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THE GREAT HIMALAYAN WATERSHED

Agrarian Crisis, Mega-Dams and the Environment

Since we tend to take water for granted, it is almost always a bad sign when it is in the news; and lately there has been all too much water-related news from some of Asia's most populous nations.* The stories have ranged from the distressingly familiar—suicides of drought-hit Indian farmers—to the surprising: evidence that pressure from water in the reservoir behind the new Zipingpu dam may have triggered the massive Sichuan earthquake in May 2008, for example.[1] Meanwhile glaciers, which almost never used to make the news, are now generating plenty of worrisome headlines.

For almost half the world's population, water-related dreams and fears intersect in the Himalayas and on the Tibetan plateau. Other regions have their share of conflicting claims over water issues: Turkey, Syria and Iraq over the headwaters of the Tigris; Israel and its neighbours around the Jordan basin; the US and Mexico over the Colorado River; the riparian states of the Paraguay, the Parana or the Nile. But none combine the same scale of population, scarcity of rainfall, dependence on agriculture, scope for mega-dam projects and vulnerability to climate change as those at stake within the greater Himalayan region. Here, glaciers and annual snowmelts feed rivers serving just under half of the world's population, while the unequalled heights from which their waters descend could provide vast amounts of hydro-power. At the same time, both India and China face the grim reality that their economic and social achievements since the late 1940s—both 'planned' and 'market-based'—have

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GUANGDONG
Beijing
Tianjin
Shanghai
Wuhan
Chengdu
Zipingpu Dam
Three Gorges Dam
Diamer Bhasha Dam
Islamabad
New Delhi
Lhasa
Dhaka
Rangoon
Bangkok
Phnom Penh
Hanoi
Pearl River Delta
Yellow
Han
Yangzi
Xi Jiang
Minjiang
Jinsha
Tongtian
Lancang
Nu
Salween
Mekong
Irrawaddy
Brahmaputra
Yarlong Tsangpo
Ganges
Indus
Sutlej
Existing Dams
Proposed Dams
Western transfer route
Middle transfer route
Eastern transfer route
Indian IRP routes
Relief is shown for altitudes over 3,000 metres
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400 miles
Less than 20 inches rainfall per year

depended on unsustainable rates of groundwater extraction; hundreds of millions of people now face devastating shortages.

In response, plans are moving forward to harness Himalayan waters through the largest series of construction projects in human history. Looked at individually, some of these carry enormous risks and, even if they work as planned, will hurt large numbers of people while helping others. Looked at collectively—as overlapping, sometimes contradictory demands on environments that will also feel some of the sharpest effects of global warming over the next several decades—their interactions will be extraordinarily complex and their possible implications are devastating. Since many of the agencies responsible for these projects are far from transparent, it is very difficult to keep track of the rapidly multiplying future scenarios. But some basic outlines do emerge if we start from China—for various reasons, the most dynamic actor in the story—and then survey the broad belt of lands that border it to the south.

Chinese shortages

Water has always been a problem in China, and effective control of it has been associated with both personal heroism and legitimate sovereignty for as far back as our records go—or perhaps even further, since the mythological sage-king Yu proved his right to rule by controlling floods. But water scarcity has perhaps been an even greater problem than excess, especially in the modern period. Surface and near-surface water per capita in China today is roughly a quarter of the global average, and worse yet, it is distributed very unevenly. The north and northwest, with about 380 million people, almost 30 per cent of the population, and over half the country's arable land, have about 7 per cent of its surface water, so per capita resources there are roughly 20–25 per cent of the average for

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* I would like to thank Mark Selden and Mark Elvin for their comments on this piece.

[1] Sharon LaFraniere, 'Possible Link Between Dam and China Quake', *New York Times*, 6 February 2009; Richard Kerr and Richard Stone, 'A Human Trigger for the Great Quake of Sichuan?', *Science*, January 2009; Lei Xinglin, Ma Shengli, Wen Xueze, Su Jinrong and Du Fang, 'Dibiao shuiti dui duanceng yingli yu dizhen shikong fenbu yingxiang de zonghe fenxi: yi Zipingpu shuiku wei li', *Dizhen Dizhi* [*Seismology and Geology*], vol. 30, no. 4, December 2008. A number of scientists had warned several years ago that the reservoirs of the Three Gorges Dam might trigger earthquakes, though on a much smaller scale than the quake that Zipingpu may have caused. See Gavan McCormack, 'Water Margins: Competing Paradigms in China', *Critical Asian Studies*, vol. 33, no. 1, March 2001, p. 13.

China as a whole, and less than 6 per cent of the global average.[2] Northern waters also carry heavier sediment loads: most readings on southern rivers fall within EU maxima for drinking water, while some on the Wei, Yongding and the middle and lower Yellow Rivers are 25 to 50 times that level; water shortages are such that northern rivers also carry far more industrial pollutants per cubic meter, even though the South has far more industry.[3] Northern China has unusually violent seasonal fluctuations in water supply, too; both rainfall and river levels change much more over the course of the year than in Europe or the Americas. North China's year-to-year rainfall fluctuations are also well above average, although not as severe as those in north and northwest India. While the most famous of China's roughly 90,000 large and medium-sized dams are associated with hydro-power—about which more below—a great many exist mostly to store water during the peak flow of rivers for use at other times.

The People's Republic has made enormous efforts to address these problems and achieved impressive short-term successes, which are now

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[2] Such numbers vary depending on definitions of regions and ways of measuring water supply, but not enough to affect the general conclusions. Here I define 'north and northwest China' to include the provinces of Hebei, Shandong, Shanxi, Shaanxi, Henan and Gansu, plus Beijing and Tianjin municipalities; my figures are derived from Charles Greer, 'Chinese Water Management Strategies in the Yellow River Basin', PhD dissertation, University of Texas at Austin, 1975, p. 96. For comparison see: Olli Varis and Pertti Vakkilainen, 'China's Eight Challenges to Water Resources Management', *Geomorphology* 41, 2001, p. 94, which defines the North China Plain as containing 34 per cent of China's population, 39 per cent of its arable land and 6 per cent of its river run-off; US Embassy in China, 'South–North Water Transfer Ready to Start Work', *Beijing Environment, Science and Technology Update*, 16 November 2001, p. 2, describes a larger North, containing 44 per cent of the population, 60 per cent of its arable land, and 15 per cent of its water; James Nickum, 'The Status of the South to North Water Transfer Plans in China', *Occasional Papers: Topical Background Research for the HDR*, gives estimates for the Huang-Huai-Hai plain of 33 per cent of population, 40 per cent of farmland and 8 per cent of water supply. The map labeled 'Water Resources Distribution in China' in Pan Jiazheng (Chinese National Committee on Large Dams), ed., *Large Dams in China: History, Achievements, Prospects*, Beijing 1987, makes the regional disparities look even larger. Mark Elvin, 'Water in China's Past and Present: Cooperation and Competition', *Nouveaux Mondes* 12, 2003, pp. 117–20, improves on some of these numbers by incorporating estimates for groundwater as well as surface water resources, but the basic regional distinctions remain of similar magnitude. His total 'north' would include 46 per cent of China's population, with just below 15 per cent of all available water resources, and thus about 20 per cent of the per capita supplies.

[3] Elvin, 'Water in China', pp. 124–5.

extremely vulnerable. Irrigated acreage has more than tripled since 1950, mostly during the Maoist period, with the vast majority of those gains coming in the north and northwest. It was this, more than anything else, that turned the notorious 'land of famine' of the 1850–1950 period into a crucial grain-surplus area, and contributed mightily to improving per capita food supplies for a national population that has more than doubled since 1949. Irrigation made it possible for much of northern China to grow two crops a year for the first time in history, often by adding winter wheat, which needs a lot of water; and plentiful, reliable supplies of water were necessary to allow the use of new seed varieties and chemical fertilizers, which can otherwise burn the soil. And, of course, irrigation greatly reduced the problem of rain coming at the wrong time of year, or not at all. During the previous two centuries, farming in northern China had become steadily more precarious, in part because population growth had lowered the water table—early 20th-century maps show much smaller lakes than 150 years before, and there are many reports of wells needing to be re-drilled at great expense—and in part because the safety net the Qing had once provided fell apart. But beginning in the 1950s and—after the setbacks of the Great Leap Forward—especially in the 1960s, things turned around very impressively.

Much of that turnaround, however, relied on very widespread use of deep wells, employing gasoline or electrical power to bring up underground water from unprecedented depths.[4] Large-scale exploitation of China's northern groundwater began in the 1960s and peaked in the 1970s, at roughly ten times the annual extraction rates that prevailed during 1949–61; it has remained steady since about 1980 at roughly four times the 1949–61 level.[5] But this amount of water withdrawal is unsustainable. The North China water table has been dropping by roughly 4–6 feet per year for quite some time now, and by over 10 feet per year in many places; if this rate of extraction is maintained, the aquifers beneath the plain will be completely gone in 30–40 years, according to

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[4] For one of many accounts of the tubewell revolution in North China see Charles Greer, *Water Management in the Yellow River Basin of China*, Austin, TX 1979, pp. 153–60. Greer notes that, as far back as 1959, Soviet engineers had seen a vast increase in groundwater exploitation as the only alternative to diverting southern waters to the north.

