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# Tibet: Plateau in Peril

*Michael Zhao and Orville Schell*

Over the past six months, demonstrations in Tibetan ethnic areas of China and the ongoing negotiations between representatives of the Dalai Lama in India and Chinese government officials in Beijing have given Tibet a higher profile than at any time over the last decade. But beyond politics, there is another even more important crisis brewing on the Tibetan Plateau: a looming environmental meltdown.

Over the next 25 years the "roof of the world," where most of Asia's great rivers find their headwaters, could well deliver an ecological crisis to Asia's billions of people. With glaciers melting away faster than anyone predicted, the people of China, South Asia, and Southeast Asia are confronting the prospect of diminished water resources. For, while irregular river flows may be accelerated in the near term by the melting ice, the long-term flows would be diminished.

We've already seen early signs on the Tibetan Plateau of the effects of warming—glaciers retreating, permafrost thawing, grassland degradation, and desertification. There's real reason to heed these signals as grave warnings of far more disturbing consequences to come that will have a global significance over the next several decades.

China triumphantly capped the successful Beijing Olympic Games by winning the most gold medals of any country. But otherwise 2008 hasn't been an entirely lucky year for the rising world power. China registered a record number of earthquakes, from the headline-making Sichuan Province monster jolt that killed 80,000 people and triggered 13,000 aftershocks, to smaller, more recent tremors in Tibet, Yunnan, and, yet again, in Sichuan.

These temblors have one thing in common: they struck around the edges of the Tibetan Plateau, a tectonic plate that was pushed skyward millions of years ago by the upthrusting Indian subcontinent to form the earth's highest mountain range, the Himalayas.

The Indian Plate, moving like a wedge, heaved the plateau to new heights and continues to slowly push the "roof of the world" to the northeast, pressing down on the Sichuan basin and other lower-elevation mountainous areas in China's midwest and southwest. It is these plate tectonics that have caused the recent earthquakes.

Such seismological events can be devastating. But climate change, elevated temperatures, melting glaciers, and changing weather patterns on the Tibetan Plateau could have much larger and more long-term

ecological consequences than all potential earthquakes combined.

Earthquakes are, of course, impossible to predict with any accuracy. But our changing climate is demonstrating its shifting patterns in many obvious ways. And on this fabled miles-high plateau a clear warning bell is sounding what's in store for the planet's future climate, if we only take the time to listen. Melting glaciers and permafrost have over-fed rivers, lakes, and wetlands in some areas, producing more frequent floods. In the northern part of the plateau, however, warmer temperatures and uneven rainfall distribution, coupled with overgrazing, have at the same time shrunk rivers and lakes, and parched dry previously lush pastures, turning them into sand dunes or degraded lands. Moreover, scientists and environmentalists are increasingly concerned about this once-isolated region's importance to much of the rest of Asia. Yao Tandong, one of China's leading glaciologists, is concerned that what is happening on the plateau could "ultimately bring about an immeasurable ecological crisis." According to his research, glaciers in Asia's higher altitudes, mostly in China, have shrunk 7 percent in size over the last 40 years. And in the next 25 years, they will melt even faster.

## *Asia's Water Tower*

China and India today worry about the problems of water pollution, but what if there's no water left to pollute in the decades ahead?

Let's look at the scale of the problem we face. Simply put, the Tibetan Plateau's environmental crisis is a 2-billion-person problem. With a population of 4 billion, Asia is home to 60 percent of humanity. As half of the Asian population rely on the mighty river systems for water—for drinking, irrigation for agriculture, industry, and hydropower—the dramatic shrinking of glaciers and permafrost will cause a degradation of the plateau's ecosystem and disrupt reliable sources of downriver water supply for much of the continent.

Sitting at the geographical center of Asia, the Tibetan Plateau, though inhabited by no more than a few million largely nomadic people, is the size of Western Europe. Home to the Himalaya, Kunlun, and other lofty mountain ranges, the plateau is the source of most of the continent's great river systems: the Yellow, Yangtze, Mekong, Salween, Brahmaputra, Ganges, and Indus, to name the most important. The nearly 60,000 square kilometers (14.8 million acres) of glaciers in China, mostly on the Tibetan Plateau, comprise the largest ice mass outside the polar regions. It is these glaciers that feed the headwaters of these mighty rivers, that in turn serve as a major water source for 2 billion people at lower elevations.

