



## The Great Himalayan Watershed: Water Shortages, Mega-Projects and Environmental Politics in China, India, and Southeast Asia

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ヒマラヤ山脈大分水嶺——中国・インド・東南アジアにおける水不足・巨大計画・環境政策

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Since we tend to take water for granted, it is almost a bad sign when it is in the news; and lately there have been plenty of water-related stories from South, East, and Southeast Asia. They have ranged from the distressingly familiar – suicides of North Indian farmers who can no longer get enough water<sup>1</sup> – to stories most people find surprising (evidence that pressure from water in the reservoir behind the new Zipingpu dam may have triggered the massive Sichuan earthquake last May).<sup>2</sup> Meanwhile, glaciers, which almost never made news, are now generating plenty of worrisome headlines.

Conflicts over water are found in every era and region: the English word “rivalry” comes from a Latin term for “one who uses the same stream as another.” And more recently, questions about who gets to exploit water have become intertwined with questions about where the technological and ecological limits of our ability to do so lie – or should lie.

Nowhere are the stakes higher than in the Himalayas and on the Tibetan plateau: here the water-related dreams and fears of half the human race come together. Other regions have their own conflicts: the Jordan, the Tigris, the Colorado, and the Parana are just a few of the better-known cases where multiple states make societies make claims on over-stressed rivers. But no other region combines comparable numbers of people, scarcity of rainfall, dependence on agriculture, tempting sites for mega-projects, and vulnerability to climate change. Glaciers and annual snowfalls in this area feed rivers serving 47% of the world’s people;<sup>3</sup> and the unequalled heights from which those waters descend could provide staggering amounts of hydropower. Meanwhile, both India and China face the grim reality that their economic and social achievements – both during their “planned” and “market” phases – have depended on unsustainable rates of groundwater extraction. As hundreds of millions face devastating shortages and the technical and financial power of these states (and of some of their smaller neighbors) increase, plans are moving forward for harnessing Himalayan waters through the largest construction projects in history. Even when looked at individually, some of the projects carry enormous risks; and even if they work as planned, they will hurt large numbers of people as they help others. (Nor is it at all clear that many of them will help as much as spending comparable sums on less heroic measures, such as fixing leaky pipes or tightening enforcement of wastewater treatment standards, would do.) 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 possible implications are staggering.

The projects to manipulate Himalayan water now completed, planned or underway are numerous, and their possible interactions are complex. And since many of the agencies responsible for them are far from transparent, the possible scenarios quickly multiply to a point where they are almost impossible to keep track of. But some basic – and frightening – outlines do emerge if we start from China – which is, for various reasons, the most dynamic actor in the story -- and then move across the lands that border it to the Southwest, South, and Southeast.<sup>4</sup>

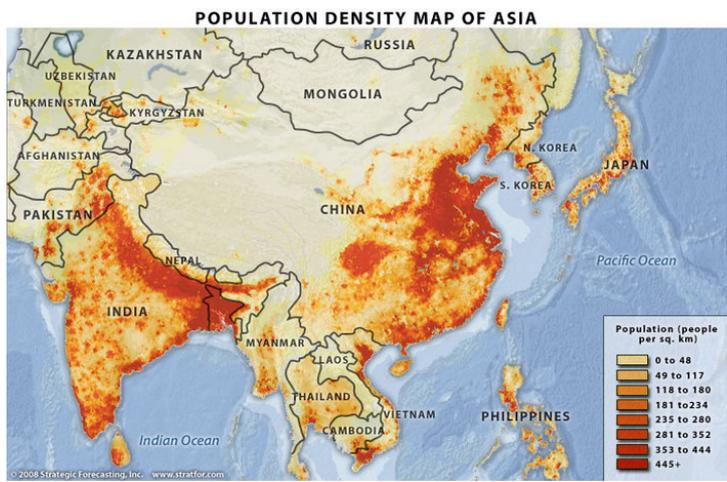
#### China’s Water Woes and the Push to the Southwest

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 ruler Yu proved his right to rule by controlling floods. But water scarcity has probably been an even greater problem than excesses, especially in the modern period. Surface and near-surface water per capita in China today is roughly ¼ of the global average,<sup>5</sup> and worse yet, it is distributed very unevenly. The North and Northwest, with about 380 million people (almost 30% of the national population)<sup>6</sup> and over half the country’s arable land, have about 7% of its surface water, so that its per capita resources are roughly 20-25% of the average for China as a whole, or 5-6% of the global average; a more narrowly defined North China plain may have only 10-15% of the per capita supply for the country as a whole, or less than 4% of the global average.<sup>7</sup> Northern waters also carry far heavier sediment loads than southern ones – most readings on Southern rivers fall within EU maxima for drinking water, while some readings on the middle and lower Yellow River, and the Wei and Yongding Rivers are 25 -50% of 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.<sup>8</sup> Northern China also has unusually violent seasonal fluctuations in water supply; both rainfall and river levels change much more over the course of the year than in either Europe or the Americas. North China’s year to year rainfall fluctuations are also well above average (though not as severe as those in North and Northwest India). While the most famous of China’s roughly 90,000 large (over 15 meters high) 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 that are now 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. Plentiful water supplies 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 plenty of chemical fertilizer (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 coming at all some years. 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 earlier, 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 especially in the 1960s (after the setbacks of the Great Leap Forward) things turned around very impressively.

Much of that turnaround, however, relied on very widespread use of deep wells, using gasoline or electrical power to bring up underground water from unprecedented depths.<sup>9</sup> Large-scale exploitation of North China groundwater began in the 1960s, peaked in the 1970s at roughly 10 times the annual extraction rates that prevailed during 1949-1961, and has remained level since about 1980 at roughly 4 times the 1949-1961 level.<sup>10</sup> 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; some people estimate that if this rate of extraction is maintained, the aquifers beneath the plain will be completely gone in 30-40 years.<sup>11</sup> 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 breadbasket.) But consider the following: 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 were home to 214,000,000 people in 2000 (80% of them rural).<sup>12</sup> 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 and/or polluted water have become common events.<sup>13</sup> So what is to be done?



China-India population density map

One hears periodically about various ways water is used inefficiently by urbanites; the Chinese steel industry, for instance, uses about twice as much water per ton produced as steel-makers in the most technologically advanced countries (though the Indian steel industry, for instance, is considerably worse than China's on this score).<sup>14</sup> Leaky pipes and other fairly straightforward infrastructure problems create considerable waste. But relatively speaking, industrial and urban residential losses are small potatoes; agriculture still uses at least 65% of all water in China (though less, even in absolute terms, than 20 years ago) and has by far the lowest efficiency rates.<sup>15</sup> Moreover, urbanites are sufficiently prosperous that price increases – unless they are very large – are unlikely to cause them to cut back on use very much. Certainly this is not where the most water waste is in commercial terms. According to some estimates, a marginal gallon of water sent from the countryside to Tianjin produces as much as 60 times as much income in its new urban locale as it did in the countryside.<sup>16</sup> The best hope in terms of moderating China's overall water demand pressure is probably to keep per capita urban use from growing very much while water use efficiency and living standards there continue improving, and urban population grows sharply. 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; and since many rural communities have no way to transfer water to those who would pay more for it, anyway, "waste" has very little short-run opportunity cost for them.<sup>17</sup> But it is worth noting here that "waste" has different meanings depending on what time frame one adopts. Irrigation water that never reaches the plants' roots and seeps back into the soil is wasted in the short term – it can't 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 re-used if treated properly but instead flows out to sea untreated is wasted in both senses, and thus represents a bigger problem. Chinese agriculture is not necessarily more wasteful in this regard than agriculture in many other places – and the deviations from market prices are no worse than in much of the supposedly market-driven United States – but its limited supplies make waste a much more pressing problem.

Various technologies that would reduce water waste exist, but many are sufficiently costly that farmers are unlikely to adopt them unless they are donated. Center-pivot irrigation systems, for instance, can save a lot of water, but at roughly \$35,000 each – almost 60 years' worth of an average North China farmer's income -- they make sense only for China's largest farms; they are also poorly suited to the geometry of existing fields, and to the particular requirements of rice and some other crops. Drip-irrigation (sometimes called micro-irrigation) is another technological fix, which 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 roots of the plants 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 precisely the ambiguity in defining "waste" mentioned above. Since drip irrigation makes sure that a higher percentage of the water used gets to the roots of the plants, it will enable a fixed, visible water source – for instance, an above-ground tank that catches winter rains for use in the spring – to irrigate more crops than if the water was distributed through traditional ditches or less-precisely targeted (and timed) sprinklers. Alternatively, one could irrigate the same amount of crops, and have some water to sell to other users. But if the water source is an underground aquifer, which can be depleted (in contrast to a system of stored rainfall, where you can't over-withdraw in the same way,

because next year's rain isn't yet available), the benefits become less clear. In that situation, much of the water that seeps away through the bottom of ditches and so forth helps recharge the aquifer, so that it isn't necessarily "wasted" from a long-run perspective. On the other hand, precisely because drip irrigation means that almost every gallon of water a farmer buys helps that farmer's crops in the current year, that water is a better buy for the farmer than water run through a less "efficient" system; the farmer is thus tempted to buy more of it. Thus, drip irrigation may be good for maximizing *current* food output while actually exacerbating longer-run water shortages in situations like those in northern China (or, as we shall see, much of northern India and Pakistan) where over-use of ground-water 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-Mexican border) came to the conclusion that water use increased in precisely this way.<sup>18</sup> In short, selectively implemented high-tech solutions may help in some ways, but they cannot provide a total answer -- even if, miraculously, all the funding for them could be found.

