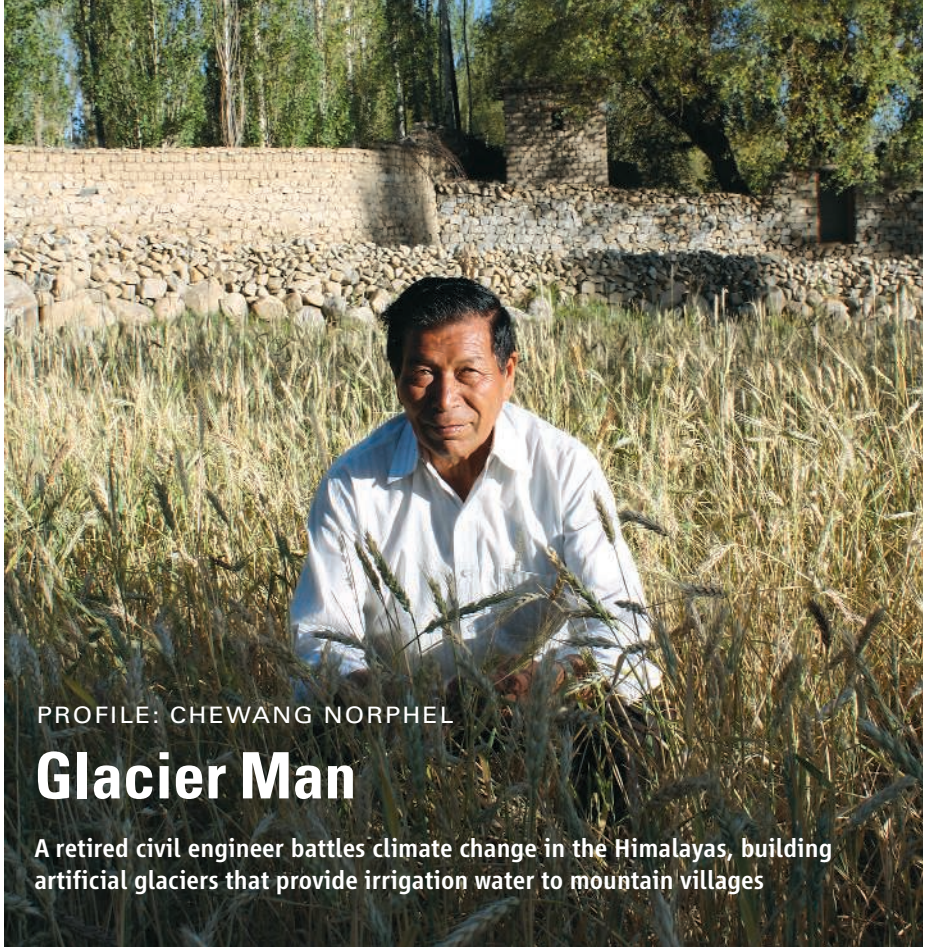

PROFILE: CHEWANG NORPHEL

Glacier Man

A retired civil engineer battles climate change in the Himalayas, building artificial glaciers that provide irrigation water to mountain villages

Icy resolve. Despite initial ridicule at his concept, Chewang Norphel has built 10 artificial glaciers

CREDITS: N. PATTINSON

STAKMO, INDIA—At more than 4000 meters above sea level in the trans-Himalayas, the air is so thin that it can be a struggle simply to breathe. Yet Chewang Norphel is almost jogging across the boulder-strewn landscape, with goatlike agility that belies his 74 years. Tonight, he will sleep in a tent 1000 meters higher up, at temperatures that dip 10°C below freezing, so as to continue his work in the morning. And what unusual work it is: Norphel makes glaciers. He takes a barren, high-altitude desert and turns it into a field of ice that supplies perfectly timed irrigation water to some of the world's poorest farmers.

