearly half a century."

Nothing more was done until work was under way on the Godavary Delta. Then, in 1847, a survey was undertaken by a Captain Lake, who worked in close cooperation with Arthur Cotton. Lake planned to irrigate a million acres in the Krishna Delta, and the government requested Cotton's opinion. In 1848 Cotton wrote that "I feel entirely satisfied that the objections to it are entirely imaginary, insofar as the stability of the work is concerned." The objections, of course, were the objections to yet another weir built on sand.

In the case of the Krishna, the dam was to have a crest length of 3,750 feet. It would rise 14 feet above the summer level of the river and would be a full 305 feet wide. A six-foot- thick curtain wall would be backed by a huge inclined mass of stone, with the first 75 feet constructed of cut blocks fitted together but the remainder, as another engineer would say, "simply thrown into the river and allowed as it accumulated to assume its own natural slopes."

The work was officially sanctioned, but nothing happened. Then, in 1851, Cotton fired off another of his broadsides. George Walch in 1899 would quote the correspondence with obvious relish: Cotton, he wrote, "could no longer restrain his impatience, and on 7th January 1852 he sent to the Board of Revenue a very characteristic remonstrance." The last paragraph of Cotton's letter was this: "Whatever may now occur I thus relieve myself from responsibility of being in any way a party to the further delay of a work so long ago ordered by the Home authorities and of such incalculable importance to a part of the country liable to such awful calamities." With a twinkle Walch says: "This woke everybody up."

Construction was entrusted to Charles Orr, who simply moved down from the Godavary works. Progress was rapid, and by 1881 470,000 acres were irrigated in the delta; by 1899, the year of Cotton's death, the figure had risen to 519,000 acres. Unlike the Godavary, however, whose flow is comparatively great even in winter, the flow of the Krishna at Vijayawada falls sharply in winter, which restricts irrigation almost completely to summer crops. That is why, when I took a look at the Krishna Delta one January, most of what I saw was fallowed rice paddies. Still, the canals looked full as they conveyed water slowly to the delta's few winter-irrigated lands, near the coast.

At one place perhaps ten miles from Vijayawada I picked a ditch-bank lane at random, parked, and began walking. The lane led to a major canal, along which there was a footpath lined with houses. Although these were people without immediate frontage on a paved road, they were anything but slum dwellers. I passed a chicken coop that was 30-feet square, with wire-screen walls and an honest tile roof; outside, a fine bull was tethered to a one-inch iron pipe, a water line. The houses themselves did not have tile roofs: they were of thatch, which extended over a wide veranda. But the walls were of mud brick, immaculately plastered with fresh mud, decorated with geometric patterns in white. They were in better shape, I thought, than the houses of my own neighbors: no flaking paint here, no discolored surfaces-just an even-hued, cinnamon-brown wall, beautiful to look at.

Goats and cattle were tethered near most of the houses, which were frequently fitted with manually operated water pumps, even if the houses were only 20 feet from the canal. Some of the houses had television antennas, and that, of course, meant power lines overhead. A full-bearded man with a pushcart on bicycle wheels was at work ironing the clothes of the housewives he passed: the iron must have weighed ten pounds and was loaded with smoldering coal. He stopped and looked up from his tidy collection of purples, yellows, greens, and blues--some neatly folded, others awaiting his attention. Good-looking children walked by on their way to catch a school bus.

Halfway to the sea I came through Vuyyuru, a town with a big sugar refinery, advertised less by smoke than by the traffic jam of bullock carts loaded with cane. But Vuyyuru also has a Christian church and, next to it, an active church school. I took a look and was immediately surrounded by friendly students, who were then shooed away by a couple of hospitable young teachers. They explained that this was a church established by a Canadian Baptist mission in 1884. The long-time missionary here, one John Craig, wrote in 1907 an account of the mission: *Forty Years among the Telugu*. In it, Craig has a photo of the school I was looking at, physically the same though its name has been changed.

And what about the delta's elite, the people who had never converted to Christianity? Down in Machilipatnam I passed a mansion but was too shy to stop and go in. I ignored it and went on the few miles to Bandar Fort, a few miles to

the east. It's as close to the coast as roads go, but it's just a clearing in the mangrove where dozens of boats make their way for unloading. The place reeked of fish, despite ice-filled baskets quickly loaded and put on diesel trucks. New boats were being built, too: wooden keels laid under hand-adzed ribs. Every shipbuilding stage could be seen, from keels and ribs to sheathing with planks and caulking with tar-soaked rope.

On the way back through Machilipatnam I mustered my nerve and stopped at the mansion I had passed an hour earlier. Two men were sitting on the porch, and I asked if one was the owner. They were businessmen, they said, here only to talk to someone else who rented the lower floor as an office. The owner, they said, lived upstairs but spoke no English. Nonetheless they called him, and it turned out that he spoke good English, held in fact a master's degree in English from a university up the coast at Vizagapatnam. He explained that the house had been built by his wife's grandfather, who had started as a lawyer but who, amassing wealth, had become a landowner. Another daughter had inherited another house down the street, but she now lived in New York City and hardly ever visited.

Like so many other former landlords, he explained that his wealth had been decimated by land reform; that was why he now lived upstairs. Still, on the way up we passed many sacks of fertilizer, which the man's son was to use on their remaining rice fields. I sat down in the front room upstairs while he proudly brought out some ivory-inlaid boxes with British coats of arms. He had a massive highboy chest, too; it had been designed to hold Victrola records: 'H.M.V," his otherwise silent wife told me. A bed hung on chains from the rafters.

In the back, downstairs, there were other rooms rented to other people, including a government lawyer who had buried an old upholstered couch under legal files. The couch belonged to the man who owned the house, and he assured me that he would not part with it for two thousand dollars. I did not tell him that I thought the couch was worth less than that even in Europe.

The house itself had been painted only the year before, but it had not been treated with the chemicals that would retard mildew. There was no money to paint it again. We walked out to the front gate, past a heavy iron fountain, no longer working but still plainly labeled with the name of the Madras foundry where it had been cast. I tried to evade a question about the rental charges on my car, but finally confessed to his shock that it cost forty dollars a day, plus gasoline. His last words to me were directions about how to get to the house of somebody really rich.