[5] Eloise Kendy, Tammo Steenhuis and David Molden, 'Combining Urban and Rural Water Use for a Sustainable North China Plain', First International Yellow River Forum on River Basin Management, Zhengzhou, 12–15 May 2003.

some estimates.[6] This is by no means a unique situation. In the United States, for instance, the Ogallala Aquifer—which lies beneath portions of western South Dakota, Nebraska, Kansas, Oklahoma and Texas, and eastern Wyoming, Colorado and New Mexico—is being depleted at roughly the same rate. Serious excess withdrawals began there in the 1950s, and as in China, turned areas previously marginal for farming—the land of the 1930s Dust Bowl—into a bread-basket. But while the 175,000 square miles served by the Ogallala Aquifer are home to less than 2 million people, the 125,000 square miles of the North China Plain are home to over 214 million, 80 per cent of them rural.[7] The 2008 North China drought—the worst since the late 1950s drought that exacerbated the Great Leap famines—focused global attention on the problem for a brief moment, but chronic water shortages, both in cities and in the countryside, have been a fact of life for years, and conflicts over scarce or polluted water have become common events.[8] So, what is to be done?

Efficiency?

One hears periodically about inefficient water use in the cities: the Chinese steel industry, for instance, consumes about twice as much water per ton produced as steel-makers in the most technologically advanced countries (though the Indian steel industry is considerably worse than China's on this score).[9] Leaky pipes and other infrastructure

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[6] Jim Yardley, Jake Hooker and Huang Yuanxi, 'Choking on Growth: Water and China's Future', *New York Times*, 28 September 2007.

[7] Figures for the comparison come from: *China News Digest*, 21 May 1998; Eloise Kendy, David Molden, Tammo Steenhuis, Liu Changming and Wang Jinxia, *Policies Drain the North China Plain: Agricultural Policy and Groundwater Depletion in Luancheng County, 1949–2000*, International Water Management Institute, 2003. For the Ogallala Aquifer, see: Marc Reisner, *Cadillac Desert: The American West and Its Disappearing Water*, New York 1993, pp. 435–55; Manjula Guru and James Horne, *The Ogallala Aquifer*, US Geological Survey, National Water-Quality Assessment Program, 2000, pp. 1–12; US Geological Survey, *High Plains Regional Groundwater Study*, 2007.

[8] A figure of 51,000 pollution-related 'incidents' for 2005 alone is cited in 'Zhongguo shui wuran diaocha: bushi tianzai ershi renhuo', 15 August 2007, available at house.sina.com.

[9] For Chinese figures, see Shao Qiujun and Zhang Qun, 'Evaluation on Sustainable Development of China's Iron and Steel Industry', *2008 International Symposium on Information Processing*, p. 701; for an idea of Indian practices see Manipadma Jena, 'Steel City Tackles its Water Woes', Infochange India website, October 2004.

problems create considerable waste. But relatively speaking, industrial and urban residential losses are small potatoes; agriculture still uses at least 65 per cent of all water in China—though less, even in absolute terms, than 20 years ago—and has far worse efficiency rates.[10] The cities are certainly not the site of the greatest wastage in commercial terms: according to one estimate, a gallon of water sent from the countryside to Tianjin yields 60 times as much income in its new urban locale as it did in the countryside.[11] The best hope of moderating overall water demand is probably to keep per capita urban use from growing too much, and improve use-efficiency, even as the urban population expands. Certainly price increases—unless they are intolerably large—are unlikely to cause city dwellers to cut back much. Any significant reductions will have to come from the countryside. That process has begun, but it is unclear how far it can go without devastating social consequences.

A great deal of water is wasted in agriculture, in part because costs to farmers are kept artificially low; besides, since most rural communities have no way to market water to those who would pay more for it, 'waste' has very little short-run opportunity cost for them.[12] But it is worth noting here that 'waste' has different meanings depending on what time-frame one adopts. Irrigation water that does not reach the plants' roots, but seeps back into the soil, is wasted in the short term—it cannot be used for anything else that year; but in the long term, it can help recharge the local aquifer. On the other hand, polluted water that could be recycled if treated properly, but instead flows out to sea untreated, is 'waste' in both senses and thus represents a bigger problem. Chinese agriculture is not necessarily more wasteful with irrigation water than that of many other countries—and the deviations from market prices are no greater than in the supposedly market-driven United States—but its limited supplies make waste a much more pressing problem.

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[10] Li Zijun, 'China Issues New Regulation on Water Management, Sets Fees for Usage', WorldWatch Institute, 14 March 2006. Elvin, 'Water in China', p. 113, citing 1990s data, suggests that between 84 and 88 per cent of water is used in agriculture. If we put these sources together, agricultural water use seems to have fallen almost 20 per cent since the late 1980s, without a decline in yields.
[11] Sandra Postel, 'China's Unquenchable Thirst', *World Watch*, vol. 20, issue 6, Nov–Dec 2007. Lower figures have been suggested, but none go below 20 times more income.
[12] If they could, they would almost certainly find ready buyers and thus ease urban shortages; but as we will see in examples from India, the results can exacerbate problems of unsustainable water withdrawal.

Technologies that would reduce water waste do exist, but many are so costly that farmers are unlikely to adopt them unless they are subsidized. Centre-pivot irrigation systems, for instance, can save a lot of water, but at roughly $35,000 each—almost 60 years' income for an average north China farmer—they make sense only for the largest farms; they are also poorly suited to the geometry of existing fields, and to the requirements of rice and some other crops. Drip irrigation, sometimes called micro-irrigation, is another technological fix that has been greeted enthusiastically by many analysts despite being relatively expensive. The idea is that water is moved through small plastic tubes directly to the plants' roots, so that much less of it is wasted; it has been a huge success in Israel, where it was first developed, and in various other water-scarce environments.

More recently, however, doubts have been raised about its benefits, in large part because of the ambiguity of 'waste' mentioned above. Since drip irrigation makes sure that a higher percentage of the water gets to the plants' roots, it will enable a fixed water source—for instance, an above-ground tank catching winter rains for use in the spring—to irrigate more crops than if the water were distributed through traditional ditches or less precisely targeted sprinklers. Alternatively, one could irrigate the same size of crop, and have some water to sell to other users. But where the water source is an underground aquifer, which can be overdrawn and permanently depleted, the benefits become less clear. In that situation, much of the water that seeps away through the bottom of ditches helps replenish the aquifer and is not necessarily 'wasted' from a long-term perspective. On the other hand, precisely because drip irrigation means that almost every gallon of water a farmer buys will help the crops in the current year, it is a 'better buy' for him than water run through a less 'efficient' system; he is therefore tempted to buy more of it.

Thus, drip irrigation may be good for maximizing immediate food output, while actually exacerbating longer-run water shortages in places like northern China—or, as we shall see, much of northern India and Pakistan—where overuse of groundwater is a big problem. This possibility is not merely a theoretical one; a recent study of drip irrigation in the Upper Rio Grande Valley, on both sides of the US–Mexico border, came to the conclusion that it increased water use in precisely this way.[13] In short, selectively implemented high-tech solutions may help in some ways, but

[13] Frank Ward and Manuel Pulido-Velazquez, 'Water Conservation in Irrigation can Increase Water Use', *Proceedings of the National Academy of Sciences*, vol. 105, no. 47, 25 November 2008.

they cannot provide a total answer to China's problems—even if all the funding for them could be found.

Ironically, low-tech water-efficiency solutions may have greater potential. It is almost impossible to get a clear sense of how much water could be saved by simple measures such as re-lining or covering irrigation ditches, fixing leaky pipes, and so on. The amounts are probably very big, given the low quality of much of the water infrastructure in China and elsewhere. But these measures also cost money; most farmers or rural communities are unlikely to invest in them without subsidies or greater incentives. More effective pollution control—some, though not all, of which is possible with fairly simple and relatively inexpensive technologies—could also help enormously; but here, too, there are serious incentive problems. Local officials generally have more to gain by protecting local factories and jobs than by conserving water; especially, of course, the water of people downstream.

More commercial pricing of irrigation water would help provide such incentives—but here there are serious social and political constraints. More expensive water would almost certainly mean decreased agricultural output. Of course, China has enough foreign currency to buy food abroad, but the government is reluctant to become more dependent on imports. Dearer water might be particularly bad for the many farmers who have been switching from grain production to fruit and vegetables—crops that it otherwise makes sense for China to produce more of, since they demand much more labour per acre than grain, and can produce relatively high incomes for people with small plots. And even if Beijing, and the rest of the world, were content to see Chinese demand for imported food rise significantly, there is the question of what would become of the farmers themselves in such a scenario. Their incomes already lag far behind those of other Chinese workers. Any significant rise in water prices would probably drive millions of marginal farmers to the wall, and greatly accelerate the already rapid rush of people to the cities. Consequently, further water savings in agriculture, though vital, potentially huge, and far less environmentally risky than large water-moving projects, are likely to come slowly and painfully.

