Expedition Clip Book: Imja Lake Region, Nepal
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Follow my expedition into the new landscapes of the Himalayas

Travelling with the Mountain Institute, I will visit Lake Imja on foot, learning about its development, and its potential risks

Starting from the western face of Kali Himal, the Imja Glacier flows through eastern Nepal, part of a glacier network that ultimately feeds the Ganges. Photograph: Nasa

Short of a trip to the north pole, there is probably no better place to view – right now, not at some distant point in mid-century – how climate change is carving out new landscapes than in the Himalayas.

The mountains which contain more than 100 peaks above 7,000m, are the largest repository of ice outside the poles. The very name Himalaya means "abode of snow" in Sanskrit. Unlike the Arctic, though, there are hundreds of millions of people who depend on this landscape to remain as it is.

Come spring, the season melt from high-altitude glaciers swell the Ganges and the Brahmaputra, the Irrawaddy and the Yangtze, providing water to farmers and cities. But the glaciers are slowly disappearing, especially those at lower altitudes, and which fall under the influence of the summer monsoons – such as many of those in the Everest region of eastern Nepal.

I'm going to be travelling through that area – mostly on foot – on an expedition led by the Mountain Institute, a US-based organisation which works to preserve mountain environments from the Andes to the Appalachians and beyond.

The Mountain Institute has assembled a group of international scientists and other experts from the US, Latin America, Europe and Asia to take a first-hand look at climate change in the region, and to try to come up with remedies for local people.
The focus – and the destination of the 18-day journey – is Lake Imja. The lake, billed as the highest in the world, did not exist before the early 1960s. But over the years water from the melting Imja glacier began pooling behind a natural dam. The lake now measures 2.5km long.

Glacier lakes, which are occurring across Nepal and Bhutan, are one of the biggest dangers of climate change in the region. When such lakes burst – and they do – they can cause catastrophic floods downstream.

The objective of the Mountain Institute on this trip is to develop safeguards against such floods and, possibly, ways local people can benefit from their new lake. There is a large contingent on the trip from Peru, where they have been dealing with glacier lakes since the 1940s – sometimes even developing them as sources of hydropower.

It's exciting new territory. The Himalayas, because of their sheer vastness, are the least understood mountain range on the planet.

That knowledge gap became painfully obvious two years ago during the controversy over the false claim in the IPCC report that the Himalayan glaciers would melt into oblivion by 2035.

Glacier experts who work in the Himalayas say they knew instantly the claim in the 2007 report was wrong, but it took two years before the IPCC officially admitted the error, damaging the public image of climate scientists.

Since then, scientists have been working hard to fill those knowledge gaps – with satellite imagery, aerial photographs, or like the Mountain Institute, a long climb up to the peaks.

We will start by flying to Lukla, a town situated at about 9,383ft in the Everest region of eastern Nepal. I'm told the descent feels like you are going to smash right into the side of a mountain.

From there it should take two days to reach the town of Namche Bazaar. It's the largest town in the region – which is not saying much – it had a population of under 2,000 during the last census 10 years ago – and a centre of Sherpa and trekking culture. It's at an altitude of 11,286ft 27°49'N 86°43'E. Then we will start making our way towards Imja Lake, 27.898°N 86.928°E

Our route is a well-known one for those familiar with the Everest region. We won't be moving fast – it's important to build rest days into the schedule to acclimatise to the high altitude. And we will be stopping en route to Imja, at the village of Tengboche, 27°50'01"N 86°41'59.85"E where there is an important Tibetan Buddhist monastery and again at the villages of Dingboche. 27°53'N 86°49'E and Chukkung 27°54'18"N 86°52'17"E.

The plan is to spend three nights at Imja, learning about its development, and its potential risks. Could a sudden rock fall cause a catastrophic flood, with waters cascading down on the villagers below? Or, is there a way the lake can benefit local people?

We will be retracing our footsteps on the way back, except for a diversion to get a closer view of Everest and climb up to base camp 28°02'26"N 86°51'34"E) at nearly 18,000ft.

I'll hope you will follow me here or on Twitter, especially those who have been there before me. You can also follow the journey on the Mountain Institute's blog.
Lukla is almost completely surrounded by mountains and is only accessible to small aircraft. We flew in on a Twin Otter. The airport shuts down when there is cloud cover.

That makes it hard to schedule research trips and to fund them. It's hard to calculate costs for donors if you don't know how long you will be waiting around for a plane.

Namche Bazaar does have a helicopter pad, but for the most part the only way in, for scientists as for other travellers, is on foot from Lukla. The only way for those scientists to bring in necessary equipment is to carry it themselves, or hire human porters, and yak or horse caravans.

And these are both just gateway towns, after all. The glaciers and glacier lakes which are already showing the imprint of climate change are even more remote.

Consider the experience of Teiji Watanabe, an expert on glacier lakes from Hokkaido University who is on the expedition.

Watanabe has done considerable research on Imja Lake – the focus of this expedition. The lake, which did not exist half a century ago, is the fastest growing glacier lake in Nepal.

Though the lake seems stable for now, local people and the authorities are worried that it could one day burst its banks, engulfing villages and destroying hard-won infrastructure.

On one of his last trips, Watanabe brought in a boat so he could get depth readings from the lake. The boat, an inflatable rubber dinghy weighing about 50kg, had to be carried in by porter. Watanabe would have liked to bring in an engine as well to power the boat – but was told that would be too heavy and expensive to bring all the way up to Imja, which is about 5,000m. Watanabe ended up rowing the boat around the lake.

Pravin Raj Maskey who has joined the expedition from Nepal's ministry of irrigation, had better luck on one of his last trips to Imja.

He managed to get a boat and an engine all the way up to Imja – only to find out that the engine could not run at that altitutde, because there was not enough oxygen.

I'm planning to spend the next day or so around Namche to see what local people think about the changing glaciers, and those who come here to study them. From there, it's on to the town of Dingboche.
Suzanne Goldenberg’s expedition in the Himalayas – map
Follow Suzanne Goldenberg's journey through the Himalayas as she documents the changing environment.
Himalayas in danger of becoming a giant rubbish dump

Nepal wants to lift itself out of poverty by expanding its tourism industry but there is no strategy for waste disposal

There's nothing like waking up to bright clear skies with spectacular views of the Lhotse and Amu Dablam ranges – and a rubbish dump.

This heap of beer cans, mineral water bottles and other material was just a few minutes' walk outside the village of Tengboche. It represents about a season's rubbish.

The dump is not on the regular trekking trails which are, aside from the stray Fanta and instant noodle wrapper, admirably clean. And most trekkers have no idea of their impact on the remote Everest landscape, said Alton Byers, who is leading our expedition as director of the Mountain Institute.

But the dump exposes the risks of Nepal's strategy of lifting itself out of poverty by expanding its tourism industry. "At this altitude and in this environment, this [rubbish] will be here for 1,000 years," Byers said.

The government has declared 2011 Nepal tourism year and has sought to double the number of visitors to 1 million. But can remote communities handle those numbers? Only a fraction of tourists to Nepal make it to the Everest region – about 31,000 last year.

But those numbers are already taxing local villages. In high season, which runs from mid-September through December, it can be hard to find a room on some of the trekking routes.
It's even harder to clean up after the trekkers once they are gone. "Thirty years ago, there was no garbage. There was no plastic," said Byers. Now, he said: "we see this in every village all the way up to Everest base camp."

Even the village of Namche Bazaar, the biggest in the region, does not have a waste treatment system. Sewage from the 45 lodges is dumped directly into a canal, which eventually feeds into the Khosi river, according to Orenlla Puschiasis, a researcher from the University of Paris West-Nanterre, who is working on water quality in the region.

"There is nothing sustainable about it," she said. "To be sustainable they have to think about the future and manage the waste and the sewage water."

Trekking companies are supposed to carry their rubbish out with them – but most do not. Lodge operators balk at the idea of paying to cart out beer cans by yak. And even if they do carry the rubbish down to Kathmandu, what then? There is no developed recycling industry in Nepal – not even in Kathmandu.

Maybe it's time for some waste treatment plants right in the Everest region.
Himalayas expedition finds evidence of ‘disaster in the making’

The disappearance the juniper bushes, which hold the soil together, will cause problems, Mountain Institute scientists say.

After a day of trekking through rhododendron forests, the Mountain Institute expedition has now travelled above the tree-line to the village of Dingboche.

The village, which sits at about 4,400m, has a population of about 70 year-round, though it will grow considerably when the trekkers starting moving through in the next week or so.

This is one of the last staging posts before the Mountain Institute moves up to Imja Lake, the focus of the expedition.

The landscape has changed with each gain of elevation: through thick forests with butterflies and wildflowers of every description, slopes covered with rhododendron, and now the higher terrain, which traditionally was covered with juniper.

The hill behind Dingboche is bare though. Much of the juniper has been cut down for firewood. Its disappearance is a disaster in the making, the scientists of the Mountain Institute say.

The juniper bushes are one of the few plants that can thrive at these heights, and that can help hold the soil together. On the trek up to Dingboche, several of the cliffs are scoured by recent landslides.
The bushes are extremely slow-growing, it could decades before the slope is covered again.

The demand for fuel didn't used to take such a toll on the local surroundings. But hundreds of tourists pass through Dingboche in the trekking season, and the lodges need the fuel to feed them.

Until a few years ago, villagers even used to chop down the juniper to send up to Everest base camp. The bushes were burned as offerings for a successful ascent.

Thankfully that practice has now stopped, and the Mountain Institute and other organisations have been working with local people to find ways to protect the juniper, and the hillsides.

There is no easy fix though. Kerosene is a more expensive cooking fuel. Solar is just too slow. A number of homes along our route have huge reflective solar dishes, which can be used to heat water for cooking or bathing. "It makes life easier sometimes," said Dilli Kumar Rai, who lives just outside the village of Tengoche. But she added, it still takes 45 minutes to make a cup of tea.
Watching a glacier die at Imja Lake

The Mountain Institute hopes it can assess the threat from Imja to villagers living below – and provide some solutions

It's an odd sensation to watch a glacier die, the snow sliding off the massive black cliffs, punctuated with the cracks of big ice blocks falling away. The Mountain Institute has been doing just that, the last couple of days, watching the scenes at Imja Lake.

Imja is the fastest-growing glacier lake in Nepal. The sheer fact of its existence is evidence of the increasing pace of climate change in the high mountains of the Himalayas. The glaciers are melting – although some undoubtedly will remain solid blocks of ice for hundreds more years – and they are spattering the high altitudes with glacier lakes like Imja.

The lake, a sludgy grey-green, stands at about 5,100 metres. It's a nine-day trek from the nearest airport at Lukla, and several days away from electricity or telephone services.

Even the Nepal government rarely ventures here. So bringing in 32 scientists from 13 countries, as the Mountain Institute has done, is a logistical nightmare.

Seventeen tents, 60kg of rice, a generator which turns out to be unreliable, and 6kg of yak cheese – it takes a lot to keep a large group going for three days.

There's been ice outside the tents some mornings. But on clear days, there are spectacular views of the Lhotse and Nupse mountains across the river bed.
The Mountain Institute is hoping the scientists will be able to assess the hazard from Imja to the villagers living below – and come up with some solutions.