"You can think of these glaciers as a water bank account that's been built up over thousands of years," explains Dr. Lonnie Thompson, a professor of glaciology at Ohio State University at Columbus who has done research on the Tibetan Plateau for many years. "During the twentieth century and in the beginning of the twenty-first century, we have been taking more out of that bank account than we have put in," Thompson observes. "We know that, long-term...that bank account will be gone."

The Quelccaya Ice Cap, on the Andes Mountains in Peru where Thompson has drilled ice cores since 1978, has lost 25 percent of its size in 30 years. The melt rate has gone up ten-fold in the past three decades, receding from six meters per year in the first 15 years to 60 meters a year in the last 15, according to measurements taken by Thompson's team.

The experience of researching and monitoring glaciers in Tibet, Peru, and other regions has made Thompson feel like a doctor seeing ill patients getting sicker year after

Bottoms up: The source of drinking water for two billion people.

year. The situation has become so severe that Peru, once 80 percent dependent on hydropower, has now had to build coal-fired plants to make up for the shortfall in its power output during the dry season, when its hydroelectric turbines run as low as 20 percent of capacity. Everywhere Thompson goes, he finds glaciers shrinking, retreating, and thinning at faster rates than he originally imagined.

On Mt. Naimona'nyi, 6,100 meters above sea level in the Himalayas, where Thompson's team of American and Chinese colleagues drilled an ice core, they expected to find two tell-tale radiation-tainted layers created by American and Russian nuclear tests in 1951 and 1962. Instead, they discovered that the glaciers showed no net ice-mass accumulation at all from snowfall during the past half-century.

Yan Tandong worked in Thompson's lab in Columbus, Ohio, in the late 1980s. He went on to found the Institute of Tibetan Plateau Research at the Chinese Academy of Sciences. A 33-year veteran of glacial studies, he is known affectionately as "Uncle Iceman." Thanks to mounting attention to global warming and increasingly generous government investments in the field of glaciology, Yan is now busy overseeing a small army of researchers who are trying to understand better the full environmental consequences of a warming plateau. They are also trying to understand not only its causes, but to figure out how to deal with the problem over the next quarter century and beyond.

Yao told China's state-run Xinhua News Agency, "The retreat over the last 30 years equals the previous 200 years combined." He predicts that by 2100, half of China's glaciers will have disappeared.

Yao and his colleagues have discovered that, until the first half of last century, China's glaciers were expanding. But during 1950s and '60s, a large-scale retreat began.

Then, during the late 1960s and into the '70s, research recorded a modest net accumulation as more glaciers expanded than retreated. But entering the 1980s, glaciers again started shrinking, this time with alarming rapidity. Since the 1990s, scientists have observed an "all out" retreat, with an overwhelming majority of glaciers beginning to shrink.

Each year, glaciers in China have been melting away at the equivalent rate of the entire annual runoff of the Yellow River, according to Yao. The Yellow River basin is the "cradle of Chinese civilization," and has nourished generations of Chinese for millennia. Now, however, its water flow has come under mounting pressure due to northern China's growth in agriculture, urbanization, and of course, the altered watershed and the shrinking runoff from glaciers on the Tibetan Plateau. Indeed, some years the river has stopped flowing long before it gets to the sea. In 1997, sections of the downstream riverbed dried up entirely for 220 days.

Yushu Prefecture in Qinghai Province, the "source region of three great rivers" or *sanjiang yuan*—the Yellow, Yangtze, and Mekong—contributes, respectively, 49 percent, 25 percent, and 15 percent of water to the three rivers, according to statistics from the Qinghai Province Meteorological Agency. Accelerated melting of glaciers in their watershed, along with desertification and growing evaporation rates as a result of rising temperatures, have significantly cut back the water supply, particularly to the Yellow River. According to a 2005 Greenpeace report on the Yellow River source region, some glaciers have retreated as much as 76 percent in the past 30 years. The situation has prompted the Chinese government to create a Weather Modification Department under the auspices of the Chinese Academy of Meteorological Sciences—which employs some 37,000 people and utilizes 7,100 anti-aircraft guns, 4,991 rocket launchers, and roughly 30 aircraft to fire silver-iodide shells into cloud formations in an attempt to induce more rainfall and increase runoff into lakes and rivers.