Transfers

Under the circumstances, many officials see no alternative to technologically ambitious mega-projects: above all, the South-to-North Water

Transfer Project. The idea behind this $65 billion plan—tossed around for decades before being officially green-lighted in 2001—is simple: to take water from the Yangzi and its tributaries and move it to North China, where water is much more scarce. But implementing the scheme is extraordinarily difficult, and the consequences of any one of several possible failures could be enormous.[14] If completed, the Transfer will be the largest construction project on earth. It would carry almost 45 billion cubic metres of water per year—roughly the average annual flow of the Yellow River.[15] It has three parts:

1) An Eastern Route Scheme, which would take water from the Lower Yangzi in Jiangsu province up to Tianjin, roughly following the route of the Ming-Qing Grand Canal, and, via a branch line, to the Shandong peninsula. This is technologically the simplest part of the project—though it still raises plenty of questions. Parts of it began operation in 2008; it is scheduled to be completed in 2010.

2) A Middle Route Scheme, running from near the Three Gorges Dam in Sichuan to Beijing. Work on this route has recently been suspended in response to environmental problems, which have proved to be more complicated than was originally foreseen, and to resistance to relocation by people in the path of the project. (There were large protests in March 2009 near Danjiangkou in Hubei, where over 300,000 people are scheduled to be moved.[16]) Still, the official projection is that water will be reaching Beijing through this route by 2014.

3) A Western Route Scheme that is really two routes, taking water from the Yalong Zangbo (Yarlung Tsangpo), Dadu, Tongtian and Jinsha Rivers—all of which flow into the Yangzi—across

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[14] A good description of the project in English is Liu Changming, 'Environmental Issues and the South–North Water Transfer Scheme', *China Quarterly* 156, December 1998, pp. 900–4. See also McCormack, 'Water Margins', pp. 19–20; US Embassy in China, 'South–North Water Transfer Ready to Start Work', pp. 1–2; Nickum, 'Status of the South-to-North Water Transfer'.

[15] 'South-to-North Water Transfer Project', Ministry of Water Resources website.

[16] See Chris Buckley, 'China's Giant Water Scheme Creates Torrent of Discontent', *Reuters*, 27 February 2009; Michael Bristow, 'Delays Block China's Giant Water Scheme', BBC News, 8 February 2009; Shai Oster, 'Water Project in China is Delayed', *Wall Street Journal*, 31 December 2008.

> mountains and the Tibetan plateau, and directing it into the Yellow River, which would then carry it across North China. This is by far the most complex part of the project; work is currently scheduled to begin in 2010, but it would not be completed until 2050.

The Transfer carries uncertainties commensurate with its size and cost. Among other things, there is considerable uncertainty about how dirty the southern waters will be by the time they arrive in the north. Diversions on this scale change flow speeds, sedimentation rates and other important qualities in unpredictable ways, and the original plans have already been modified to add more treatment facilities than were originally thought necessary. Changes in water volume will also affect the ability of other rivers to scour their own beds—effects on the Han River, one of the Yangzi's largest tributaries, are a particular concern. Conveyance canals passing through poorly drained areas may also raise the water table, add excess salts to the soil—already a common problem in irrigated areas of North China—and increase salt-water intrusion rates in the Yangzi Delta.[17] For better or worse, we will begin learning about the effects of the Eastern Route soon, and probably about the Middle Route in just a few years.

But despite its long time horizon, it is the Western Route—along with other projects in China's far west—which is the big story. First of all, it offers the most dramatic potential rewards. The idea is that it will tap the enormous water resources of China's far southwest—Tibet alone has over 30 per cent of the PRC's fresh-water supply, most of it coming from the annual snow and glacier melts in the Himalayas. These water resources are an aspect of the Tibet question one rarely hears about, but the many engineers in the CCP leadership, including Hu Jintao and Wen Jiabao, are very aware of it. Chinese citizens are increasingly conscious of it, too—advertisements for bottled Tibetan water now adorn the backs of train seats and other sites, offering an icon of primitive purity of a type long familiar to Western consumers. Hydro projects in this mountainous region can offer enormous yields in electricity, as well as in water supply. The amount of power that water can generate is directly proportional to how far it falls into the turbines: the Yangzi completes 90 per cent of its drop to sea level before it even enters China proper, and the Yellow River 80 per cent of its descent before it leaves

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[17] Liu, 'South–North Water Transfer Scheme', p. 905.

Inner Mongolia.[18] In April 2009, the Chinese government announced plans for twenty additional hydro projects on the upper Yangzi and its tributaries; if completed, these would theoretically increase the already existing hydro-power capacity on the river, which includes the Three Gorges Dam, by 66 per cent.[19]

Yet the Western Route also poses by far the biggest complications—and not simply because the engineering challenges are the most complex and the solutions most untested. It is here, and in nearby Yunnan, that the needs of agrarian and industrial China collide most directly with the lives of Tibetans, Yi, Miao and other minority groups. It is here that the environmental risks of dam-building become major *international* issues, with enormous implications for the Mekong, Salween, Brahmaputra and other rivers upon which hundreds of millions of people in the Subcontinent and Southeast Asia rely. And it is here that major water projects—which always include many uncertainties—collide with what has always been an extraordinarily fragile environment, and one which now faces far more than the average amount of extra uncertainty from climate change. Tibet, home to by far the largest glaciers outside the two polar regions, is expected to warm at twice the average global rate during the 21st century.[20]

Dam-building in Tibet

Although the PRC built plenty of dams between the 1950s and the mid-1980s, relatively few of them were in the far west. This may seem surprising given the concentration of hydro potential in that region, but makes sense in other terms. The need to maximize energy production was less urgently felt before the boom of the 1990s, and there was much less concern about relying on coal, which still provides 80 per cent of China's electricity.[21] Many of the dams were constructed

[18] On the Yangzi, see Tao Jingliang, 'Features of the Three Gorges Reservoir', in Joseph Witney and Shiu-hung Luk, eds, *Mega-Project: A Case Study of China's Three Gorges Project*, Armonk, NY 1993, p. 68; Lyman Van Slyke, *Yangtze: Nature, History and the River,* Reading, MA 1988, p. 15. On the Yellow River, see *Huanghe shuili shi shuyao*, Beijing 1982, pp. 4–7.

[19] Calculated from figures gathered in Li Jing, 'Yangtze hydro projects to get a boost', *China Daily*, 21 April 2009.

[20] Timothy Gardner, 'Tibetan Glacial Shrink to Cut Water Supply by 2050', *Reuters*, 6 January 2009.

[21] Keith Bradsher, 'China Outpaces US in Cleaner Coal-Fired Plants', *New York Times,* 10 May 2009.

by mobilizing large amounts of labour—especially off-season peasant labour—in place of scarce capital: it was a lot easier to deploy those workers close to home than to send them far away. The supporting infrastructure—roads, for example—and technology for dam-building in remote mountain locations were not available; the far reaches of the upper Yangzi were not even surveyed until the late 1970s. The central government was also more ambivalent about rapid development in the far west than it is today; leaders tended towards more paternalistic policies, avoiding radical cultural change, as offering the best formula for political stability there.

But in the last two decades all this has changed, leading to a sharp shift towards huge dam-building projects in Yunnan and, above all, Tibet. The technical capacities and supporting infrastructure needed for capital-intensive projects in these areas are now available. The pressure to increase domestic supplies of both energy and water has become intense. In addition, the regime has clearly decided that raising incomes in the far west is the best way to keep control and make use of those territories—even if the wrenching cultural changes, massive Han immigration and severe inequalities accompanying this development increase conflict in the short to medium term. For better or worse, the kind of paternalism previously apparent in western frontier policy—dating back to at least the Qing, though it has been gradually weakening for a long time—is now being decisively abandoned. Meanwhile, changes in the relationships between central government, provincial governments and private investors have helped create enormous opportunities to gain both power and profit through accelerated dam-building.

Plans to 'send western electricity east', with a particular focus on developing Yunnan hydro-power for booming Guangdong, date back to the 1980s; seasonal deliveries of power first arrived in 1993. From 2001, Guangdong officials began concluding deals for regular annual power purchases with the authorities in Yunnan. At the same time, officials in Beijing began vetoing plans for additional coal-fired power plants in Guangdong, which made hydro-power an absolute necessity for the rapidly growing Pearl River Delta.[22] It is not clear, at least not to me,

[22] Darrin Magee, 'Powershed Politics: Yunnan Hydropower under Great Western Development', *China Quarterly* 185, March 2006, pp. 25–6; Grainne Ryder, 'Skyscraper Dams in Yunnan', Probe International, 12 May 2006, p. 3.

exactly what the relationship is between provincial and central government power in this story. One can see wealthy Guangdong reaching out to secure its own energy supplies here; but complaints from Guangdong about Beijing preventing the construction of power plants in the province, and about power shortages when sufficient hydropower failed to come online on time, suggest that new inter-provincial agreements may often be shotgun weddings imposed by the centre, for whom the opportunity to create these configurations offers a means of both maintaining leverage over coastal boom areas and of integrating peripheral regions more deeply into the Beijing vision of a national political economy.

More generally, what has been called the 'corporatizing' of the Chinese electrical power industry has created complex webs of public and private actors with strong interests in southwestern hydro development.[23] In 2002 the government-owned State Power Corporation of China was broken into five corporations, each with exclusive development rights over particular watersheds (a sixth, connected to the Three Gorges, is directly under the State Council). These corporations are state-owned, but have created partly-owned subsidiaries which can sell shares to private investors on the Shanghai, Hong Kong and New York stock exchanges, thus raising capital while retaining control. For investors, meanwhile, power-generation stocks provide a way to bet on the Chinese economy in general, without needing accurate information on the prospects for any particular manufacturers. These subsidiaries, in turn, have combined with other subsidiaries of the big five, or with companies established by provincial governments, to set up still other firms that undertake particular projects.