It's been difficult to get a clear answer over the years on the likelihood of Imja one day breaking its banks, which are made of rock and debris piled over ice. By this point, however, the local people who have trekked up to the lake from nearby Dingboche say they are beyond caring what science has to say about the melting glaciers.
The sound of a glacier – Wind Horse by Stephanie Spray
The anthropology PhD candidate from Harvard describes the sound of a glacier as being ‘like the belly of the Earth groaning’

Wind Horse by Stephanie Spray.
What does a glacier sound like?

An anthropologist from Harvard, who has made a collection of awe-inspiring sounds, says it is like 'the belly of the Earth groaning'.

Stephanie Spray, a PhD candidate in social anthropology from Harvard, has joined the Mountain Institute expedition with the hope of producing a sound installation of the people and landscapes along the way.

Spray, who has been visiting Nepal for 12 years, started on the project last year, with the original idea of tracking the Dudh Khosi river, up to its source in the glaciers.

By the time she had climbed into the Himalayas, however, Spray decided that the sounds of glaciers were more interesting, and she spent some time recording around the Khumbu glacier, near Everest.

So what does a glacier sound like? Spray said she captured a collection of sounds, from the sharp crack of falling ice to the gurgling sounds of trapped water.

"It sounds like the belly of the Earth groaning," said Spray. "I find it terrifying. That is part of the appeal to me. For me it restores a kind of awe to the environment."

Her earlier recording is called Blue Sky, White River and you can listen to it below.
Himalaya earthquake brings home urgency of securing glacier lakes
With avalanches and mudslides, the quake was yet another reminder of the dangers of living in an unstable region

This week’s earthquake in the Himalayas was another reminder of the dangers of living in an unstable region, as you might expect. This part of the Himalayas got off relatively lightly – as opposed to the epicentre of the quake in the Indian state of Sikkim.

Even so, it brought avalanches and mudslides, wiped out a strategic wire foot bridge near the town of Lukla, and damaged a number of homes.

For the Mountain Institute expedition the quake brought home the urgency of securing glacier lakes such as Imja. The Mountain Institute is winding up its expedition, and will reconvene in a series of workshops in Kathmandu next week.

It is not immediately clear how – or even if – the earthquake destabilised the natural dams holding in Imja or any of the region’s other newly formed glacier lakes. But the scientists and engineers are hoping the expedition will help develop new methods of dealing with climate hazards.
First: south-south co-operation. A main premise of the expedition is that Nepal can learn from the experience of Peru, which has been dealing with the problems of glacier lakes for decades – without foreign assistance.

That's a departure from the normal order where Nepal, one of the poorest countries in the world, typically looks to Europe or North America for disaster preparedness or development funding. This expedition is almost entirely funded by the US government, with contributions from the US Agency for International Development, the State Department, and the National Science Foundation.

But it is heavy on Andean expertise. César Portocarrero, head of the department of glaciology and water resources at the National Water Authority of Peru, had decades of experience in dealing with glacier lakes, before making the trek to Imja.

He has overseen engineering works on 35 lakes securing them against future collapse. "I think we can be proud that we created our own technology in Peru to work with these kinds of problems," he said. Portocarrero now hopes to suggest some of those solutions for Imja and other glacier lakes in Nepal.

The other underlying premise of the Mountain Institute's expedition is involving local people in decisions about glacier lakes.

As I've said earlier local people are getting fed up with scientific expeditions to Imja. They say they want a final decision on whether the lake is safe – or could one day unleash a catastrophic flood. And yes, they would like hydropower from the lake too.

But making yourself popular here is harder than might appear. Nepali studies suggest that a flood from Imja Lake could devastate up to 100km of farmland and infrastructure. So which local communities to involve?

As the Mountain Institute itself notes on its blog of the expedition:

It is unclear right now who our best partners might be in the Imja Valley. There are village and district level committees; in some areas, committees of lodge owners are forming. But there is little or no coordination between the various constituents on many issues ... There is the Sagarmatha (Mt Everest) National Park management. And there is the Nepali national government. A project of the scale of managing Imja Lake's flood risk calls for a big partner, not a village of a few dozen families and a handful of tourist lodges. However, the national government's influence in the Imja area is not evident — there are few schools and no post offices.

There is another issue the post fails to raise – gender. How to ensure that women and men have a say in community decisions.

On our first meeting with local people in the town of Dingboche, the women left the room, after singing a traditional welcome song and serving tea. None of the women participated in the discussion about what to do about the lake.

The delegation from the Mountain Institute did not set much of an example. Of the 32 scientists participating in the trek only one – a geologist for the government of Bhutan – is a woman. There are two other women on the trip: a PhD candidate in anthropology who is listed as a
member of the social media team, and an intern at the Mountain Institute office in Kathmandu, also listed as a member of the social media team.

But it does suggest that ensuring adequate representation and inclusion are not solely a challenge for the developing world.

I'll be returning to these issues – and others – in the days ahead.
Everest’s ice is retreating as climate change grips the Himalayas

Climate change is altering the face of the Himalayas but research seeking to confirm this is yet to catch up with the mountain communities sounding the alarm. After an 18-day trek with scientists, Suzanne Goldenberg finds the warning signs hard to ignore.

The climb to Everest base camp is a journey into a monochrome world, a landscape reduced to rock, ice and grey sky. The only spots of colour are the bright, domed tents of the few climbing teams willing to attempt the summit in the off-season.

There are no birds, no trees, just the occasional chunks of glacier splashing into pools of pale green meltwater like ice cubes in some giant exotic drink. The stillness suggests nothing has changed for decades, but Tshering Tenzing Sherpa, who has been in charge of rubbish collection at base camp for the past few years, remains uneasy. "Everything is changing with the glaciers. All these crevasses have appeared in the ice. Before, base camp was flat, and it was easy to walk," he said.

Climbers had reported that they barely needed crampons for the climb, there was so much bare rock, Tenzing said. That's not how it was in Edmund Hillary's day. Tenzing pointed towards the Khumbu ice fall – the start of the climb, and part of a 16km stretch of ice that forms the largest glacier in Nepal. "Before, when you looked out, it was totally blue ice, and now it is black rock on..."
"top," he said. He's convinced the changes have occurred in months – not years, or even decades, but during the brief interval of the summer monsoon. "This year it's totally changed," he said.

This much is known: climate change exists, it is man-made, and it is causing many glaciers to melt across the Himalayas. Beyond that, however, much is unclear or downright confusing.

For that, scientists blame a blunder in a United Nations report that was presented as the final word on climate change. The 2007 report – which included the false claim that the Himalayan glaciers would disappear by 2035 – probably did more to set back science, and delay government action on climate change, than any other event. The scandal, known as Glaciergate or Himalayagate, was a gift to climate-change sceptics when it came to light early last year, and a deep embarrassment to glaciologists. Now they are desperately trying to recover.

Mention melting and Himalayas to almost any glacier expert working in the region, and they will instantly plead for caution: please do not repeat the mistake of thinking all the ice will be gone in the next few decades. "It was just nonsense," said Alton Byers, the scientific director of the Mountain Institute. "It's absolutely staggering when you look at some of those high mountains. They are frozen solid, at minus 15 or 20 degrees, and they are going to remain that way."

At lower elevations, it's a different scenario, Byers acknowledged. Low-lying glaciers are melting, and far more rapidly in the past 10 or 15 years than in previous decades, scouring out new landscapes and creating a whole new realm of natural disasters for countries that are some of the poorest on Earth.

I accompanied the Mountain Institute and 32 scientists and engineers from more than 13 countries on an expedition looking into some of the new hazards.

After flying to the Nepali town of Lukla – landing in an airport partly built by Edmund Hillary – the 18-day trek took us to Everest base camp and to Imja lake to look at a prime potential danger of climate change in the mountains: catastrophic, high-altitude floods. Melting ice turns to glacial lakes which grow in size until – one day – they risk rupturing their banks, spewing out rocks and debris. Such outbursts can kill, and they almost always invariably destroy infrastructure and land, burying fields in several metres of rubble.

That's seen as the biggest potential hazard. There are more than 1,600 glacial lakes in Nepal alone, of which about a half dozen are considered very dangerous. But glacier loss could also destabilise mountainsides or devastate water supplies. Some of Asia's mightiest rivers – the Indus, Ganges, Brahmaputra – depend to some extent on seasonal glacier melt. In Pakistan, the Indus river system derives between 60% and 80% of its flow from summer melt, according to Amjad Masood of Islamabad's Global Change Impact Studies Centre. In Uzbekistan, half of the rivers in the Tashkent area rely on water from glaciers, said Maxim Petrov, head of glaciology at the Academy of Sciences.

The problem is people who live with the mountains are already convinced their landscape is changing, and have given up on waiting for scientists to confirm it. Local people say they can see evidence of climate change everywhere: trees growing higher up mountain slopes, houseflies buzzing at 5,000m, monsoon rains arriving at inconvenient times.
Some see the hand of divine retribution. Kancha Sherpa, the sole surviving member of Hillary's expedition, believes the melting glaciers are a punishment for defiling nature. Now 79, he spends his time in the main town of Namche Bazaar in a room painted pale pink and lined with pictures of past expeditions. "I believe the gods reside in the mountain, and now with all the mountains being climbed they have been polluted. I believe God is not happy with all the people climbing in the hundreds."

Birendra Kandel, a conservation officer at the Sagamartha national park, which includes Everest, argues that animals are already roaming beyond their typical ranges. A few years ago, on a field trip, he spotted a common leopard prowling well into snow leopard heights. He assumed it was climate change. "The species are on the move," he said.

Others are also convinced familiar landscapes are changing before their eyes, and that the cause is global warming. Not far from Everest, tucked into the mountains at about 5,050m, near the village of Lobuche, there's a three-storey glass pyramid that looks like it belongs on the set of an Austin Powers movie.

It's a high-altitude research station run by an Italian organisation dedicated to research on the Himalayas. Earlier this year, crews from the pyramid, as it is usually known, strapped on crampons and installed a weather station on the south col of Everest at about 8,000m. There are plans to go even higher next spring, placing a weather station on the summit itself.

The data from the south col, on temperature, air quality and ozone levels, has just started coming in. Ka Bista, a Nepali staffer who mans the pyramid when the Italians are back in Europe, says the changes are evident right now. "Since the last five or 10 years before and now, there are many differences in the glaciers. Before you could see ice," Bista said, pointing to the bare black rock visible through the pyramid. "Yearly the snow is melting and going further up the mountain, and the temperature is also going up." Winters have also grown milder, he said. In 2006, typical February temperatures were minus 23 or 24 celsius. This past February it was almost balmy in comparison, Bista said, at minus 17 or 18 degrees.

The changes are disorienting for local people, Bista said. "Ten years ago a trekking guide could tell you the name of every mountain, but now they are all completely black and the guides can't recognise their names."

What became clear on the Mountain Institute expedition, however, was the disconnection between such personal experiences and the scientific process. People living in the mountains say they can see signs of climate change. Climbers who have scaled Everest say they can see evidence of climate change.

The problem is that it is immeasurably harder to produce conclusive scientific documentation of those changes – which glaciers are melting and how fast? — and Himalayagate has made scientists especially cautious.

Put simply, the region is just too big, and too remote. Between them the mountains of the Himalayas, the Hindu Kush, Karakorams, Pamirs and Tien Shan store more ice than anywhere outside the north and south poles. There are believed to be about 15,000 glaciers across the Himalayas – 3,800 or so in Nepal alone, according to the International Centre for Integrated Mountain Development, in Kathmandu.
But even that number should not be taken as gospel, according to Dorothea Stumm, of Icimod. Scientists can't even agree on which mountain ranges should be included in the count. "Currently it is safer to talk about several tens of thousands of glaciers instead of a specific number," Stumm wrote in an email.

