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A Mighty River Runs Dry

Hydro dam reservoirs will soon trap the Yangtze's entire flow

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Introduction

The annual filling of the Three Gorges Dam reservoir reduces water levels downstream in the Yangtze basin, causing a plethora of problems for the millions of people who live and work along the banks of the Yangtze River. But the Three Gorges Dam is not the only perpetrator.

So prodigious have dam builders been, the upper reaches of the Yangtze are now intercepted by numerous hydropower projects which also impound the river's vital water flow before it reaches Three Gorges. With even more projects underway, the fate of the Yangtze is sealed. When all of the planned hydropower projects are completed, the amount of water needed to fill all the reservoirs along the Yangtze will exceed the river's flow during the impoundment period each year and the Yangtze River will run dry.

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1 The cost of low water levels downstream of the Three Gorges Dam

The Three Gorges Dam was built to have a normal pool level[1] of 175 metres above sea level. In 2003, upon completion of the barrage, authorities filled the reservoir to the 135 metre mark. In 2006, they began raising the reservoir again, reaching 156 meters by October 28. For downstream areas, that is when the trouble – extremely low water levels, severe drought and other negative environmental effects – began.

By the time the reservoir had reached 156 metres in 2006, water levels in the lower reaches of the Yangtze had dropped rapidly, leading to the intrusion of seawater into the estuary at Shanghai. Between September and November of 2006, the city was hit by several salinity crises, resulting in problems with their water supply.

[1] The normal pool level, or NPL, refers to the maximum height of the reservoir level above sea level under normal operating conditions, as opposed to the "flood control level" which in Three Gorges' case is 145 metres above sea level.

In late 2006 and early 2007, water levels in Dongting Lake,[2] one of China's two largest freshwater lakes downstream of the reservoir, plummeted to the lowest levels in history and a great deal of the lake bottom was exposed. This created favorable conditions for the over-breeding of rodents. Then, as the flood season began and water levels rose in June and July of 2007, rats plagued the lake area, with as many as 2 billion of these voles migrating from Dongting Lake and surrounding areas.

But it wasn't just the filling of the Three Gorges reservoir that caused the devastating drying of the middle and lower reaches of the Yangtze. The impounding of a string of reservoirs along the upper Gan River (in Jiangxi Province, about 1,000 km downstream of Three Gorges) also took a toll and severe drought hit the Poyang Lake[3] area, China's largest freshwater lake, further downstream of Dongting Lake. As with Dongting Lake, by the end of 2006 and the beginning of 2007, large areas of Poyang Lake's floor were exposed. Almost a year later, in December 2007, once again ships began running aground in the middle and lower reaches of the Yangtze.

Then, in 2008, and later in 2009, two attempts were made to fill the reservoir to its highest level of 175 metres. Both attempts failed. The first attempt to fill the reservoir to 175 metres in 2008 failed, mainly because of a series of geological disasters in the reservoir area, upstream of the dam.[4] The second attempt to fill the reservoir to 175 metres in 2009 failed because severe drought downstream in the middle and lower reaches of the Yangtze forced dam operators to release water from the reservoir. Indeed, the attempt to fill the reservoir aggravated the downstream drought so severely that in October 2009, a large number of ships ran aground because of extremely low water levels in the middle and lower reaches of the Yangtze.

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[2] Dongting Lake is a large, shallow lake in the northern region of Hunan Province of China. It is a flood-basin of the Yangtze River; hence the lake's size depends on the season. Dongting Lake is famous in Chinese culture as the place of origin of Dragon boat racing. It is the site of Junshan Island, and is a home to the Finless Porpoise, which is endangered in China.

[3] Poyang Lake, located in Jiangxi Province, is the largest freshwater lake in China. The lake provides a habitat for half a million migratory birds, and is a favourite destination for birding. It is fed by the Gan and Xiu rivers, which connect to the Yangtze through a channel. During the winter, the lake becomes home to a large number of migrating Siberian cranes, up to 90% of which spend the winter there.