While this system allows dam-builders to take advantage of private capital markets and corporate organization, their links to the state remain crucial. Huaneng Power Group, which holds development rights for the Lancang/Upper Mekong, was until recently headed by Li Xiaopeng, son of former Premier Li Peng, a chief advocate of the Three Gorges project. (The younger Li, who like so many other Chinese leaders has a background

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[23] Magee, 'Powershed Politics', p. 35. For a useful timeline of China's electrical power reforms, see the working paper by John Dore and Yu Xiaogang, 'Yunnan Hydropower Expansion', Unit for Social and Environmental Research, Chiang Mai University, March 2004, p. 13.

in engineering, has now moved on to become Deputy Governor of Shanxi, with responsibility for industry and coal mining.[24]) In setting up a subsidiary, the parent company will often endow it with important assets—generators, transmission lines, development rights—in return for a large stake in the new business; since well-developed markets for these assets rarely exist, and the state-owned parent company does not face the same pressures to be profitable as the subsidiary, the prices at which they are transferred can easily be manipulated to lower the costs (and increase the profits) for the subsidiary and its investors. And since all these firms continue to do business with each other—sending power over another company's lines, for instance—there are many opportunities to transfer costs back and forth between entities that need to show a profit and those that do not, or which are less favoured by powerful actors.[25] Government connections also make it easier for these companies to avoid acknowledging—much less bearing—the full social and environmental costs of their work.

Last but not least, the large and sometimes unpredictable fluctuations in water volumes far upstream mean that the turbines will not always be fully utilized, so that the actual amount of power generated may be much less impressive than the enormous figures for 'installed capacity' listed for these projects; uncertainties which holders of development rights seeking either investment partners or permission to build have no incentive to highlight.[26] This does not mean, of course, that dams—including large ones—may not make economic and even environmental sense in some cases, given China's limited options. It does mean, however, that in a number of instances dams are almost certainly being built for political motives, or as a result of profit-seeking by those with government connections, where even a narrowly economic analysis would not justify them.

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[24] Yang Lifei, 'Li Xiaopeng Named Deputy Governor of Shanxi', *Shanghai Daily*, 12 June 2008; Xinhua Economic News Service, 'Li Xiaopeng Appointed Vice Governor of Shanxi Province', 12 June 2008.

[25] Grainne Ryder raises doubts about the economic rationality of Three Gorges and various Yunnan hydro projects on this basis: see 'Skyscraper Dams', pp. 5–6, and 'China's New Dam-Builders and the Emerging Regulatory Framework for Competitive Power Market', draft paper presented on the Mekong Programme on Water Environment and Resilience website, 6–7 July 2006.

[26] Mark Elvin concludes that 'in engineering terms, the better opportunities for hydro-electric power have already been used up': 'Water in China', p. 125.

Even the water-engineering projects that will genuinely help millions in northern and eastern China—and perhaps others, if they serve to curb the country's carbon emissions and future food imports—have serious implications for people who live in the regions where they will be built. Tibetans and other ethnic minorities in the far southwest are likely to be the most affected. In May 2009, an unconfirmed report by the Tibetan government-in-exile stated that at least six Tibetan women were injured when security forces opened fire on them as they protested against a hydro project on the Tibet–Sichuan border.[27] One issue here is that of human tampering with lakes and rivers that Tibetans hold sacred, such as the large dam at Yamdrok Tso.[28] A massive dam—40,000 megawatts, or almost twice the capacity of Three Gorges—proposed at the great bend in the Yalong Zangbo would again wreak a dramatic transformation on a holy site, in order to create power and water supplies that would mostly go to far-away Han Chinese.

Meanwhile, the project poses serious risks for the traditional livelihoods of many people. Road-building and railway-building—particularly the Qinghai–Tibet highway and the railroad that runs near it, completed in 2006—seem to have substantially degraded the permafrost layer in adjacent areas; the permafrost, in turn, protects a series of underground lakes, so that damaging it is likely to exacerbate an already worrisome drying trend in the region. A Chinese surveying team recently reported that some of the sources of the Yangzi itself are drying up, and the area is turning to desert. Wetlands and grasslands that are important to the large numbers of livestock herders in Tibet have already shrunk quite significantly; this is likely to accelerate the process. Existing dams in Yunnan appear to be interfering with local fisheries, and new ones pose significant threats to China's greatest concentration of biodiversity.[29] Since much of

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[27] '6 Tibetans Seriously Wounded in Protests Against China's Hydro-Electric Dam Project', Central Tibet Administration website, 26 May 2009.

[28] On Yamdrok Tso, see *Death of a Sacred Lake*, London 1996, produced by the Free Tibet Campaign (UK).

[29] 'Permafrost Soil in Yangtze River Area Disappearing', Xinhua News Agency, 13 February 2009; for the Chinese survey see Yang Jibin, 'Changjiang zai zheli shizong le', *Nanfang zhoumo*, 18 February 2009, available on the infzm.com website. The desertification of the wetlands is the subject of an informative video on the Asia Society website: 'Origins of Rivers: Omens of a Crisis'. A recent UN report refers to the area as 'one of the most biodiverse and least disturbed temperate ecosystems in the world', while noting plans to build 28 dams nearby: World Conservation Monitoring Centre, 'Three Parallel Rivers of Yunnan Protected Areas', pp. 1, 4–6.

this region is seismically active, the risk of an earthquake precipitating a catastrophic dam failure and sudden floods cannot be dismissed.

South of the mountains

Hundreds of millions of people further downstream also depend on rivers that start in the Himalayas, of course. States to China's south that also have ambitious plans to harness their waters are worried that Chinese initiatives may preempt their own current or future usage. The massive hydroelectric dam and water-diversion scheme on the great bend of the Yalong Zangbo River is a case in point. The 40,000 megawatt hydro project is itself a huge issue. But what matters more for people south of the Himalayas is that the plan not only calls for impounding huge amounts of water behind the dam, but for changing the direction in which the water flows beyond it—so that it would eventually feed into the South-to-North Transfer project. That water currently flows south into Assam to help form the Brahmaputra, which in turn joins the Ganges to form the world's largest river delta, supplying much of the water to a basin with over 300 million inhabitants. While India and Bangladesh have worried for some time that China might divert this river, Beijing has repeatedly denied any such intentions. But rumours persist that a diversion project is in fact underway, and Indian premier Manmohan Singh is said to have raised the question of river boundaries in his January 2008 visit to Beijing. The latest Chinese denial was issued by former water minister Wang Shucheng this May.[30]

In 1999, Wen Jiabao, then Vice-Premier, told a meeting of Chinese scientist and engineers that water scarcity threatened the 'very survival of the Chinese nation'. Water is indeed a matter of survival, but not just for China. Most of Asia's major rivers—the Yellow, the Yangzi, the Mekong, Salween, Irrawaddy, Brahmaputra, Ganges, Sutlej and Indus—draw on the glaciers and snowmelt of the Himalayas, and all of these except the Ganges have their source on the Chinese side of the border, in Tibet. In many cases, no international agreements exist for sharing these waters, or even exchanging data about them. There are urgent water problems

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[30] See respectively 'Plan to Open Two More Trade Points with China', *Hindustan Times*, 21 November 2006; 'India Quakes over China's Water Plan', *Asia Times Online*, 9 December 2008; 'China won't divert world's highest river to thirsty north', Xinhua News Service, 25 May 2009. Unconfirmed reports from 2000 suggested that Beijing had already decided to go ahead, but not until 2009, when the Three Gorges project would be finished: McCormack, 'Water Margins', p. 18.

throughout South and Southeast Asia, but their nature varies as one travels from west to east. Pakistan and much of northern India face grave shortages of water for agriculture and daily domestic use, as well as poor provision of rural power. For many people the latter problem intensifies the former, as it makes the operation of deep wells increasingly impractical; but in the longer run, easing the power deficit without solving the water-supply crisis will just intensify future shortages. By contrast, in most of Southeast Asia there is plenty of water, for now; but electricity is in short supply, and plans to alleviate that problem through hydro-power threaten delicate riverine ecosystems.

Pakistan may be more dependent on irrigation than any large nation on earth. Over half of the country receives less than 8 inches of rainfall per year; by way of comparison, Phoenix averages 8.4 inches; only 8 per cent of Pakistan gets over 20 inches—the amount that falls in Tel Aviv. Yet the country is predominantly agricultural, and almost 80 per cent of its farming requires irrigation. As recently as 1990, irrigation accounted for a stunning 96 per cent of water use. As much of the groundwater is brackish or badly polluted, people often rely on diversions from irrigation canals to get water for their daily needs.[31] Agriculture remains central to the economy, and there are even plans, backed by foreign investors, for a sharp increase in grain exports, mostly to the Middle East.[32] Efforts to improve irrigation efficiency are underway, but the government is also looking for ways to engineer large increases in supply.