Standing at the first bridge across the Yellow River in Madoi County, Qinghai Province, a vast, high grassland area of the Tibetan Plateau, one would never imagine that the quiet, steady, and crystal clear stream—fed by drop after drop of centuries-old melted ice—could become one of Asia's great rivers flowing down to the ocean. If current trends hold, Chinese scientists say that the Tibetan Plateau will lose two-thirds of its glacial ice cover by 2100, without even factoring in what many scientists believe is a probable accelerated warming trend. Because accelerated glacial retreat is proving more commonplace than scientists had originally predicted, this seemingly distant-future projection could very well arrive much sooner. Indeed, as Greenpeace has reported, many glaciers in the region have been melting ten times faster than three centuries ago.

The Yellow River is the foremost of the great rivers to experience a water overdraft from its upstream "bank account." Ironically, China may have to deal with dry rivers before it has even had a chance to clean up the "rivers running black."

And, the Yellow River is not unique. Not far from its headwaters are the sources of the Yangtze and Mekong. The "source region of three great rivers," is such an important area that, a Qinghai newspaper reported, a recent provincial-sponsored joint study with People's University in Beijing put a price tag on its ecological value at 11.3 trillion yuan, or $1.65 trillion.

## *Warmer & Sandier*

The backdrop of the winding streams that comprise the tributaries of the Yellow River are snowcapped mountains in the far dis-

tance. This is typical plateau country, a wild, rugged, and windy, open grassland dotted with lakes and streams. The vast, pristine pastoral landscape is, however, showing signs of drying out, a trend that is only predicted to accelerate over the next 25 years.

Further out on the plateau, lakes and ponds lay scattered everywhere across a mixture of fragile pastures and sandy dunes. Called the "Sea of Stars," this area boasts stunning natural beauty. Gusty winds are almost always blowing, rippling through hilltop prayer flags silhouetted against pearl white clouds in azure blue skies. But a closer look reveals a scene that isn't so lovely: golden sand has encroached on slope after slope of formerly lush pastures and forming beaches along a web of small ponds and lakes.

> "Desertification has become so serious in this region that whole sections of road are now buried under sand."

Hashi Tashi-Dorjie, a government official-turned environmentalist who is based in Yushu Prefecture, has traveled through the *sanjiang yuan* for years. An orphan since age eight, he grew up cadging meals from other nomad families living in yak hair tents on the grassland. Hashi was smart and worked hard enough to get a decent education, ultimately becoming a teacher back in his hometown. Then, he and another friend joined Jiesang Suonan-Dajie, also a teacher, to start a program to protect Tibetan antelopes which were being hunted in the vast area of Kekexili by poachers and illegal gold miners. Jiesang, the leader, was gunned down by antelope poachers in early 1992, bringing the issue into the national spotlight. The incident also jolted Hashi into pursuing a political career.

After attending a Communist Party school, Hashi returned home to Yushu Prefecture and soon became the party secretary of Suojia Township, and then a spokesman for the county of Zhidoi, which in Tibetan means the "source of the Yangtze." But sitting in his government offices, he couldn't stop thinking about Jiesang, his mentor and the environmental crusader in the wilderness. So in late 1990s, Hashi quit his government job and, once again, began roaming the Tibetan Plateau, doing environmental education while working on preservation projects.

"This is what everybody is talking about: desertification of the river source region," Hashi says as he points to the sand dunes creeping down the hills. Ironically, he is standing a few steps away from a billboard swaying in the strong wind that proudly advertises government investment in projects to curb desertification as it takes over pasture lands. But despite these projects, desertification has become so serious in this region that in recent years Hashi's team now sometimes finds whole sections of road buried under sand.