And was this, then, Arthur Cotton's legacy: three weirs, great wealth, great inequalities? Not quite. Cotton retired to Dorking, near London; his house there still stands, though it is now a nursing home, much abused both inside and out.

For many years he occupied himself with gardening experiments, with developing tricycles for adults, and with writing Arabic primers for missionaries. Irrigation was still on Cotton's agenda, too, including correspondence on that subject with eminent people, including General Charles Gordon of Khartoum.

And always there was India. In 1873 Cotton proposed that a reservoir be created upstream on the Krishna by exploding a million pounds of gunpowder in ten mines that would create a mass of rock a quarter-mile wide across the Krishna River. With such a dam, he said, a second irrigated crop would be possible in the delta: a winter crop to supplement the traditional monsoon crop of summer. The government of Madras did not take the proposal seriously: with heavy-handed ridicule, it replied by saying that the dam's outlets would have to be built before the dam was created and that 'their entire destruction might be involved in its sudden precipitation on them by the agency proposed."

Such criticism only energized Cotton. He developed a plan to spend 50,000,000 pounds sterling on canals that would not only irrigate India but would tie it together with navigation routes that Cotton was convinced would be far more economical than railways. These proposals were the subject of much attention in England, and a parliamentary committee in 1879 took Cotton to particular task for his planned Great Equalizing Reservoir on the Krishna branch known as the Tungabhadra. That proposed dam, with a crest length of 8,000 feet, was to irrigate another million acres and provide much of the water supply for a canal system literally crossing the peninsula.

Ironically, both the Krishna and Tungabhadra dams were eventually built, although not until after the British left India. The Krishna dam is part of the Nagarjunasagar Project--NSP for short--and when it was completed it ranked as the world's largest masonry dam: it's more than 400 feet tall, nearly 5,000 feet long, and has a reservoir volume about a third that of Lake Mead, behind Hoover Dam. The Tungabhadra Dam is part of the Tungabhadra Project--TBP for short--and stands a few hundred miles upstream. As proposed by Cotton, it is 100 feet high and 8,000 feet long.

Is *this*, then, the extent of Arthur Cotton's legacy: three deltas and ideas for yet more irrigation? And still the answer is not quite, for if Cotton were to return and visit the NSP or the TBP today he would be dismayed. Below the dams he would find hundreds of miles of distributary canals and ditches that have never seen water, thousands of acres that remain, as Indians say, "rainfed." He would see that, for some reason, water entering the main canals does not move through the system as it is supposed to; every farmer in sight would tell him that there was a "tailender" problem. I doubt that Sir Arthur Cotton ever heard that word in the deltas of the Cauvery, Godavary, and Krishna, but here on the NSP and TBI, upstream farmers take too much water and downstream farmers--the unlucky "tailenders"--get little or none.

How have things gone so wrong? The answer is complicated, but looking for it takes us to North India, where a very different approach to irrigation was developed by Arthur Cotton's great rival, Sir Proby Thomas Cautley. This was an approach that worked far less well than Cotton's, yet it nonetheless became paramount in India. We shall see why, though the answer in essence is that it broke with Indian tradition and, appealing instead to European notions of equity, promised to ration water among a great many farmers. In practice such rationing could not be enforced. Headenders took more than their fair share; tailenders got less. That's the story on big irrigation projects across Asia today, not just at Nagarjunasagar and Tungabhadra, and it derives from the Ganges Canal, Proby Cautley's great work and the first European venture in reclaiming the plains of North India from dependence on rain.

Much of this canal remains in use, and to see it I set out eastwards from Delhi one day. An unmanageably large map was draped over the passenger seat of my car as I drove on the great iron bridge that crosses the Jumna River. This is the "GT" or Grand Trunk Road of Kipling's Kim, and for no good reason I anticipated that it would be a high-speed highway. Not so, at least not so in early 1990. I immediately landed in a traffic jam so severe that the truck drivers were turning off their motors and gathering in threes and fours for a sociable cigarette.

I asked around and learned there was no accident. The border between Delhi and the state of Uttar Pradesh lay just ahead. Most of the trucking firms had offices at this point to ease the paperwork of interstate shipments, so almost every truck wanted to stop and back into its office yard. The problem was that the Grand Trunk Road was only two lanes wide, so once the trucks began to pile up, there was no room for anyone to back anywhere, not without a great deal of yelling and measuring centimeters of clearance. Not knowing how far the jam extended, I began to wonder if this was all a terrible mistake. After a few hours I miraculously broke free and began scooting along to the turnoff for Meerut. I almost missed it, partly because the people I asked could not recognize the name from my pronunciation. (I gradually learned to accent the first syllable and include the "r" in it.) I did finally find the turnoff, and the traffic thinned to a fine stream of bicycles. It never vanished altogether. There were times in the next few days when I'd be on an unpaved track miles from asphalt. Thickets would block my lateral view, and bends in the road would shut off my line of sight after a hundred yards or so. I'd think I was alone. But then a cyclist would come by, or a donkey loaded with a few dozen bricks; perhaps I'd only hear the chopping of brushwood.

The road to Meerut was straight, tree-lined, and well-paved; between the shoulder and the fields I saw mud-walled stacks of cowpats, elegantly assembled into cylindrical stacks very different from the pup tents of Oscar Lewis's Rani Kheri. Perhaps the cylinders were six feet tall and six feet across; their dark brown shade was handsome against the green background.

The green was largely sugarcane, and quite by accident I was here for the start of the harvest. Everywhere I went during the next two weeks I'd see people chewing on two-foot stumps; often I'd see nothing until I heard a crunch and turned to see strong teeth at work. The cane fields themselves were impassible near-jungles, and I only saw the cutting gangs when they emerged to carry headloads of cane up earthen ramps for loading on bullock carts or big diesel flatbeds. The only other field crop I noticed was wheat, six inches tall and quiet.

The irrigation works that bring the water to the wheat were in sad shape, however: the gates that were supposed to control the flow of water in the branch canals had been removed or destroyed by farmers who were free now to use as much water as they liked. Downstream, I suspected, I would find "tailenders" relying on rain or wells, and so it proved to be.