Northern and northwestern India are not quite as dry as Pakistan, but nonetheless have millions of farmers, several arid regions and highly irregular, often inadequate rains. For India as a whole, the per capita water supply is about a quarter of the global average, as for China. Moreover, half the annual rainfall comes in 15 days, and 90 per cent of total river flow comes during four months. Yet India has built only a fifth of the water-storage capacity per capita that China has, and about 4 per cent of that of the US or Australia. Canals for surface irrigation were built in some areas under the British, and on a considerably larger scale after Independence; but many have been poorly maintained or only serve those with political influence. In northern and northwestern India, probably even more than in northern China, well-digging has been

[31] For these data, see P. K. Jensen, W. Van Der Hoek, F. Konradsen and W. A. Jehangir, 'Domestic Use of Irrigation Water in Punjab', WEDC Conference, Islamabad 1998.
[32] Shripad Dharmadhikary, *Mountains of Concrete: Dam Building in the Himalayas*, Berkeley 2008, p. 8.

essential to enable farmers to survive. It has also underlain the 'green revolution' which has raised agricultural production enough to keep up with the enormous population growth of the last half-century; the high-yielding hybrid wheat, rice and cotton seeds on which this was based all requiring more water than older varieties. Groundwater now provides 70 per cent of India's irrigation needs, and close to 80 per cent of water for domestic use.[33]

This aggressive exploitation of groundwater is unsustainable. Well water is free to any farmer who can reach it by digging down on his land; the electricity to run the pumps is heavily subsidized, straining the budgets of many Indian states.[34] Even at low prices, however, energy costs have become a huge burden for many small farmers, as water levels drop and pumps must work harder; moreover, irregular electricity supplies, with frequent spikes and interruptions, can often ruin pumps, wreaking sudden devastation on unlucky farmers. The large inequalities in landholding within many Indian villages—much more pronounced than in rural China—are a further complication. Richer farmers have every reason to drill deeper wells, take more water from aquifers, and resell whatever they do not use themselves at high mark-ups to people without wells, for domestic use; indeed, this is often more profitable than using the water to raise crops. Other farmers then also need to dig deeper, in response; as a result a tube-well race has developed, depleting aquifers even faster. Suicides of farmers who cannot get enough water to continue planting have become common in recent years, including instances of protest by mass suicide.[35] Some of these protests have been

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[33] For water supply see G. Karakunan Pillai, 'Interlinking of Rivers in India: Objectives and Plans', in Anil Kumar Thakur and Pushpa Kumari, eds, *Interlinking of Rivers in India: Costs and Benefits*, New Delhi 2007, p. 3; in the same collection, Shashi Bala Jain, 'Interlinking of Indian Rivers: A Viewpoint', p. 24. For irrigation see John Briscoe, *India's Water Economy: Bracing for a Turbulent Future*, World Bank draft report, 2005, pp. 4, 14–23, 41–5. Briscoe emphasizes that better maintenance and operation of existing facilities is now a more urgent need than further construction, but that the required shift in resources has not occurred.

[34] Briscoe, *India's Water Economy*, pp. 23–4, gives figures relative to the fiscal deficits of various Indian states. Daniel Pepper, 'India's Water Shortage', *Fortune*, 24 January 2008, puts the cost to the electrical power industry of subsidizing farmers at $9 billion per year.

[35] Sean Daily, 'Mass Farmer Suicide Sobering Reminder of Consequences of Water Shortages', *Belfast Telegraph*, 15 April 2009. The story refers to a recent mass suicide of 1,500 farmers, and an estimate that 200,000 farmers have committed suicide (presumably not all as a protest gesture) over a period of 12 years.

aimed at state governments that have raised electricity prices too high for many farmers to manage, although the rates are still far below those charged to city dwellers. Some are also aimed at corporate users and polluters of water—Coca-Cola has been a popular target.[36]

There is also increasing concern that water scarcity and pollution could create dangerous shortfalls in agricultural output, especially in the Indian state of Punjab—which produces the country's largest agricultural surpluses, including roughly half the wheat and rice procured by the central authorities to stabilize prices—and in neighbouring Pakistan.[37] The pollution, bad enough to cause large increases in birth defects and cancer, has many sources, including the legacy of years of intensive irrigation, fertilization and pesticide use. Salination and water-logging, which also increases the incidence of malaria, have been mounting problems in the Punjab since the introduction of year-round irrigation by the British at the end of the 19th century.[38] It is estimated that in East Punjab today, 50 per cent of groundwater is recycled water from irrigation canals; in West Punjab, 80 per cent. Near Karachi, where it reaches the sea, the Indus now often fills only a small fraction of its bed; fishing has disappeared, an invasion of sea-water is harming agriculture, and water for domestic use is desperately short.[39]

This crisis has been met with a proliferation of plans for new water projects. Though people are well aware that the unintended consequences of past projects have played a role in creating current difficulties, the prospect of losing the gains in agricultural output achieved through irrigation is terrifying, and possibilities for alleviating serious electricity shortages—

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[36] See, for instance, Georgina Drew, 'From the Groundwater Up: Asserting Water Rights in India', *Development* 51, 2008, pp. 37–41. Coca-Cola's defenders note that they pay a higher rate for the electricity with which they bring up water than do farmers; nonetheless, they are able to afford larger amounts of it, which lowers the water table and leaves less for farmers. Waste products from Coca-Cola plants have also been a source of controversy.

[37] See Government of Punjab Food, Civil Supplies and Consumer Affairs Department website; Dharmadhikary, *Mountains of Concrete,* pp. 8–9.

[38] Indu Agnihotri, 'Ecology, Land Use and Colonization: The Canal Colonies of Punjab', *Indian Economic and Social History Review,* vol. 33, no. 1, 1996, pp. 48–55; Mike Davis, *Late Victorian Holocausts,* London 2001, pp. 332–5 points to a number of problems with British irrigation projects in India (not just Punjab) that began appearing even in the late 19th century.

[39] Briscoe, *India's Water*, p. 22; 'Pakistan's Water Crisis', *PRI's The World,* 13 April 2009. Where the river used to be 5 km wide near Karachi, it is now only 200 metres.

which, among other things, inhibit manufacturing growth that could reduce reliance on agriculture—seem very tempting. And while many plans are driven by real needs, China is hardly the only country where political and economic interests create incentives to build mega-projects that are incomprehensible in terms of costs and benefits. In India, for instance, the central government's inability to enforce water-sharing agreements among the states has led some upstream states to build extra storage facilities, in order to hang onto water that is at least as badly needed downstream; meanwhile, some downstream states, despite desperate shortages, have balked at implementing water-saving measures that might weaken their claims to a larger allocation from rivers flowing through multiple states. And since only direct human employment of water counts as 'needs' for these allocations, any other uses—e.g. releasing water to help maintain estuarial ecosystems—count as 'waste' that might weaken future claims, and are thus discouraged.[40] (Water-sharing agreements between India and Pakistan have thus far been more consistently observed than have those among Indian states, despite decades of hostility between these countries.)

Unsurprisingly, the most ambitious new plans are for sites in the highest mountains. Pakistan, India, Bhutan and Nepal are all aiming to build huge dams in the Himalayas. Planned construction over the next decade totals 80,000 megawatts, compared to around 64,000 for the whole of Latin America; India alone plans to add a further 67,000 megawatts in the next decade. Like China, India exploited the hydro-power in its less mountainous areas first, and has only 11,000 megawatts of non-Himalayan potential left. Even excluding China, potential Himalayan capacity is a staggering 192,000 megawatts, almost half of it in India.[41] Meanwhile, India's 2001 census reported that 44 per cent of households had no access to electricity; the figure is about the same in Bhutan and closer to 60 per cent in Nepal. Interest in dam-building is just as intense in Pakistan, though there irrigation is a higher priority than electricity. However, the estimated cost of the projects planned for the next 10 years is roughly $90 billion, much of which remains unsecured. India has financing for slightly more than

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40 Briscoe, *India's Water*, pp. 37–8; Anju Kohli, 'Interlinking of Indian Rivers: Inter-State Water Disputes', in Thakur and Kumari, *Interlinking of Rivers in India*, pp. 287–92.

41 Dharmadhikary, *Mountains of Concrete*, p. 7. The world's installed hydro-electric capacity is currently around 675,000 megawatts: see National Renewable Energy Laboratory, *Power Technologies Energy Data Book*, Golden, CO 2005, p. 51.

half of its planned dam construction through 2012, but much less for needs through 2017. Pakistan has recently turned to Chinese financing and technical expertise for its Diamer Bhasha dam, a $12.6 billion project which was announced in 2006, but had trouble attracting capital. There has also been some financial support from Middle Eastern sources and various international development banks.[42]

Meanwhile, other foreign-backed plans will place additional strains on Pakistan's water supply. Investors from various wealthy but arid Middle Eastern states have recently been making large purchases of farmland, both in Pakistan and elsewhere in Asia and Africa. (South Korea and China have also been doing this, though not, as far as I know, in Pakistan.) The Pakistani Minister of Investment, seeking to dispel any fear that local farmers will be displaced, has said that all the 6 million acres up for sale or lease to foreigners—equal to roughly 10 per cent of the country's cultivated acreage—is currently unused.[43] If true, this means that any water devoted to it will represent an addition to existing demand. Indeed, a recent story in the *Economist* noted that many of these land deals seem to be aimed above all at the water rights that go with the land; it quotes the chairman of Nestlé referring to them as 'the great water grab'.[44]

Interlinking India's rivers

Since India, like China, is currently mining groundwater to produce grain surpluses in some of its vast dry regions, it may be no surprise that it, too, is contemplating a major scheme for water diversion. The most ambitious part of its Interlinking of Rivers Project, the Himalayan

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[42] Dharmadhikary, *Mountains of Concrete*, pp. 8–15. For Pakistani funding see also Ann-Kathrin Schneider, 'South Asia's Most Costly Dam Gets an Infusion', *World Rivers Review*, vol. 23, no. 4, December 2008, citing a consortium involving Chinese companies and 'some Arab countries'.