Ironically, low-tech solutions may actually have greater potential. It is almost impossible to get a clear sense of how much could be saved by technologically simple measures that can be implemented on either a large or a small scale -- re-lining and/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, and many farmers, or even whole rural communities, are unlikely to invest in them without subsidies and/or greater incentives. More effective pollution control -- some, though not all, of which is perfectly 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 commercially realistic 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 -- and though China certainly has enough foreign exchange to buy more food abroad, the government is quite reluctant to become much more dependent on imports. More expensive water might be particularly bad for the many farmers who have been switching from grain production to fruits and vegetables -- crops that it otherwise makes sense for China to produce more of, since they demand much more labor per acre than grain, and can produce relatively high incomes for people with small plots. And even if China -- and 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. With farmers' incomes already lagging far behind those of other Chinese, 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.

Under the circumstances, many officials see no alternative to technologically ambitious mega-projects: above all, the South-North water diversion scheme. The idea behind this \$65 billion plan -- which had been tossed around for decades, and was 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.<sup>19</sup>

If completed, the Diversion will be the largest construction project in history. It would carry almost 45 billion cubic meters of water per year -- roughly the average annual flow of the Yellow River. It has three parts:

- 1) an Eastern route, 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 the technologically simplest part of the project -- though it still raises plenty of questions. Parts of it began operation in 2008; it is scheduled to be complete in 2010.

- 2) a Central route, running from near the Three Gorges Dam in Sichuan to Beijing. Work on this route was recently suspended -- in response to environmental problems that have proved to be more complicated than was originally foreseen, and to problems with the relocation of people in the path of the project. (There were large protests in March near Danjiangkou in Hubei, where over 300,000 people are supposed to be moved.)<sup>20</sup> Still, the official projection is that water will be reaching Beijing through this route by 2014.

- 3) a Western route that is really two routes, taking water from the Yarlong-Tsangpo, Dadu, Tongtian and Jinsha Rivers (all of which flow into the Yangzi) across mountains and the Tibet-Qinghai plateau, 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.



**South-North water diversion plans**

The project carries uncertainties commensurate with its size and cost. Among other things, there is considerable uncertainty about how dirty southern waters will be by the time they arrive in the north; diversions on this scale change flow speeds, sedimentation rates, and other important rates 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 and add excess salts to the soil – already a common problem in irrigated areas of North China – and salt water intrusion rates in the Yangzi Delta.<sup>21</sup> For better or worse, we will begin learning about the effects of the Eastern line soon, and probably about the Central line in just a few years.

But despite its long time horizon, it is the Western line – 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% of China's fresh water supply, most of it coming from the annual snow melt and the annual partial melting around the edges of some Himalayan glaciers. These water resources are an aspect of the Tibet question one rarely hears about, but the many engineers in China's leadership, including Hu Jintao and Wen Jiabao, are very much aware of it. (And ordinary Chinese are increasingly aware of it too – advertisements for bottled Tibetan water now adorn the backs of passenger train seats and other common locations, offering an icon of primitive purity of a type long familiar to Western consumers.) And hydro projects in this very mountainous region offer enormous potential rewards in electricity as well as in water supply. How much electricity water can generate is directly proportional to how far it falls into the turbines: the Yangzi completes 90% of its drop to the sea before it even leaves Tibet to enter China proper, and the Yellow River 80% of its decline before it leaves Inner Mongolia.<sup>22</sup> On April 21, the Chinese government announced plans for 20 additional hydro projects on the upper Yangzi and its tributaries; if they are all completed, they would theoretically add 66% to the already existing hydropower capacity on the river (which includes Three Gorges).<sup>23</sup>

But secondly, the western route also poses by far the biggest complications. It is here that the engineering challenges are 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 relied on by hundreds of millions of South and Southeast Asians. 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.<sup>24</sup>

### **State-building and Dam-building in the Himalayas**

From the 1950s to the mid-1980s, China built plenty of dams, but relatively few of them were in the far west. This may seem surprising, given the concentration of hydro potential in that region, but makes perfect 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% of China's electricity<sup>25</sup>). Many of the dams that were built were constructed by mobilizing large amounts of labor (especially off-season peasant labor) in place of scarce capital, and it was a lot easier to use that labor close to home than to send it far away. The supporting infrastructure (e.g. roads) and technology for dam building in remote mountain locations was not available; the far reaches of the upper Yangzi were not even surveyed until the late 1970s. And the government was much more ambivalent about rapid development in the far west than it is today, with some leaders prioritizing more paternalistic policies that would avoid radical cultural change as the best formula for assuring political stability in the region.

But in the last two decades, all of this has changed, leading to a sharp shift towards the building of huge dam projects in Yunnan and Tibet above all. The technical capacities and supporting infrastructure needed for capital-intensive projects in these areas are now available; the pressure to increase domestic supplies of energy (and other resources, including of course water) has become intense; and 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, a kind of paternalism in western frontier policy dating back to at least the Qing (albeit one that has long been gradually weakening) is now being discarded quite decisively. Meanwhile, changes in the relationships among the 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 hydropower for booming Guangdong, date back to the 1980s; seasonal deliveries of power began in 1993.<sup>26</sup> Beginning in 2001, Guangdong officials began concluding deals for regular annual power purchases with Yunnan officials – and at the same time, officials in Beijing began vetoing plans for additional coal-fired power plant construction in Guangdong,<sup>27</sup> which made reliance on hydropower an absolute necessity for the rapidly growing Pearl River Delta. It is not clear, at least to me, exactly what the relationship between provincial and central government power is 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 emerging when sufficient hydropower failed to come online on time, suggest that new inter-provincial agreements may often be shotgun weddings imposed by the center: a center for which creating these configurations is both a means of maintaining leverage over coastal boom areas and of integrating peripheral regions more deeply into Beijing’s vision of a national political economy.

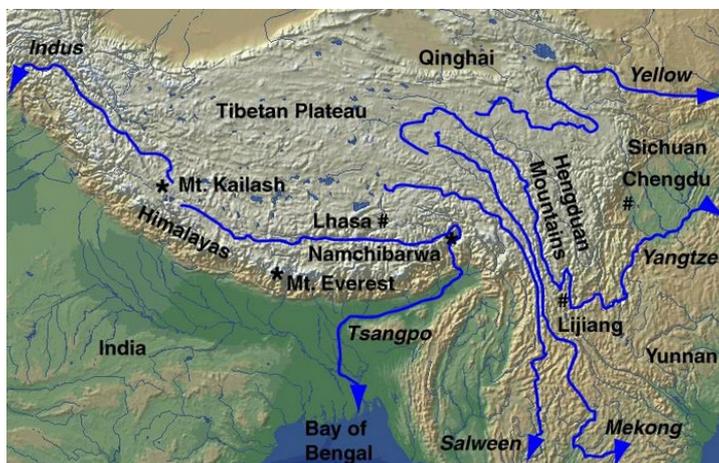
More generally, the “corporatizing”<sup>28</sup> of the electrical power industry has created complex webs of public and private actors with strong interests in Southwestern hydro development. In 2002, the government-owned State Power Corporation of China was broken into 5 corporations, each of which was given exclusive development rights in particular watersheds. (There is also a sixth, connected to Three Gorges, which is directly under the State Council.) These companies were 100% state-owned, but have created partially-owned subsidiaries which sell shares to private parties (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 growth of the Chinese economy in general without needing lots of reliable information on the factors that might cause a particular manufacturer to succeed or fail.) And these subsidiaries, in turn, have combined with other subsidiaries of the big 5 and/or companies established by provincial governments to establish still other companies that undertake particular projects.

While this organization 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 (and chief advocate of the Three Gorges project) Li Peng. (The younger Li, who like so many other Chinese leaders has a background in engineering, has since moved on to become deputy governor of Shanxi, with responsibility for industry and coal mining.<sup>29</sup>) His sister, Li Xiaolin, is the CEO of Huaneng’s most important subsidiary, China Power International Development Ltd. (a Hong Kong corporation).<sup>30</sup> The transactions which create subsidiaries often involve the parent company giving the subsidiary some important asset (such as generators, transmission lines, or development rights) in return for a large stake in the new company; since there are rarely well-developed markets for these assets and the state-owned parent company does not face the same pressures to be profitable as the subsidiary, the prices at which these assets are transferred can be easily manipulated to artificially lower the costs (and increase the profits) of the subsidiary and its investors. And since all of these companies continue to do business with each other (sending power over somebody else’s lines, for instance), there are many opportunities to transfer costs back and forth between entities that need to show a profit and others that do not (or that are less favored by powerful actors).<sup>31</sup>

Powerful government connections also make it all the more likely that these companies will be able 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 is suggested by the enormous figures for “installed capacity” that are listed for these projects:<sup>32</sup> uncertainties which holders of development rights seeking either investment partners or permission to build have no incentive to highlight. This does not mean, of course, that dams – including large dams – may not make economic and even environmental sense in many cases, given China’s limited options. It does mean, however, that both political motives and profit seeking by politically-connected people are almost certainly causing dams to be built in a number of additional cases, where even a narrowly economic analysis would not justify them.