For now, however, I was headed upstream, to the headworks of the Ganges canal, and everywhere there were animals: cattle and camels, dogs and pigs, sheep and geese. There were goats, the billies grubbily contracepted with sacks over their hips. I steered around hundreds of cart-pulling bullocks, shod and clip-clopping with total indifference. Mornings are chilly here in the winter, and the bullocks were covered with blankets from which a patch had been cut for their humps. Trucks and buses rushed at them front and rear, but the animals took no notice. Nor did the camels that were also walking along these roads. They were unshod and silent, but they radiated scorn. Occasionally I saw elephants, a sad business. They walked with what looked like the stains of dried tears on their cheeks.

Meerut itself testifies to the wealth that irrigation can produce. Famous as the site of the outbreak in 1857 of the Indian Mutiny, a few months after my visit it would make the international press once again, this time for violence during the first round of voting in the electoral season that saw the assassination of Rajiv Gandhi. But what I noticed most, apart from the ferocious traffic, was a sign posted by a doctor. It said that patients didn't have to go to Delhi for a catscan: they could get one right here.

Along the way, in fact, I saw not a single village that didn't have at least some brick buildings. For that matter I don't recall seeing a village that didn't have electricity, at least poles and a couple of wires tracing their way through the main street. Markets were thriving everywhere. I know it is so because secondary highways in India think nothing of simply debouching into village lanes. The transformation from paved surface to mud occurs so fast that you think you've missed a turn.

Three or four bullock carts filled with cane or manure would try to squeeze by. A tractor driver would smile and motion me into the path of a bus that had no intention of stopping. Loose animals, motor scooters, pedestrians: everyone

and everything was trying to thread its way through an intersection that no one through the centuries had ever thought needed supervision. Yet in towns such as these, of no more than a thousand people, I'd pass a dozen stalls with bicycles and bicycle parts. Another dozen would sell truck tires. There would be shops selling grain and shops selling cloth. There would be vegetable and sweets merchants. What impressed me most were the carts heaped with bananas. It sounds like a small thing, but every village had at least one such cart, even though bananas don't grow in this part of India. Nor were these bananas intended for India's middle classes: there were bananas in the hands of kids walking out of town into the countryside.

I wandered around Meerut in search of the old church where the Mutiny's first victims are memorialized. (The Survey of India's guide map to the town shows several churches but not St. John's: you have to ask and ask again for directions.) Only a few visitors had come recently: most who had signed the ledger in 1990 were Britishers or members of embassy staffs in Delhi. The nearby cemetery was more interesting than the church itself: it had the most orientalized Christian tombstones I'd ever seen, all overgrown with the scrub known in India as jungle. (Like the word *tank*, the word *jungle* is of Indian origin; coming to English, its meaning shifted.)

Late in the afternoon, as I approached Roorkee, I finally crossed the main canal, a huge work even today and the feeder, when it opened in 1854, of the biggest irrigation system in the world. Its 900 miles of main canal and its many thousands more of minors were designed to irrigate a million and a half acres. Before construction of the canal, none of them had ever received a drop of canal water.

I was worried. The World Bank was helping to pay for the reconstruction of the canal. The work was scheduled to include the construction of a new aqueduct over the Solani River, near Roorkee. The old aqueduct, built in the 1840s and containing fully eighty-five million bricks, was scheduled to be demolished. Was I too late? I could have called somebody at the bank and asked, but the World Bank cultivates an aura of untouchability all its own, and I was more comfortable simply going and seeing for myself.

The reconstruction work was obviously moving ahead, for I crossed a new and spankingly ugly bridge of prestressed concrete. An old bridge stood nearby: gracefully arched plastered brick, neatly dated with a plaque from the 1840s.

The shoulder traffic kept increasing until I was on a town street too crowded for the car to move faster than the pedestrian flow. I was apprehensive, unsure whether cars were allowed here. Had I made a wrong turn? Suddenly I realized that I was on the canal embankment. I kept moving, crossed the canal on a bridge, and caught site of the line of arches stretching 950 feet over the Solani River. Shorter by half than the Gunnavaram Aqueduct in the Godavary Delta,

and no more than 40 feet high, the Solani's claim to fame has always been its bulk, for it sometimes carries as much as twelve thousand "cusecs" or cubic feet of water per second in a channel fully 150 feet wide by 10 feet deep.

There is no shortage of information available about the aqueduct, because Proby Cautley himself wrote a full account of the Ganges Canal. Before setting out from the United States, in fact, I had rummaged around in an obscure corner of the Library of Congress. (Those were the days when librarians there, with a little finessing, would give you a stack pass.) On a bottom shelf of folios, I had found Nadault de Buffon's 1843 classic *Traite' theorique et pratique des irigations*, in its day just about the only textbook of irrigation engineering. And next to it was an immense volume, one cover detached, spine badly frayed: *The Ganges Canal: Plans*. The date was 1860; the place of publication, London; the author, Proby Thomas Cautley. Three big volumes of accompanying text were shelved nearby. The frontispiece of the volume of plans contained a tinted drawing of the Solani Aqueduct. Perhaps it was twelve inches by twenty-four. It showed the aqueduct in all its mass and much of its detail, including decorative railings on the roadside and pairs of sculpted lions at both ends of the structure. The lions were the work of one Lieutenant George Price, 1st Fusiliers.

The aqueduct had been built so well, Cautley reported, that at the removal of the “centerings," the wooden frameworks used in constructing the arches--the keystones sagged only about an eighth of an inch. (And the work was done so methodically that the sag of each arch had been precisely measured.) No wonder that someone at the World Bank once told me that the budgeted demolition costs were extraordinarily large because the work of taking the aqueduct apart would be so difficult.

And now it stood before me in the twilight: filled with water, the roadway busy with cyclists and buses. I maneuvered across the road and drove along the other side of the canal. Still unsure whether this was legal or not, I stayed with the pedestrians and bullock carts and drove slowly, slowly, across the aqueduct. No one objected, including two canal guards.