So far, Norphel has built 10 artificial glaciers, which sustain crops that feed some 10,000 people. It's become his obsession. "When it is very cold and very difficult work, I have to remain focused. All I can think about is making the most successful glacier," he says.

Legend has it that villagers in nearby Pakistan once grew glaciers to block Genghis Khan and his Mongol warriors from advancing through mountain passes, but until Norphel came along there was little evidence that man could reliably duplicate this geological trick. Thanks to his talent, Norphel is now known as "Glacier Man" among the locals in these mountains. Wearing a beige sweater, gray pants, and a pair of leather lace-up shoes, he looks more schoolteacher than superhero, but Norphel has arguably pulled off something miraculous, doubling agriculture yields in one of the most climate-change ravaged regions in the world.

Part engineer, hydrologist, and glaciologist, Norphel has had to create his own field of expertise. "What he has achieved in such circumstances, in remote parts of this mountainous desert, is remarkable," says Pankaj Chandon, coordinator of the WWF-India's High Altitude Wetlands Conservation Programme in the Himalayas, based in Leh, who has followed Norphel's progress over the past decade. "It is testament to his sheer force of character. But also, he has come up with a unique, innovative idea that provides water when it is needed. It is a fantastic adaptation technology for the climate changes that we are experiencing in this region."

From runaway to road builder

Leh, where Norphel was born into a farming family, is the principal town of the ancient kingdom of Ladakh. Wedged between Pakistan, Afghanistan, and China, the territory consists entirely of mountains. It's the highest inhabited region on Earth, originally settled by pilgrims and traders traveling on the Silk Road between Tibet and India or Iran. It's now home to an 80% Tantric Buddhist population.

In the 1940s, when Norphel was growing up, there was just one school in Leh, a primary school, and the young boy had to beg his father to attend it. "He agreed as long as I also kept up my faming duties. So I would rise at 4 a.m. and take the cows and goats for grazing before school. After school, I would rush home to help in the fields," Norphel recalls. Even there, however, he thought of school, scratching times tables and equations into the dirt with a stick as he minded the herds.

The youngest of three brothers in a poor family, Norphel expected that he would be sent to live in a Buddhist monastery after primary school, as tradition dictates. So, at 10 years old, he simply ran away to attend the nearest secondary school, in Srinagar more than 400 kilometers away. He paid for lessons by cooking and cleaning for his teachers.

As his education progressed, Norphel realized two things: He loved mathematics and science, and he wanted to help the farmers he'd seen struggling so hard during his early childhood. One of his heroes was his father's cousin, who had been to London, returned to Leh as Ladakh's first engineer, and built the town's airport and the road from Leh to Srinigar.

There was no university in the state at that time, so Norphel traveled south to Lucknow to earn a civil engineering degree. He loved the rigor of the subject and the practical application of physics and materials science. "You can really make a difference with engineering. You can solve people's problems quickly and in a way that they can see," he says.

Norphel ultimately returned to Leh as a governmental civil engineer. There was hardly a road or bridge in the region when he started in 1960, and everything had to be built by hand. Over the next 35 years, the enthusiastic, raven-haired engineer became a familiar site to the locals, who grew to trust him. "There is scarcely a village in Ladakh where I have not made a road, a culvert, a bridge, a school building, an irrigation system, or a zing [a small water-storage tank fed by glacial meltwater]," he says.

More than 90% of those he helped were subsistence farmers, living and working in tightly knit communities. There was no money around—when Norphel needed labor for his projects, people willingly came forward. His designs had to be sustainable, using locally available materials. For example, he built a number of canals in which instead of using an expensive cement lining that would crack during winter, he allowed

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weeds to grow and thicken, their roots naturally plugging the gaps.

Vanishing ice and a gush of inspiration

By the time Norphel retired in 1995, priorities among Ladakhis were shifting from road-building to a far more serious problem: water scarcity. "Glaciers were vanishing and streams were disappearing," Norphel says. "People would beg me to bring them water. Their irrigation systems were drying up and their harvests were failing. The government was starting to bring in grain rations."

