HYDROLOGY

Out of the Mist

Water-starved communities are betting that a fog-harvesting forest will one day quench their thirst

Netting the fog. Large plastic nets suspended on top of a hill trap moisture from the sea air to provide water in coastal Lima, where it rarely rains.

CREDIT: NICK PATTINSON

LIMA—On a sand dune on the outskirts of this city, residents of a shantytown are attempting to grow a forest. This coastline is one of the driest regions on Earth—Lima receives less than 1.5 centimeters of rain per year. Nevertheless, the forest plan is not as crazy as it sounds, as these Incan hills were wooded until Europeans cut the trees for lumber in the 1600s.

Javier Torres Luna is hoping that reforesting the dunes above his hastily constructed plywood home will provide a long-term solution to an urgent problem: There is no water in his community for drinking, washing, or sanitation. And there is certainly none for forestry irrigation.

But change is in the air. Literally.

It's not that there's no water in Lima; it's just that there's no rain. From May through November, the chilly Humboldt ocean current cools the water-laden air coming from the Pacific, preventing rain along the coast. Instead, this thermal inversion blankets the city in a thick, gray fog.

Over the past couple of years, Luna and his neighbors have erected a series of 4-meter-high nets at the top of the dune to capture precious drops from the wet air. In as few as 4 years, Luna's irrigated saplings will themselves trap the fog, creating a microclimate that should yield a self-sustaining runoff.

Fog harvesting and other experiments, such as painting mountains (see p. 751), are how Luna and other Peruvians are trying to adapt to a heightening water crisis. Peru is losing its glaciers, a key source of water for the country, and the government is struggling to come up with solutions, particularly for Lima. "Fog nets are an extremely useful idea," says Elizabeth Silvestre, scientific director of the National Meteorological and Hydrological Service in Lima. "As water shortages become more of a pressing issue, we are going to have to expand adaptive techniques like this."

A thirsty city

The world's largest desert city after Cairo, Lima is entirely dependent for its water and its electricity on the seasonally erratic, drought-prone Rimac River. Two-thirds of the glacier at the Rimac's headwaters has disappeared, decreasing the river's glacier-contributed volume by 90% in the past 40 years. The little—highly contaminated—water that remains is primarily from rainwater.

Unfortunately, because of climate change, the glaciers are only getting smaller. Not only are warmer temperatures melting glaciers, but rain that used to fall as snow is also washing them away. In just 30 years, Peru's total glacier-covered area has shrunk from 2000 to 1500 square kilometers. That represents an estimated 7 billion cubic meters of water—the equivalent of 10 years of water consumption in Lima. To make matters worse, the lakes at the base of the glaciers, on which thousands of rural people depend, are disappearing as well.

Water shortages and drought have driven many people, such as Luna, from the countryside to the cities. More than 80% of Peru's population now lives on the country's desert coastal strip. Well over half of them—9 million—call Lima home. This migration is putting even greater pressure on the city's dwindling water resources.

Part of the problem is that the state agency charged with managing Lima's water supply, Sedapal, is not doing a great job, losing by its own admission some 40% of the city's 220-million-cubic-meters-per-year supply through leakages and theft. Even in the wealthier parts of downtown Lima, businesses and residences periodically have nothing flowing through their taps.

But the problem is far worse in the 1800 slum communities that are home to some 2 million migrants. There, it can take decades to be hooked up to the city's supply, says Abel Cruz, director of Peruvians Without Water, an action group started by Cruz in reaction to the poorest Peruvians having to pay the most for water. Lacking a municipal source, they must hire private water trucks, paying 10 times what downtown Lima residents pay for city water.

"And because these water companies are private and not monitored, they supply cheap, contaminated water that makes us sick," says Cruz, who lives in a community neighboring Luna's. The slums have a high incidence of dysentery and other waterborne diseases.

Out of thin air

Luna and his neighbors have given up waiting for the city's help. With assistance from the German nonprofit organization Alimón, the community has built reservoirs and tanks and constructed 8-by-4-meter plastic nets, supported by steel cables secured to poles, on the top of the dune to trap the precious fog. Fog-carrying wind from the ocean collides with the nets, and all the condensing water sounds like a gushing fountain. In the sunny season, January to April, weeks can go by without the nets collecting a drop, but from May through November, the fog is a thick, daily occurrence. The record catch per net is 590 liters in a single day. "We had no idea it would work so well," Luna says.

Water courses down the nets where it is captured in gutters and stored in tanks. It falls by gravity, irrigating tree saplings, and then continues through a sand filter after which it can be used by the community. The fog water collected is more than sufficient

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for the tree nursery but not enough for everyone's daily needs—currently a meager 10 to 15 liters per person. For that they must wait until their cloud forest has grown enough to make the nets redundant.