On the far side I was finally able to stop. I got out, climbed down to the base of the aqueduct, inspected the arches, noted some minor leaking and some simple timber props. I looked at the cast-iron railings. They were definitely the originals, the same ones shown in the frontispiece drawing. Then I drove a hundred yards upstream, beyond the aqueduct proper, and found the lions: flat snouted, curly maned, and well plastered with posters and graffiti. And here was the new canal, the replacement. It was stilt dry, and it ended just before the old aqueduct. What was happening? Later on, back in Delhi, I was told that work on the new aqueduct had been held up. People feared, according to one man at the World Bank office, that an excellent old structure would be replaced by a crummy new one.

The headworks of the canal lay another 20 miles upstream at Hardwar, where the Ganges emerges from the Himalayan foothills: they can't be more than a few hundred yards from Hardwar's famous bathing steps, which are popular even in the winter, when the water is frigid. The river itself hardly exists downstream from Hardwar, for the canal takes almost all its visible flow. (Not to worry: bedflow and tributaries soon restore the river.) But the headworks are not particularly impressive: they're nothing compared with the Solani Aqueduct.

By an odd coincidence, the young Proby Thomas Cautley began his surveys for the Ganges Canal in 1836, the same year that Arthur Cotton built the Coleroon Anicut. Cautley, too, knew his local history, and he based his Ganges plans on two earlier works, the Western Jumna Canal, on the Delhi side of that river, and the Eastern Jumna Canal, which runs through part of the plains stretching from the Jumna eastward to the Ganges. Both had been out of commission a long time when the British arrived: the Western Jumna, for example, had been built about 1350 and abandoned four hundred years later, about 1750. The British restored some four hundred and fifty miles of it by 1820. Ten years later they restored the Eastern Jumna. Proby Cautley was in charge of that canal when he began looking at the feasibility of bringing water onto the same plain, but this time from the Ganges.

Like its predecessors, the Ganges Canal was approved by the government of India as a money-making, or at least a money-saving, venture. A contemporary put it this way: "It is very certain that if the restoration and extension of these works had not promised an increase of revenue to the British Government, they would not have been undertaken." The meaning is simply that the government depended for its income on land taxes, which could not be collected in years of famine. Such a year came in 1837, when, according to Cautley, drought led "to famine in its most aggravated shape, and to misery such as is unknown in civilized Europe."

Cautley's first report on the Ganges Canal was submitted in 1840. In it he proposed a canal with a capacity of 1,000 cusecs, to use the technical term. That was just big enough, he estimated, to be a paying proposition. Within a year, however, he was told to revise his plan upwards to 6,750 cusecs, the entire visible stream during low water at Hardwar. This would be an immense work, for such a canal would be about half the size of such twentieth-century American behemoths as the California Aqueduct or the All-American Canal. The plan of the enlarged work was approved, and by July 1842, Cautley wrote, his men had "lined out nearly one hundred miles, collected a large quantity of materials, and had excavation in full progress at three different points." The canal was to run 180 miles southeasterly, past Aligath; then it would split into two roughly parallel canals, one terminating in the Ganges at Kanpur (the British spelling was Cawnpore), and the other (after dropping plans to extend it to Allahabad) terminating in the Jumna due south of Kanpur.

The government of India was fully occupied by troubles in Afghanistan, which according to Cautley "appeared to be perpetually the rock upon which the advancement of these works was to be wrecked." And there were intrinsic difficulties, too: the engineers, in Cautley's words, had "to deal with the mountain torrent in all its deformity, with illimitable depths of sand, and with difficulties in procuring material such as would hardly be credited without personal experience of them."

In 1845 Cautley took a three-year medical leave: "My health," he wrote, "which after twenty-six years of Indian service had been gradually failing, determined me to proceed to Europe." In the interim the works were handed over to his assistant, W. E. Baker, and Baker's own final report, from 1848, hints at the difficulties he faced. Fearing his successors might not appreciate those difficulties, Baker observed trenchantly that "the power requisite to maintain the regular and equable motion of a vast machine, is no measure of the force required to set it going."

Cautley must have been pleased upon returning in 1848 to find the work "marked by an uninterrupted and steady advance." Perhaps it helped to have the enthusiastic support of Lord Hardinge, the governor-general. Hardinge had met Cautley in 1845 and seems to have picked up Cautley's excitement about the project: writing to his daughter-in-law in 1847, Hardinge wrote that he was "now as eager about aqueducts as bombs & shells & villainous saltpeter a year ago." As for the canal itself, Hardinge went on to say that the Ganges "is to be brought through a sandy district of 800 miles in extent, irrigating 2000 square miles of land and producing food for a million of people & mitigating, if not altogether preventing, the famine produced by drought."

Many years later Sir William Willcocks, builder of the first Aswan Dam and, in a lighter moment, double-checker of Rudyard Kipling's backyard powerhouse in Sussex, would write of Proby Cautley that "the word thorough was written over all his works." Something of that quality is evident even in such a small detail as the tree plantings that Cautley ordered: mangoes ("not grafts") were to be placed at 100-foot intervals on both sides of the main canals. They were to be spaced 40 feet from the inner slope of the canal itself, and Cautley wrote that they were to be irrigated by perforated earthen pots planted alongside and regularly filled. Something of Cautley's broader interests can be retrieved, too, from the project's official library a few hundred yards from the Solani Aqueduct. Alongside works on leveling and arches, I saw Andrew Jackson Downing's *Cottage Residences*, John Ruskin's *Seven Lamps of Architecture*, and an assortment of travel books including Washington Irving's *A Tour of the Prairies*, and Herman Melville's *Typee*.

The canal opened in 1854, some 18 years after Cautley began his surveying. When Cautley left India that same year, Dalhousie ordered a ceremonial salute at Calcutta. In retirement in Sydenham, a few miles south of London and not

far from the eventual siting of the Crystal Palace, Cautley wrote his account of the canal.

It was then that he got enmeshed in a dispute with Sir Arthur Cotton. He did so reluctantly, for, smiling through his mutton-chops like Franz Schubert, Cautley was as equable as Cotton was volatile. The dispute centered on the location of the Ganges Canal headworks, with Cotton arguing that they should have been built farther downstream and of the "cheap" school. Had such a plan been followed, Cotton said, the Solani Aqueduct could have been skipped altogether. Cautley responded gently at first but was finally provoked into saying that Cotton was "better qualified to magnify the mistakes of others, than to be trusted with a project of his own."