In the so-called rain shadow of the Himalayas, Ladakh receives just 5 centimeters of rainwater a year—about the same as the Sahara desert. The population is entirely dependent on the melting of glaciers and snow. But global warming has hit this region particularly hard. The tree line has risen more than 150 meters during Norphel's lifetime, and glaciers have retreated by as much as 10 kilometers.

Above the small village of Stakmo, Norphel points up at the dark rock slopes rising from the valley. "There were two large glaciers here and here," he says, "and many smaller ones that only persisted during wintertime." The glaciers that remain are now far from the villages and at high altitudes where they don't produce significant meltwater until May or June.

That's too late to help local farmers. Because they experience such a brief summer, villagers must plant their one annual crop of barley, peas, or wheat by late March; otherwise it won't mature before winter arrives in September, after which the temperature drops below –30°C.

By the mid-'90s, Norphel was living in the small village of Skarra, a few kilometers outside of Leh, with his wife and a daughter they adopted from one of his brothers. Determined to address the irrigation problem, Norphel came upon inspiration within 100 meters of his house, one bitingly cold winter morning. "I saw water gushing from a pipe and was thinking what a shame it is that so much abundant water is wasted during wintertime—the taps are left open to stop the water freezing in the pipes and bursting them," he says. "Then I noticed that on its route to the stream, the water crossed a small wooded field, where it was collecting in pools. Where the trees provided shade, it was freezing into ice patches. By early March, the ice patches melted."

Norphel realized that if he could somehow copy this on a much larger scale, he would have a way of storing up this winter water in an artificial glacier that would melt at just the right time for crop sowing and irrigation.

Scorn, then gratitude

It was a beautifully simple concept, but the initial reception to it was rough. "People laughed when I first presented the idea," Norphel says. "Officials and villagers were skeptical. 'What crazy man are you? How can anyone make a glacier?' I was told."

Norphel's idea was to divert the lost winter water from its course down the mountain, along regularly placed stone embankments that would slow it down and allow it to spread and trickle across a large, shaded surface depression a few hundred meters from the village. Here, the slowed water would freeze and pack into a glacier that would begin melting when the sun rose high enough in spring to expose the thick ice sheet—just in time for the sowing season.

But Norphel had no equipment and, even after some relentless lobbying, just a little seed money from the national Desert Development Programme. That was a problem given the societal change in the region that had occurred over the past decade. As water scarcity increased and the roads brought in trucks with government-subsidized grains, many villagers had left their fields to find paying jobs. "The attitude completely changed: If I wanted any of the villagers to repair a canal or help build a new glacier, I had to pay them," Norphel says.

He thus built his first artificial glacier with very little help, above the village of Phuktse. It was an immediate success, supplying water to irrigation channels from late March to late April, after which meltwater from the natural glacier higher up took over. "When people saw the benefits of the artificial glacier, they started helping me and we stretched the length of the glacier to 2 kilometers," Norphel says.

Giving thanks. Norphel (*left*) with a local farmer—some call him a "miracle worker."

The glacier supplies water for crops sustaining more than 1500 people in four villages. It's so precious that during the irrigation season, a man sleeps by the sluice gate to guard against water theft. "It was like a miracle, people quickly started to cultivate more land and started planting willow and poplar trees between their fields," says Phuktse

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Farm aid. Using inlet channels, Norphel directs winter precipitation into stone-built reservoirs. …

The stored water freezes into an artificial glacier and in the spring, outlets direct meltwater into irrigation. …

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farmer Skarma Dawa. "This technology is very good because it works and it is simple and there's very little maintenance required."

Norphel has built nine glaciers since that first one, which he began in the late 1980s and worked on until 1994. They average 250 meters long by 100 meters wide; the Phuktse glacier remains the largest. Norphel estimates that each one provides some 6 million gallons (23,000 meters^3) of water, although there has been no accurate analysis to date, and the undulating ground makes it difficult to guess the volume of ice in each glacier.