Then, there is the question of size. "How big does an ice patch need to be to be called a glacier?" said Stumm. Smaller ones might not even show up on low-resolution satellite images. And how do you count a bigger glacier that has split into two smaller blocks of ice? And it's not as if scientists can just pop out for an afternoon and measure some of the large glaciers in the Himalayas. The Khumbu glacier, which runs alongside Everest, is a good eight or nine days' walk from the nearest airport at Lukla. The glaciers of Bhutan are even further removed, and the Siachen glacier is an actual battlefield, with India and Pakistan maintaining troops there at 6,000m.

"Himalayan glaciers are much more remote," said Andreas Kaab of the University of Oslo, who was not on the expedition. "From Zurich you take the train a few hours, you take a cable car and there you are at the glacier and you take your measurements," he said.

The result, according to Byers, is a big knowledge gap. Scientists have access to satellite images of the Himalayas, but compared with other regions, such as the Andes or the Alps, there is relatively little on-the-ground research. Satellite imagery only gives a partial picture; it can reveal a glacier shrinking in length, but it gives little indication of whether the ice is thinning. In addition, record-keeping on glaciers and temperatures got under way relatively late in Nepal.

"It's pretty much a vacuum, the Himalayas," Byers said. "The Alps and Andes are well studied. I think they have a good database on glaciers there. The Himalayas, in terms of these sorts of studies – there are fewer than elsewhere in the Himalayas for reasons of logistics, hardship and altitude there still hasn't been a whole lot of detailed field work done, on-the-ground field work."

Nevertheless, some definitive patterns are emerging. In Nepal, south-facing glaciers, especially at lower elevations below about 5,000m, are thinning and growing shorter at a rapid rate. Some – especially the glaciers that are relatively clear of debris — have already disappeared.

Those glaciers covered in a sufficiently thick mask of grit and rock have a better chance. If the covering is thick enough, say greater than a metre, the layer of rocks and debris acts like an insulation blanket, preserving the glacier from more rapid warming. A thin coating seems to have the opposite effect, however, absorbing the sun's rays, and speeding the melting process.

But even the greatest glaciers, such as Khumbu, are in retreat. On the way up to base camp, the signs seem evident in the small ponds now forming on the surface. "There are a lot of things on the surface of the Khumbu glacier. It is a sign of degradation," said Petrov. "Of course, this glacier is not degrading so intensely as smaller glaciers, but if you compare the old glacier 40 or 50 years ago with the glaciers of today, then it is retreating."

So where does that leave the Himalayan glaciers? Will there still be glaciers in the big ice repository a generation from now? Probably, but don't count on it for much longer than that, Byers said. "Your grandkids are going to go up there and see glaciers. I just don't believe in this scenario of all that ice being gone in the next 30 years or so."
But he added: "If you are looking really long-term, say 100 or 200 years from now, at current warming trends I would say that the outlook is not good, not good at all."

• This article was amended on 27 September 2011 to replace the term "climate-change" deniers with "climate-change sceptics" in accordance with the [Guardian and Observer Style Guide](#) which states: "Rather than opening itself to the charge of denigrating people for their beliefs, a fair newspaper should always try to address what it is that people are sceptical about or deny. The term sceptics covers those who argue that climate change is exaggerated, or not caused by human activity."
It's strangely calming to watch the Imja glacier lake grow, as chunks of ice part from black cliffs and fall into the grey-green lake below.

But the lake is a high-altitude disaster in the making – one of dozens of new danger zones emerging across the Himalayas because of glacier melt caused by climate change.

If the lake, situated at 5,100m in Nepal's Everest region, breaks through its walls of glacial debris, known as moraine, it could release a deluge of water, mud and rock up to 60 miles away. This would swamp homes and fields with a layer of rubble up to 15m thick, leading to the loss of the land for a generation. But the question is when, rather than if.

Mountain regions from the Andes to the Himalayas are warming faster than the global average under climate change. Ice turns to water; glaciers are slowly reduced to lakes.

When Sir Edmund Hillary made his successful expedition to the top of Everest in 1953, Imja did not exist. But it is now the fastest-growing of some 1,600 glacier lakes in Nepal, stretching down from the glacier for 1.5 miles and spawning three small ponds.

At its centre, the lake is about 600m wide, and according to government studies, up to 96.5m deep in some places. It is growing by 47m a year, nearly three times as fast as other glacier lake in Nepal.

"The expansion of Imja lake is not a casual one," said Pravin Raj Maskey, a hydrologist with Nepal's ministry of irrigation.

The extent of recent changes to Imja has taken glacier experts by surprise, including Teiji Watanabe, a geographer at Hokkaido University in Japan, who has carried out field research at the lake since the 1990s.

Watanabe returned to Imja in September, making the nine-day trek with 30 other scientists and engineers on a US-funded expedition led by the Mountain Institute. He said he did not expect such rapid changes to the moraine which is holding back the lake.

"We need action, and hopefully within five years," Watanabe said. "I feel our time is shorter than what I thought before. Ten years might be too late."

Unlike ordinary flash floods, a glacier lake outburst is a continuing catastrophe.
"It's not just the one-time devastating effect," said Sharad Joshi, a glaciologist at Kathmandu's Tribhuvan University, who has worked on Imja. "Each year for the coming years it triggers landslides and reminds villagers that there could be a devastating impact that year, or every year. Some of the Tibetan lakes that have had outburst floods have flooded more than three times."

But mobilising engineering equipment and expertise to a lake 5,100m up and several days' hard walking away from the nearest transport hub is challenging in Nepal, one of the poorest countries in the world. People living in the small village of Dingboche below the lake say scientists and government officials have been talking about the dangers of Imja for years.

Some years ago one of the visiting experts was so convincing about the dangers of an imminent flood that the villagers packed up all their animals and valuables and moved to the next valley. They came back after a week when the disaster did not materialise, but say it's hard to dismiss the idea that there could be a flood one day.

"When I was 21 I went to the lake and it was black and really small," said Angnima Sherpa, who heads a local conservation group in Dingboche. "Two years ago I went there and it was really big. I couldn't believe it could get so big. It was really scary."

But scientists and engineers still cannot agree on whether to rate Imja as the most dangerous glacier lake in the Himalayas, or a more distant threat.

Mobilising international assistance for large-scale engineering projects during a global recession is also difficult. The Mountain Institute's initiative was to call in experts from the Andes, where Peruvians have developed systems for containing glacier floods since a disaster in the 1940s killed nearly 10,000 people.

Cesar Portocarrero, who heads the department of glaciology at Peru's national water agency, has overseen engineering works to drain more than 30 glacier lakes, building tunnels or channels to drain the water and reduce the risk of flooding.

But he conceded it would be an enormous challenge to apply these methods at Imja.

"It's not easy to say 'we are going to siphon the water out of the lake'," Portocarrero said. "Where do you find the people who can work at high altitudes? How do you move in the equipment? What do you do in bad weather? You have to have exhaustive planning." There are also other contenders for immediate action, with some 20,000 glacier lakes across the Himalayas, although many are concentrated in the Everest region. Bhutan alone has nearly 2,700.

Three of those, known as the Lunana complex, are practically touching, increasing the possibility of cascading floods far more devastating than any rupture at Imja.

"If the barrier fails between them we are going to have a massive glacier lake outburst flood," said Sonam Lhamo, a geologist for the Bhutanese government.

The United Nations Development Programme and other agencies have supported a project to drain the lakes but those funds are running out.
John Reynolds, a British engineer and expert on glacier lakes who has worked in Nepal, argues that the international community has focused on Imja because of its proximity to Everest and trekking routes popular with western tourists. He says there are other, more hazardous lakes elsewhere.

The Nepali government ranks Imja among the six most dangerous glacier lakes in the country largely because it is growing so quickly. More than 12 other such lakes are also seen as high risk.

But Reynolds argued: "Just because a lake is getting bigger doesn't necessarily mean that it is getting more hazardous. As the climate is changing, generally speaking more glacial lake systems are forming.

"The question is how to decide which ones are hazardous now and which ones have the propensity to become hazardous in the future."

Imja, though fast-growing, is held in by a relatively wide moraine, which makes it secure in comparison to some others.

Most glacial lake floods begin as high-altitude tsunamis. A large block of ice falling from a glacier at great height sets off a series of giant waves that wash over the moraine.

That's not such a risk for Imja. The glaciers feeding the lake are gradual in slope, which reduces the risk of a large chunk of ice falling from a great height and setting off large waves.

Watanabe concedes the geography of the lake could keep disaster at bay, at least in the next year or two. But, he says, there are signs that an outlet channel at the bottom of the lake may be widening dangerously.

Reynolds said Nepal and the international community need to think of a Himalaya-wide action plan.

"As the climate is changing more glacial lake systems are forming," he said. "The question is how to decide which are hazardous now and which are going to become hazardous in the future."
Calls for long-term Everest waste management plan – starting with toilets
Nepalese government urged to install portable toilets at Everest base camp, and devise strategy to keep region clean

A Nepali environmental group is petitioning the government in Kathmandu to put portable toilets on the top of the world – Everest base camp – as part of a new management plan for the high-altitude region.

The environmental group, Eco Himal, argues public toilets would make it easier to maintain a clean environment at base camp, which sees dozens of climbing expeditions a year.

It is also proposing public toilets at other popular peaks in the Everest region such as Pumori, Ama Dablam, and Island Peak, said Eco Himal's director, Phinjo Sherpa.

Everest base camp, a rocky plateau at 5,300m that is the starting point for climbing expeditions, has for years been the focus of clean-up operations after a series of stinging reports in the 1990s about rubbish and filth in what had once been pristine environments.

This year, Eco Himal led a push to recover 8,000kg of rubbish from base camp as well as Camp 1 and 2 – including the wreckage from an Italian helicopter crash.

But Sherpa argued that such sporadic clean-up efforts – though well-meaning – do not go far enough.
His organisation is pressing the government to develop a broader management plan that would set aside adequate funds to conserve the Everest region.

"Everybody talks about waste in the mountains but nobody talks about proper solutions," Sherpa said. "Cleaning up Everest every once in a while does not help. The main thing is management, waste management.

Expeditions have already made great strides to reduce their impact on Everest, carting away rubbish and swapping solar panels for conventional generators.

But Sherpa argued that portable toilets would make it easier for the organisations overseeing clean-up at base camp to deal with the problem of human waste.

"During the season time, there are thousands of climbers and most of the expeditions have toilet tents with barrels up there. But porters and others who need them normally just go back and forth," he said.

"Having one or two toilets in the base camp could solve this problem."

However, the proposal has critics even within the coalition trying to develop the sustainable management plan for Everest.

Wangchhu Sherpa, president of the Everest Summiteers Association, which is also trying to press the Nepal government to do more for the region, said his group did not support the proposal.
The mission to clean up Mount Everest

Environmentalists in Nepal are pressing the government to keep the Himalayas free from litter

Mount Everest – more than 2,500 people have reached the summit since Edmund Hillary in 1953. Photograph: Desmond Boylan/REUTERS

The people who set out to climb Everest spend months dreaming about reaching the summit. They pay $65,000 (£41,000) in fees to the Nepali government; they train, trek for days, endure extreme discomfort, even danger. So it should be a simple thing to get them to pick up after themselves.