### Implications for Tibet and Tibetans

Even many projects that will genuinely help millions in northern and eastern China – and perhaps others that will curb China’s carbon emissions and its future food imports – have serious implications for people who live near the projects. Tibetans and other ethnic minorities in the far Southwest are likely to be the most affected. An unconfirmed report by the Tibetan government-in-exile says that at least 6 Tibetan women were recently shot by security forces as they protested a hydro project on the Tibet/Sichuan border.<sup>33</sup>



Tibetan and West China rivers

First, there is the question of human tampering with sacred lakes and rivers. A good deal of this has already happened in Tibet (as with the large dam at Yamdrok Tso).<sup>34</sup> A massive dam proposed at the great bend in the Yalong Zangbo (Yarlong Tsangpo) – 40,000 megawatts, or almost twice the capacity of Three Gorges – would again dramatically change a sacred site, to create power and water supplies that would

mostly go to Han Chinese very far away. 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 damaged 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 turning to desert.<sup>35</sup>) Wetlands and grasslands that are important to the large numbers of livestock herders in Tibet have already shrunk quite significantly; this is likely to make them shrink faster. (A video on the Asia Society website covers some of these issues very well.<sup>36</sup>) Dams in Yunnan appear to be interfering with local fisheries, and new ones pose significant threats to China's greatest concentration of biodiversity.<sup>37</sup> And since much of this region is seismically quite active, the risk of an earthquake precipitating a catastrophic dam failure and sudden floods cannot be dismissed.

### **The Other Side(s) of the Mountains: Pakistan, India, Nepal, Burma, Vietnam**

Of course, people and governments further downstream also use rivers that start in the Himalayas – and many have plans to do so much more intensively. Many of them are very worried about Chinese initiatives that may preempt their own current or future water usage.

On December 9, 2008, *Asia Times Online* reported that China was planning to go ahead with a major hydroelectric dam and water diversion scheme on the great bend of the Yalong Zangbo River in Tibet.<sup>38</sup> The 40,000 megawatt hydro project itself raises huge issues for Tibetans and for China. But what matters most for people outside China is that the plan not only calls for impounding huge amounts of water behind a dam, but also for changing the direction that the water flows beyond the dam – so that it would eventually feed into the South-North diversion project. The water that would be diverted 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 South Asians have worried for some time that China might divert this river, the Chinese government had denied any such intentions, reportedly doing so again when Hu Jintao visited New Delhi in 2006. However, rumors that China was indeed planning to begin such a project soon continued to circulate. (As we will see later, some Indian essays published in 2007 already assumed that China would make a major diversion from the Brahmaputra, citing this as a reason for India not to proceed with its own plan to transfer water from the Brahmaputra to other river basins south and west of it.) Indian Prime Minister Singh reportedly raised the issue during his January 2008 visit to Beijing, but a December, 2008 report from *Asia Times Online* said that China provided no assurances this time, and is in fact planning to divert the river. (No public statement was made at that time, but fewer official denials have been issued; the latest came former water minister Wang Shucheng on May 26, 2009.) Chinese Prime Minister Wen Jiabao has said that water scarcity is a threat to the “very survival of the Chinese nation.” Interestingly, unconfirmed reports back in 2000 had suggested that Beijing had already decided to go ahead; but not until 2009, when the Three Gorges would be completely finished.<sup>39</sup>



**Brahmaputra river in Tibet**

Water is indeed a matter of survival – not only for China, but for its neighbors. 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 of these cases, no international agreements exist for sharing the waters of those rivers that cross borders, or even sharing data about them.

There are water problems throughout South and Southeast Asia, but not the same ones in all places. Very crudely, the nature of the most pressing current problems varies with longitude. Pakistan and much of India (especially in the North and West) face very serious shortages of water for agriculture and for daily domestic use, as well as serious rural power shortages. The latter problem intensifies the former for many people, as it makes the operation of deep wells increasingly impractical; but in the longer run easing the power shortage without solving the water supply crisis will just intensify future shortages. In most of Southeast Asia, by contrast, there is plenty of water for now, but electricity is in short supply, and plans to alleviate that problem through hydropower threaten delicate riverine ecosystems.

Starting in the West, Pakistan may depend more on irrigation than any other large country 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.<sup>40</sup> Only 8% of the country gets over 20 inches per year – the amount that falls in Tel Aviv.<sup>41</sup> Yet the country is predominantly agricultural, and almost 80% of farming requires irrigation. As recently as 1990, irrigation accounted for a stunning 96% of water use.<sup>42</sup> Meanwhile, much of the groundwater is brackish and/or badly polluted – partly due to current pollution, but also in part a legacy of past irrigation projects; some of the brackishness results from salination and waterlogging that goes back to colonial era projects. Consequently, people often rely on diversions from irrigation canals to get water for their daily needs.<sup>43</sup> (Since increased use of drip irrigation would reduce the availability of water in surface canals, this may be another way in which more “efficient” technologies, though very helpful in some ways, could intensify the problems of certain people -- in this case, some particularly vulnerable ones.) Agriculture remains central to the economy, and there are even plans, backed by foreign investors, to sharply increase grain exports (mostly to the Middle East).<sup>44</sup> Efforts to increase 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 elsewhere. For India as a whole, the per capita water supply is about 1/4 of the global average – as it is for China.<sup>45</sup> Moreover, half the annual rainfall comes in 15 days, and 90% of total river flow comes during 4 months.<sup>46</sup> Yet India has built only 1/5 as much water storage capacity per capita as China (and about 1/25 as much as the US or Australia).<sup>47</sup> Canals for surface irrigation were built on a large scale in some areas under the British, and on a considerably larger scale after Independence; but many have been poorly maintained and/or not run to serve those who lack political influence.<sup>48</sup> So in north and northwest India (and some other regions), probably even more than in northern China, well-digging has been essential to enabling farmers to survive, and to a “green revolution” that raised agricultural yields enough to keep up with the enormous population growth of the last half century. (As in many other cases, the high-yielding hybrid wheat, rice, and cotton seeds all required more water than older varieties.) Groundwater now provides 70% of India’s irrigation water, and close to 80% of water for domestic use.<sup>49</sup>

This extremely aggressive exploitation of groundwater is unsustainable. Well water is free to any farmer who can reach it by drilling down from his land, and the electricity to run the pumps is heavily subsidized, greatly straining the budgets of many Indian states.<sup>50</sup> Even at heavily subsidized prices, however, energy costs have become a huge burden for many small farmers as water levels drop and pumps must work harder;<sup>51</sup> moreover, the irregular way electricity is provided, with frequent spikes and interruptions, often ruins pumps, wreaking sudden devastation on unfortunate farmers. The large inequalities in landholding within many Indian villages are a further complication which is much more pronounced than in any part of rural China. Richer farmers have every reason to drill deeper wells, take more water from aquifers, and re-sell whatever they don’t use themselves at high mark-ups to people without wells for their domestic use; indeed, this is often more profitable than using the water to raise crops. Other people then also need to drill deeper in response; a sort of tube well race has developed, depleting aquifers ever faster. Suicides of farmers who cannot get enough water to continue planting have become common events in recent years, including instances of protest by mass suicide.<sup>52</sup> (Some of these protests are aimed at state governments which have been raising electricity prices to farmers; these rates are still far below those charged to urbanites but too high for many farmers nonetheless. Some protests are also aimed at corporate users and polluters of water; Coca Cola has been a particularly popular target.<sup>53</sup>) Meanwhile, there is increasing concern that water scarcity and pollution could create dangerous shortfalls of agricultural output, especially in Punjab – which produces India’s largest agricultural surpluses, including roughly half the wheat and rice procured by the central government pool that aims to stabilize supplies and prices<sup>54</sup> – and in neighboring Pakistan.<sup>55</sup> The pollution in question, which is bad enough to cause large increases in birth defects and cancer, has many sources, including the legacy of years of intensive irrigation, fertilization, and use of pesticides;<sup>56</sup> salination and water-logging (with the latter problem also increasing the incidence of malaria) have in fact been mounting problems in the Punjab since the introduction of year-round irrigation by the British at the end of the 19th century.<sup>57</sup> It is estimated that in East Punjab today, 50% of groundwater is recycled water from irrigation canals; in West Punjab, 80%.<sup>58</sup> 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 seawater is harming agriculture, and water for domestic use is desperately short.<sup>59</sup>

In this crisis, plans for new water projects have sprouted in large numbers. Though people are well aware that past projects often had unexpected effects that have led to current difficulties, the prospect of losing the agricultural output gains achieved through irrigation is terrifying, and possibilities for alleviating serious electricity shortages (which, among other things, inhibit manufacturing growth that could reduce reliance on agriculture) seem very tempting. And, ironically, the loss of water storage capacity that has occurred as some old dams have silted up has become an argument for more dam building.