[4] For more details, see "The Three Gorges reservoir has become a danger," by Yang Chuanmin, March 3, 2009, in *South Urban Daily* (*Nanfang dushi bao*), translated by Probe International and posted on Probe International's website, http://journal.probeinternational.org/2010/03/11/three-gorges-reservoir-has-become-danger/.

The Yangtze's fish species have also suffered. The construction of the Gezhouba dam, about 40 km downstream of Three Gorges, dammed the main channel of the Yangtze in the early 1980s. Gezhouba not only blocked the migration path of the Chinese sturgeon, but forced the species to form a new spawning ground just below the dam.

The filling of the Three Gorges reservoir lowers water levels and water temperatures in the natural spawning grounds of the sturgeon, forcing a delay in the spawning period by almost a month.

The filling of the Three Gorges reservoir, some 20 years later, worsened the conditions for the river's fish stocks. The period in which the reservoir is filled every year, especially October, coincides with the sturgeon's spawning period; as less water is discharged from the reservoir, water levels in downstream natural spawning grounds are lowered and the water temperature decreases. This forces a delay in the sturgeon's spawning period by almost a month.

Data from hydro power stations along the Yangtze valley show, without doubt, that the filling of the Three Gorges reservoir has resulted in a decrease of water levels in the rivers, lakes and tributaries of the middle and lower reaches of the Yangtze River basin. The simultaneous damming of water in a number of other reservoirs in the Xiang, Zi, Yuan and Li rivers in Hunan province (below the Three Gorges Dam), and the Gan River in Jiangxi province (also below Three Gorges), have made the situation that much worse. The filling of all of these reservoirs is thought to be responsible for the shortage of water in both the Dongting and Poyang lake areas in recent years, particularly in the winter and spring.

For example, in October 2009, as the second attempt to fill the Three Gorges reservoir to 175 metres began, the average inflow to the Three Gorges reservoir was 12,500 m^3/second, while the outflow discharged from the reservoir was as low as 6,500 m^3/second. In October 2009, to ease the risk of drought downstream, the Yangtze River Flood Control and Drought Relief Headquarters of the Ministry of Water Resources ordered the dam authorities to release more water from the reservoir.

Specifically, they ordered that 9,500 m³/second of water be discharged from the reservoir if the average inflow to the Three Gorges reservoir was more than 9,500 m³/second. But, if the rate of inflow fell below 9,500 m³/second, then water must be passed through the dam immediately and unimpeded. As it happened, by November 2, 2009, the inflow was 9,200 m³/second and the outflow was 9,490 m³/second. Therefore, as a result of inadequate inflow and mandatory releases that the Three Gorges operator was obliged to make, by November 2009 the second attempt to fill the reservoir to 175 metres had failed too.

By October 26, 2010, for the first time, the Three Gorges reservoir was filled to the normal pool level of 175 metres.... But it came at a price, as downstream areas experienced rapidly plummeting water levels, and residents suffered inadequate water supplies.

2 Filling the Three Gorges at any cost

In 2010, the Three Gorges Dam authorities were determined to reach the normal pool level of 175 metres. So, they started to back water up on September 10, rather than at the end of September, as had been their practice in earlier years. They did this despite the added risk that populations living upstream of the dam would be flooded out of their homes.

During the period from September 10 to September 15, the water inflow to the Three Gorges reservoir was around 20,000 m³/second or more, with a maximum of about 38,000 m³/second. On average, the outflow was significantly less than the inflow, ranging from 1,000 m³/second and 15,000 m³/second. Then, from September 16 to September 25, inflow and outflow were approximately 20,000 m³/second.[5]

From September 26 to September 30, inflow was about 15,000 m³/second, while outflow was between 10,000 and 15,000 m³/second. From October 1 to October 18, inflow was between 13,000 and 16,000 m³/second. To fill the reservoir to 175 meters, daily outflow was reduced during this period to 7,000 m³/second; only about half of the total inflow. From October 19 to October 25, inflow was between 13,000 and 15,000 m³/second, while the outflow was between 10,000 and 13,000 m³/second, allowing the reservoir to finally, and for the first time, be filled to the normal pool level of 175 metres on October 26.