[43] Amena Bakr, 'Pakistan offers farmland to foreign investors', *Reuters*, 20 April 2009, and 'Pakistan Opens More Farmland to Foreigners', *Maktoob*, 17 May 2009. Pakistan had over 56 million acres under cultivation in 1997.

[44] 'Buying farmland abroad: Outsourcing's third wave', *Economist*, 23–29 May 2009. The International Food Policy Research Institute tracks these transactions, while noting that many appear to be kept secret: Joachim von Braun and Ruth Meinzen-Dick, '"Land Grabbing" by Foreign Investors in Developing Countries', available on IFPRI website, April 2009. Chinese purchases seem to be predominantly in Africa, and mostly with an eye to biofuel production.

section, would move water from the upper parts of the Ganges, Yamuna and Brahmaputra Rivers westward, ending in the Luni and Sabarmati Rivers in Rajasthan and Gujarat; Haryana and Punjab would also receive some of the water. The project's second—'Peninsular'—section would direct water to dry parts of Orissa and Tamil Nadu. And just as China seems to be retreating from its earlier assurances to India that it had no plans to divert water from the Yalong Zangbo–Brahmaputra, so this project suggests that India is hedging on its more formal promises to Bangladesh—including a written understanding of 1996—that no water would be diverted away from the Ganges above the barrage at Farakka, a few kilometers from the India–Bangladesh border.[45]

Some of the intermediate links would create shipping channels, and the project also aims to reduce seasonal flooding problems on the Yamuna, especially near Delhi. It is also supposed to generate 30,000 megawatts of net hydro-power—that is, power available for other uses after subtracting the energy needed for moving water. The main purpose, however, would be to provide large amounts of additional irrigation water, mostly in western India; official plans claim it could increase the total irrigated area by as much as 35 million hectares.[46] Official estimates for the cost of the total project, with 260 links between rivers, run at $120 billion, which would make it even bigger than China's planned river diversions. Based on subsequent comments by members of the task force that drafted the plan, one study has suggested a revised price tag of $200 billion.[47]

Plans for the project have been shrouded in a degree of secrecy unusual for India—even more so, it appears, than with China's river diversion

[45] Ramaswamy Iyer, 'River-linking Project: A Critique', in Yonginder Alagh, Ganesh Pangare and Biksham Gujja, eds, *Interlinking of Rivers in India*, New Delhi 2006, pp. 61–2; A. Muniam, 'Water Crisis in India: Is Linking of Rivers a Solution?', in Thakur and Kumari, *Interlinking of Rivers: Costs and Benefits,* p. 229; in the same collection, Debotpal Goswami, 'Linking of Major Rivers: the Case for Mighty Brahmaputra', pp. 297–8.

[46] Narendra Prasad , 'A Bird's Eye View on Interlinking of Rivers in India', in Thakur and Kumari, *Interlinking of Rivers: Costs and Benefits*, p. 19.

[47] See the map in Jayanta Bandyopadhyay and Shama Perveen, 'A Scrutiny of the Justifications for the Proposed Inter-linking of Rivers in India', in Alagh et al., *Interlinking of Rivers*, p. 30. For cost estimate, see Ashok Khosla's 'Foreword', p. 11, and for estimates of power generation, Iyer, 'River-linking Project', p. 57, in the same collection. See also Narpat Singh Rathore, 'Proposed Plan for Satluj–Ghaggar–Yamuna–Jojari–Luni–Sabarmati River Link channels', presented at Map India conference, January 2003.

projects. It is hard to get an estimate of the number of people likely to be displaced, though two scholars put the number as high as 5.5 million.[48] Parts of the plan that have been revealed have been sharply criticized on a number of grounds, and it is unclear what will end up being built. Aside from posing several technological and ecological questions about specific aspects of the projects, both domestic critics and a World Bank study have noted that the water transfers being contemplated are only politically feasible if enforceable legal agreements can be reached on allocating the waters and compensating the 'donors'; such accords have generally not fared well in India. There is also a widespread consensus that more water conservancy money needs to go into improving maintenance of existing facilities, rather than further construction. One scholar largely supportive of the Interlinking of Rivers Project estimates that net water availability would be increased just as much by a 20 per cent improvement in water-use efficiency (although he points to other benefits, including hydro-power, and favours doing both).[49] Some opponents, on the other hand, have suggested that the project would so deplete resources for other water-works that the latter might have to be privatized to raise cash, at considerable risk to poorer customers.

Environmental risks

Before considering some of the wider environmental risks associated with these water projects, it is worth noting that in the case of large dams, environmental uncertainties represent considerable financial risks for the dam-builders themselves. Such dams have huge construction costs, but very modest operating expenses once they are finished; thus they *can* become big cash cows once they are generating power—especially if, as seems likely in this part of the world, demand for electricity continues to rise. Profitability is therefore dependent on how long they continue generating power after completion. That period can be cut short by many factors, of which sedimentation may be the most common. Sanmenxia dam on the middle Yellow River, completed in 1962, is a particularly notorious example—not only because it failed quickly and expensively, but because many of the problems had been predicted.

[48] H. H. Uliveppa and M. N. Siddingappanavar, 'Interlinking of Rivers in India: Problems and Prospects', in Thakur and Kumari, *Interlinking of Rivers: Costs and Benefits*, p. 276.

[49] Krishna Nand Yadav, 'Interlinking of Rivers: Need of the Hour', in Thakur and Kumari, *Interlinking of Rivers: Costs and Benefits*, p. 71.

(The project went ahead anyway, in part it seems because, after the withdrawal of Soviet technical experts, China wanted to prove that it could build such a dam without outside help.[50]) Because interest must be paid on the construction costs, profitability is also affected by how much time elapses before its revenue starts to come on-stream. Mega-projects that take a long time to complete are thus especially vulnerable, economically speaking, to any shortfall in power generation.

Three factors, at least, could make the lives of these new projects shorter than anticipated. First, the Himalayas are comparatively young mountains with high rates of erosion, and their upper reaches have relatively little vegetation to hold soil in place—a situation exacerbated by deforestation in recent decades. This tends to make for high sediment burdens in rivers descending from the Himalayas. A 1986 study found that almost 40 per cent of the small hydro-dams built in Tibet since 1949 had become defunct or unusable by being silted up; similar problems have developed on a number of Pakistani dams, which have lost their capacity for seasonal water storage and irrigation, as well as power generation.[51] Ironically, this loss of storage capacity has become an argument for building more dams. Second, any errors in predicting future river flow can have dramatic effects on the durability of a dam, sharply reducing profitability. Long-run data on flow fluctuation are not available for many of the Himalayan rivers, and the Chinese government has not been very forthcoming about the figures it has assembled. But there are reasons, mostly connected with climate change, to think that the future may be drier than the last few decades, especially in the western Himalayas (though there are also some reasons to believe the opposite). And it becomes exponentially harder to model future river flows when a great many large projects are being planned on the same set of rivers and tributaries. Several analysts of India's Interlinking of Rivers have questioned whether the Brahmaputra basin—a critical water source for this project—can be meaningfully considered to have a water 'surplus' even now; the likelihood (in their view) of a major Chinese diversion

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[50] On Sanmenxia, see Pomeranz, 'The Transformation of China's Environment, 1500–2000', in Edmund T. Burke III and Kenneth Pomeranz, eds, *The Environment and World History 1500–2000*, Berkeley 2009, p. 138.

[51] Free Tibet Campaign, *Death of a Sacred Lake*, p. 7; Wang Xiaoqiang and Bai Nianfeng, *The Poverty of Plenty*, p. 89; and Dharmadhikary, *Mountains of Concrete*, p. 28.

upstream and of glacial retreat due to global warming make the idea that any water is available to be transferred extremely dubious.[52]

A World Bank study of India's water future argues that the Himalayas offer one of the world's 'most benign environments' for dam-building. The basis of this estimate is simple: a calculation of people to be displaced and acreage to be submerged per megawatt generated.[53] Given the huge power potential in the denominators of these projects and the sparse population of many highland areas, these ratios are not surprising, and they deserve to be taken seriously. But they are by no means a complete measure of the costs and risks involved. Like all dams, those planned for the Indian Himalayas would submerge significant amounts of land, including forests and grazing areas important to a number of the remaining migratory people in the region. Several involve diverting rivers through underground tunnels which would create large dry regions, with serious impacts on local fisheries and farming. Moreover, the Himalayas represent a major—and fragile—concentration of biodiversity. Their rapid rise, from 500 metres to over 8,000 metres, creates a remarkable range of ecosystems within a relatively small space. Conservation International reports that, of an estimated 10,000 plant species in one Himalayan sub-region, over 3,100 are found nowhere else.[54] And here, too, as in Tibet and Yunnan, there are significant risks of earthquakes and glacial lake outbreak-floods.