While many of these plans are driven by very real needs, China is hardly the only country where political and economic interests create incentives to build some mega-projects that are incomprehensible in terms of overall 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 water storage in order to keep for themselves 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 need a larger allocation from rivers flowing through multiple states. And since only direct human uses of water count as “needs” in these allocations, any other uses – e.g. releasing water to help maintain estuarial eco-systems – count as “waste” that might weaken future claims, and are thus discouraged.<sup>60</sup> (Somewhat surprisingly, 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.<sup>61</sup>)

The most ambitious new plans are, not surprisingly, found amidst the highest mountains. Pakistan, India, Bhutan, and Nepal all have plans for huge dams in the Himalayas. Planned construction over the next decade totals 80,000 megawatts (versus 60-64,000 in all of Latin America); India alone plans to add a further 67,000 MW in the following decade. India, like China, exploited the hydropower in its less mountainous areas first, and has only 11,000 MW of non-Himalayan potential left; potential Himalayan capacity (not counting China) is a staggering 192,000 MW, almost half of it in India.<sup>62</sup> (The entire world currently has about 675,000 megawatts of installed hydroelectric capacity.<sup>63</sup>) Meanwhile, India’s 2001 census reported that 44% of households had no access to electricity; the figure is about the same in Bhutan and closer to 60% in Nepal. Interest in dam building is just as intense in Pakistan, though there irrigation is a higher priority than electricity.<sup>64</sup> 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 a bit over half of its planned dam construction through 2012, but much less for needs through 2017.<sup>65</sup>) 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.<sup>66</sup>

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.<sup>67</sup>) The Pakistani Minister of Investment, seeking to dispel any fear that local farmers will be displaced, has said that all of the 6 million acres (equal to roughly 10% of the country’s current cultivated acreage) up for sale or lease to foreigners was currently unused.<sup>68</sup> 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 purchases seem to be aimed above all at the water rights that go with the land; it quotes the chairman of Nestlé’s referring to these purchases as “the great water grab.”<sup>69</sup>

India, like China, has both extremely dry areas and some with plenty of water; and, as we have seen, it is also like China in that it is currently mining groundwater to produce important grain surpluses in some of these dry areas. So it may be no surprise that, like China, it is also contemplating a major scheme for diverting water from some river basins to others. The most ambitious, Himalayan, part of its Interlinking of Rivers Project would move water from the upper parts of the Ganges, Yamuna (a major tributary of the Ganges) and Brahmaputra Rivers westward, ending in the Luni and Sabarmati Rivers in Rajasthan and Gujarat. (Other Northwestern areas that would receive water are in Haryana and Punjab; a second, Peninsular, part of the project would mostly direct water to dry parts of Orissa and Tamil Nadu.) And just as China seems to be retreating from its earlier representations 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 formal promises to Bangladesh (including a written understanding from 1996) that no water

would be diverted away from the Ganges above the barrage at Farakka (a few kilometers from the India/Bangladesh border).<sup>70</sup>

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). The project is also supposed to generate 30,000 megawatts of net hydropower (i.e. power available for other uses after subtracting the energy it would use 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 total irrigated area by as much as 35 million hectares.<sup>71</sup> Official cost estimates for the total project, with 260 links between rivers, was estimated at \$120 billion, which would make it larger than any construction project in history so far, and even bigger than China's planned river diversions;<sup>72</sup> 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.<sup>73</sup>

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 projects; among other things 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.<sup>74</sup> Many of the parts of the plan that have been revealed have been sharply criticized on a number of grounds,<sup>75</sup> and it is unclear which parts will actually wind up being built. Aside from a number of technological and ecological questions about specific parts of the projects, both domestic critics and a World Bank study have noted that the transfers being contemplated are only politically feasible if enforceable legal agreements can be reached on allocating the waters and compensating the "givers," and such agreements have generally not fared well in India. There is also widespread agreement that Indian governments need to put more of their water conservancy money into improving maintenance and management of existing facilities (many of which are decaying quickly), rather than further construction.<sup>76</sup> Indeed, even one scholar who is largely supportive of the project estimates that net water availability could be increased as much by improving the current efficiency of water utilization by 20% as by building this project (though he favors doing both, and points to hydropower and other benefits of the project besides increased water supply).<sup>77</sup> Some opponents, on the other hand, have suggested that building this 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.<sup>78</sup>

We will turn momentarily to some of the environmental risks associated with these new and proposed water projects. First, though, it is worth noting that in the case of large dams, environmental uncertainties not only represent risks to others, but financial risks for the dam builders themselves. Big dams have huge construction costs, but very modest operational costs once they are finished; thus they can become big cash cows once they are generating power while incurring very low additional costs (especially if, as seems very likely in this part of the world, demand for electricity continues to rise). Profitability is therefore very much dependent on how long they continue producing 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 were in fact predicted. (The project went ahead anyway, in part it seems because in the aftermath of the withdrawal of Soviet technical experts, China wanted to prove that it could build such a dam without outside help.)<sup>79</sup> Because interest must be paid on the construction costs, profitability is also very much affected by how much time elapses between the beginning of the project and the beginning of this revenue stream; thus mega-projects that take a long time to complete are especially vulnerable, economically speaking, to any shortfall in power generation.

In the case of Himalayan dams, at least three factors could well make the lives of these projects shorter than anticipated. First, the Himalayas are relatively young mountains with relatively high rates of erosion, and their upper reaches have relatively little vegetation to hold soil in place. (There has also been a lot of deforestation in recent decades.) This tends to make for high sediment burdens in rivers descending from the Himalayas. In Tibet, for instance, a 1986 study found that almost 40 percent of the small hydrodams built since 1949 had become defunct or unusable by being silted up; similar problems have developed on a number of Pakistani dams (which have not only lost their utility for generating power but for seasonal water storage and irrigation).<sup>80</sup> Second, any errors in predicting future river flow can also have dramatic effects on the durability of a dam, sharply reducing profitability. In many of the Himalayan cases, there is not a very long run of data available (particularly since the Chinese government has not been very forthcoming about sharing the data that it has assembled), and 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, as hard as it is to model future river flows in any case, it becomes exponentially harder when a great many large projects are being planned on the same set of rivers and tributaries. Several analysts have questioned whether the Brahmaputra basin – a critical water source for this plan – can be meaningfully considered to have a water "surplus" even now; some add that the likelihood (in their view) of a major Chinese diversion upstream and of glacial retreat from global warming make the idea that any "surplus" is available to be transferred extremely dubious.<sup>81</sup>

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.<sup>82</sup> 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 Himalayas would submerge significant amounts of land – including forests and grazing lands important to a number of the remaining migratory people in the region. Several involve diverting parts of rivers through underground tunnels, creating large dry regions, with serious local impacts on fisheries and on farming. Moreover, the Himalayas – though we don't often think of them this way – are a major and fragile hotspot of biodiversity. Their rapid rise from 500 meters to over 8,000 meters 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.<sup>83</sup> And here, too, as in Tibet and Yunnan, there are significant risks of major disasters from earthquakes and/or glacial lake outbreak floods (see below).<sup>84</sup>

Perhaps most surprising, it is no longer clear that large hydrodams are even a consistently climate-friendly source of energy. While hydroelectricity can clearly be a substitute for fossil fuel consumption that produces carbon dioxide, the reservoirs behind large dams often include large amounts of rotting vegetable matter, and thus are potent sources 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 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% of India's greenhouse gas emissions, while hydropower accounts for only 16% of the country's electricity (and thus a much smaller percentage of its total energy use).<sup>85</sup> These figures are still preliminary estimates; moreover, methane emissions might well be lower than average for dams high in the Himalayas, which is not an area where plant matter grows and decays rapidly. And there may well be ways to mitigate these effects by capturing and burning the methane to generate more power. But they do raise questions about the common assumption that despite their environmental risks, large dams are a clearly "greener" energy source than the most common alternatives; the non-trivial greenhouse emissions involved in creating huge amounts of concrete and steel further complicate the picture.