[5] As the inflow and outflow were approximately the same, no water accumulated in the reservoir from September 16 until September 25.

The filling of the reservoir came at a price though, as Dongting Lake, the Xiang River (which flows into Dongting Lake and then into the Yangtze)[6] and other places experienced rapidly plummeting water levels, and residents downstream suffered inadequate water supplies.

3 Why the Three Gorges is difficult to fill

There are two reasons why filling the Three Gorges reservoir to its highest level have been problematic. First, the reservoirs of a large number of dams on the upper Yangtze are being filled at the same time the Three Gorges reservoir is being filled, leading to a reduction of water flowing from the upper reaches. Secondly, at the same time the Three Gorges reservoir is being filled, the areas below the Three Gorges Dam need that water, especially during periods of droughts, and demand that water be discharged from the Three Gorges reservoir.

Clearly, a serious conflict exists between water supply and demand along the Yangtze River valley.

Thus, the Three Gorges Dam authorities are caught in a pincer-like action: they are deprived of water by upstream hydropower plants whose reservoirs are being filled, and they are pressured to keep the water flowing to downstream areas. Clearly, a serious conflict exists between water supply and demand along the Yangtze River valley.

We are witnessing today a new phenomenon. To keep rivers running, as well as meet the various needs for river water and protect water quality, a number of hydro dams – such as the Xiaolangdi on the Yellow River – have had to release water from their reservoirs at the expense of power generation. For this reason, many power generators today are unable to reach the generation capacity they were designed for.

This same situation plagues the Yangtze and is likely to worsen after a number of giant hydro dams – the Xiangjiaba and Xiluodu, in particular – are put into operation on the upper Yangtze reaches. As Weng Lida, former director of the Yangtze Water Resources Protection Bureau under the Changjiang Water Resources Commission (CWRC), says, "There are many difficulties in attempting to fill the Three Gorges reservoir to its highest level. It is no surprise it is so difficult to achieve."

[6] Chairman Mao was born in a small village by the Liuyang River, a tributary of the Xiang River.

4 Lessons from the Yellow River

There is no shortage of examples of the over-exploitation of a river's hydropower capacity in China, but the Yellow River is perhaps the most dramatic. Dozens of big dams such as Sanmenxia, Longyangxia, Qingtongxia, Wanjiazhai and Xiaolangdi have been built on the main channel of the Yellow River, and more than 3,300 dams of various sizes have been built on a number of tributaries flowing into the river. Currently, the total storage capacity of all those reservoirs is 66 billion m^3. But, according to statistics from the Huayuankou Hydrological Station from 1950 to 1997, the average runoff of the Yellow River was only 57.77 billion m^3. In the period from 1990 to 1997, the average runoff was even lower, at 45.53 billion m^3.[7]

The Yellow River began drying up as early as 1972, and every year the situation has worsened. During the 1970s, the river dried up six times, leaving stagnant pools of water – the longest dry period lasted 21 days. In the 1980s, it dried up seven times, with the longest dry period lasting 36 days. The first eight years of the 1990s saw seven dry spells with the longest lasting a staggering 226 days. In 1997, no water at all flowed into the sea from the Yellow River for 330 days. The drying up of the Yellow River affects not only industrial and agricultural production, but also the domestic lives of people who live along the watercourse. The deterioration of water quality in the middle and lower reaches also poses a serious threat to the ecosystems and species in the Yellow River basin, as well as the delta wetland.

The Yellow River began drying up as early as 1972… The first eight years of the 1990s saw seven dry spells with the longest lasting a staggering 226 days. In 1997, no water at all flowed into the sea from the Yellow River for 330 days.