Perhaps most surprising, it is no longer clear that large hydro-dams are even a consistently climate-friendly source of energy. While hydro-electricity can be a substitute for carbon-dioxide producing fossil fuels, the reservoirs behind big dams often include large amounts of rotting vegetable matter and thus are a significant source of methane—a much more potent greenhouse gas. (This is not an issue for 'run of the river' dams, which have no reservoirs; but these make up a very small percentage of big projects.) These methane emissions are larger in tropical and sub-tropical climates, where vegetation both grows and decays faster. A 2007 study suggested that methane from dam reservoirs actually accounted for 19 per cent of India's greenhouse-gas emissions, while hydro-power accounts for only 16 per cent of the country's electricity and

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[52] See the essays in Thakur and Kumari, *Interlinking of Rivers: Costs and Benefits*, especially Sharma and Kumari, 'Interlinking of Rivers: Rationale, Benefits, and Costs'.
[53] Briscoe, *India's Water*, pp. 45–6.
[54] Dharmadhikary, *Mountains of Concrete*, pp. 23–7.

less still of its total energy use.[55] These figures are still preliminary estimates; methane emissions may be lower than average for dams high in the Himalayas, which is not an area where plant matter grows or decays rapidly; and there may be ways to mitigate these effects, by capturing and burning the methane to generate more power. But they call into question the common assumption that, despite the environmental risks, large dams are a 'greener' energy source than most alternatives; the non-trivial greenhouse emissions involved in creating huge amounts of concrete and steel further complicate the picture.

Indochina

Further east, the plans are not quite as ambitious, but they still portend dramatic changes for millions of people. Those affecting the Salween River—known as the Nu in eastern Tibet and Yunnan—are shrouded in the greatest mystery, since for most of its length it is either in China or Burma, in places forming the Burmese-Thai border; neither regime welcomes publicity. Because the Salween still runs within steep mountain gorges for many miles after crossing into Burma, before dropping quite suddenly just before reaching its delta, there is enormous hydro potential here, and much less domestic demand. To date, the Salween has not been tapped very much for human use; it remains one of the few large free-flowing rivers left in Asia. A major dam on the Chinese side of the border was stopped in 2004 for environmental reasons, and work has recently been suspended again. However, there are now a number of dams planned or underway on the river, both in China—where the maximum programme calls for a 'staircase' of thirteen dams—and in Burma.[56] The expectation is that the power generated in Burma will be exported to Thailand, Vietnam and perhaps China.

A number of the Burmese projects are being built by Chinese companies and will be operated by them for several years after completion.

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[55] For the emissions, see Ivan Lima, Fernando Ramos, Luis Bambace and Reinaldo Rosa, 'Methane Emissions from Large Dams as Renewable Energy Resources: A Developing Nation Perspective', *Mitigation and Adaptation Strategies for Global Change*, vol. 13, no. 2, February 2008, pp. 200 and 202, table 2.

[56] Shi Jiangtao, 'Wen Calls Halt to Yunnan Dam Plan', *South China Morning Post*, 21 May 2009, re-published by the International Rivers Network's China Dams List; Dore and Yu, 'Yunnan Hydropower Expansion', p. 14; planned projects on the Jinsha (a Yangzi tributary) and Lancang–Mekong are listed on p. 15.

Many are located in highland areas of Burma's Shan state, where the government has been trying for many years to gain fuller control over ethnic-minority populations. Activists have charged that the regime is taking advantage of the dam-building to further its political and military aims in the area by relocating the inhabitants.[57] Another planned dam would be built in what is essentially a war zone in the Karen minority region near the Burmese–Thai border. Much of the area is officially a wildlife sanctuary, but it has been heavily logged in recent years, particularly after Thailand banned logging on its side of the border; roads are now being built through it to facilitate dam construction—and state control.[58] Given the difficulty of visiting these areas, and the absence of information on which projects are at what stage, it is hard to guess at their likely social and environmental impact. And since the Salween watershed, with around 7 million people, is far less populated than the Mekong to its east, with around 70 million—not to mention the Ganges–Brahmaputra to the west, or the major Chinese rivers to the north—it has not had as much attention. Nonetheless, it raises the full range of complex issues and trade-offs, with fears about endangered species, fisheries and other resources upon which local people rely, forced relocations—and, according to some, forced labour—on one side, and pressures for development in an exceptionally poor country on the other.

The larger and more densely populated Mekong basin raises all these issues and more. Here both physical and political geography create an important divide more or less at the Chinese border. For one thing, the vast majority of the river's hydro-power potential is on the Chinese side. The river starts 5,500 metres up on the Tibet–Qinghai plateau, and is down to 500 metres above sea level when it leaves China. Its hydro potential within Yunnan alone almost equals its potential in Burma, Laos, Thailand, Cambodia and Vietnam combined—though the latter is far from trivial—despite the fact that Yunnan accounts for just a third of the river's descent within China.[59] Thus far, China has completed three

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[57] Milton Osborne, 'The Water Politics of China and Southeast Asia II: Rivers, Dams, Cargo Boats and the Environment', Lowy Institute, May 2007, pp. 4, 10–11. See also Shan Herald Agency for News, 'Activists Protest Tasang Dam', 26 October 2003. The Shan themselves are mostly lowland agriculturalists, but the Shan territory includes many other peoples.

[58] Karen Environmental and Social Action Network, *Khoe Kay: Biodiversity in Peril*, July 2008.

[59] Figures from Magee, 'Powershed Politics', pp. 28–9, and accompanying notes.

hydro-dams on the Mekong, and has at least two more under construction; the complete plan appears to call for a cascade of at least eight, and perhaps as many as fifteen, large hydro-dams.[60]

Planning for the Lower Mekong began under a US- and UN-backed Mekong River Committee in the 1950s; China and the Democratic Republic of (North) Vietnam were excluded, and Cambodian participation was also intermittent as its relations with the US fluctuated. While Lyndon Johnson, among others, spoke frequently of a major Lower Mekong Project modeled on the US Tennessee Valley Authority, no substantial work was done during the war years; what were apparently private US promises to help build Mekong dams as part of postwar reconstruction aid for Vietnam were never implemented either. Only in the late 1980s did a new Mekong River Commission emerge, with Vietnam and Cambodia now full members.[61] The Commission is relatively weak, however—neither China nor Burma are members—and the riparian states are mostly developing their own projects, often with partners from China, Japan or the US. So far China's main interest in the Lower Mekong has been in navigation. A whole series of projects have been carried out since 2000 to improve shipping, and traffic appears to have increased significantly in the last five years, along with road construction linking Yunnan province to Burma, Thailand and Laos. It is not clear just how important a shipping artery China hopes to develop along the Mekong. While one Chinese official spoke of Middle East oil shipments coming up the Mekong to China, should the US Navy block the Straits of Malacca in some future conflict, it seems implausible that such shipments could ever be large enough to matter much—although the idea of moving oil on the Mekong, with the risk of toxic spills, is a matter of concern to its farmers and fisher-people.[62]

While the hydro potential of the Lower Mekong may not match that of the Upper Mekong, it remains large—and all the more tempting when per

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[60] Geoffrey Gunn and Brian McCartan, in 'Chinese Dams and the Great Mekong Floods of 2008', *Japan Focus,* 31 August 2008, suggest 15 dams; Magee, 'Powershed Politics', pp. 31–2, notes plans for between 8 and 14.

[61] A useful short history is Nguyen Thi Dieu, *The Mekong River and the Struggle for Indochina*, Westport, CT 1999; pp. 49–96 cover the years between the end of World War II and American escalation in the mid-1960s.

[62] Osborne, 'Water Politics of Southeast Asia', pp. 11–16; Gunn and McCartan, 'Chinese Dams and the Great Mekong Floods of 2008', note that China's emphasis for the Mekong is now changing from transport to energy.

capita income in the Greater Mekong region is estimated at one dollar a day. At least eleven large hydro-power dams are currently planned for the mainstream of the Mekong in Southeast Asia, mostly in Laos.[63] While there are widespread concerns that these dams could harm agriculture and fishing in the Lower Mekong—both of which are absolutely essential to the lives of its almost 70 million residents—regimes thinking in terms of industry, cities and 'modern' development may give electricity a higher priority. Meanwhile, the rather weak coordination among Lower Mekong states, and the absence of any real control on what China does, may well create a 'prisoner's dilemma' that encourages dam construction: if others are going to mess up the river's ecosystem anyway, why not at least get some electricity for one's own people out of it?

An obvious but important point here is that there is no 'ideal' river, divorced from any point of view or set of interests. For instance, if Chinese projections about the effects of the three existing dams and the two under construction on the Lancang–Upper Mekong are correct, the results would be a greater flow downstream in the dry season, and lesser in the wet season, with no change in overall annual flow; this would be good for navigation, for power generation, and perhaps for irrigation as well.[64] Projects designed to aid navigation also generally aim to balance out seasonal water flows. But even if this is true, dams on the Lancang could nonetheless have a serious impact on Lower Mekong fisheries, for at least two reasons. First, dams inevitably trap some nutrient-rich sediment that would otherwise flow through to the delta; this has been a problem with big dams elsewhere, appears already to be happening in parts of Yunnan affected by the first three Lancang dams, and is expected to happen on the Lower Mekong as well. Second, many species of fish respond to subtle variations in water flow to know when to migrate and spawn; changes in the seasonal timing of peak flow after the completion of the Three Gorges Dam, for instance, has had a devastating effect on four species of Yangzi River carp. The UN estimates that 40 million people are active in Lower Mekong fisheries, and one report estimates

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[63] See Foundation for Ecological Recovery website, 'Key Points' from the International Conference, 'Mekong Mainstream Dams: People's Voices across Borders', 12–13 November 2008.