Neither man addressed the central problem of the Ganges Canal, the same problem that would emerge a century later on the Nagarjunasagar and Tungabhadra and so many other projects: the problem of tailender shortages. Neither man in fact paid much attention to the central question of how the Ganges Canal was to operate. Unlike the farmers in the southern deltas, northern farmers were to be limited in the amount of water they took. How should the government enforce those limits?

Cautley had anticipated problems. That is why on his medical leave between 1845 and 1848 he made a quick visit to northern Italy to see how the canals there, the most sophisticated in the world, were managed. Two years later he arranged to send an engineer named Richard Baird Smith on a more extended tour of Italian irrigation. Smith promptly wrote a two- volume treatise, *Italian Irrigation* (1852), which remains of great value not only for its discussion of Italian irrigation but also for its discussion of how Italian technology might be adapted to the Ganges Canal.

Richard Baird Smith took over the Ganges Canal. A man to join the likes of Meadows Taylor, Arthur Cotton, and Proby Cautley, Smith had great physical energy; on his way back from Italy he examined Cotton's three deltas and in so doing traveled 1,500 miles by palanquin in six weeks. His report on those deltas, *The Cauvery, Kistnah, and Godavery* ... [1856], remains a primary source for their history. Much would have been heard of him in later years if he had not played a leading--some have argued *the* leading--role in breaking the siege of Delhi during the Mutiny. He received what he thought was a trivial wound to the heel, wrote to his wife in Meerut that it was hardly more than a bruise. But complications arose. A few months later he was given a sinecure, but rest did not help. He finally was sent on medical leave but died shortly after leaving Calcutta. He was forty-three. His body was put ashore and buried in Madras.

Like Meadows Taylor, Arthur Cotton, and Proby Cautley, Baird Smith had an almost religious faith in irrigation. With it, he wrote, "men who were the

Ishmaelites of society fall, without force or constraint, into the ranks of the great army of industry." One hears in those words the echoes of Jeremy Bentham.

But how was the Ganges Canal to be operated? That was the critical question, and the nub of the problem was that since it had been conceived as a famine-control work it was designed to spread water thinly over a large area. That design decision had been crucially important, and it was supported by rational as well as moral justification, for some farmers might not want to pay for water, might be skeptical of its value. To recoup the canal's cost, in other words, Cautley wanted to offer water to as many farmers as possible.

But what would happen if the canal brought water past many farmers and all chose to irrigate? *That* was the all-important question. Baird Smith devised an ingenious solution. The canal, as we have seen, would divert 6,750 cusecs. On the Jumna canals, one cusec would irrigate 218 acres. This was an unusually high "duty" for water: down in Madras the duty was taken to be well below a hundred acres. But the crops here in the north were chiefly wheat and cotton, not rice. Based on Jumna experience, Smith anticipated further that about half of the land irrigated by the Ganges Canal would be planted to winter grain; the other half would be sown to summer crops divided so that a quarter of the total annually irrigated acreage would be planted to rice, a sixth to sugar and indigo, and a twelfth to cotton.

So Baird Smith went on to multiply 218 by 6,750 to arrive at a figure of about 1.5000,000 acres to be irrigated by the Ganges Canal. Experience on the Jumna again suggested that most farmers would want irrigation water for only about a third of their land, partly because some of their land would be fallowed or used for summer crops that, with a decent monsoon, did not require irrigation. So Smith multiplied three by 1.5 million and concluded that the Ganges Canal could provide famine protection to the owners of almost 5,000,000 acres. The great plain between the Jumna and Ganges contained about 11,000,000 acres, so the canal would eradicate famine in half the area--even more, if one assumed that farmers without irrigation might earn money by working for those with it. "This great tract," Smith concluded, "will become the garden of the North Western Provinces; and we shall hear no more of those devastating famines, which have hitherto swept across it."

That was the theory. But suppose farmers wanted to irrigate more than a third of their land? Suppose they wanted to grow a lot of sugarcane? Without controls, the tails of the main canals would soon be dry. So would the tails of the branches and capillary distributaries. So would the tails of the village watercourses, the tiny ditches below the outlets where the government released water to a group of farmers. Cautley had looked for solutions to this problem during his visit to Italy; so had Baird Smith. Both men knew that continuous monitoring of the canals was impossible. It would be doubly

impossible to watch how farmers divided water among themselves below the outlets. A contemporary put it this way: "To attempt to regulate all village water-courses, numbering (as these do) several thousands, we regard as impracticable." Trying to do so, moreover, "would place an enormous degree of power in the hands of a corrupt, because under-paid establishment."

So it was that Baird Smith proposed the following procedure. First, determine how much water would be required below each outlet. Then make sturdy outlets with a fixed discharge sufficient to meet the land's requirement. (Here, in particular, one sees the Italian influence, for Smith had seen such devices there.) Finally, enter into 20-year supply contracts to supply water at its true value. "True value" was difficult to determine, but Cautley insisted that "to know, in fact, the true value of the property that we hold for distribution ... [is] the great desiderata." And in a way that a modern economist would applaud, Smith encouraged a local market for irrigation water. Farmers, he anticipated, would sell their rights to one another and thereby disclose the true local value of irrigation water, which in turn would be used in setting lease terms. The great virtues of Smith's system, he wrote in conclusion, were that it required almost no policing and would lead to the economical use of water.

During the canal's first season, the summer of 1855, Smith wrote optimistically that contracts had been signed with 48 villages. The average contract called for the release of less than one cusec. That was hardly a drop of the canal's initial flow of three thousand cusecs, but Smith was not discouraged. Down in the Etawah District, the collector wrote that his farmers "as a rule believe that irrigation neither improves the quality nor increases the quantity of the produce." But this was a transitory state, Smith argued: farmers closer to the existing Eastern Jumna Canal knew better, and he detected an "induced effect, so to speak, exercised by the Eastern Jumna Canal districts on others near them, which is stimulating to irrigation."

In the following winter 107 villages applied for a total of 90 cusecs, and by the summer 1,134 villages were irrigating about 50,000 acres. Using his own one-in-three rule, Smith calculated that the owners of about 150,000 acres were, therefore, already protected from famine.