According to current development plans, a total of 30 more hydro dams, including those already completed and those under construction, are being added to the main channel of the Yellow River. The total storage capacity of all of these older and newer reservoirs combined is estimated at more than 98 billion m^3, about 2.15 times the average runoff of the 45.53 billion m^3 measured at the Huayuankou Hydrological Station between 1990 and 1997.

[7] Runoff diminished for a number of reasons including diversion for irrigation purposes and drought.

Unfortunately, the Yellow River valley in China's north is but one example of the disastrous consequences of dammed rivers. Many great rivers are running dry – like the Yangtze, in the south.

5 The Yangtze River is likely to dry up too

According to studies by Weng Lida, and based on statistics by the Yichang Hydrological Station from 1950 to 2000, the average runoff from the upper Yangtze, upstream of Yichang[8] was 451 billion m^3. Sixty-six percent of that (about 298 billion m^3) occurred in the flood season from May to September, while only 34% (153 billion m^3) flowed in the period from October to April.[9] More specifically, from October to November, the period in which the Three Gorges reservoir is filled, the runoff was only 74.6 billion m^3.

In fact, a series of water crises, and even the drying up of rivers, has already occurred because of the over-exploitation of water resources on some tributaries of the upper Yangtze.[10]

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The Min River, a tributary that flows into the Yangtze upstream of Chongqing, for example, is almost fully covered by a cascade of dams – 15 in all, including those that are completed or under construction, or planned but not yet underway. As a result, the Min River's water levels drop section by section in the dry season; the riverbed is entirely exposed in some sections. Meanwhile, the Jinma River, the main channel of the Min after it enters the Chengdu Plain (and before it joins the Yangtze), runs dry eight months of the year because of the over-exploitation of water resources by hydro dams upstream.

A cascade of 17 hydropower dams is planned for the Jialing River, a tributary that joins the Yangtze at the city of Chongqing. The cascade is slated for the stretch of Jialing that runs between Chongqing and the upstream city of Zhaohua (which is under the administration of Sichuan Province). Nine of those 17 have already been completed.

Meanwhile, many more dams have already been built on the main channel of the Jialing River upstream of Zhaohua, and along the Bailong River (which is itself a tributary of the Jialing River), and its tributaries.

[8] Yichang is 40 kilometres downstream of Three Gorges and is the site of the Gezhouba dam.
[9] These numbers are corrected and based on the *Yangtze Conservation and Development Report 2007* by Yangtze Press (2007).
[10] The "upper Yangtze" includes the river upstream of Yichang, which is itself 40 km downstream of the Three Gorges Dam.

In the winter of 2007, because of the filling of these various reservoirs, and because there was lower rainfall, some of the lowest water levels in history were recorded below several of the dams in the cascade of dams along the Jialing River. In fact, levels were so low, people were able to wade across the Jialing in some sections, and residents in downstream Chongqing experienced water shortages.

Once all the hydro dam projects proposed by the original 1990 Plan for the Comprehensive Utilization of the Yangtze River Basin are built, their total maximum storage capacity will be 212.58 billion m^3 if the controversial Tiger Leaping Gorge dam is built to its highest proposed height, or 193.04 billion m^3 if the lower design for Tiger Leaping Gorge is chosen.[11] Even at their lowest levels, these reservoirs will still collectively require 114.3 billion m^3 or 103.8 billion m^3 (depending on the height of the dam at Tiger Leaping Gorge), or about 1.53 to 1.45 times the average runoff of the Yangtze (74.6 billion m^3) in the period from October to November.[12]

If Three Gorges and all the reservoirs upstream are filled to their normal pool levels from September to April, the river section below the Three Gorges Dam will likely dry up.

This poses a serious dilemma: if all reservoirs upstream of Yichang (including Three Gorges) are filled to their normal pool levels, or their high water levels, the river section below the Three Gorges Dam will likely dry up during the period in which these reservoirs are filling, from September to April, which coincides with the dry season. Conversely, if the normal water levels are to be maintained in the middle and lower reaches of the Yangtze River valley, it is impossible for all the big upstream hydropower reservoirs to be filled to their highest water levels and therefore to operate at their designed power generation capacities.