Apparently not. Nearly 60 years after Edmund Hillary conquered Everest, and 30 years after climbing turned commercial, the region is still struggling to deal with mass tourism.

By the standards of the 70s, when the main climbing routes were littered with discarded tents and food packets, Everest is a lot cleaner, with just a smattering of plastic bottles and sweet wrappers on the rocky plateau that is base camp. But a Nepali environmental coalition is pressing the government in Kathmandu to adopt a new management plan to safeguard the Himalayas in the age of mass tourism – and to make amends for the environmental sins of the past.

"Everybody talks about waste in the mountains but nobody talks about proper solutions," says Phinjo Sherpa, director of Eco Himal. "Cleaning up Everest every once in a while does not help. The main thing is management, waste management." The group has lodged a plan with the government that calls for tougher penalties against litterbugs at Everest and the surrounding areas. They are also pushing for the installation of portable toilets at base camp and investment in waste treatment facilities – which currently do not exist in the region – with proposals for five incinerators and sewage treatment plants.
It's difficult to tread lightly in the high-altitude environment, especially in areas this remote. The first expeditions to Everest were monumental in scale. The 1953 attempt, which brought success to Hillary, set off from Kathmandu with 1,200 porters for their equipment, according to Kancha Sherpa, the last surviving member of the team that made it to base camp.

The 1953 expedition required 25 wooden crates just to carry the coins they would spend along the way. A single oxygen bottle weighed 15kg. As for dealing with the detritus of such a huge human endeavour, Kancha looks blank. "You have to remember that was a long time ago. Things were very different then," he says. Even Hillary admitted to leaving equipment behind, and more than 2,500 people have made it to the summit since his day. The heavy traffic left its mark. "People were careless. They would take a rubbish bag but they would still leave stuff behind," said Tshering Tenzing Sherpa, an official of the Sagarmatha Pollution Control Committee, the NGO charged with overseeing the Everest cleanup.

Modern expeditions are much more conscious of their footprint. Groups must pay a $4,000 (£2,500) deposit on their equipment – in the hope that they will carry down everything they brought. Repeat visitors to Everest see a difference. "It's visibly and spectacularly better," says Jan Morava, an electrical engineer from the Toronto area who was attempting the summit with his brother and a climber from the UAE. "There were piles of rubbish in base camp before."

But conservation groups say the deposit is small compared with the other expenses associated with an ascent on Everest. They also argue the Sagarmatha Pollution Control Committee lacks the resources to keep up with all the groups climbing Everest and to make sure that do indeed carry all their equipment back down to Kathmandu.

The committee says it brought back 25 tonnes of rubbish from Everest last spring – including 12,000kg of paper and plastic and 11,250kg of human waste. But conservationists argue that waste disposal is haphazard. There are rubbish dumps with heaps of tuna cans and plastic bottles only a few minutes' walk away from villages on the trekking trail.

On a trek near the village of Lobuche last May, Alton Byers of the Mountain Institute came across a 10 sq metre open pit of human waste, hauled down from Everest, close to a seasonal stream. The pit had been covered over by the time of a subsequent visit in May.

And, says Tshering, there is plenty more detritus of the past still out there – rubbish discarded by climbers years and even decades ago, preserved in ice and snow. "Just above the ice falls at crampon point you can see cans from 10, 20, 30 years ago or even older," Tshering says. "There's a lot of old rubbish out there."

Other high peaks less famous than Everest are even dirtier, notes Tshering. And with climate change, snow and ice on mountaintops is melting, exposing even more rubbish. "We are in a garbage race," he says.
Expedition to a New Glacial Lake

The following is edited from several recent posts from the Imja Lake Expedition team at The Mountain Institute. Follow the full series at http://www.mountain.org/blog/.

Glaciers Are Melting, and We’re Taking Action!
The mountain world is changing faster than any of us could have imagined: these changes threaten all of us who live downstream. Glaciers are melting, rainfall patterns are changing, and the world’s most important fresh water supplies are endangered.

The Mountain Institute is currently leading a month-long series of workshops and an expedition to Imja Lake, a newly-formed, potentially dangerous, glacial lake near Mount Everest. They’re going to the field and talking to local people in order to research and educate.

The team is made up of over 30 engineers, photographers, journalists, and world-class scientists from Tajikistan, Uzbekistan, Kyrgyzstan, Pakistan, Nepal, China, Bhutan, Peru, Bolivia, Japan, the US and Europe to the field to exchange knowledge with local people about monitoring and controlling glacial lakes. We’ll evaluate the danger of Imja, and determine how to control it so it can supply fresh water safely and reliably to downstream communities for drinking, irrigation, and the generation of electricity.

The Local Point of View
Ang Rita is a long-time conservationist and activist for the Sherpa people and culture; he has been The Mountain Institute’s Senior Program Manager in Nepal for years. As a native to the region, he has a unique view into what makes this expedition stand out:

“In the past, scientists met with Sherpa villagers interested in the future of the Imja valley. But the scientists only discussed the threats, not the solutions. My people were unhappy. So, The Mountain Institute promised an expedition with solutions. And now, every morning, people call me to ask when the expedition will reach their village – they are very excited for us to talk to them about solutions to the threats from glacial lakes, and how the water from the lakes can be used to help local communities with irrigation, electricity and other practical purposes.”

International Inspiration and Collaboration
One might think that the Peruvian scientists, familiar with the high Andes, would feel right at home in the Himalaya. There is however one major distinction that is noted repeatedly: “Peru is very different from the Himalayas because here the scale is just huge.”

In Peru, roads make most of the dangerous lakes accessible within one or two days; but Imja lake is at least a week’s trek from Lukla, the nearest large village.

Jorge Recharte, the director of the Andean Programs at TMI commented on the benefits of having such a diversity of backgrounds and perspectives on the expedition:

“There was a conversation last night between Ang Rita, a Nepali, and Cesar, a Peruvian, discussing what’s possible… and what’s not possible – it is just fantastic, the sparks of ideas that happen when you bring [together] different backgrounds, different nationalities. [...] There is a common goal to understand glacial lakes, to share our respective experiences… the process of working through that, and then collaborating. If we continue as we have so far these two days, the result will be very powerful.”

The Technical Challenges

Since the team is in such a remote location, all communications are going out via a satellite phone. Physically it looks like an indestructible cellphone with an 80's-style antenna. It’s not very fast, but up here it’s the only option.

To facilitate writing posts, they’ve hauled a pair of netbooks up with plenty of spare batteries. With any luck the power will hold out through the remotest stretch of the expedition.

LATEST UPDATE: Arrival at Imja Lake!

9/12/11 — This morning we woke to a dusting of fresh powder, inspiring thoughts of the song “Snow, snow, snow” from the movie-musical White Christmas. With Bing Cosby’s melodies in head the team gathered for breakfast, only to find our departure to Imja Lake was delayed...

Luckily, the slushy rain let up around 10am and our
expedition was able to depart after lunch. A few hours later, we found ourselves in a neon yellow tent village at Imja Lake Base Camp. We have arrived! For the next three days, we will explore the lake, exchange with locals, and brainstorm future research and action items. And with walls of mountains surrounding us and the lake in our backyard, inspiration will surely flow.

*Follow the full blog series of the Imja Lake Expedition at [http://www.mountain.org/blog/](http://www.mountain.org/blog/).*
Sept. 30, 2011, National Geographic, Andrew Howley

Your Questions Answered From the Mountain Top

Recently, National Geographic Facebook fans posted their questions for members of The Mountain Institute’s international expedition to a potentially dangerous new glacial lake in the Himalayas.

The team responded via satellite phone with audio answers and photos. Listen below, or scroll to the bottom to read the transcripts.

AUDIO TRANSCRIPTS

Question from Moira Brigitte Rauch: Is there any correlation with the data they are collecting and other parts of the World?

Answer from Jorge Recharte: Thank you for your question Moira. I’m Jorge Recharte from Peru. I work with the Mountain Institute in Cordillera Blanca, which is a very large glacier region in central Peru. And yes, the issues that we have seen here at Imja Lake in the Himalayas are very similar to what is being observed in the Andes of Peru.

Glaciers are receding very fast and behaving in similar ways. Now glacier lakes are forming in very much the same fashion—both in Peru and in the Himalayas. The challenges that people are facing are also very much the same in terms of understanding the challenges they're facing and how to get organized to respond to these problems.

In fact, one of the purposes of the expedition is to find out how we can learn from one region to the other because these issues are so similar. We’re trying to share learning both in terms of biophysical aspects of glaciers receding and lakes forming and also in terms of social organization to respond to these challenges.
Question from Jennifer Lynn: What is your greatest hope or fear in this adventure?

Answer from Alton Byers: Hi Jennifer, this is Alton Byers speaking. I’m the Director of Science and Education at the Mountain Institute and also leader of this expedition.

My greatest hope for this expedition is that it leads to even greater collaboration and research between scientists from different countries from all over the world—countries that are experiencing the new hazard of glacial lakes and glacial lake outburst floods.

My greatest fear is that of the weather, and also altitude. At any time, this whole expedition could be scrapped if it rains too much and the planes can’t fly or we can’t walk —and number two—if somebody gets sick with altitude.

Fortunately, this expedition has been absolutely blessed. We’ve had nothing but good weather the whole time, and because we know how to deal with altitude, if somebody comes down with the symptoms we send them down to a lower altitude where they recover for a day or two and the rejoin us. Thanks very much for your question.

Question from Noor Al-Iman: Are the lakes of any benefit? (fishing, tourist attraction, etc)

Answer from Dale McKinney: My name is Daene McKinney. I’m a civil engineer working on glacial lake problems. Thank you for your question, Noor.

These lakes don’t have much benefit in terms of fisheries because of the high sediment content of the water. Tourism is mostly of interest because of the mountains in these areas, but the
lakes do offer some benefit. The most benefit probably comes from potential hydro-power generation and also downstream uses for irrigation—or perhaps domestic municipal water supply.

The full team stands proudly beneath the soaring peaks of the Himalayas. (Photo by Daniel Byers/TMI)
In the land where 'the mountains used to be white,' science works slowly

Namdu Sherpa picked potatoes as a girl in Namche Bazaar, the only economy in her village before Mount Everest-bound adventurers made a habit of trekking through with their Gore-Tex jackets and titanium walking poles. Almost overnight, the 75-year-old great-grandmother said, her small trading post in Nepal's Khumbu Valley transformed into a bustling tourist hub of lodges and cyber cafes.

Nodding toward her gleaming Samsung refrigerator and microwave, Namdu Sherpa said life has changed dramatically from the days of tending crops and cooking over firewood. Through the years, though, one thing remained constant: the majestic snow-capped Himalayan mountains. Until recently, that is.

"The mountains used to be white. Now, the mountains don't seem so white. It's all rocks," she said, looking out her kitchen window at the cloud-covered peaks. "We don't know exactly what's happening."

Neither, it seems, do scientists. There is widespread acknowledgement that the snow cover in the Himalayan mountain range is declining, and that many glaciers are retreating at a rapid rate. But everything else -- from where melt is occurring to how fast, how much melt contributes to downstream water use, and even to what extent greenhouse gas emissions play a role compared to soot -- is being answered at a glacial pace.