The Mutiny flared the next year. Smith went to Delhi and never returned, and his system was soon abandoned. Why? The reasons were discussed most clearly in the report of the Indian Irrigation Commission of 1901-1903. The commission's president was Sir Colin Scott-Moncrieff, an engineer who had basically fixed the Egyptian irrigation system. Before being assigned that task, however, Scott-Moncrieff had worked in India, including on the Ganges system. Something of his character may be inferred from a letter he wrote during his early years in India to General Gordon, whom he sought to join in the Sudan. "I am no sportsman," Scott-Moncrieff wrote, "and know nothing of horses, but

don't mind a ride of one hundred miles. I have always been used to hard work." Gordon said no, and it was years before Scott-Moncrieff got to Africa. Returning to India many years later to head the irrigation commission, Scott-Moncrieff produced what remains the most valuable survey ever written of Indian irrigation.

It was probably Scott-Moncrieff who was responsible for the irrigation commission's statement that the Italian modules did not work on the Ganges Canal because the distributaries did not operate at a constant supply level. Moreover, in what I assume are also his words, "the cultivators on the Ganges Canal were not used to irrigation, and looked on the module with considerable suspicion.... The system was [therefore] abandoned, and it has never since been restored." Abandoned, too, were the long-term leases, wisely in Scott-Moncrieff's view, because the canal was being continually modified and "it would have been fatal to have stereotyped for a long period of years the existing conditions of each irrigation outlet." As for the crop-water requirements that Baird Smith had wanted to investigate, nothing had been done in the interval of fifty years. The commission report states that the farmers have "no idea of the quantity of water required for the irrigation of an acre." Worse yet, neither does the irrigation staff, though the knowledge remains "extremely desirable."

But if Smith's ideas foundered, what was the alternative? The answer is that the Ganges Canal began to operate just as the Jumna canals had always operated: by charging, in Cautley's words, for the "surface of land irrigated, without reference to the amount of water taken, but with reference to the species of crop." It was a poor system, Cautley wrote, "but bad as it is, it has been much easier to recognize its imperfections, than to remedy them." What imperfections? For one thing the system implied the costly measurement of irrigated acreages each season. Second, it encouraged farmers in the summer season to delay signing up for irrigation water until they were sure that the monsoon would fail. As one observer wrote, "Every cloud in the sky is watched ... in the hope of being able to dispense altogether with canal water." Third, it gave farmers no incentive to conserve water. Fourth, it was a system that almost encouraged cheating. Smith grew angry enough to write that "stealing water should be stamped as a felonious act, quite as much as stealing money."

But how to cope? In 1873 an engineer in Cawnpore said simply that "the stronger parties generally take more than their share." He did not use the term "tail-end shortage," but that is what he was describing. Moreover, as Smith knew, the subordinate staff was corrupt. There was nothing secret about this, although the irrigation department didn't advertise the fact. In times of shortage, the outlets were put on a rotation known as a *tatil*, under which farmers at each outlet were allowed to take water only at certain times. That was the theory; the practice was that powerful farmers bribed their way to extra water.

Scott-Moncrieff had encountered this situation as a young man working on the Ganges system. In a letter to an aunt in 1859, he wrote that seeing that "the Government subordinates don't practice bribery and oppression, etc., and that all get fair justice in the water-supply, it is often depressing enough to see how a native revels in bribery and forgery, lying and double lying, as if his creed was, 'Thou *shalt* bring false witness.'" Twenty-odd years later he wrote, in a more temperate and official capacity, that "measurements have been dishonestly performed, lands have been unfairly assessed, water has been given out of turn."

And what was the result? The irrigation department had an incentive to encourage the development of sugar-cane, which would require water year after year without fail and which would use so much water that the canal's effectiveness as a preventer of famine would decline. Powerful or head-end farmers meanwhile got an inequitable share of canal water. Consider an example. A superintending engineer is speaking to the irrigation commission about the system as it had operated in the 1880s: "Water was consumed with much waste in the upper reaches of channels; but little got down to the middle reaches; and scarcely any, or none at all, flowed to the tail, where the outlets were starved." Here is another engineer, giving an example of conditions on one distributary in 1877: "The distributary is 18 miles long and in the first 6 miles there was in 1877 an enormous area irrigated; from mile 6 to mile 13 a part was irrigated; from mile 13 to mile 18 absolutely none."

The problem of equitable apportionment was not insuperable, even in practice. William Willcocks, for example, who like Scott-Moncrieff also began his career on the Ganges Canal before moving to Egypt, recollects in his memoirs how

> the monsoon rains of 1877 failed along the Ganges Canal, and we had the greatest difficulty in insuring the irrigated crops against drought. The principal part of our duty was patrolling the distributaries and seeing that the rotations were properly enforced. My wife took the keenest interest in the work, and through the whole of the hot weather did her share of the inspection just as though she were a canal official. She rode down one distributary recording facts in her note-book, while I rode down another, or we rode on different banks of the same canal. We met at mid-day at some inspection house. On one occasion she had a sunstroke, but I was able to get ice by train and pack it round her head. After a day's rest she continued her work.

These efforts sound promising, as if the solution were simply diligent inspection and enforcement, but Willcocks's unintentional punch line is this: "We were encouraged by seeing the splendid appearance of our irrigated fields in the midst of the general desolation." In short, compliance was the exception, not the rule, and it was destined to remain so, because reforming the irrigation

bureaucracy did not—and has never--appealed to governments, either colonial or independent.

The British ameliorated the shortages on the Ganges Canal in two ways. First, they increased the canal's water supply during the 1870s by adding a second diversion point from the Ganges: this was the so-called Lower Ganges Canal, which not only had its own service or command area but which intersected and topped-up the lower half of the Ganges Canal. Ever since, the original canal upstream of the intersection has been known as the Upper Ganges Canal. Arthur Cotton must have taken it as vindication of his old argument that the original diversion should have been where this new canal's intake actually was.

The new supply helped, but demand was so great that water remained short. One study suggests that a cusec used at the top of the canal irrigated less than half the land irrigated by a cusec downstream. Or, to take another case, upstream Meerut District was able to spread a cusec over 265 acres, but downstream Bulandshahr spread it over 396 acres.