Two attempts, once in 2008 and then again in 2009, to fill the Three Gorges reservoir to its normal pool level of 175 metres failed. And in both cases, a number of big reservoirs under construction in the upper Yangtze had not yet been completed.

[11] The two proposed normal pool levels for the Tiger Leaping Gorges dam are 2,012 metres above sea level, with a total storage capacity of 37.4 billion m^3, or 1950 metres above sea level, with a total storage capacity of 17.9 billion m^3.
[12] The average runoff of the Yangtze is 74.6 billion m^3 from October to November, i.e. over two months.

The over-exploitation of water by dams on the main tributaries of the upper Yangtze, including the Dadu River, has already caused a water crisis, affecting tributaries, as well as the upper reaches of the main channel of the Yangtze itself.

As Weng Lida points out, it is inevitable that, when they are finished, giant power companies will compete for the water in the river to fill the reservoirs of their hydro dams along the main channel and the tributaries of the upper Yangtze, so they can maximize their hydropower revenues. But filling all the reservoirs at the same time will inevitably deprive downstream areas of water and exacerbate the costs to downstream agriculture, fishing, industry, shipping, and domestic water uses along the Yangtze, not to mention the dramatic effects of salt water intrusion into the Shanghai estuary.

6 Crisis looms as the Dadu River dries up

The Dadu River is a tributary of the Yangtze River and one of the most important rivers in Sichuan Province. Not only does the cascade of dams on the Dadu River include the largest number of dams of any other cascade in Sichuan, the Dadu River is also the source of water for the proposed western route of the South-North Water Diversion Project,[13] as well as the source for another water diversion project to the Min River.

Starting with the available data, I did further research to compare the storage capacity of hydro dams on the main channel of the Dadu River with the river's runoff. I discovered that the over-exploitation of water by dams on the main tributaries of the upper Yangtze (including the Dadu) has already caused a water crisis, affecting tributaries, as well as the upper reaches of the main channel of the Yangtze itself.

According to data from the Wuyousi Hydrological Station in Leshan City, Sichuan Province, the average rate of flow of the Dadu River (excluding the Qingyi River) – based on records collected over 44 years – was 1,470 m^3/second, while the annual runoff was 46.358 billion m^3.

[13] The diversion scheme is among the most ambitious projects that China, which is already famed for megaprojects such as the Three Gorges Dam across the Yangtze, has ever undertaken. The scheme is intended to divert water from the more water-abundant south to the drought-plagued northern regions of China, especially the national capital of Beijing. It involves three sections. The Eastern Route runs along the route of the 14th-century Grand Canal from the southern city of Hangzhou to Beijing and its port city of Tianjin. The Middle Route runs along a canal being built from the Danjiangkou reservoir on the Han River, a tributary of the Yangtze, to Beijing. And the Western Route will come from the Tibetan plateau. For more details, see Probe International's website, http://journal.probeinternational.org/category/beijing-water/south-north-water-diversion-project/.

The total storage capacity of the 24 hydropower stations planned for the main channel of the Dadu River amounts to 18.65 billion m³; or about 40.2% of the annual runoff of the river. This figure doesn't include the total storage capacity of hydropower stations on the main tributaries of the Dadu river, including a cascade of eight hydro dams on the Suomo River, 17 on the Xiaojinchuan, seven on the Wasigou, four on the Tianwan, seven on the Nanya, and seven on the Guanliao, among others, and doesn't take into account the 4 billion m³ of water that would be diverted by the proposed western route of the South-North Water Diversion Project.

During the period following each flood season in which water is typically impounded (over three months, from October to December each year), the average flow rate of the Dadu River is 1,187 m³/second, and the runoff is 9.435 billion m³. Of the 24 power stations planned for the Dadu River (including those already built, those under construction, and those still in the planning stages), 16 have a total capacity of 10.11 billion m³, which exceeds the runoff during the impoundment period.