Further east, the plans are not quite as ambitious, but they still portend dramatic changes for millions of people. The Salween (called the Nu River in Eastern Tibet and Yunnan) is shrouded in the most mystery, since for most of its length it is either in China or Burma (elsewhere it forms the Burmese-Thai border); neither regime welcomes publicity. Because the Salween still runs within steep mountain gorges for many miles after crossing into Burma (it drops 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.<sup>86</sup> However there are now a number of dams planned and/or underway, in both China (where the maximal program calls for a staircase of 13 dams<sup>87</sup>) and Burma, with the expectation 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 the first several years after completion). 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;<sup>88</sup> activists have charged that the regime is taking advantage of the relocation of people which dam building requires and of providing security to the builders to further its political and military aims in the area.<sup>89</sup> Another planned dam would be built in what is essentially a war zone in the Karen minority area near the Burmese-Thai border; much of the area is theoretically a wildlife sanctuary, but it has been heavily logged in recent years (particularly after Thailand banned logging on its side of the border) and roads are now being built through it to facilitate dam construction (and control).<sup>90</sup>

Given the difficulty of visiting these areas, and the absence of information on exactly what projects are at what stage, it is hard to even guess at the likely social and environmental impact of the projects. And since the Salween watershed, with 6-7 million people, is far less populated than the Mekong to its east (around 70 million people)—not to mention the Ganges/Brahmaputra to the west, or the major Chinese rivers to the north—it has not gotten as much attention as these other rivers. Nonetheless it raises the full range of complex issues and trade-offs, with fears about endangered species, fish and other resources that local people rely on, forced relocations (and according to some forced labor<sup>91</sup>) 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 hydropower potential is on the Chinese side of the border. The river starts 5,500 meters up on the Tibet-Qinghai plateaus, and is down to 500 meters 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 bit over one-third of the river's descent within China.<sup>92</sup> China has thus far completed three 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 hydrodams.<sup>93</sup>

Planning for the lower Mekong began under a U.S. and U.N.-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 U.S. fluctuated. While Lyndon Johnson, among others, spoke frequently of a major Lower Mekong Project modeled on the U.S. Tennessee Valley Authority, no substantial work was done during the war years; what were apparently private U.S. promises to help build Mekong dams as part of postwar reconstruction aid for Vietnam were never implemented either. Only in the late 1980's did a new Mekong River Commission emerge, with Vietnam and Cambodia now full members.<sup>94</sup> The Commission is relatively weak, however, and the riparian states are mostly developing their own projects, often in partnership with China, Japan (especially through the Asian Development Bank) or U.S. partners.<sup>95</sup>

Moreover, China has remained largely outside even the limited coordination generated within the Commission framework. Today, it sometimes sends representatives to attend meetings, but neither it nor Burma is a member. So far China's main interest in the Lower Mekong has been in navigation. A series of projects have been carried out since 2000 to facilitate this, and traffic appears to have increased quite significantly in the last 3-5 years, along with quite a bit of road construction linking Yunnan province with Burma, Thailand and Laos.<sup>96</sup> 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 in case the U.S. Navy blocked the Straits of Malacca in some future conflict, it seems implausible that such shipments could ever be large enough to matter much.<sup>97</sup> (Nonetheless, the idea of moving oil on the Mekong – with the possibility of toxic spills – is a matter of great concern to farmers and fisher-people who rely on the river.)

While the hydro potential of the Lower Mekong may not match that of the Upper Mekong, it remains large – and all the more tempting given the severe poverty of the Greater Mekong Sub-region, where per capita income is estimated at one U.S. dollar per day.<sup>98</sup> At least 11 large hydropower dams are currently planned for the mainstream of the Mekong in Southeast Asia, mostly in Laos.<sup>99</sup> 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 (despite the existence of the commission) and the absence of any real control on what China does may well create a “prisoner's dilemma” that encourages dam construction: if others may well take actions that will mess up the river's ecosystem anyway, why not at least get some electricity for oneself out of it?

An obvious but nonetheless important point here is that there is no such thing as the ideal state of a 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 two further dams currently underway on the Lancang/Upper Mekong are correct, the results would be a much greater flow downstream in the dry season,<sup>100</sup> and lesser flow in the wet season, with no change in overall annual flow. (The claim that these dams will have only limited effects is far from universally accepted – in fact many in Southeast Asia blame the Chinese dams already completed on the Lancang for the huge Mekong floods of 2008.<sup>101</sup>) This would be good for navigation, for power generation, and perhaps for irrigation as well.<sup>102</sup> Projects designed to aid navigation also generally aim to even 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 to already 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 seasonal 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 has, for instance, had a devastating effect on four species of Yangzi River carp. The United Nations estimates that 40 million people are active in Lower Mekong fisheries, and one report estimates that local fishing provides 80% of the protein for people living in the Lower Mekong 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.<sup>103</sup> 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.<sup>104</sup>

Dams on the Middle and Lower Mekong could have the same effects, and others 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 different times and places involved in migrations.)<sup>105</sup> 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 various ways, then, downstream dams on the Mekong may be more dangerous than upstream ones, and they would be far more expensive per kilowatt generated.<sup>106</sup> 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.

But 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 rivers in question start on China's side of the border, so that their claims cannot be pre-empted by actions further upstream. A second crucial difference is that they alone, of the countries involved, can finance any project they choose without recourse to international lenders. And 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.<sup>107</sup> China's domestic dam-building industry is also increasingly technically sophisticated, and is in fact 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) fairly weak.

Late in January, Jiang Gaoming of the Chinese Academy of Sciences released a sobering piece (China Dialogue, January 22, 2009, [link](#)) about how accelerating the construction of dams in China's Southwest – part of the P.R.C.'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. Protests against Three Gorges by some leading scientists and engineers did not stop that project;<sup>108</sup> it remains to be seen whether they will have more effect in the future. Recent reports that some poorly built dams on the Yellow River in Gansu – and perhaps many others elsewhere in China – are in dire need of repair<sup>109</sup> – may strengthen people, both within and outside the government, who are urging a more cautious approach to further mega-projects, but the outcome of such arguments remains unclear.

In short the possible damage to China's neighbors from this approach to its water and energy needs is staggeringly large – 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 from environmental groups), and, as noted above, a project on the Nu River (which becomes the Salween in Thailand and Burma) which was suspended in the face of significant domestic and foreign opposition in 2004 and then re-started, has recently been halted again by order of Prime Minister Wen Jiabao.<sup>110</sup> But some projects now underway or being contemplated have considerably larger implications, both for 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 things – and having generated considerable power along the way, the relief for China's seriously 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 gigantic.

### **Climate Change, Disappearing Glaciers, and Other Nightmares**

Meanwhile, evidence is mounting that thanks to climate change, the water supplies all these projects seek to tap are much less dependable than planners have frequently projected. A report published in *Geophysical Research Letters* on November 22, 2008 noted that recent samples taken from Himalayan glaciers were missing two markers that are usually easy to find in ice cores: evidence of radiation from open air nuclear tests in 1951-2 and 1962-3. These markers are apparently absent because the glacier had lost all ice that had formed at any time since the mid-1940s, rather than just (as was previously known) some ice from its edges.<sup>111</sup> 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 has 1/3 of the Himalayan glaciers disappearing by 2050, and 2/3 by 2100.<sup>112</sup> (Models currently in use 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.<sup>113</sup>) If that scenario is right, then even if all the engineering challenges of South-North water diversion 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 (GLOFs). As glaciers in high altitude regions melt, they can form large lakes behind natural dams of ice and rock. 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. And like those temporary lakes, such lakes are dangerous, because they can burst through their walls at any moment, creating devastating flash floods downstream. (Some readers may remember seeing Chinese soldiers dynamiting the walls of those lakes before they got any bigger, for just that reason.) Such floods could easily overwhelm man-made dams downstream, causing a chain reaction of disaster. Bhutan has identified 2,600 such lakes just within its borders, including 25 at high risk of bursting.<sup>114</sup> 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 changes.<sup>115</sup>

### **Conclusion**

China is not, of course, the only country ever to try solving its water problems at the expense of its neighbors. (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 – and some of which, by treaty, should still be going there.) And it would be foolish to completely rule out large water 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 much more 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 megaprojects 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 re-used, selective implementation of more efficient irrigation technologies, building smaller-scale dams, accepting greater reliance on imported food (and thus higher food prices in many parts of the world), and continuing to create huge numbers of new non-farm jobs without straining either other aspects of the environment or the social fabric to the breaking point.

## Further Reading

A good general survey of water-related issues in China is Ma Jun, *China's Water Crisis* (1999; English edition, Eastbridge, 2004) – though things change fast and books tend to date quickly. Mark Elvin, "Water in China's Past and Present: Cooperation and Competition," *Nouveaux Mondes* 12 (2003), is a very helpful attempt to place these issues in a long-run perspective, and to make narrow the range of disagreement about some of the important numbers. On the Indian side, a good introduction is Binayak Ray, *Water: The Looming Crisis in India* (Lanham, MD: Lexington books, 2008). Nguyen Thi Dieu, *The Mekong River and the Struggle for Indochina* (Westport, CT: Praeger, 1999) provides a useful discussion overview of the Mekong, with a focus on the lower stretches of the river; Darrin Magee, "Powershed Politics: Yunnan Hydropower Under Great Western Development," *China Quarterly* 185 (March, 2006) is good for the Chinese (upper) part of the river, for more recent events, and for the complex institutional structure of China's semi-privatized power industry. A now slightly dated but still very useful guide to irrigation crises in many countries is Sandra Postel, *Pillar of Sand: Can the Irrigation Miracle Last?* (New York: W.W. Norton, 1999).

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This article was written for *The Asia-Pacific Journal* and for *New Left Review* where it appears simultaneously. The version here includes the complete notes, maps and illustrations.

Recommended citation: Kenneth Pomeranz, "The Great Himalayan Watershed: Water Shortages, Mega-Projects and Environmental Politics in China, India, and Southeast Asia," *The Asia-Pacific Journal*, Vol 30-2-09, July 27, 2009.

## Notes

<sup>1</sup> Sean Daily, "Mass Farmer Suicide Sobering Reminder of Consequences of Water Shortages," *Belfast Telegraph*, April 15, 2009, re-posted [here](#).