The difficulty in obtaining solid data on the mountain range is rooted in both the area's remoteness and regional political rancor. Compounding the uncertainty is doubt about the credibility of the Intergovernmental Panel on Climate Change, which had stated in 2007, wrongly, that Himalayan glaciers could melt by 2035. Scientists say the doomsday scenario error did lasting damage to popular understanding of the Himalayas. It also underscored how tenuous their grasp on the region really is.

"The knowledge gap is large," said Richard Armstrong, a glaciologist and senior research scientist at the National Snow and Ice Data Center in Boulder, Colo. Armstrong and dozens of other scientists met in Washington, D.C., this month with the National Academy of Sciences to begin to tease out the answers to some of the most vexing questions.
Scientists note that the Himalayan glaciers are sensitive to summer warming because both accumulation and ablation, or melting, primarily occur during the summer monsoon season. That means small increases in summer temperatures accelerate the melt while at the same time causing precipitation to fall as rain, which flows away, rather than snow.

**Romance, exaggeration overlie a multitude of risks**

"Glaciers are a dynamic system, sort of a conveyor belt of ice from a higher elevation to a lower elevation," each part with its own individual behavior, he said. If everything is going well for a glacier, the mass it loses by seasonal melts at lower elevations is replaced by snowfall at higher elevations -- which then is packed down into ice and and carries its mass downhill over decades.

Particularly in the eastern Himalayas, glaciers in lower elevations "are definitely seeing a warming," Armstrong said, while those above 18,000 feet appear far more resilient. Meanwhile, contrasting patterns of growth are evident in the western Himalayas among some 230 glaciers.

Armstrong rattled off a handful of hyperbolic statements that have made their way into the mass media -- like that glaciers are melting faster in the Himalayas than anywhere else in the world, or that glacier melt will lead to catastrophic floods throughout Asia. There is little or no scientific evidence for some of these claims, he argues.

While Armstrong chalks up exaggerations to the mysterious romanticisms that people apply to glaciers, he worries that those claims ultimately do a disservice to grasping the damage that the retreat of lower-elevation glaciers in the eastern Himalayan region will have on the wider region's water resources.

"If a glacier can melt fast enough to cause a flood in Bangladesh, we're in bigger trouble than we thought," he said. Like other outsized claims, he said, "it's an example where there's not a lot of good data available, so if there's some emotional trigger ... people can say whatever hits them emotionally, and you can't prove them wrong."

But understanding the area of what is called the Hindu Kush-Himalayan region is crucial. The remote mountain region encompasses about 15,000 glaciers -- sometimes referred to as the planet's third pole because it is the largest concentration outside of the Arctic and Antarctic -- and sweeps through Pakistan, India, China, Nepal and Bhutan. The melted snow becomes the mother of headwaters for Asia's seven largest rivers, which in turn sustain some 1.5 billion people.
While new research is showing that not all glacier-fed rivers are as dependent on melt as others, the Indus River is heavily fed by the Himalayan snow and ice melt (see related story). In Pakistan, the Indus and its tributaries keep more than 80 percent of the country's agricultural land fertile. One U.S. Agency for International Development (USAID) report predicts Pakistan could face a "terrifying" 30 to 40 percent drop in Indus River Basin flows over the coming century.

**Glimmers of grief for huge populations**

Some scientists predict the Ganges River could drop off by two-thirds, affecting the more than 400 million people who depend on it. The Brahmaputra River flows through China and India into the Bay of Bengal in Bangladesh. If that river dries up, so will water availability for the millions of people along the Brahmaputra in Assam and Bangladesh.

In the short term, the melting glaciers mean increased risk of mudslides, erosion and flooding. Countries like Bhutan and Nepal are particularly at risk of glacier lake outburst floods, or GLOFs, that threaten to destroy entire villages.

"All over the world, the cryosphere is being affected, but in this region especially you see the huge populations that are being sustained by agriculture," said Syed Iqbal Hasnain, a distinguished visiting fellow at the Stimson Center and chairman of the Glacier and Climate Change Commission established by the state government of Sikkim in India.

"The global community has to come forward and do something," he said. "It's critical, because of the huge populations in this entire region which are directly dependent on this water."

The physical act of studying Himalayan glacier melt is no easy task. Basic field measurements present a formidable challenge, since even the most rugged of researchers, able to hike for weeks through pine forests and Sherpa villages at high altitudes, can access only lower-elevation glaciers.

Recently, a group of scientists led by the Mountain Institute and funded by USAID trekked for 18 days through Nepal's Khumbu Valley merely to observe the severely threatened Imja Lake. Just arriving at the growing glacier lake took eight days of uphill hiking, with time built in to adjust to the 5,000-meter climb.

Dirk Hoffmann, a geographer with the Bolivian Mountain Institute who was on the trek, said getting to Imja -- still one of Nepal's most accessible and most studied glacier lakes -- put the difficulties of research in Bolivia's Apolobamba Mountain Range into perspective.

"The Apolobamba is little-explored, and the least accessible mountain range in the Andes. But that is relative, as I learned here in the Himalayas," Hoffmann said.

And the dangers have not been limited to exhaustion and altitude sickness.

**How wars and politics work against research**

Nepal, while currently peaceful, is recovering from a decadelong civil war. Teiji Watanabe, a professor of environmental science at Hokkaido University in Japan who has studied Imja Lake
for more than three decades, recalled how the perils of research became almost too great in the
1990s. Working in a lodge caught between the Nepalese police forces headquarters and Maoist
insurgents, Watanabe said he still remembers shouting "Japanese! Scientist!" every time he
raced to the outhouse.

Meanwhile, the Siachen Glacier in Kashmir -- sometimes called the highest battleground on
Earth at 20,000 feet -- feeds Pakistan's Indus River, but is "impossible to study," said Saleem
Ali, a professor of environmental studies at the University of Vermont. India and Pakistan
maintain a large military presence in the region, and only a select group of Indian scientists has
ever been able to conduct field research on the glacier.

Perhaps not surprisingly, cooperation in a region so rife with conflict is far from easy. Daan
Boom, a knowledge management specialist with the International Centre for Integrated
Mountain Development (ICIMOD) in Kathmandu, calls the lack of regional cooperation one of
the greatest challenges in addressing the impacts of hydrological changes in the Himalayas.

"There's not enough data to predict what's going on in the mountains, and obtaining data is
difficult," he said. "Regional cooperation is not optimal for data sharing."

That's slowly starting to change, and activists are eyeing a major ministerial-level conference
next month in Bhutan as a place where the region could finally start to make strides in working
together to promote Himalayan health. The Climate Summit for a Living Himalayas, as it is
being called, is for the first time bringing together regional governments to try to develop a 10-
year blueprint for climate change adaptation in the region. Madhav Karki, deputy director-
general of ICIMOD, called the Bhutan summit "a truly unique approach," and said he hoped
such a road map could be replicated elsewhere.

Yet even here the divisions are visible. Bhutan, Nepal, India and Bangladesh are co-hosting the
event, and so far, there is little evidence of Pakistan or China's involvement. Organizers officially
say the omission is simply geographic -- the eastern Himalayas require urgent action -- but
activists quietly acknowledge that regional politics play a part, as well.

In the meantime, all people in countries like Nepal can do is watch as the stunning scenery
outside their homes is perhaps forever altered.

"We used to have snow -- lots of snow. Now we see less snow, and even when it does snow,
because the land is warmer, it melts. The glaciers are also melting. That we know," said Ang
Phurba Sherpa, 69, the former head of Namche Bazaar's governing board. But, he said, despite
the several workshops on global warming that local activists have sponsored, local people are
not sure what they can do to stop the changes they see around them.

"We know that change is in the mountain," Ang Phurba Sherpa said. "The glacier is so much
changed. We have town meetings about global warming, but the only thing they can do is
advise the people and make them aware."
New research sheds doubt on doomsday water shortage predictions

From the Andes to the Himalayas, scientists are starting to question exactly how much glaciers contribute to river water used downstream for drinking and irrigation. The answers could turn the conventional wisdom about glacier melt on its head.

A growing number of studies based on satellite data and stream chemistry analyses have found that far less surface water comes from glacier melt than previously assumed. In Peru's Rio Santa, which drains the Cordilleras Blanca mountain range, glacier contribution appears to be between 10 and 20 percent. In the eastern Himalayas, it is less than 5 percent.

"If anything, that's probably fairly large," said Richard Armstrong, a senior research scientist at the Boulder, Colo.-based Cooperative Institute for Research in Environmental Sciences (CIRES), who studies melt impact in the Himalayas.

"Most of the people downstream, they get the water from the monsoon," Armstrong said. "It doesn't take away from the importance [of glacier melt], but we need to get the science right for future planning and water resource assessments."

The Himalayan glaciers feed into Asia's biggest rivers: the Indus, the Ganges and the Brahmaputra in India, Pakistan and Bangladesh, and the Yellow and Yangtze rivers in China. Early studies pegged the amount of meltwater in these river basins as high as 60 or 70 percent. But reliable data on how much water the glaciers release or where that water goes have been difficult to develop. Satellite images can't provide such regular hydrometeorological observations, and expeditions take significant time, money and physical exertion.

New methods, though, are refining the ability to study this and other remote glacial mountain ranges. Increasingly, scientists are finding that the numbers vary depending on the river, and even in different parts of the same river.
"There has been a lot of misinformation and confusion about it," said Peter Gleick, co-director of the California-based Pacific Institute for Studies in Development, Environment and Security. "About 1.3 billion people live in the watersheds that get some glacier runoff, but not all of those people depend only on the water from those watersheds, and not all the water in those watersheds comes from glaciers. Most of it comes from rainwater," he said.

A key step forward came last year when scientists at Utrecht University in the Netherlands, using remote sensing equipment, found that snow and glacier melt is extremely important to the Indus and Brahmaputra basins, but less critical to others. In the Indus, they found, the meltwater contribution is 151 percent compared to the total runoff generated at low elevations. It makes up about 27 percent of the Brahmaputra -- but only between 8 and 10 percent for the Ganges, Yangtze and Yellow rivers. Rainfall makes up the rest.

That in itself is significant, and could reduce food security for 4.5 percent of the population in an already-struggling region. Yet, scientists complain, data are often inaccurately incorporated in dire predictions of Himalayan glacial melt impacts.

"Hyperbole has a way of creeping in here," said Bryan Mark, an assistant professor of geography at Ohio State University and a researcher at the Byrd Polar Research Center.

Mark, who focuses on the Andes region, developed a method of determining how much of a community's water supply is glacier-fed by analyzing the hydrogen and oxygen isotopes in water samples. He recently took that experience to Nepal, where he collected water samples from the Himalayan glacier-fed Kosi River as part of an expedition led by the Mountain Institute.

Based on his experience in the Rio Santa -- where it was once assumed that 80 percent of water in the basin came from glacier melt -- Mark said he expects to find that the impact of monsoon water is greatly underestimated in the Himalayas.

Jeff La Frenierre, a graduate student at Ohio State University, is studying Ecuador's Chimborazo glacier, which forms the headwaters of three different watershed systems, serving as a water source for thousands of people. About 35 percent of the glacier coverage has disappeared since the 1970s.

La Frenierre first came to Ecuador as part of Engineers Without Borders to help build a water system, and soon started to ask what changes in the mountain's glacier coverage would mean for the irrigation and drinking needs of the 200,000 people living downstream. Working with Mark and analyzing water streams, he said, is upending many of his assumptions.