An attempt to simultaneously fill all 16 reservoirs to their normal pool levels during the main period of impoundment from October to December would be futile: the total volume of designed water storage in the 16 reservoirs would be greater than the runoff of the Dadu River. Even taking into account the fact that the water level of the reservoirs in the initial stages of annual impoundment (in early October) is normally higher than the dead water level, the total volume of water that would be impounded in the upper Dadu reservoirs during the main impoundment period would still be almost equal to the runoff, or 9.435 billion m³. Even then, these figures do not include the water slated for storage by reservoirs on the tributaries of the Dadu River. Therefore, once all 24 hydro dam reservoirs on the Dadu *and* those on its tributaries are completed as planned, the Dadu River will run dry after the flood season ends and the period of impoundment begins.

The situation becomes much worse if we take into account the water to be diverted by the proposed western route of the South-North Water Diversion Project.

An attempt to fill just 16 of the 24 planned dams for the Dadu River would be futile: their designed water storage exceeds the river's runoff.

The situation becomes much worse if water is diverted from the Dadu for the South-North Water Diversion Project.

Based on studies by experts, if the water transfer project is implemented, the runoff of the Dadu River would be reduced by at least 32% in the 300 km-long section of the river between Xieerga and Shimian in the seven months from November to May alone. Based on this, it is estimated that the Dadu's runoff may be less than 6.5 billion m^3 during the main period of impoundment (from October to December). Therefore the total amount of water which the hydro dam reservoirs on the mainstem of the Dadu River would be designed to contain – about 10 billion m^3 – would exceed the total runoff during the main period of impoundment in the upper Dadu River which would be under 6.5 billion m^3.

7 The proposal to divert water from the Dadu River to the Min River

Despite the threat of a severe water crisis facing the Dadu River, a plan "to divert water from the Dadu River to the Min River" has been proposed.

Despite the threat of a severe water crisis facing the Dadu River, a plan "to divert water from the Dadu River to the Min River" has been proposed. The plan to transfer water from the west to the east by the government of Sichuan Province was conceived in the 1970s and 1980s and was officially announced at the beginning of the 21st century. In an effort to deal with the water shortages in the province, the first phase of the water diversion plan is being implemented and should be completed by 2030, with the second phase to be completed by 2050.

One of the motives for the ambitious plan was to alleviate water shortages in the Min River and a low level of per capita water resources in Chengdu (the capital of Sichuan Province). The total annual water available in Sichuan is 261.5 billion m^3, or 3,040 m^3 per capita; higher than the national average of 2,200 m^3. Ganzi, Aba and other regions in the western part of Sichuan enjoy the highest water resources per capita (between 40,000 and 70,000 m^3 per person), the mountainous areas around the Chengdu Plain receive between 2,600 and 11,000 m^3 per capita, but only 825 m^3 is available to the people in the hinterland of Sichuan. Chengdu, for example, receives as little as 684 m^3 per capita, much lower than the national average. At the same time, the average annual runoff has gradually decreased in the upper reaches of the Min River, from 17.4 billion m^3 in the 1930s to 13.26 billion m^3 in the 1990s.

According to the plan, there are three options to divert water from the Dadu River to the Min River:

1. To divert water from the Suomo River, a tributary of the Dadu River upstream of Maerkang (a county in Sichuan Province), to the Heishui or Zagunao rivers (tributaries of the Min River). The advantage of this option is that the Suomo River is not far from the Heishui and Zagunao rivers, the former being separated only by a mountain from the latter two. The rivers would be connected by a tunnel (either the Suomo to the Heishui, or the Suomo to the Zagunao) through the mountain with the longest tunnel being only 15 km. This is convenient to build, requires a relatively small investment, and a short construction period. The disadvantage, however, is that with a total annual runoff of 730 million m^3, only 300 million m^3 is available for diversion from the Suomo River.