"The general trend is warmer and drier," Hashi observes. Standing beside a barbed-wire fence put up by a pasture restoration program, he speaks appreciatively about the government's investment and attention to the ecological degradation of Qinghai's grasslands. But, he also points out that some government policies are based on assumptions that put more blame on the nomads and their yak and sheep herds than on other factors—a critique he fears will only intensify during coming years.

In fact, Hashi believes that Tibetan nomads who have been living on the plateau

for centuries play an integral part in maintaining the environmental health of this highland ecosystem. Traditionally, nomads move their herds between different pastures at varying altitudes during each season, thus preventing overgrazing. But the new fences, designed to keep nomad families and their herds within fixed perimeters can easily lead to overgrazing of a particular area, because without rotation the pasture never gets a chance to rest. Hashi has also witnessed many instances where livestock, birds, and other animals have become caught in the barbed wire fences erected by government programs.

The government has also been handing out eight-year living allowances that encourage nomads to move into towns and to move their herds off environmentally fragile grasslands. Such programs are based on a presumption that nomads are to blame, in a large part at least, for the degradation of these grasslands. Hashi disagrees with such an analysis. There are areas, he admits, that used to be wilderness in the 1930s that have now been severely damaged by overgrazing. But, he insists, it's difficult to make sweeping generalizations about the whole plateau.

The real problem, Hashi believes, is that higher temperatures and changing rainfall patterns have lead to desertification. "I don't know exactly what is causing the warming and drying here," Hashi confesses, "but I think global climate change is the driving force behind all this."

### *Nomadic Livelihood Under Threat*

That the Tibetan Plateau—sometimes referred to as the world's "third pole"—is one of the early victims of planetary warming, is hardly news to glaciologists like Thompson and Yao. The plateau is extremely sensitive to a warming environment: elevated temperatures arrive five years sooner in these high altitudes than at lower elevations. Over the last few decades, the annual mean temperature rose .33 degree centigrade per decade on the plateau, while in central China it rose only .22 degree, according to China's national and provincial meteorological records. Some areas on the plateau, such as Lhasa and Nagchu in northern Tibet, have warmed even faster, with temperatures rising .36 and .40 degree respectively. The world's average temperature, by way of comparison, has only risen by about .13 degree every 10 years.

The difference between this so-called "third pole" and the Arctic and Antarctica is that, while it may take decades for the melting ice in the polar regions to raise sea levels to heights that can threaten coastal communities elsewhere, the disrupted weather patterns on the plateau have already begun to affect the traditional way of life for millions of Tibetans, and are on the precipice of threatening the lives of hundreds of millions more downstream users.

The quality of summer pastures is of enormous importance to animal husbandry on the Tibetan Plateau, because during the winter when the grass is covered by snow, livestock must survive by burning fat stored during the short months when the pasture is lush. However, if this cycle of feast and famine (to which animals on the plateau have uniquely adapted) is disrupted, it affects not only the animals, but the lives of the nomads themselves, whose subsistence is entirely dependent on their herds.

"In the past there was usually still snow on the ground when the rainy season came," says Suonan-Norbu, a former nomad who now works for a state-owned herding farm in Suojia Township. During the summer solstice rainy season, or monsoon, the grass would grow very rapidly. "At this time, no matter how many yaks and sheep you had," Suonan-Norbu explained, "there was endless grass for feed."

In the past, these rains came in the form of light sustained showers. Now, however,


It looks refreshing now, but for how long?

they come in the form of intermittent heavy thunderstorms. When these downpours end, Suonan-Norbu says, the grass, which needs to be irrigated by slow steady rains, dries up and stops growing. "Now we have an uneven distribution of rainfall," he observes. "The pattern doesn't follow the rules as we knew it."

Nomads' deep knowledge about rainfall patterns and the grassland ecology on which they depend is born of experience. "Nomads don't look at the calendar," Hashi tells me. "They look at the sun, moon, stars, and plants in making decisions about their herding and lives." But in recent years, these regular seasonal events have started to be upset. "Our knowledge about rain patterns and our common sense about how to lead our lives has become invalid," Hashi observes sadly.