The second thing the British did to reduce shortages was to reconstruct, mostly during the 1890s, the distributaries to operate biweekly, rather than continually. The result was that tatils were abolished. With them, the prime source of corruption disappeared, for it is a much simpler thing to turn off an entire distributary than to see that outlets along its course take water according to schedule.

Some examples may clarify the point. The chief engineer of the United Provinces told the irrigation commission of 1901 that in 1887 he had been stationed in Etawah District and had completely redesigned the distribution system there. The "number of outlets," he said, "was reduced from 7,500 to 4,500 and an immensity of waste prevented." At the same time, he continues, "tatils were abolished and the power of the petty officials in levying blackmail was minimized." The payoff was dramatic: irrigation in the canal's Etawah division rose from 170,000 to 230,000 acres without any increase in the water supply. The same work was begun in Bulandshahr District in 1892: "In one year 1,700 outlets were cut out of a total of 5,700 and tatils abolished," while winter irrigation with the same water supply rose from 134,000 to 180,000 acres. "Tatils used to be so strict in this division that murders were frequent," the engineer concludes, "and petty canal officials amassed large sums by illegal methods."

Another engineer, with a different perspective, testified that he had worked on the Ganges canals between 1881 and 1893, then had left for seven years. When he returned, "the most noteable and far-reaching change was the abolition of internal tatils on distributary systems. When I left it was exceptional for any distributary of any size to run except with internal tatils of outlets; in other words, the capacity of the distributary was not equal to the total outlet

discharge. On my return I found this system abolished. Distributaries had been remodelled.. . and the system of alternate running of distributaries had replaced the old tatils."

So much water was saved by this reconstruction that it was possible to build new branch canals. This was all to the good of famine prevention, but Scort-Moncrieff was surprised to learn that much of the water saved went to increase the acreage irrigated by farmers who had been irrigating for decades: there was simply too much political pressure to resist these fortunate headenders. Scott-Moncrieff asked one district collector the following question: "People say the irrigated lands are not half as well protected as they used to be. Is there anything in it?" The collector replied yes, "the demand for water is enormous." How enormous? "In Meerut and elsewhere we are told that 70 or 80 percent of the land is now watered every year."

The inequity bothered Scott-Moncrieff. In the famine year of 1878 he had been in South India, in Bangalore, from where he wrote of "a scene of lamentation and mourning and woe. ... We went to church, and I remember when the familiar 'Be joyful in the Lord, all ye lands,' was chanted. I felt, What nonsense this is! How could we be joyful?" A friend adds that Scott-Moncrieff came to Bombay and collapsed: "He was not delirious, but told me he was haunted by awful sights--little children like skeletons gazing at him with wistful, pleading eyes as if he should help them. 'And I can do nothing,' he exclaimed."

As president of the irrigation commission a generation later, Scott-Moncrieff brought that compassionate perspective to bear. "Water," he said, "is so priceless that I should be jealous of giving more where there was enough already." He asked one engineer in particular: "Do not you think it would be better, with whatever water you saved, instead of going in to the same old villages if you might extend the area of irrigation?" The engineer replied: "I think it is too late in the day to consider that now; it should have been considered sooner." Scott-Moncrieff persisted: "But this increase has occurred within the last seven years; it is not of very long standing." The engineer said: "it would lead to very great trouble if it were at all tampered with now." So it was not tampered with, and the problem of inequity was let be for the remainder of the British Raj.

And today? To find the answer, I traveled down past Aligarh to the point where the canal splits into the Kanpur and Etawah lines. The division works are essentially as Cautley left them, with a stone plaque dated 1852, but I saw only slack water in the canal. I went down to villages below that point and asked farmers who spoke English if they received canal water. Their answer was not at all. They irrigated, but they used groundwater lifted with the aid of pumps. The canal water, I believe, was being diverted upstream. I cannot prove it, because data on the actual performance of the system remain amazingly rare, even rarer, I think, than they were a century ago. And the reason is plain to

see: no irrigation department stands to gain by documenting its own deficiencies, and in the case of the still-underpaid Indian irrigation bureaucracy there is much to be gained by letting things remain as they are.

In this connection I spent a frustrating hour with the director of an irrigation-management research center at Okhla, on the outskirts of Delhi. I was asking about inequities of water delivery, and the director's initial strategy was to assure me that the Ganges canals worked as they were supposed to work. He brought out a leaflet showing the operating times and design discharges of each channel. Deviations? He said he knew of outlets that had not seen water in five years, but he said that on average farmers at heads and tails were getting within 15 percent of the same quantity of water. I doubted this, but without facts I could not dispute his point. He, with the means of building a mountain of data, had no reason to do so.

Still, when I left his office one of his staff members invited me to his office. Almost clandestinely he told me about a small study he had been conducting on the Agra Canal, which starts at Okhla with a fine late-nineteenth-century channel, these days filled up with frighteningly fetid Delhi sewage. He told me about a study he had made of a minor canal that branches off near the tail of the Agra main. The minor channel, he said, was supposed to carry twenty-two cusecs, but actually carried fifteen, thanks to excessive withdrawals upstream. Worse, the minor canal was supposed to supply 35 outlets, each one irrigating the lands of perhaps a dozen farmers. In fact, he said, only a dozen outlets got water on schedule; the two dozen tail-end outlets got water at night or not at all. I asked about the Ganges canals, but he said he did not know; there had been no studies.

Some days later I was talking in Delhi with Dr. Ikbal Singh, an agricultural economist at the Pusa Institute, which is India's national agricultural research organization. He himself was from a village near Meerut, and the minor canal serving his village had received no water at all during the last five years. The situation was deteriorating, he said, because demand for water was continuing to rise at the same time as farmers no longer feared punishment for violating the canal-operating rules. The result? Previously, he said, farmers in his village had relied on wells for supplemental irrigation; now those wells were their sole source of irrigation water. The "15 percent deviation" I had heard at Okhla he dismissed as nonsense.

Now we can understand what happened in the projects that Arthur Cotton had advocated but which were not built until long after his death. As early as 1901, during debates on the merits of building a dam at Nagariunasagar, the acting chief engineer for Madras argued that "the stored water should be utilized in the upper taluks [district subdivisions] and not in the delta proper." The engineer went on to say that in principle "I consider it is better to increase the area of irrigation than to try double cropping."