2. To divert water from the Shuangjiangkou reservoir upstream of Jinchuan (a county in Sichuan Province), to the Zagunao River, a tributary of the Min River. Because the water intake would be as high as 2,410 meters above sea level and the outlet as low as 2,310 meters above sea level, the water could flow by force of gravity. A 97 km long diversion canal and tunnel linking the Shuangjiangkou reservoir to the Min River would need to be built.

3. To divert water from another reservoir near the county seat of Jinchuan to the Zagunao River, with the water intake as high as 2,200 meters above sea level and the outlet as low as 2,120 meters above sea level. Again, this diversion would also flow by force of gravity and would require a 93 km long diversion tunnel to be built.

A number of experts involved in planning the water diversion project are in favour of the second and third options to transfer 3.32 billion m^3 of water from the Dadu to the Min River. They are planning for a 2020 start date, at which time they will divert 1.1 billion m^3 of water per year to the Min River by 2030, with the eventual goal of transferring a total of 3.32 billion m^3 of water per year to the Min River by 2050.

There are three options to divert water from Dadu River to Min River. They are planning for a 2020 start date, with the goal of transferring 3.32 billion m^3 of water per year.

Some experts insist that the current water shortage is created by a shortage of engineering projects. This approach to dealing with water shortages dates back to 1949 and has made China the most prolific builder of reservoirs in the world. But, despite the proliferation of engineering projects to control water, the water shortages and droughts remain unresolved.

8 Water transfer projects cannot solve the fundamental problem of water shortages

In China, the diversion of water is a typical policy and engineering response to water shortages. The proposal to divert water from the Dadu River to the Min River, as a way of dealing with the Min's water shortage, is, therefore, unsurprising.

As with other projects of its kind, the proposal raises a number of questions: What caused the water shortage in the first place? Is the water diversion project the best solution to the water crisis? Are there sufficient water resources available for diversion? What are the economic, social, and environmental costs of the water diversion project?

Some experts insist that the current water shortage is created by a shortage of engineering projects and, by this rationale, the relocation of water resources through various engineering projects is the solution to the water crisis. This traditional way of dealing with water shortages dates back to 1949, making China the most prolific builder of reservoirs and other types of water management facilities in the world. But, despite the proliferation of engineering projects to control water, the water shortages and droughts remain unresolved.

The Min River is an excellent example of the inefficient utilization of water resources:

1. Most of the water in the upper reaches of the Min River is used for irrigation. The traditional method of flood irrigation is still utilized, leading to a great deal of wasted water. In the upper Min region, water consumption for irrigation is as much as 650 m^3 per *mu* (1/15 *ha*), much higher than the national average of 450 to 500 m^3 used per *mu*, which is itself double the amount of water that should ideally be used according to the Ministry of Water Resources.

2. Despite the limited water resources on the Min River, more and more industries which consume large volumes of water and produce large amounts of pollution (such as chemical, cement and so on) continue to be built.

The petrochemical plant in Pengzhou City, between the Min (on the west) and the Tuo (on the east), both major tributaries of the Yangtze, is a good example: the petrochemical plant consumes the equivalent of about 20% of the combined annual runoff of the Jian River (a tributary of the Tuo River), and Renmin Canal (part of the Min River system) in Dujiangyan, both of which provide water to the facility. The waste water discharged from the petrochemical facility into the Tuo River is approximately equivalent to 14% of the runoff of the Tuo River in the dry season.

3. A large number of power stations and reservoirs are built on the upper reaches of the Min River, forming a cascade. In order to reduce the silt content of the reservoirs, an operation model of "discharging the turbid and impounding the clear" has been implemented. In this model, water must be released in the flood season and impounded during the dry season. The demands of this design feature – silt-laden flood water must be discharged during the flood season, while clear, slow flowing water should be impounded during the dry season – compound the existing conflict between electric power generators and downstream water users.

If we combine the water which would be impounded by the reservoirs in the upper reaches of the Dadu with water that would be diverted, it is obvious that the Dadu River will run dry.