As a result, many nomads are giving up nomadic life and are moving into towns. "As far as I can see, 30–40 percent of nomad families around here no longer keep yaks and sheep," he says. "Some don't have a horse either, because motorcycles have replaced horses." With commercialization and urbanization, nomads are slowly abandoning their old pastoral way of life. If that abandonment accelerates and millions more motorcycles, followed by cars and four-wheel-drive vehicles arrive on the grasslands, consuming vastly more oil and other nonrenewable resources, one can only imagine the pressure on the environment over the next quarter century.

"Should I choose to migrate to a town or city, I could get a government subsidy," Suonan-Norbu says. "But if I leave nomadic life, I can't do business. I'm illiterate and don't have other skills." His lament is shared by many.

In Jeigu Prefecture, high on the Tibetan Plateau, a visitor would have a hard time detecting any traces of traditional pollution. The air is fresh and clear, the roads are rela-

tively well-maintained, and the sky is always a crisp blue with clouds scudding overhead. But for how long? Local residents have begun to notice a growing amount of garbage, sewage, and some occasional industrial waste around town. And they are far more disturbed and perplexed by the fact that the mountains that surround the town of 23,000 are now rarely capped by snow. One teacher recalls that during his childhood there used to be snow all year round on the mountaintops.

*Deserts, Permafrost, and Monsoons*

Jiegu residents have also started to experience occasional dust storms. When one small storm hit in late September last year the sky didn't become fully brown as it often does in the spring in Beijing and other northern cities. But given the town's distance from and elevation above China's major deserts—Qaidam, Taklamakan, and long stretches of Inner Mongolia's Gobi—such dust and winds were still bizarre, if not shocking. Indeed, even as far inland as Lhasa, there have been reports of dust storms, which, last year, enveloped the city as early as January. And as many weather stations record ever higher temperatures, and as desertification spreads southward over the next 25 years and beyond, these dust events look destined to be more and more commonplace.

In Madoi, desertification has already affected 13,000 square km (3.2 million acres), or more than half of the county. According to satellite imaging, desertification was getting increasingly serious: from 1987 to 2000, sand coverage grew by 300 square km per year, eventually covering 16,330 square km, or 65 percent of the county. The good news, though, is that from 2000 to 2006, the total acreage of desertified areas in the region fell back to the 1987 level, largely due to a government policy that caps total herd sizes based on the health of the grassland and precipitation levels.

But, Dr. Xue Xian, a visiting fellow at the University of Oklahoma's glaciology department and a researcher with the Lanzhou Institute of Cold and Arid Regions Environmental and Engineering Research of the Chinese Academy of Sciences, has studied the causes of desertification in the Yellow River headwater region. In a paper to be published by *Geomorphology Journal*, she and her colleagues argue, like Hashi, that climate change and permafrost thaw, not overgrazing, are the main causes of the area's desertification.

Although herd control has helped restore the pasture ecosystem a bit since 2000, the herd levels have continuously fallen from a peak of 650,000 head in 1980 to only 200,000 head in 2005, about the same level as during the 1950s. But, even when herd levels were plummeting from 1980–2000, desertified areas kept expanding. A crucial factor seems to be the area's average temperature, which increased 1.5 degrees centigrade from 1953–2005, and contributed to the sinking and thinning of permafrost, a key to maintaining grassland ecology. If yak herd levels continue on the same downward trajectory over the next quarter century, barely 60,000 of these unique creatures would be left in the area.

At high elevations, water that becomes tabled above the permanently frozen layer of earth (permafrost) in the spring and summer is a major irrigation source for aboveground vegetation. This accumulation of water also helps form the wetlands that have long characterized the plateau. If the top levels of permafrost layers melt, the frost layer gets thinner and lower, which results in the dropping of the moisture-rich layer—thus reducing the sub-soil water supply, triggering sinking water levels in lakes, wetlands, and a commensurate degradation of grass and other

vegetation. This is precisely what's occurring on the plateau.