"The easy hypothesis is that it's going to be a disaster here. I don't know if that's the case," La Frenierre said. He agreed that overstatements about the impacts are rampant in the Himalayas as well, saying, "The idea that 1.4 billion people are going to be without water when the glaciers melt is just not the case. It's a local problem; it's a local question. There are places that are going to be more impacted than other places."
Those aren't messages that environmental activists will likely find easy to hear. Armstrong recalled giving a presentation in Kathmandu on his early findings to a less-than-appreciative audience.

"I didn't agree with the doomsday predictions, and I didn't have anything that was anywhere near spectacular," Armstrong said. But, he added, "At the same time, it's just basic Earth science, and we want to do a better job than we have been."

The more modest numbers, they and other scientists stressed, don't mean that glacier melt is unimportant to river basins. Rather, they said, they mean that the understanding of water systems throughout the Himalayan region must improve and water management decisions will need to be made at very local levels.

"We need to know at least where the water comes from," Armstrong said. "How can we project into the future if we don't know where the water comes from now?"
Can Asia put aside its rivalries to deal with the Himalayan melt?

In the weeks before a major meeting of Indian and Pakistani ministers, disaster experts and youth leaders in Lahore to discuss Himalayan glacier melt, Malini Mehra avoided reporters.

The normally outspoken director of an Indian environmental organization that was helping to organize the conference, Mehra said she had seen too many exchanges between India and Pakistan on critical water issues disintegrate in a pool of visa denials and political acrimony. Too much attention, she worried, could doom her conference to the same fate.

"Before I started this, I was warned that it was impossible," Mehra said. "At the beginning, we were beset with fear and suspicion that it was going to be derailed by people who would prefer that Indians and Pakistanis didn't have a full, frank and healthy dialogue on water impacts and how to manage disasters effectively. I heard story after story of just absolute horror."

The conference went off without a hitch, but even those who hosted the exchange say it was just a drop in the bucket of badly needed scientific and policy cooperation on the Himalayas between the two nuclear-armed archrivals.

India and Pakistan share a fractious border, 60 years of enmity and the waters of the Indus River. Originating more than 17,000 feet above sea level in the Tibetan Plateau, the Indus crosses the hotly contested Himalayan Kashmir, fertilizing rich farmland in both India and Pakistan, before flowing into the Arabian Sea south of Karachi.

The river’s flow has always been a source of tension, for a simple reason: Whoever controls the headwaters controls the river. Despite the Indus Water Treaty, which for more than 50 years has allowed the two countries to share the Indus and its five tributaries, control and access to water have remained a volatile issue. Disputes over hydroelectric dams, in particular, have made basic data sharing about the melting Himalayan glaciers a constant struggle, scientists from both countries say.

"When you talk about water data, it's very sensitive," said Pradeep Mool, a remote sensing specialist at the International Centre for Integrated Mountain Development (ICIMOD) in
Kathmandu. "There’s so many disputed points where there’s a glacier located, and it's very difficult for countries to get the information to each other. It takes a diplomatic dialogue."

**Where intrigue flows with the water**

Syed Iqbal Hasnain, a leading Indian glaciologist and senior fellow at the Stimson Center in Washington, D.C., added: "The issue is that nobody is sharing the low flows data, because if they share that data, they will be exposing their own intrigues into the water. If you look at the geopolitical implications of this glacier melt, there is so much potential for conflicts and accusations that ‘You’re stealing my water.’ And all of these are nuclear power countries."

Yet the steady melting of low-elevation glaciers in the Himalayan mountain range makes cooperation critical. Without better sharing of real-time water flow information, Hasnain and others said, India and Pakistan will be ever more vulnerable to floods. In the long run, disputes can cripple national and local governments’ abilities in both countries to manage what is expected to be a serious decrease in water availability.

"If they don't work together, both will suffer. Everybody will suffer, and there will be a situation that is beyond either's control," Hasnain said.

Dane McKinney, a professor of environmental engineering at the University of Texas, Austin, noted that water conflicts and secrecy over flow are hardly unique to Asia.

"Everywhere in the world, streamflow data is very closely guarded," he said. "It's one thing to know how much rain is flowing, but it's another thing to know how much flow. That water is used for economic and strategic reasons, so countries then feel it's part of their national security."

Yet the intertwined dependence of India, Pakistan, Bangladesh, China, Laos, Thailand, Myanmar, Cambodia and Vietnam on mutual river systems make South Asia uniquely fraught. Experts say the region is badly in need of a new, holistic way of thinking on water resources management.

"Water is power in our countries," said Pravin Raj Maskey, a hydrologist with Nepal's Ministry of Irrigation. "From the India side, we find the hydrological data very secret, and that's in their national interest."

**Can Finland end a deadly silence on floods?**

Pakistan has been pressing for the release of data gathered by the Geological Survey of India on glacier melt, but much of it remains classified. According to the Indian media, the issue has been referred to the country’s defense ministry, which is reviewing whether transparency of scientific research in the border area would compromise India's national security.

Meanwhile, India and Pakistan are hardly the only acrimonious players in the region. Meltwater from the Tibetan glaciers also supplies India and China, which fought a war over disputed Himalayan border territory in 1962. The search for water resources has been a persistent source of tension between the two countries, and both are exploring ways to harness the Himalayan melt for hydroelectric power projects.
"The source of the Indus is in China," Archana Chatterjee, regional program coordinator of the World Wildlife Fund in India, reminded participants at a mountain conference in Kathmandu recently who were criticizing Indian secrecy.

"It's undergoing a lot of mining activities and pressures," she said. "If the source is under so much pressure ... I think the three countries need to sit together, not just two countries."

Chinese scientists, meanwhile, turn the tables back on India. "Truly we are sharing," said Lizong Wu with the Chinese Academy of Science. "In this region, China was the first to complete a glacier inventory," he said, noting that it has been archived and is available for public download online. "India completed a glacier inventory, but where?"

Yet scientists and some policymakers in all of the Himalayan countries are working hard to end the cycle of hide-and-blame.

ICIMOD, based in Kathmandu, has made regional cooperation and the exchange of information among the eight countries in the Himalayan region a top priority. The common threat of climate change, some experts say, is actually starting to push parties to the table, making them more willing to cooperate.

Mandira Shrestha, a water resources specialist with ICIMOD, said the 2010 establishment of a regional flood information system in the Hindu Kush-Himalaya region has the potential to make significant strides. Funded by the government of Finland, the partnership of Bangladesh, Bhutan, China, India, Nepal and Pakistan is designed to foster timely exchanges of flood data, focusing on the Ganges-Brahmaputra-Meghna and Indus river basins.

Shrestha noted that most of the Himalayan glacier lakes are in Tibet, while the impacts of floods, landslides and glacier lake outburst floods are primarily felt downstream. Floods account for 30 percent of all natural disasters in the Hindu Kush-Himalaya region.

**Visa denial prolongs a lack of capacity**

"Most of our river basins are transboundary rivers. There are no borders for rivers, and the impacts are shared between borders," she said. In addition to the need to encourage data sharing, Shrestha added, the lack of technical capacity in many of the affected countries poses an enormous problem. Without weather stations, for example, there is little data to share.

"There's a lack of technical and human capacity, and the political will and regional cooperation is still emerging," she said.
Ghazanfar Ali, a glaciologist with Pakistan's Global Change Impact Study Center, noted that the country has over the past decade installed five glacier monitoring stations. But more are needed.

"If you can share data on a real-time basis, we may avoid a lot of damages due to floods," he said and called upon ICIMOD to help countries in the region develop their own technical skills.

Yet one of the biggest hurdles to cooperation, scientists in India and Pakistan say, is the not-so-simple act of getting into one another's countries. The denial of visas from both countries has become so routine that many now simply bypass both countries and organize conferences in neutral countries. Next month, ministers from the region will meet in Bhutan to lay out a blueprint for adapting to Himalayan glacier melt. Hasnain, meanwhile, is working to bring more than 100 scientists together in Nepal.

"If we bring 120 Indians to Pakistan or Pakistanis to India, we will have a visa issue, so we will do the workshop in Kathmandu," he said.

Yet with the climate threat looming, more and more activists are urging the two countries to deal with one another head-on. Saleem Ali, a professor of environmental studies at the University of Vermont who along with Mehra helped organize the youth conference in Lahore this year, said they made a conscious decision that the meeting must be held in Pakistan.

"We insisted that we wouldn't do it in Dubai or Nepal. That makes it a sideshow. Access is in itself a touchy issue, and you can't get all those poor Pakistani students to get to Kathmandu," Ali said. He argued that if the countries don't cooperate to find regional water management solutions, they will be signing death warrants for millions of their own citizens.

"Lives are at stake," Ali said. "It's a very serious human security issue. This is very serious business."
What happens when the lake comes down the mountain?

The scruffy group of scientists had taken their first showers in more than a week after trekking the snow-capped Himalayan mountains, and were eager to tell officials in Kathmandu about the growing dangers they witnessed at Nepal's fastest-growing glacier lake.

But Andreas Schild, director-general of the International Centre for Integrated Mountain Development (ICIMOD), was not impressed. Lake Imja, he said, is low on Nepal's list of vulnerable lakes -- and he suggested it might be in greater danger of overflowing with scientists than with water.

"Be careful," Schild warned the stunned group of glaciologists, geologists and engineers working with the Mountain Institute, a Washington, D.C.-based conservation and research group that led the expedition with funding from the U.S. Agency for International Development. "If you are cocksure about your findings, remember that others are equally sure of their findings. Some think that there are areas that are more risky, but not as easy to access as Imja Lake."

The lake, a massive pool of concrete-gray waters in Nepal's Dudh Kosi Basin, barely existed a half-century ago. But as the Imja Glacier southeast of Mount Everest receded, the accumulating waters steadily swelled a handful of melt ponds that grew together to form Imja Tsho, or Imja Lake.

Perched at an altitude higher than 16,000 feet, and the size of about 200 football fields, Imja drains through a valley that traces the country's only trail to Mount Everest Base Camp. The glacier continues to lose about 35 meters of ice each year, and the lake has grown an average of half an acre each year.

If Imja were to burst in what is known as a glacier lake outburst flood, or GLOF, it could kill hundreds and perhaps thousands of people, the Mountain Institute scientists and others warn. It could also cripple the region's economy, sweeping away the Everest trail, which beckons 30,000 tourists each year, as well as the hundreds of tea houses and lodges whose owners' livelihoods depend on trekking traffic.
"At the moment, the lake looks stable, but we don't know how long it will be stable," said Ugan Manandhar, manager of the climate change team at the World Wildlife Fund's Nepal office. Nepal already has suffered 24 GLOFs, including one in 1985 that destroyed 14 bridges and a nearly completed hydroelectric project. If a flood from Imja took out the Everest trail, it could effectively eliminate the $350 million in tourist dollars that feeds Nepal's economy each year.

"If Imja becomes unsafe, not only the economy of that region will suffer but the whole country will be impacted," Manandhar said.

Where 'tipping points' are not just rhetoric

Over the years, dozens of scientists have made their way to Imja, following a well-worn trail from Lukla -- an airstrip town at an altitude of 9,800 feet that serves as the gateway to the Everest region -- up steep terrain through Sherpa villages and forests of fir and rhododendron, past colorful Tibetan prayer flags and stupas, spinning Buddhist prayer wheels along the way.