[64] Dore and Yu, 'Yunnan Hydropower Expansion', p. 21, cite estimated increases of dry-season flows ranging from 40 to 90 per cent for various points on the river. The claim that these dams will have only limited effects is far from universally accepted—many blame the Lancang dams for last year's huge Mekong floods: Gunn and McCartan, 'Chinese Dams and the Great Mekong Floods of 2008'.

that local fishing provides 80 per cent of the protein for people living in the region, as well as significant export revenues. Thai and Lao fishermen claim that the Chinese dams already in existence on the Upper Mekong have begun affecting their catches, while spokesmen for the dam-builders claim these projects have had no significant impact on the Lower Mekong. There are also claims that reduced water flow at some times of year has led to greater invasion of the delta by salt water, harming agriculture.[65]

Dams on the Middle and Lower Mekong could have other effects as well. They will interfere with fish migration, which is concentrated on the lower and middle (especially lower) parts of the river. Mitigating technologies to allow for fish passage have proved only partially effective even on low dams in North America and Europe, and the Mekong poses a vastly more challenging problem: the amount of fish biomass is perhaps 100 times what it is on the Columbia, where fish ladders have achieved some positive results, and the number of species several times greater. (The more diverse the species, the more various the times and places involved in migrations.)[66] The territory that the Middle and Lower Mekong passes through is also much less steep and even more biodiverse than the Upper Mekong—and being lower and more tropical, would probably have higher methane emissions from any reservoirs. In numerous ways, then, downstream dams on the Mekong may be more dangerous than upstream ones, and they would be far more expensive per megawatt generated. But their benefits would accrue mostly to people in the same countries that will suffer their probable harms—and that might be all that matters to planners thinking in terms of national interests.

Unilateralism?

However, while everybody is looking to dam the rivers descending from the Himalayas, China's position is unique. It is not only that most of the

[65] Jorgen Jensen, '1,000,000 Tonnes of Fish from the Mekong', Mekong River Fisheries Newsletter, *Catch and Culture*, vol. 2, no. 1, August 1996; Frank Zeller, 'New Rush to Dam Mekong Alarms Environmentalists', Agence France Presse, 27 March 2008; 'UN Says China Dams Threaten Water Supplies to Mekong Delta Farmers', VietNamNet/TT, 27 May 2009. See also Elizabeth Economy, *The River Runs Black: The Environmental Challenge to China's Future*, Ithaca 2005, p. 204.

[66] See Patrick Dugan, 'Mainstream Dams as Barriers to Fish Migration', Mekong River Fisheries Newsletter, *Catch and Culture*, vol. 14, no. 3, December 2008.

rivers in question start on China's side of the border, so that Beijing's claims cannot be pre-empted by actions further upstream. A second crucial difference is that the PRC alone, of all the countries involved, can finance any project it chooses without recourse to international lenders. While the World Bank, Asian Development Bank and big private banks are not among the world's most ardent environmentalists, they have—either for their own reasons or because of pressures from third parties—refused to support some particularly controversial projects. China's domestic dam-building industry is also increasingly technically sophisticated, and is now exporting its engineering know-how in this area. Thus, the only constraints Chinese dam-building faces are those generated within the country, and these are often—though not always—quite weak. Late in January 2009, Jiang Gaoming of the Chinese Academy of Sciences released a sobering piece about how accelerating the construction of dams in China's southwest—part of the PRC's ambitious stimulus package to fight the global recession—is worsening the already considerable environmental and social risks involved, with some projects beginning before any Environmental Impact Assessments have been completed.[67] Protests against Three Gorges by some leading scientists and engineers did not stop that project.[68] It remains to be seen whether they will have more effect in the future.

In short, the damage to China's neighbours from this approach to its water and energy needs could be severe—and the potential to raise political tensions is commensurate. Previous water diversion projects affecting the source of the Mekong have already drawn protests from Vietnam; and, as noted above, a project on the Nu, suspended in the face of significant domestic and foreign opposition in 2004 and then restarted, has recently been halted again by order of Wen Jiabao. But some projects now underway or being contemplated have considerably larger implications, both for the Chinese and for foreigners. The diversion of the Yalong Zangbo—if that is indeed on the agenda—would have the largest implications of all. If the waters could arrive in North China safely and relatively unpolluted—by no means sure—having generated considerable power along the way, the relief for China's seriously

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[67] Jiang Gaoming, 'The High Price of Developing Dams', *China Dialogue*, 22 January 2009.

[68] McCormack cites protests by, among others, the senior water engineer Huang Wanli: 'Water Margins', p. 13. Probably the best known critic of the Three Gorges, Dai Qing, is also an engineer by training, though not a water engineer.

strained hydro-ecology would be considerable. On the other hand, the impact on eastern India and Bangladesh, with a combined population even larger than North China's, could be devastating. The potential for such a project to create conflicts between China and India—and to exacerbate existing conflicts over shared waterways between India and Bangladesh—is clear.

Climate change

Evidence is meanwhile mounting that, thanks to climate change, the water supplies all these projects seek to tap are less dependable than one might hope. A 2008 report published in *Geophysical Research Letters* noted that recent samples taken from Himalayan glaciers were missing two markers that are usually easy to find, reflecting open-air nuclear tests in 1951–52 and 1962–63. The reason: the glacier apparently had lost *any* ice built up since the mid-1940s, melting not just from the edges but from the top as well.[69] And since the Inter-Governmental Panel on Climate Change estimates that the Himalayan highlands will warm at about twice the average global rate over the next century, there is every reason to think the situation will get worse. One estimate suggests that a third of Himalayan glaciers will disappear by 2050, and two thirds by 2100.[70] Current models predict that this will happen much faster in the western than the eastern Himalayas; the situation for Pakistan and northwest India is thus particularly grim, with an initial windfall period of increased flows to be followed by a devastating loss of water in the already declining Indus, Sutlej and other rivers.[71] If that scenario is right, then even if all the engineering challenges of the South-to-North Water Transfer can be solved—and even if we ignore the costs to other users of these waters—the resulting benefits might prove short-lived.

Climate change poses other problems as well. Among the most serious are glacial lake 'outburst' floods. As glaciers in high-altitude regions melt, they can form large lakes behind natural dams of ice and rock.

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[69] Natalie Kehrwald, Lonnie Thompson, Yao Tandong, Ellen Mosley-Thompson, Ulrich Schotterer, Vasily Alfimov, Jürg Beer, Jost Eikenberg and Mary Davis, 'Mass Loss on Himalayan Glacier Endangers Water Resources', *Geophysical Research Letters*, vol. 35, L22503, 2008.

[70] Gardner, 'Tibetan Glacial Shrink to Cut Water Supply by 2050'.

[71] Briscoe, *India's Water*, p. 32 has projections for the Indus, Ganges and Brahmaputra.

These are somewhat like the temporary lakes that formed behind dams of debris after the Sichuan earthquake last May, except that some of the 'wall' is ice. Such lakes are dangerous because they can burst through their barriers at any moment, creating devastating flash-floods downstream. (This was why Chinese soldiers dynamited the walls of Sichuan lakes, before they got any bigger.) Floods of this kind could easily overwhelm man-made dams downstream, causing a chain reaction of failure. Bhutan has identified 2,600 such lakes within its borders, including 25 at high risk of bursting out.[72] Meanwhile, though projections of likely changes in the monsoon due to global warming vary significantly, most suggest that South Asia will see fewer days of rain per year but a larger number of 'extreme precipitation events'—raising the need for water storage, but also increasing the risk of catastrophic failure should a large dam be built without sufficient allowances for these variations.

China is not, of course, the only country to try solving its water problems at the expense of its neighbours. I am writing this in southern California, where far more people live than could ever have been accommodated without diverting Colorado River water that once flowed to Mexico—some of which, by treaty, should still be doing so. And it would be foolish to rule out large projects in addressing the serious water and energy shortages facing hundreds of millions of people throughout this enormous region. But it seems increasingly clear that, even in a best-case scenario, such projects cannot solve all the problems they are meant to address—and they are likely to worsen many others.

Averting major disasters will require choosing carefully among the projects proposed, and coordinating efforts across national borders, to a much greater extent than is the case today. At least in the long run, technologies such as wind and solar seem much better bets to provide genuinely clean and affordable power; how to find badly needed palliatives for the immediate future without locking in reliance on less satisfactory technologies is a very difficult question. Above all, surviving the looming water crises probably rests much less on mega-projects and more on the implementation of an endless series of small-scale, unglamorous and sometimes painful conservation measures: fixing pipes and lining ditches; making factories treat water so that it can be reused; selective

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72 Ann-Kathrin Schneider, 'Dam Boom in Himalayas Will Create Mountains of Risk', *World Rivers Review*, vol. 24, no. 1, March 2009, p. 10.

implementation of more efficient irrigation technologies; building some smaller dams; accepting greater reliance on imported food, and thus higher food prices elsewhere in the world; and continuing to create huge numbers of new non-farm jobs—without straining either the environment or the social fabric to breaking point.

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