<sup>2</sup> On Zippingpu and the earthquake, see Sharon La Franiere, "Possible Link Between Dam and China Quake," *New York Times*, February 6, 2009.; Richard Kerr and Richard Stone, "A Human Trigger for the Great Quake of Sichuan," *Science* 323: 5912 (January 16, 2009), p. 322, summarizing both Chinese and American papers suggesting this. See also "[Early Warning](#)" a [piece by Evan Osnos of the *New Yorker* about the Chinese Engineer Fan Xiao, who had warned of such a possibility and was one of the first to suggest publicly that it had actually happened: February 6, 2009. 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 Zippingpu may have caused. See Gavan McCormack, "Water Margins: Competing Paradigms in China," *Critical Asian Studies* 33:1 (March, 2001), .p. 13

<sup>3</sup> [Sudha Ramachandran](#), "Greater China: India Quakes Over China's Water Plan," *Asia Times Online*, December 9, 2008.

<sup>4</sup> For reasons of brevity, I am omitting rivers that flow east or northeast from the Tibet-Qinghai Plateau and wind up in Central Asia.

<sup>5</sup> See for instance "Experts Warn China's Water Supply May well Run Dry," *South China Morning Post*, September 1, 2003, available [here](#).

<sup>6</sup> Definitions of "North and Northwest China" vary – I have used as an approximation the provinces of Hebei, Shandong, Shanxi, Shaanxi, Henan, and Gansu, plus Beijing and Tianjin municipalities. Population data for 2008 are available on the [website](#) of the US-China program at the University of Southern California.

<sup>7</sup> As this suggests, such numbers vary depending on definitions of regions and ways of measuring water supply, but not enough to vary the general conclusions. My figures here are derived from Charles Greer, "Chinese Water Management Strategies in the Yellow River Basin," (Ph.D. dissertation, University of Texas at Austin, 1975), p. 96. Olli Varis and Pertti Vakkilainen, "China's Eight Challenges to Water Resources Management in the First Quarter of the Twenty-first Century," *Geomorphology* 41 (2001), p. 94, define the North China plain in a way that gives it 34% of China's population, 39% of its arable land and 6% of its river run-off. United States Embassy in China, "South-North Water Transfer Ready to Start Work," *Beijing Environment Science and Technology Update*, November 16, 2001, p 2, gives the whole area North of the Yangzi watershed (presumably including Manchuria and the far Northwest) 44% of China's population, 60% of its arable land, and 15% of its water. James Nickum ("[The Status of the South to North Water Transfer plans in China](#)"), gives estimates for the Huang-Huai-Hai plain of 8% of water supply, one third of population and 40% of farmland. The map labeled "Water Resources Distribution in China" in Pan Jiazheng (Chinese National Committee on Large Dams), ed., *Large Dams in China: History, Achievement, Prospect* (Beijing: China Water Resources and Electric Power Press, 1987), unpaginated, defines both regions and resources differently (the latter in ways that are unexplained) and makes the regional disparities look even larger. Mark Elvin, "Water in China's Past and Present: Cooperation and Competition," *Nouveaux Mondes* 12 (2003) pp. 117-120, improves on some of these numbers by incorporating estimates for groundwater as well as surface water resources, and gives different numbers again, but the basic regional distinctions remain of similar magnitude. His total "North" has just below 15% of all available water resources, and, since it includes the Northeastern and far Northwestern provinces plus northern parts of Anhui and Jiangsu in addition to the provinces named in note 6, would have close to 600 million people, or 46% of China's population, and thus about 20% of the per capita supplies of the rest of the country.

<sup>8</sup> Elvin, "Water in China Past and Present," pp. 124-125.

<sup>9</sup> For one of many accounts of the tubewell revolution in North China see Greer, "Water Management," pp. 153-160. He 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.

<sup>10</sup> Eloise Kendy, Tammo S. Steenhuis, and David J. Molden, "Combining Urban and Rural Water use for a Sustainable North China Plain," p. 4. International Water management Institute (Colombo, Sri Lanka), 2003 available [here](#).

<sup>11</sup> Jim Yardley, "Choking on Growth, Part II: Water and China's Future," *New York Times*, September 28, 2007; [also available](#) at *Japan Focus* October 13, 2007.

<sup>12</sup> Figures for the comparison come from China News Digest (May 21, 1998); Eloise Kendy, David J. Molden, Tammo S. Steenhuis, Changming Liu and Jinxia Wang, *Policies Drain the North China Plain: Agricultural Policy and Groundwater Depletion in Luancheng County, 1949- 2000* (International Water Management Institute Research Report # 71. Colombo, Sri Lanka: IWMI, 2003). For the Ogalala Aquifer, see Marc

Reisner, *Cadillac Desert: The American West and Its Disappearing Water* (New York: Penguin, 1993), pp. 435-455, and Manjula V. Guru and James E. Home, *The Ogallala Aquifer* (U.S. Geological Survey, National Water-Quality Assessment Program, 2000), pp. 1-12; US Geological Survey, *High Plains Regional Groundwater Study* ([link](#), last modified February 16, 2007, accessed October 1, 2008).

<sup>13</sup> ["Zhongguo shui wuran diaocha: bushi tianzai er shi renhuo."](#) August 15, 2007, cites a figure of 51,000 pollution-related "incidents" for 2005 alone.

<sup>14</sup> 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 some Indian data (which does not give an average but suggests a range in which best practice is close to the Chinese average, and most firms are much less efficient), see [Manipadma Jena](#), "Steel city tackles its water woes," Infochange India, accessed April 23, 2009.

<sup>15</sup> [Ziun Li](#), "China Issues New Regulation on Water Management, Sets Fees for Usage," WorldWatch Institute, March 14, 2006; Elvin, "Water in China," p. 113, using 1990s data, still has the percentage at 84-88%. If we put these sources together, agricultural water use seems to have fallen almost 20% since the late 1980s, without a decline in yields.

<sup>16</sup> The 60 times figure comes from Sandra Postel of World Watch in, ["China's Unquenchable thirst."](#) *Alternet* January 24, 2008. I have seen some lower figures, but none are lower than 20.

<sup>17</sup> If they could move this water more easily, they would almost certainly find ready buyers and thus ease urban shortages – but as we will see later in examples from India, the results of such a system can easily exacerbate the problems of unsustainable water withdrawals.

<sup>18</sup> Frank A. Ward and Manuel Pulido-Velazquez, "Water Conservation in Irrigation Can Increase Water Use," *Proceedings of the National Academy of Sciences* 105:47 (November 25, 2008), pp. 18215-18220, available [here](#).

<sup>19</sup> A good description of the project in English is Liu Changming, "Environmental Issues and the South-North Water Transfer Scheme," *The China Quarterly* #156 (December, 1998), pp. 900-904. See also McCormack, "Water Margins," pp. 19-20; United States Embassy in China, "South-North Water Transfer Ready to Start Work," *Beijing Environment Science and Technology Update*, November 16, 2001, pp. 1-2; Nickum, "Status of the South to North Water Transfer."

<sup>20</sup> See ["China's Giant Water Scheme Creates Torrent of Discontent."](#) March 9, 2009; ["Delays Block China's Giant Water Scheme."](#) February 8, 2009; *Wall Street Journal*, December 31, 2008.

<sup>21</sup> Liu, "South-North Water Transfer Scheme," p. 905.

<sup>22</sup> On the Yangzi, see Tao Jingliang, "Features of a Reservoir," in Joseph Witney and Shiu-hung Luk, eds., *Mega-Project: A Case Study of China's Three Gorges Project* (Armonk, NY: M.E. Sharpe, 1993), 68; Lyman Van Slyke, *Yangtze: Nature, History, and the River* (Stanford: Stanford Alumni Association, 1988), 15. On the Yellow River, which completes 80 percent of its drop on its upper course (at the end of which it is still in Inner Mongolia), see Huang He shuilii weiyuanhui, Shuilii bu, *Huang He shuilii shi shuyao* (Beijing: shuilii dianli chubanshe) 4-7.

<sup>23</sup> Calculated from data in "China To Build 20 Hydro Dams on Yangtze River," Associated Press, April 21, 2009, distributed by China Dams List, [internationalrivers.org](#)

<sup>24</sup> [Timothy Gardner](#), "Tibetan Glacial Shrink to Cut Water Supply by 2050," Reuters, January 6, 2009, citing the glaciologist Lonnie Thompson.

<sup>25</sup> [Keith Bradsher](#), "China Far Outpaces US in clearer Coal-Fired Plants," *New York Times*, May 11, 2009.

<sup>26</sup> Darrin Magee, "Powershed Politics: Yunnan Hydropower Under Great Western Development," *China Quarterly* 185 (March, 2006), p. 25

<sup>27</sup> Magee, p. 26; Grainne Ryder, "Skyscraper Dams in Yunnan: China's New Electricity Regulator Should Step In," Probe International Special Report, May 12, 2006, page 3, available [here](#).

<sup>28</sup> Magee, p. 35. For a useful timeline of China's electrical power reforms, see John Dore and Yu Xiaogang, "Yunnan Hydropower Expansion" (working paper Chiang Mai University's Unit for Social and Environmental Research and Green Watershed, Kunming, March 2004), p. 13.

<sup>29</sup> Shanghai Daily.com June 12, 2008; "Li Xiaopeng Appointed Vice Governor of Shanxi Province," Xinhua Economic News Service, June 12, 2008.