Each artificial glacier is built using local labor and materials for about 3 to 10 lakh Indian rupees (US$6000 to $20,000), depending on the size and site, compared with about US$34,000 for a cement water reservoir, Norphel says. "And the technique also helps recharge groundwater and nearby springs," he points out.

"Before the artificial glacier, we really struggled to get any barley," says Tashi Tundop, a 76-year-old farmer from Stakmo village. "But now we can grow many crops, even potatoes, which need to be planted earlier in the spring, but sell for much more money. I get three times more income than I used to."

A new climate threat

Norphel's glaciers are site specific—they require a certain altitude, water flow, and surface area temperature, so they are not suitable for every location, notes Andreas Schild, head of the International Centre for Integrated Mountain Development in Kathmandu. "Nevertheless, we are going to have to do some serious out-of-the-box thinking when it comes to sustainable water storage and investigate the efficiency of artificial-glacier technology," Schild says.

Norphel notes that he has already had interest in his glaciers from nongovernmental organizations working in Afghanistan and Turkmenistan. "In some areas, reservoirs are a much more practical solution," he says. "But in terms of water storage and release at the irrigation season, you can't beat artificial glaciers."

Despite his success, there has been little attention from the academic world. "I could do with some scientific help from specialists," Norphel says. "I am trying to collect data on how and where the glacier forms best, and which parts precipitate first and why, so that I can improve on them and people can use the technique elsewhere.

This September day, Norphel and his glaciers receive their first scientific visitor. Adina Racoviteanu, a geography graduate student at the Institute of Arctic and Alpine Research and the National Snow and Ice Data Center at the University of Colorado, Boulder, is passing through Stakmo en route to her glacier field stations farther east. When she offers to make Norphel a topographic map of the artificial glacier site using her hand-held GPS monitor, a $3000 device, his eyes light up. The pair spend the next several hours taking readings across the site, achieving what would take Norphel weeks to do with his tape measure and plumb line.

Later that day, as Norphel leaps nimbly across the boulders above Stakmo village, he points out his latest design tweaks. In 2006, when it rained for a week and the Zanskar River, which freezes over each winter, melted ahead of time, flash floods and landslides devastated his glacier here. "Blocking walls and canals were damaged by floods," recalls Norphel. "I'm still at the experimental stage, but I've been able to completely redesign this glacier site to make it withstand floods better.

The Stakmo site will soon have three artificial glaciers at increasing altitudes, so by the time the lowest one is spent, the one above it will have begun melting, and then the highest before the natural one at the top starts to liquidize. Norphel points out his latest seepage-avoidance technology: a 200-meter cement chamber that will be connected to the artificial glacier with 2- to 3-meter-long pipe. This will help distribute and freeze sheets of water evenly in the artificial glacier as well as providing a water reservoir for later in the year. "Creating the first such chamber is difficult in terms of design and funding," he says. "The rest will still be expensive but easy to replicate."

Money remains a huge problem. Norphel says that 75 other nearby villages are in suitable locations for his artificial-glacier technique, but he lacks funds, and what funds are promised do not typically arrive in full. The watershed development program allots $50,000 per project per village, but so far, only $12,000 has been released in two installments over the past 6 years.

And there's another problem: continued climate change. There is less and less snowfall during wintertime, when it is needed to contribute to Norphel's artificial glaciers. Instead, rain is arriving in September, ruining the harvests. It's a worrying trend. "These glaciers are not magic formations. They need that water over winter," says Norphel.

As the "retired" engineer makes his way up the mountain to his glacial work site, singing drifts up the valley from the villagers in the fields below, who are harvesting the last of this year's barley with simple scythes. It's a scene that must have played out for centuries. Without the Glacier Man, this village might well have fallen silent a decade ago.

–GAIA VINCE

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The strategy has helped farming villages such as Stakmo maintain productive harvests.

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