Whether the Dadu River has sufficient water resources to transfer to the Min River is a problematic question. From the above discussion, it is clear that diverting 3.32 billion m^3 of water from the Dadu River would reduce the runoff of the Dadu by about 26.6% during the seven months of the dry season, and transferring a total of 4 billion m^3 of water through the proposed western route of the South-North Water Diversion Project would reduce runoff of the same river by an additional 32%. If we combine these totals, approximately 58.6% of the runoff from the Dadu River would be used in the seven months of the dry season. If we combine the water which would be impounded by the reservoirs in the upper reaches of the Dadu, it is obvious that the total amount of water to be impounded exceeds the runoff and that the Dadu River will run dry.

It will be difficult, if not impossible, for the hydropower projects to reach their design capacity, resulting in an enormous waste of money.

Many rivers, interrupted by hydro stations, will no longer flow naturally, in turn creating severe ecological damage, an increase in social conflict, and worsening water shortages.

There is a clear conflict over how water resources in the Dadu River are to be used; the planning and construction of hydro dams is based on the amount of water resources currently available. But, taking into account the water diversion projects (both the proposal to divert water from the Dadu to the Min and the western route of the South-North Water Diversion Project), it becomes clear that it will be difficult, if not impossible, for the hydropower projects to reach their design capacity, resulting in an enormous waste of money.

Moreover, no research whatsoever, let alone a scientific study or comprehensive assessment, has been done on the social and environmental effects of the diversion of water from the Dadu River valley to the Min River.

Conclusion: Single-sided use of water should be abandoned

River water is a resource with multiple functions such as irrigation, navigation, water supply, power generation, maintaining aquatic ecosystems, absorbing and purifying pollutants and so forth. However, in the interest of attaining high GDP growth rates, tax revenues, earnings on investments, and profits from project contracts, the government and power companies have focused only on the development of hydropower facilities while they ignore the other vital uses and functions of water resources.

Thus, hydro projects are being built, planned, or proposed for almost every river in China, but particularly in the southwest. With no comprehensive planning for the development and environmental protection of the valleys involved, each dam builder behaves according to the Chinese saying *gezi weizheng*, which means “each administers its affairs regardless of the overall interest.” Dam builders are eagerly trying to build more dams to sell power, at the expense of the lives, livelihood and environment of the affected people. They pay little regard for the wise use and protection of water resources which eventually leads to water shortages and parched rivers. As a result, many rivers, interrupted by hydro stations, will no longer flow naturally, in turn creating severe ecological damage, an increase in social conflict, and worsening water shortages.

The driving force behind this messy situation is denial of the fact that river water resources are limited. Instead, the focus is on immediate economic gain and local interests that preclude the use of water in a comprehensive and conservative manner. The unchecked development of hydropower resources is like "draining the pond to catch the fish," resulting in a water crisis in rivers and valleys on the one hand, and a large waste of financial resources through the construction of crippled water projects on the other.

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Currently the overall plan for the Yangtze Basin is under revision. Now is the time to take a serious look at the water crisis and the negative impact brought about by the one-sided and short-sighted energy policy and inappropriate hydropower development activities along the Yangtze River. Planning should be conducted according to the principles of scientific, sustainable development and comprehensive coordination. A series of new ideas and approaches should be taken into account, including scientific feasibility studies and tough measures that cancel unfeasible hydro dam projects. In an effort to curb the over-exploitation of hydropower resources, the number and size of hydropower projects, should be cut.

No hydro projects should be allowed in national nature reserve zones or in regions listed as World Heritage sites, such as the proposed Xiaonanhai, Zhuyangxi and Shipeng dams in the national nature reserve zone in the upper Yangtze and the planned Tiger Leaping Gorge project in the Three Parallel Rivers World Heritage site. Sensitive areas prone to geological disasters such as earthquakes, landslides, mud-rock flow and so on, and regions where construction is likely to trigger social instability (caused by flooding and massive population resettlement), should also be off-limits to hydro projects in order to protect the environment while using rivers and water resources wisely, effectively, and sustainably.

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