<sup>30</sup> [Isabel Hilton](#), "Still Waters Run Deep," *China Dialogue* June 29, 2009.

<sup>31</sup> Ryder, "Skyscraper Dams," pp. 5-6 raises doubts about the economic rationality of both Three Gorges and various Yunnan hydro projects on this basis. See also Ryder, "China's New Dam builders and the Emerging Regulatory Framework for Competitive Power Markets," draft paper for Mekong Region Waters Dialogue meeting, Vientiane, Laos July 2006, pp. 2-3, 8-9. Available [here](#).

<sup>32</sup> Elvin, "Water in China," p. 125, who concludes from this that "in engineering terms, the better opportunities for hydro-electric power have already been used up."

<sup>33</sup> "6 Women Protestors Hurt by Gunfire," Voice of America News, May 26, 2009, forwarded to the China Dams List of [internationalrivers.org](#).

<sup>34</sup> On Yamdrok Tso see Free Tibet Campaign (UK), *Death of a Sacred Lake* (London, 1996).

<sup>35</sup> Yang Xuyi, "Changjiang zai zheli shicong le," *Nanfang zhoumo* February 18, 2009, available [here](#).

<sup>36</sup> [Link](#). See also "Permafrost soil in Yangtze River area disappearing" English Xinhuanet, [www.chinaview.cn](#), February 13, 2009.

<sup>37</sup> [United Nations Environment Program, World Conservation Monitoring Center](#), "Three parallel Rivers of Yunnan Protected Areas, Yunnan, China," pp. 1, 4-6, referring to the area as "one of the most biodiverse and least disturbed temperate ecosystems in the world," and noting plans to build 28 dams nearby.

<sup>38</sup> [Susha Ramachandran](#), "Greater China: India Quakes over China's Water Plan."

<sup>39</sup> For the 2006 assurances, see the excerpt from a November 22, 2006 *Hindustan Times* article [here](#). For Wang Shucheng's denial that China intends to do this see ["Nation Won't Divert Yarlung Tsangpo River to Thirsty North."](#) China.org.cn, May 26, 2009. For the earlier rumors that China would move forward on this project beginning in 2009 see McCormack, "Water Margins," p. 18.

<sup>40</sup> For Pakistan, see P.K. Jensen, W. van der Hoek, and F. Konradsen and WA. Jehangir, "Domestic Use of Irrigation Water in Punjab," paper from 24th WEDC conference on "Sanitation and Water for all," Islamabad, 1998, p. 297. Available [here](#). For Phoenix, see [this link](#).

<sup>41</sup> [Link 1](#); [link 2](#).

<sup>42</sup> Calculated from figures in Jensen et al. p. 297.

<sup>43</sup> *Ibid.*, p. 298.

<sup>44</sup> Shripad Dharmadikary, *Mountains of Concrete: Dam Building in the Himalayas* (Berkeley: International Rivers, 2008), p. 8

<sup>45</sup> 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: Deep and Deep Publications, 2007) p. 3; Shashi Bala Jain, "Interlinking of Indian Rivers: A Viewpoint," in *Idem.*, p. 24.

<sup>46</sup> John Briscoe et al., *India's Water Economy: Bracing for a Turbulent Future* draft report of the World Bank, 2005; available [here](#), p. 4

<sup>47</sup> Michael Specter, "The Last Drop," *The New Yorker*- October 23, 2006, available [here](#), p. 8. Briscoe, *India's Water Economy*, p. 44.

<sup>48</sup> Briscoe, *India's Water Economy*, pp. 14-21; pp. 41-44, emphasize 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.

- <sup>49</sup> Briscoe, *India's Water Economy*, p. 23.
- <sup>50</sup> Briscoe, *India's Water*, pp. 23-24, gives figures relative to the fiscal deficits of various Indian state governments ["India's Water Shortage."](#) *Fortune* January 24, 2008, p. 2, puts the cost of farmers' subsidies to the electrical power industry at \$9 billion per year.
- <sup>51</sup> See, for instance, the two part National Public Radio series by Daniel Zwerdling, "Green Revolution' Trapping India's Farmers in Debt," and "India's Farming 'Revolution' Heading for Collapse," May 11, 2009 [here](#) and [here](#).
- <sup>52</sup> Sean Daily, "Mass Farmer Suicide Sobering Reminder of Consequences of Water Shortages," *Belfast Telegraph*, April 15, 2009, re-posted [here](#). The story refers to a recent mass suicide of 1,500 farmers, and an estimate that 200,000 farmers have committed suicide over a period of 12 years.
- <sup>53</sup> See, for instance, Georgina Drew, "From the Groundwater Up: Asserting Water Rights in India," *Development* 51 (2008), pp. 37-41. Coke'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 large 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.
- <sup>54</sup> See [Punjab](#), Government Department, Food, Civil Supplies, and consumer Affairs Department, accessed April 23, 2009.
- <sup>55</sup> Dharmadikary, *Mountains of Concrete*, pp. 8-9.
- <sup>56</sup> ["Punjab water is risk to health"](#) BBC News, November 29, 2007.
- <sup>57</sup> Indu Agnihotri, "Ecology, Land Use and Colonisation: The Canal colonies of Punjab," *Indian Economic and Social History Review* 33:1 (1996), pp. 48-55; Mike Davis, *Late Victorian Holocausts* (London: Verso, 2001), pp. 332-335 points to a number of problems with British irrigation projects in India (not just Punjab) that began appearing even in the late 19th century.
- <sup>58</sup> Briscoe, *India's Water* p. 22.
- <sup>59</sup> ["Pakistan's Water Crisis."](#) *PRi's The World*, April 13, 2009. Where the river used to be 5 km wide near Karachi, it is now 200 meters wide.
- <sup>60</sup> Briscoe, *India's Water*, pp. 37-38; Anju Kohli, "Interlinking of Indian Rivers: Inter-State Water Disputes," in Thakur and Kumari, *Interlinking of Rivers in India*, pp. 287-292.
- <sup>61</sup> Briscoe, *India's Water*, p. 36
- <sup>62</sup> Dharmadikary, *Mountains of Concrete*, p.7
- <sup>63</sup> Figure from [Water Encyclopedia](#) citing the (U.S.) National Renewable Energy Lab.
- <sup>64</sup> *Ibid.*, pp. 8-9.
- <sup>65</sup> *Ibid.* 11-15.
- <sup>66</sup> *Ibid.*, pp. 13-14. See also [Ann-Kathrin Schneider](#), "South Asia's Most Costly Dam Gets an Infusion," *International Rivers World River Review*, December 15, 2008, citing a consortium involving Chinese companies and "some Arab countries."
- <sup>67</sup> The International Food Policy Research Institute maintains a database of reports of 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: Risks and Opportunities," April, 2009. Chinese purchases seem to be mostly in Africa, and mostly with an eye to biofuel production.
- <sup>68</sup> [Myra MacDonald](#), "Pakistan: Now or Never?" Reuters, May 6, 2009; has the minister's comments. The 6 million acre figure comes from Armina Bakr "Pakistan opens more farmland to foreigners," May 17, 2009. Pakistan had 22.6 million hectares, or 56.5 million acres under cultivation in 1997 –see [link 1](#), [link 2](#).
- <sup>69</sup> "Outsourcing's Third Wave," *Economist* 391:8632 (May 23-29, 2009), pp. 65-66.
- <sup>70</sup> Ramaswamy R. Iyer, "River-linking Project: A Critique," in Yonginder K. Alagh, Ganesh Pangare, and Biksham Gujja, eds. *Interlinking of Rivers in India* (New Delhi: Academic Foundation, 2006), pp. 61-62; A. Muniam, "Water Crisis in India: Is Linking of Rivers a Solution?" in Thakur and Kumari, *Interlinking of Rivers in India* p. 229; Debotpal Goswami, "Linking of Major Rivers: The Case for Mighty Brahmaputra, in *Idem.*, pp. 297-8
- <sup>71</sup> Narendra Prasad, "A Bird's Eye View on Interlinking of Rivers in India," in Thakur and Kumari, *Interlinking of Rivers in India*, p. 19.
- <sup>72</sup> See the map in Jayanta Bandyopadhyay and Shama Perveen, "A Scrutiny of the Justifications for the Proposed Inter-linking of Rivers in India," in Yonginder K. Alagh, Ganesh Pangare, and Biksham Gujja, eds. *Interlinking of Rivers in India* (New Delhi: Academic Foundation, 2006), p. 30. For cost estimate, see Ashok Khosla, "Foreword," p. 11. Estimate of power generation is in Iyer, "River-linking Project," *Ibid.*, p. 57. See also Naipat Singh Rathore, "Proposed Plan for Satluj-Ghaggar-Yamuna-Jojari-Luni-Sabarmati River Link channels," 2003, [here](#).
- <sup>73</sup> H.H. Uliveppa and M.N. Siddingappanavar, "Interlinking of Rivers in India: Problems and Prospects, in Thakur and Kumari, *Interlinking of Rivers in India*, p. 273.
- <sup>74</sup> Uliveppa and Siddingappanavar, "Interlinking of Rivers: Problems and Prospects," p. 276.
- <sup>75</sup> See most of the essays in Alagh, Pangare, and Gujja, eds., *Interlinking of Rivers*, and Thakur and Kumari, *Interlinking of Rivers in India*.
- <sup>76</sup> Iyer, "River-linking Project," pp. 60-63; Briscoe, *India's Water Economy*, pp. 5-6, 41-44, 48-49.
- <sup>77</sup> Krishna Nand Yadav, "Interlinking of Rivers: Need of the Hour," in Thakur and Kumari, *Interlinking of Rivers in India*, p. 71.
- <sup>78</sup> P.N. Sharma and Anju Kumari, "Interlinking of Rivers in India: Rationale, Benefits, and Costs," in Thakur and Kumari, *Interlinking of Rivers in India*, p. 129.
- <sup>79</sup> On Sanmenxia, see Kenneth 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: University of California press, 2009), p. 138.
- <sup>80</sup> Free Tibet Campaign, *Death of a Sacred Lake*, 7; Wang Xiaoqiang and Bai Nianfeng, *The Poverty of Plenty*, 89; and Free Tibet Campaign, *Tibet Facts #7*; Dharmadikary, *Mountains of Concrete*, p. 28.
- <sup>81</sup> For doubts about a surplus even in the present, Sharma and Kumari, "Interlinking of Rivers: Rationale, Benefits and Costs," p.127; Tapan Kumar Shandily, "Interlinking of Rivers in Indi: Justification, Benefits and Costs," in *Idem.*, pp. 150-151; Goswami "Linking of Major Rivers," p. 299; on Chinese diversions and glacial retreat as further problems, Prasad, "Bird's Eye View," p. 19; Sharma and Kumari, "Interlinking of Rivers: Rationale, Benefits, and Costs," p. 125.
- <sup>82</sup> Briscoe, *India's Water*, pp. 45-46.
- <sup>83</sup> Dharmadikary, *Mountains of Concrete*, pp. 23-27.
- <sup>84</sup> *Ibid.*, p. 33.
- <sup>85</sup> For the emissions, see [South Asia Network on Dams, Rivers and People](#), "Indian Dams Methane Emissions," May 18, 2007, citing a study by Ivan Lima et al., "Methane Emissions from Large Dams as Renewable Energy Resources: A Developing Nation Perspective," *Mitigation and Adaptation Strategies for Global Change* 13:2 (February, 2008), pp. 193-206; for hydro as a percentage of Indian electricity generation, see US Department of Energy 2006 figures [here](#).
- <sup>86</sup> Shi Jiangtao, "Wen Calls Halt to Yunnan Dam Plan; Premier Orders Further Environmental Checks," *South China Morning Post* May 21, 2009, re-published by the China Dams List of International Rivers Network