It can take about 10 days to trek to Imja, and that makes it one of the most accessible glacier lakes in the Himalayas.

Teiji Watanabe, a professor of environmental science at Hokkaido University in Japan, has been studying Imja Lake since the 1980s. Chatting in a Himalayan lodge a day after he descended from Imja in September, Watanabe recalled the first time he saw a picture of the lake.

"I knew it was very special. Like a holy something," he said. He felt that same rush of emotions on his first field visit. "Again, I felt a very ... something I cannot explain in English," he said. And, he added, "Compared to other places, it's much easier to research."

Yet the relative ease with which hardy scientists can access Imja also makes it a target of suspicion to some experts who say it's not overflowing -- just overstudied. In 2009, ICIMOD scientists conducted extensive field studies at Imja and two other potentially dangerous glacier lakes, and put Imja at the bottom of the list.

The study noted that while the lake is growing in volume, the "end-moraine complexes" -- dams that hold water in place -- are stable, and free-flowing water outlets serve to reduce pressure.

At the top of the dangerous list was Tsho Rolpa Lake, which threatens to burst through its unstable dam, destroying lives and livestock in Nepal's scenic Rolwaling Valley just south of the Tibetan border. Tsho Rolpa was the object of a partially successful $4 million attempt to lower the water levels and a failed experiment in installing an early warning system.

"Tsho Rolpa is the most dangerous lake, and it has to be a priority, but it's very difficult to access," said Pravin Raj Maskey, a hydrologist with Nepal's Ministry of Irrigation who joined the expedition.

Like Thulagi Lake, another vulnerable glacier lake in the Upper Marsyangdi River Basin that ICIMOD listed as second in vulnerability, Tsho Rolpa is not on a tourist route. That means in addition to the days or weeks it takes to hike up to the lakes, scientists must carry in all their food, supplies and research equipment. Imja, Maskey said, "is a place where scientists like to come, but it is not the first-priority place where they should be working. It is the third."
Local villagers also have a beef with the multitude of scientists who come to study Imja.

**Scientists 'make people scared'**

"So many scientists do global warming projects at Imja Lake," said Ang Nuru Sherpa, 44, a former Everest trekking guide who is building a lodge at the edge of Namche Bazaar. "They make people scared. That's not good," he said.

"They make their project and they forget it, just like that," said Nyima Tsering Sherpa, 31, who owns a trekking gear shop in the region. "Lots of people are scared of the GLOF, and other people say the scientists are the ones that bring the problems. They're just studying; they don't care. They bring the problems, but not the solutions."

That, however, was precisely the problem that the Mountain Institute and the 30 glaciologists, engineers and social scientists from 15 countries who made the climb to Imja were trying to remedy. In what many villagers in the region described as an unprecedented collaboration, the scientists not only met with members of local communities in the town of Dingboche but trekked with them to Imja to observe it together.

"Local people are very tired of researchers who parachute in and never provide results to the local people," said Alton Byers, a mountain geographer who has spent decades working in Nepal and led the Mountain Institute's expedition.

Together, Byers said, they saw dangers at Imja Lake that have either been overlooked or have developed in the two years that have passed since ICIMOD researchers conducted field research. Not only had the volume of the lake grown, but the researchers found new ponds that were not there in 2009, as well as cracks and seepage in the moraine.

Watanabe, who only a few years ago wrote a report noting the lake's stability, said he left Imja worried. "The changes are getting more rapid," he said. "It's larger if you compare to the late 1980s, but even if you compare to three years ago, it's bigger." Watanabe said Imja may not be in immediate danger of flooding, but "10 years later, nobody knows. We really need to monitor it every year."

It remains unclear if that monitoring will happen or who will be in charge. ICIMOD scientists ended a two-day conference with the Mountain Institute scientists in Kathmandu saying they had heard nothing to change their position. Most remain lukewarm about acting at Imja, preferring to focus on Tsho Rolpa, which, they say, might not capture the attention of the international community but is more important locally.
"Both lakes are classified as dangerous. Depending on the resources, we have to monitor this, and depending on the resources, we have to do something about it," said Madhav Karki, deputy director-general of ICIMOD.

That concerns environmental activists, who note that the magnitude-6.9 earthquake that hit the Nepal-India border last month, causing landslides throughout the Himalayas, was a worrisome reminder that anything could set off dangerous changes at Imja.

"What trigger will it take?" Manandhar asked. "Just saying that Lake Imja is safe doesn't take away the vulnerability."
Using the Himalayas as a laboratory to understand a dire new global threat

The Sherpa stew sloshed out of my bowl as the wooden table in our Himalayan lodge swayed back and forth. Someone yelled "Earthquake!" and I bolted for the door with other panicked trekkers, tumbling into the chilly mountain night.

Farther up the mountain, the international group of glaciologists and engineers I was climbing to meet were huddled outside their own lodge in the village of Lobuche below Everest Base Camp. At higher than 16,000 feet in the dark, they could hear -- but, terrifyingly, not see -- an avalanche of snow falling from one of the highest peaks in the world.

They were just a day's hike from Imja Lake, a sweeping body of gray water along the Everest trail that had swelled from a few ponds in just half a century as the seemingly indestructible glacier above it steadily melted away. Many of them experts in a phenomenon known as glacier lake outburst flooding, or GLOFs, the scientists knew a magnitude-6.8 temblor like the one that struck that night had the power to make a fragile lake empty itself, destroying everything in its path.

Some had seen it before in Peru's Cordillera Blanca range, when a 1970 earthquake shook a section of glacier off Mount Huascarán. The glacier plummeted thousands of feet into the Rio Santa Valley, collecting boulders as it fell to overflow the banks of the Rio Santa and kill more than 10,000 people in the towns below.

"It just came down the valley, a massive ice rock that just created a huge, gigantic avalanche. That one avalanche killed around 10,000 people. Imagine the size of it," said Jorge Recharte, director of the Mountain Institute's South America programs. "Mountains are fragile," he said. "It's gravity acting, and even though it seems like rocks are well set in the mountains, you're in a vertical landscape, and earthquakes just trigger instability."

Recharte was one of the 30 experts I met in the Khumbu mountain range last month who, under a program funded by the U.S. Agency for International Development, were trying to marry the decades-long experience of the Andes with Nepal's needs. Hailing as well from Japan, Bhutan, Pakistan, China, Tajikistan, Kyrgyzstan, Uzbekistan, Chile and Bolivia, the scientists also hoped
to develop a global understanding of the new threat that melting glaciers are delivering to all their countries.

"This is almost unprecedented in human history," said Alton Byers, science and research director at the Mountain Institute, who organized the expedition.

"We have no real frame of reference for glacier lake outburst floods," he said, noting that the rate of glacier melt brought about by climate change is fundamentally changing the need to understand disaster risk management in different parts of the world. "This is all new, and suddenly we're being smacked in the face with something we had never had to deal with before."

**Questioning the conventional wisdom**

Peru, though, actually does have solid experience with the type of devastating floods that can occur when the dam containing a glacier lake fails. The tropical Andes has been susceptible to the problem since the 1940s. Learning from tragedy, Peru has over the past half-century successfully managed 34 lakes, drilling tunnels or channels to slowly siphon out water and prevent future flooding.

Much of that work was overseen by Cesar Portocarrero, the head of the glaciology department at Peru's national water agency. A civil engineer by training, Portocarrero started to work with dangerous lakes in the 1970s because, he said, "the glaciers were right in front of me." By the 1980s, he said, "I started to see the glaciers were retreating faster than before."

The question the Mountain Institute set out to answer was whether Portocarrero and his team could use their experience to help Nepal lower Imja Lake.

If Imja bursts, it could destroy dozens of villages along the Everest trail as well as the trail itself, which brings in badly needed tourist dollars to Nepal. But the Nepali government has become deeply suspicious of major engineering endeavors -- and with good reason. In 1995, Nepal and European donors installed a siphon at Tsho Rolpa, the country's largest glacier lake, with the intent of lowering it 20 meters. About 11 years and millions of dollars over budget later, they had managed to siphon away only 3 meters.

But the engineers who went up to the Khumbu last month weren't put off by the numbers. Byers, for one, said that while flying or paying porters to carry pipes and other supplies 16,000 feet up in the mountains would present a unique challenge, the mechanical problems are not insurmountable.

"Based on one experience which has resulted in a conventional wisdom that says it's impossible to do engineering, we don't accept that," he said. "We don't agree that's necessarily gospel."

Added Portocarrero, "I am a civil engineer like many in the world, but I know about this kind of work, and I can help."

The real question, Byers, Portocarrero and others said once they had spent time in the Khumbu, was whether communities living downstream of Imja want that help.
The scientists meet the villagers

The group did something no scientists have ever done in the Khumbu: They worked with a local community group from the village of Dingboche to survey the glacier lake and discuss what recent findings may mean for downstream villages. That appeared to have alleviated a good deal of frustration among locals who said they are sick of researchers who leave Imja with notebooks full of data but not a word to those who could lose their lives and livelihoods if a major flood struck.

The scientists and development experts, on the other hand, emerged from the experience with more questions than answers. Many said they left with the distinct impression that communities were simply waiting for foreigners to protect them, and pay for it. They saw an absence of community involvement and civil infrastructure, as well as government neglect.

"If we can't find a partner, we're not going to succeed, so there's no point in starting work here," said John Furlow, a climate change specialist at USAID who accompanied the group. He pointed to black rubber pipes snaking out of each mountain home and lodge toward the river, and said it suggested an every-family-for-itself system that could make finding a partner in the region difficult. And, he noted, neither the International Centre for Integrated Mountain Development, an international mountain research group based in Kathmandu, nor the Nepali government appeared enthusiastic about Imja.

"I want to make sure that any engineering is based in a social structure that's acceptable," Furlow said.

Upon my return to Kathmandu, though, nonprofit groups that do extensive work in the region told me the Khumbu most certainly has a civic structure. Villagers routinely trek miles up and down the valleys to public hearings -- though, noted Ugan Manandhar, manager of the climate change team at the World Wildlife Fund's Nepal office, "When you start a meeting at 10 o'clock, it will never start at 10 o'clock. It will start at 2 o'clock."

The pipes, Manandhar said, might not look like an organized system, but they are, and villagers pay for their water use. He described long-standing committees that successfully lobby for -- as well as pay for and maintain -- mini-hydropower plants in remote villages off the Everest trail. He and representatives of other Kathmandu non-governmental organizations suggested that the U.S.-funded expedition should have done more legwork to understand the region, or to reach out to different groups that could easily answer questions.

Forming a global glacier lakes partnership

While confusion over Imja and how best to approach downstream communities to determine what level of protecting they want from glacier lake flooding persists, it also is clear that a potentially groundbreaking partnership is on the horizon.

Talking over a plate of french fries at a Kathmandu hotel after three weeks of tea and steamed Nepali dumplings on the trail, Byers began to speak of Imja more as a laboratory for global understanding of glacier lakes -- not just in the Himalayas, but also in Central Asia and Latin America.
"In all cases, all these countries are mountainous. All of them are experiencing a warming trend and the enlargement of glacier lakes. And all have governments, with the exception of one or two, that are probably not equipped to handle a GLOF," he said.

Over the next five years, Byers said, he wants to see communities in the Himalayas receive the attention they need to decide if an engineering solution to Imja is something they want. But he also outlined a vision for a global partnership where scientists in other parts of the world can go to learn how to work with glacier lake communities.