Xue finds that warming trends not only thaw permafrost, reducing the water retaining capacity of grassland soil, but also expedites evaporation of water above ground, decreasing overall moisture. Thus the melting of permafrost spells a drying trend, even without dwindling precipitation.

Melting permafrost also destroys roads and other kinds of infrastructure. Indeed, many sections of the roads on the plateau are now riddled with cracks and bumps. The Qinghai-Tibet rail line was also partially built on lands that sit on top of permafrost, and its melting could significantly damage the railbed.

> "Scientists are worried that a warming Tibetan Plateau will change the dynamics of the Asian monsoons."

In the southern plateau, melting permafrost has sometimes raised the water table. *China News Magazine* reported that in Naqchu Prefecture in central Tibet, many nomad families who live near big lakes have recently witnessed gushing spring water coming out of the grassland, a phenomenon connected with thawing of permafrost. The lakes in some areas have been expanding year after year, flooding old pastures and forcing families and their herds to relocate to higher ground.

To the south of the Tianshan Mountain in Xinjiang Province, melting glaciers are now feeding 5.5 percent more water than the historical average into rivers, refreshing oasis towns and dried-up pastures. But there are also more floods than before, and more irregularity of flow. So, while some areas are enjoying more than plentiful water, other regions are experiencing less. The Three Rivers source region is one such place. Further north in Qinghai Province, the Qinghai Lake has shrunk 700 square km over a century, with its water level dropping by 13 meters. Then, in recent years, the lake reversed this trend and grew back to 4,318 square km. The cause—whether melting permafrost and glaciers, grassland restoration, nomad relocation programs, or man-made rains—is difficult to know. But over the next 25 years, we can scarcely count on this overall trend reversing. The rivers that flow into the lake, the largest inland water body in China, have themselves been disappearing and have been fed by declining runoffs. Half a century ago, *People's Daily* reported, there were 108 rivers feeding the lake. Now there are only 40, and many often flow only intermittently.

A changing plateau, with immediate implications for local people and wildlife, is also a key research interest of concerned scientists, who are worried that a warming plateau will change the dynamics of the Asian monsoon's circulatory patterns and thus cause broader disruptions not only over Asia but also the whole northern hemisphere. The changing heat patterns in the atmosphere over the plateau is likely a key factor in bringing more moisture in on the summer monsoons from the Indian Ocean, explains Ding Yihui, a climate expert with China's Meteorological Administration. But these monsoons aren't powerful enough to push across a warmed plateau to bring much needed rainfalls to the northern part of China. Instead, increased moisture in the southern plateau could add ever more precipitation and flooding to the already wet southern summer.

### *A Wake-up Call*

It's becoming increasingly clear that there is a lack of solid, comprehensive understand-

ing of all the varied environmental consequences that could be caused by further climactic warming on the Tibetan Plateau over the next quarter century. Scientists, from Thompson to Yao, are at the forefront of efforts to find out more. It is urgent that the world puts more of its brightest minds together to seriously deal with the impacts of climate change in this fragile region. If we fail to learn more and then to act soon, we will likely see "an ecological crisis" spread off the plateau and radiate downstream—with enormous consequences for the two billion people who inhabit the rest of Asia, and even other parts of the northern hemisphere.

The nomads of this region may have been among the first to notice the changes in the land and the weather around them, and then to sound the alarm. But it would be folly to assume that they alone can fully plumb the complexity of the new dynamics now in play in this critical region, much less assess the long-term impact on much of Asia.

In the next quarter century, scientists and environmentalists like Hashi are surely going to encounter more of the consequences of a warmed plateau. Nomads like Suonan-Norbu, who has stayed with his herds and continued his traditional nomadic practices, may soon find his lifestyle unsustainable. But as sad as it would be to see this nomadic life largely, or even partially, extinguished, its consequences would pale before the harm done to downstream users of water from the great river systems that rise on the Tibetan Plateau.

Alarms are sounding all around the world as growing carbon emissions exacerbate global warming. But one alarm which begs our close futurev attention is the health of the glaciers and grasslands, and the nomadic life on the Tibetan Plateau, a very delicately balanced ecology. ●