- <sup>87</sup> Dore and Yu, "Yunnan Hydropower Expansion," p. 14. The following page lists planned projects on the Jinsha (a Yangzi tributary) and Lancang/Mekong.
- <sup>88</sup> The Shan themselves are mostly lowland agriculturalists, but the Shan state as a territory includes many other peoples.
- <sup>89</sup> [Milton Osborne](#), "The Water Politics of Southeast Asia," *Japan Focus* June 11, 2007, pp. 4, 10-11.
- <sup>90</sup> Karen Environmental and Social Action Network, *Khoe Kay: Biodiversity in Peril*. [Link](#).
- <sup>91</sup> "[Activists Protest Tasang Dam.](#)" Shan Herald Agency for News, May 23, 2005.
- <sup>92</sup> Figures from Magee, "Powershed Politics," pp. 28-29 and accompanying notes.
- <sup>93</sup> [Geoffrey Gunn and Brian McCartan](#), "Chinese Dams and the Great Mekong Floods of 2008," *Japan Focus*, August 31, 2008, p. 5, say 15 dams; Magee, "Powershed Politics," pp. 31-32, notes plans for 8-14 dams.
- <sup>94</sup> A useful short history is Nguyen Thi Dieu, *The Mekong River and the Struggle for Indochina* (Westport, CT: Praeger, 1999); pp 49-96 cover the years between the end of World War II and American escalation in the mid-1960s. Both Dieu and Lloyd Gardner, *Pay Any Price: Lyndon Johnson and the Wars for Vietnam* (Chicago: Ivan R. Dee, 1995, pp. xiv, 53, 123,191-198, 298, 320-321, emphasize Johnson's genuine interest in a major Mekong dam project as central to development efforts that they hoped would win "hearts and minds" in Southeast Asia – as well as his ultimate subordination of all policies for Southeast Asia to anti-communism.
- <sup>95</sup> Nguyen, *Mekong River*, pp. 207-216.
- <sup>96</sup> Osborne, "Water Politics of Southeast Asia," pp. 11-16; Gunn and McCartan, "Chinese Dams and the Great Mekong Floods of 2008," p. 6 note that China's emphasis for the Mekong is now changing from transport to energy.
- <sup>97</sup> Osborne, "Water Politics," p. 14.
- <sup>98</sup> Gunn and McCartan, "Chinese Dams," p. 1.
- <sup>99</sup> See program and papers for Foundation for Ecological Recovery, "[Mainstream Mekong Dams: Voices Across Borders.](#)"
- <sup>100</sup> Dore and Yu, "Yunnan Hydropower Expansion," p. 21, cite estimates ranging from 40% to 90% for various points in Southeast Asia.
- <sup>101</sup> Gunn and McCartan, "Chinese Dams and the Great Mekong Floods of 2008."
- <sup>102</sup> Dore and Yu, "Yunnan Hydropower Expansion," p. 21.
- <sup>103</sup> Frank Zeller, "New Rush to Dam Mekong Alarms Environmentalists," Agence France Presse, March 27, 2008, [available](#) at International Rivers Network, and [Grainne Ryder](#), "Chinese Dam Planner Says Upper Mekong Dam Impacts 'Limited,'" October 29, 2008. The 80% figure is cited in "[Dam the consequences.](#)" *Guardian Weekly* April 6, 2007.
- <sup>104</sup> "[UN Says China Dams Threaten Water Supplies to Mekong Delta Farmers.](#)" VietNamNet/TT May 28, 2009, Probe International. See also Elisabeth Economy, *The River Runs Black: The Environmental Challenge to China's Future* (Ithaca: Cornell University Press, 2005), p. 204
- <sup>105</sup> See Chris Barlow, "Mekong fisheries: Impacts of Mainstream Dams on Fisheries and Mitigation Options – Current Status of Knowledge," powerpoint presentation for conference on "[Mekong Mainstream Dams: People's Voices Across Borders.](#)" Bangkok, November 12-13, 2008, and [Patrick Dugan](#), "Mainstream dams as barriers to fish migration: international learning and implications for the Mekong," *Catch and Culture* 14:3 (December, 2008).
- <sup>106</sup> McCormack, "Water Margins," p. 17.
- <sup>107</sup> For instance, in the 1990s, the World Bank and Japan's Overseas Economic Cooperation Fund withdrew support for the Sardar Sarovar high dam on the Narmada River in West India under pressure from Indian protestors, NGOs, and ultimately, the European Parliament (though Gujarat has continued building with its own funds): see John Wood, "India's Narmada River Dams: Sardovar Under Siege," *Asian Survey* 33:10 (October, 1993), pp. 979-983 and Thakor Patel, "funds for Narmada Dam Assured," *The Tribune* (Chandigarh), October 25, 2000 ([online edition](#)). Slightly later, the World Bank refused to help fund Three Gorges Dam in China. See Economy, *The River Runs Black*, p. 206, and 317, n. 80; much aid to China from overseas development agencies has shifted towards environmental protection projects in recent years. See *Idem.*, pp.189-190.
- <sup>108</sup> See, for instance, McCormack, "Water Margins," p. 13, citing protests by, among others, the senior water engineer Huang Wanli. Probably the best know critic of Three Gorges, Dai Qing, is also an engineer by training, though not a water engineer.
- <sup>109</sup> [Agence France Presse](#), "Dams on china's yellow River Near Collapse," June 19, 2009.
- <sup>110</sup> For the recent decision, see Shi Jiangtao, "Wen Calls Halt to Yunnan Dam Plan; Premier Orders Further Environmental Checks," *South China Morning Post* May 21, 2009, re-published by the China Dams List of International Rivers Network. For background to the earlier stoppage see Dore and Yu, "Yunnan Hydropower Expansion," p. 18.
- <sup>111</sup> Natalie M. Kehrwald et al., "Mass loss on Himalayan glacier endangers water resources," *GEOPHYSICAL RESEARCH LETTERS*, VOL. 35, L22503, doi:10.1029/2008GL035556, 2008
- <sup>112</sup> [Timothy Gardner](#), "Tibetan Glacial Shrink to Cut Water Supply by 2050," Reuters, January 6, 2009.
- <sup>113</sup> Briscoe, *India's Water*, p. 32 has projections for the Indus, Ganges, and Brahmaputra.
- <sup>114</sup> Ann-Kathrin Schneider, "Dam Boom in Himalayas Will Create Mountains of Risk," *World Rivers Review*, March 2009, p. 10.
- <sup>115</sup> Briscoe, *India's Water*, pp. 33-34.