"We're going to do prevention and mitigation of hazards. It's going to save lives, and it's going to operate in a dozen countries worldwide," he said. The endeavor could also make way for more scientists to put down the satellite data and hike their way up mountains to see the glacier lakes they study for themselves.

"I see a new generation of mountain geographers who focus on the culture and environs of mountains," Byers said. "It's what I call the climber-scientists. We have a new generation of scientists who are hungry to get into the field, and we need to combine the best of muddy boots research with the best science can give us."
Himalayans find monsoon changes 'very bad for business'  

KATHMANDU, Nepal -- Rain pummels the chaotic streets here. Cars, rickshaws and motorbikes pack the roads, swerving around the occasional cow. The unrelenting blare of honking that is the music of this city seems to amplify with every falling drop.

Dipak Khan looks outside his jewelry shop in Thamel, where vendors hawk yak wool blankets and wallets decorated with Buddha eyes. It is the first day of Dashain, the Hindu festival that marks the end of the long monsoon season. A group of tourists ducks under a doorway for cover from the downpour. Khan is worried.

"This is the global warming," Khan says with conviction. "The rains should not come this late. It hurts everything. The tourists do not want to walk around in this. It is very bad for business."

Climate change cannot be linked to any one weather event. But scientists, environmental activists and Nepalis themselves say the monsoon season so critical to agriculture is undoubtedly changing. Whether driven by cyclic changes, rising global temperatures or both, they say, the new patterns shaking up the June-through-September South Asian monsoon season are hurting crop yields and exacerbating already-existing problems of poverty and failed development.

The breathtaking Himalayas and the fate of their glaciers may capture the majority of climate change attention in Nepal. But activists point out that from the fertile plains to the overcrowded capital of Kathmandu, the landlocked country sandwiched between China and India faces widespread threats to crop production, livestock and water availability.

The national flower tries to adapt

"When the issue of climate change comes here, people understand about the glaciers and the Himalayas. It is true that the Himalayas are melting, but when you come inside Nepal, you see the other impacts," said Manjeet Dhakal, director of Clean Energy Nepal.

Farmers in the plains are seeing more sedimentation and land erosion, higher river flooding and even unusual blossoming times of the rhododendron, Nepal's national flower. Just a few years
ago, winter droughts and a delayed summer monsoon left agricultural land uncultivated. Oxfam called the 2008-2009 drought one of the worst on record, with 3.4 million people estimated to need food assistance.

This year, Nepal is seeing the highest rate of rainfall in 30 years.

"The monsoon is so unreliable, and the farmers who depend on it for agriculture are getting the brunt," said Shubash Lohani, deputy director of WWF's Eastern Himalaya program. Because the country's irrigation system is not well developed, he said, people rely almost completely on rainfall for 80 percent of the country's agricultural needs.

In Kathmandu, meanwhile, water demand is exploding. The population rate has tripled in the past 20 years to about 4 million people. Most of the city's drinking water comes from the Bagmati River system, but officials say it is poorly managed -- used as a dumping site in some areas -- and can only meet half the city's demand.

Tunnel vision

"Kathmandu in particular is expanding very rapidly. The whole water balance is being screwed up, and that is fundamental. Now, on top of that, with climate change we are going to have erratic rain patterns," said Bhushan Tuladhar, coordinator of Climate Change Network Nepal and a technical adviser on water for U.N. Habitat Nepal.

Since 2007, the Nepal government has worked hard to develop a strong presence at the U.N. climate talks and to build awareness inside the country of the threats. Recently, the prime minister developed a climate change council aimed at integrating knowledge about the impacts of rising global temperatures with local planning.

Yet in places like Kathmandu, according to Tuladhar, that's a serious challenge. Plans are currently under way to divert water to Kathmandu through a 28-kilometer tunnel from the Melamchi River in a neighboring valley. The Melamchi is a tributary of the larger Indravati River basin, fed in part by the Himalayan glaciers.

"If the glaciers are melting very fast, when we dig that tunnel, Melamchi may not have as much water as we thought," Tuladhar said, adding that he hopes a growing understanding of climate change in Nepal will somehow provide an opportunity for policymakers to develop better water planning methods.

"It highlights a lot of issues that we should be taking care of anyway," he said.
Himalayan alchemy -- a 'diamond' grows from garbage

KATHMANDU, Nepal -- Cigarette packs, candy wrappers, plastic water bottles and the occasional shoe litter the narrow streets here and clog the gutters. Sanu Kaji Shrestha looks around and sees gems.

From a shed in a quiet courtyard a few hundred yards from the chaos of the city streets, Shrestha tries to turn Kathmandu garbage into its energy future. Everything from seaweed to sawdust makes its way into his Foundation for Sustainable Technologies, coming out the other end a "briquette" of low-smoke, long-burning fuel that he believes could change the lives of the poor in Nepal and elsewhere.

"Every bit of grass has energy," he proclaims with a broad smile, showing off the fuel bricks he has made from dried leaves, kitchen scraps and even date pits from the Middle East. "I just make energy from the waste material that we produce."

About 3 billion people across the globe cook by burning biomass like wood, crude coal or animal dung. The World Health Organization estimates that toxic smoke from such unsafe cookstoves is responsible for nearly 2 million premature deaths every year, and contributes to everything from low birth weight to respiratory infections.

Groups like the U.N. Foundation have sought to change that trend. Through the Global Alliance for Clean Cookstoves, the U.N. Foundation, along with the Clinton Global Initiative and others, is working to see 100 million homes in developing countries adopt cleaner cooking alternatives by 2020.

Yet in Nepal, where only 10 percent of households are connected to the power grid, Shrestha said, convincing people to change their way of cooking is no easy feat.

Shrestha was a part-time inventor even before he retired from the World Bank in 2001. His first creation was a small solar cooker. Having seen one at an exhibition, he decided in 1995 to make his own after one of Kathmandu's kerosene shortages.
Funding from Rotary clubs

His wife, however, would have nothing to do with it.

"Solar cooking habit is not the Nepali habit. It's very difficult to cook dal bhat," he said, referring to the lentil and rice dish that is a staple of nearly every Nepali meal.

"I had to cook it for her myself to convince her it would taste the same," Shrestha said. He did the same for his neighbors. "That is the main thing, not changing the food habit."

A few years later, the idea for fuel briquettes was born when Kathmandu's drains became blocked in a major flood. The culprit: wet cardboard boxes clogging the pipes. Shrestha took some, mashed them into a pulp and molded it with a tin can.

"This is my diamond," he said, holding up that first lump of grayish-brown hardened pulp. Since then, he has worked constantly to refine the briquettes, mashing them first with a lever press that required three people before coming up with a device that a single person could operate. The goal, he said, is to develop a process that people, particularly people in poor and rural areas, can do easily on their own. Then he serves a glass of sweet tea, cooked over a small briquette fire.

As with solar cookstoves, he said, convincing the public to use cleaner-burning and longer-lasting waste fuel will take time despite the benefits. But, he said, "Once we show people food will take less time and taste as good, then they will accept it."

Though his work has been recognized by the Nepal Academy of Science and Technology, the British Council and U.S. EPA, Shrestha's foundation receives little outside funding beyond support from some Rotary clubs in the United States. With that, though, he has traveled from Cambodia to Afghanistan to train villages on ways to segregate waste and use it wisely. He wants to see the movement spread.

Said Shrestha, "People used to say, 'Water for all.' That was the global vision. I say, 'Why not fuel for all?' We have the full resources."
When a team of scientists from 15 countries including Nepal made an observation tour of the Imja glacial lake (5,023 metres) in the Everest region early last month, they were alerted by the sheer size of the lake that has increased over the decades. Though an inspection visit is hardly sufficient for drawing scientific data, members of the tour organised by The Mountain Institute pointed out that things may become quite precarious in a decade or so though the lake is quite stable at the moment.

The water is already seeping through the moraine or the natural dam that holds the water, and the wall may weaken over the years as the lake water volume keeps rising. The worst may come in case of a major earthquake, said Dr. Alton Byers of The Mountain Institute.

Accompanying the scientists’ team was a US journalist Lisa Friedman who writes on climate issues for ClimateWire magazine. The magazine has published Friedman’s articles on climate impacts on the Himalayas, Nepal and the surrounding region. She reports that the mountains are vulnerable with the possibility of glacial lakes bursting but also points out those things are being blown out of proportion in the absence of solid scientific data.

Her report centres around the myths that glacial melts will eventually dry up the rivers, the snow-covered mountains will turn bare in decades and that Himalayan ice melts are taking place at the highest rate in the world.

Gathering expert views, Friedman reports that major rivers originating in the Himalayas will not dry up as predicted because the role of glacial melt in their flow is minimal. They are mainly fed by the rains. The Indus and Brahmaputra have relatively higher content of water coming from the Himalayan ice melt but will not see a major impact on their flow from the glacial melting.

Critical gap in scientific data on the impact of global warming on the Himalayas was well reflected in the fourth assessment report of the International Panel on Climate Change (IPCC). The report stated that the Himalayan ice will melt away completely in a few decades. IPCC chairman Rajendra Pachauri had to apologise, admitting that the prediction was erroneous.

Participating in the Imja expedition was Cesar Portocarrero, the head of the glaciology department at Peru’s National Water Agency who has good experience on disasters related to bursts of glacial lakes in the Andes mountains. Sharing his Andean experience, Portocarrero said that steps should be taken to siphon the water off to lower the lake water level. The water could be used to generate hydropower but such a project will not succeed unless local communities are actively involved.
One should learn from the Tsho-Rolpa lake where four million dollars were spent to drain out the water and install an early warning system. Now the project is in tatters.

In her report, Friedman says that the local people in the Khumbu region are fed up with scientists visiting Imja and returning with dooms-day predictions. She interviewed a local Sherpa businessman who said that spreading baseless rumours about looming catastrophes on the Everest trails will negatively affect tourism and his business.
U.S. offers help for dangerous Himalayan lake
An Assessment to the Himalayan Glacial

Several United States agencies have offered Nepal help and a possible solution to a potentially dangerous lake formed in the Himalayas by melting glaciers. The U.S. State Department, USAID, the Mountain Institute and the U.S. National Science Foundation are sponsoring a month-long trek to Lake Imja, a recently-formed glacial lake at an altitude of 5,010 meters near Mt. Everest.

During the trek, an international team of more than 30 scientists, engineers, photographers and journalists will evaluate the danger of Imja, and determine how to control it so it can supply fresh water safely and reliably to downstream communities for drinking, irrigation, and the generation of electricity.

A 2009 study described this lake of melt water as one of the fastest-growing in the Himalayas. Holding an estimated water volume of 35 million cubic meters and growing over the decades, scientists have put Imja on the list of glacial lakes with potential risk of outburst.

Scientists who trekked for over a week to reach the lake indicated no immediate danger from the lake but suggested steps to reduce water level to minimize future risks.

Immediate measures to lower the water level, such as siphoning, are important because the volume is growing, said Dr. Alton Byers of The Mountain Institute, the organizer of the Imja expedition.

"In an event of an earthquake, potential risk is higher," said Byers.

Researchers participating in the study are from Nepal, Bhutan, Pakistan, Tajikistan, Uzbekistan, Kyrgyzstan, China, Peru, Bolivia, Japan, the U.S. and Europe.