This was a departure from the Madras school and Arthur Cotton. It was an echo of Proby Cautley, a plea for equity. And when Nagarjunasagar was finally built, its water was indeed assigned in the name of equity to the nearby plains, not to the delta. The planners went further and rationed the water with a "localization" plan. On the right-bank canal, for example, head-end farmers, who generally cultivated light upland soils, would be told to irrigate crops that required little water. Tail-end farmers, who farmed heavy soils closer to the Krishna River, would be allowed to grow rice. It was both and logical, because rice paddies on light soil waste water. But why would head-end farmers worry about waste? The government of India lacked the means to impose discipline, at least on more than a pilot- scale level. And so by 1980 about 1,200,000 acres were nominally irrigated on the NSP but only half that land actually got water. What land was irrigated? Head-end land. What was grown? Rice.

The same thing happened on the Tungabhadra Project, that descendant of Arthur Cotton's Great Equalizing Reservoir. Water began to flow through irrigation canals in 1953, but thirty years later only two-thirds of the 600,000 acres to be irrigated on the left bank actually got any water. Why? Localization plans called for 60,000 acres of rice, but project farmers ignored the plans and grew rice on 250,000 acres.

Who was to stop them? These are huge projects, after all. The left-bank NSP alone has fifteen thousand miles of branch canals and distributaries, and landholdings are so small that twenty or more farmers clamor for the water released at each 100-acre outlet. The irrigation officers today, as a century ago, are underpaid and easy to bribe. There have been reports explaining how these engineers buy their jobs, how they recoup the cost through collecting bribes. But corruption reaches to the top, according to the reports, and so nothing is done. What can be done? A member of Parliament stood up in 1952 and said that his constituents believed that "with independence they would be saved." He meant saved by irrigation. It's the same today: time and again, the logical and humane wish to provide a little water to a great many farmers has swept away the demonstrated fact that water cannot be spread thinly, at least not in a country where the poor cannot resist the rich.

It is not just an Indian story. By the late 19th century the British were concentrating their irrigation-development efforts in the Punjab, where chunk after chunk of semiarid plain was settled by colonists cultivating land newly irrigated by huge canals. The Punjab was split in 1947, and 25,000,000 irrigated acres were lost to Pakistan. There, as in India, aid agencies are now rebuilding the old British systems. Still, there is no real prospect of an end to tail-end shortages. After all, these are political problems more than social ones, and farmers can always find a way to circumvent engineering.

Time and again it has happened across Asia. A visiting expert recommendgs special floating gates, developed in France and much ballyhooed by many

French engineers. Then he finds that the farmers prop up the gates so that water flows freely. That's the story in Morocco. On the other side of the continent, I recall a project near Chainat, a hundred miles north of Bangkok. The control gates on the branch canals had simply been removed by local farmers. I asked a group of engineers when this had happened, and they replied matter-of-factly that it had happened the day the gates had been installed. Or I think of Sudan and Aftica's largest irrigation scheme, the Gezira, where folk wisdom knows that those same gates make excellent baking pans. You can hunt all day for one and have no luck until you visit a lady's kitchen. And let me stress again the North Indian connection. Who is responsible for the irrigated plains north of Bangkok? Choose one person and it will be Sir Thomas Ward, an old Punjab hand whom the Thais hired in 1913 straight from India. And who conceived the Gezira Scheme? Name one person and it will probably be Sir William Garstin, who was one of the handful of engineers whom Sir Colin Scott-Moncrieff brought to Egypt from North India. I do not say it is incestuous: I have too much respect for the integrity of these men to make jokes like that. I do say that the connection is very clear and very strong. And the consequences go beyond low irrigation efficiency: they go to the kind of world these projects create.

I think of the east side of California's San Joaquin Valley and of a place where a new irrigation canal—nearly straight and lines with blindingly white cement--runs close to a nineteenth-century canal that, unlined and heavily overgrown, meanders on a near-contour. Engineers will deplore this old ditch: it loses water to percolation and transpiration, and its rough edge impedes the flow of water. Yet the one looks natural; the other does not. The one could be the subject of a painting; the other will only be photographed. The one is beautiful; the other, as Joan Didion once remarked about the generators at Hoover Dam, is autonomous. It rebuffs--is insulted by--any human being who seeks to establish rapport with it. It has, as my Muskogee teacher would say, no spirit.

Arthur Cotton's projects had spirit, were grafted onto the indigenous style of irrigation development. But Arthur Cotton is now a historical curiosity; Proby Cautley is the man with the influence. And you can see the results all over Asia today.

I think of Sri Lanka, once British though never administratively part of the British Indian empire. The highlands around Kandy are elaborately terraced and irrigated with ancient and indigenous canal systems. Yet superimposed upon them--and the pride of the nation, one would sometimes think--are huge new storage dams and concrete canals built to bring water through a capillary distribution system to newly irrigated plains. Perhaps these new systems will work better than those of India, though there is plenty of evidence of headender dominance in Sri Lanka. But where will a tourism promoter turn for

pictures? To the old terraces, of course, not to the fine products of modern engineering.

Or I think of Bali and of deep ravines intricately terraced for rice. The materials of the traditional diversion works were simple--just rocks and logs--but the ditches were carefully maintained; sometimes the structures even included tunnels through ridges of relatively soft volcanic ash. Everything was village-made, down to the bamboo logs laid horizontally across the head of each branch canal. Notches cut in the log made sure that the volume of water in each branch was proportional to the amount of paddy land it served.

But water was "wasted" in these systems, wasn't completely captured at the diversion; if captured, it was lost to seepage. And so about half of the island's 1,300 irrigation systems were "improved" by the Asian Development Bank about a decade ago. Improved with steel and concrete. I visited one of the projects. The villagers were unhappy. They could no longer control the flow of water and were no longer willing to maintain a system that the government had insisted on building in the first place. I remember one quick tour of the massive concrete headworks of one of these new structures: a farmer had put an offering of a tiny lump of rice on a leaf and left it on a concrete railing. The young engineers showing me the dam were embarrassed. They were looking through the eyes of British engineers they had never even heard of.

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