Fog collecting is not a new idea: Indigenous cultures from Europe to Africa have exploited the natural fog-harvesting properties of trees to catch their water. In the Spanish Canary Islands, for example, people used to construct funnels at the base of trees to collect the fog runoff.

Alimón biologist Kai Tiedemann spent a decade researching the fog-harvesting properties of various Canary Island trees. "From walking through a forest, it's possible to see that some trees harvest fog—they are dripping—whereas others are dry," Tiedemann says. He tested several types of trees and bushes, hanging the branches from a line suspended in the coastal fog and measuring the volume of water produced by each. "The ones with needlelike [rather than broad] leaves were the best fog harvesters," and those with leaves oriented vertically rather than horizontally were the best, he explains.

Certain trees are highly adapted to harvest fog water—some, like the Californian redwood trees, satisfy the majority of their water needs in this way. The trees create a physical barrier that intercepts and precipitates fog that would otherwise rise and dissipate in the warm air. In doing so, the trees create a localized water cycle: The fog water collected on leaves drips down and nourishes grasses, shrubs, and other plants that in turn trap their own water. All this dripping water sinks into the ground, filling wells and giving rise to small streams that people can use.

The technique works. In the 1800s, British naturalist Charles Darwin helped to make the dry, volcanic Ascension Island habitable for British troops stationed there by foresting a hill with seedlings brought from botanic gardens in London. In 20 years, there was enough water to grow food for hundreds of troops. "The once-barren hill is now known as 'Green Mountain,'" says ecologist David Wilkinson of Liverpool John Moores University in the United Kingdom, who is an expert on the island's ecosystem. "This experiment shows that such an ecosystem that would normally take millions of years to develop can be created in a matter of decades."

Urban forestry. Residents of this slum settlement are hoping to use fog water to reforest the hill above their homes.

Tiedemann and his partner Anne Lummerich decided to try this approach in the bone-dry outskirts of Lima. They selected a native species, *Caesalpinia spinosa* ("tara" in Spanish), for planting. It was the second-best collector among four they tested, but it is commercially valuable, so it offers two benefits: to harvest fog water and to produce fruit that could generate new income for the community. Tara fruit is used to produce an organic acid for the tire, tanning, and herbal medicine industries.

Other organizations are also proposing fog-harvesting projects, with plans for as many as 20 nets in some Lima communities. There is some debate over which nets are the best design. Robert Schemenauer, who heads the Canadian nonprofit FogQuest based in Vancouver, pioneered fog harvesting with a small experiment in the Chilean desert some 20 years ago. He developed the Standard Fog Collector, a simple, double-layer net system (double so as to improve drainage), used by Luna's community, which removes 60% of the water in the air that hits it. Schemenauer's model is now being used in projects in Oman, Namibia, Guatemala, and elsewhere.

Lummerich and Tiedemann now say they have improved on Schemenauer's standard model. Alimón's latest Eiffel Tower design, located above a community near Luna's, is a three-dimensional system. The double layer is separated by strips of netting oriented 90 degrees to the main nets, capturing fog from the different wind directions. With this model, they say, each net achieves a yield of 300 liters per day, averaged over a year, and a best yield that tops 2650 liters per day, six times the yield of the Standard Fog Collector model—something Schemenauer disputes as "impossible."

This July, at an international congress on fog research and fog collection, held in Münster, Germany, several new designs were pitched. They included a hexagonal "bee hive" system that can be lived in, an enhanced natural net fiber, and a Buckminster Fuller–inspired design.

No matter what the net design, this technology may not be the long-term solution that thirsty Lima residents yearn for, however. "Fog harvesting will only provide for people's drinking, washing, and small-scale agricultural needs," says Schemenauer. Once a community gets large enough to support businesses, such as cafes, swimming pools, and so on, the per capita daily water use goes up from about 45 liters per person to hundreds. Then, governments need to invest in piped water supply.

And fog nets won't work just anywhere. On the Peru-Chile coast, nets must face the prevailing wind 500 to 700 meters above sea level and 5 to 10 kilometers inland to be most effective.

Finally, climate change brings more uncertainty. Typically, the ocean-warming phenomenon of El Niño, which occurs off the Pacific coast at roughly 5- to 7-year intervals, leads to more fog. But as these episodes become more intense in the future, scientists are divided over whether they will bring more fog or less. It could be less because the fog-carrying air may be so warm that the fog droplets will be too small to be captured by the nets, and the moist air will rise too high for the nets.

For the moment, however, Luna is betting that watering trees might just solve his water problem. **–GAIA VINCE**

Gaia Vince writes on environmental issues in the developing world at wanderinggaia.com.

CREDITS: NICK PATTINSON

Desperate measures. At 4500 meters above sea level, Peruvian villagers are painting a mountainside white to try to keep it cool. They plan on allowing water to trickle over the lightened landscape so it freezes and starts rebuilding a glacier. They are already seeing ice formation, but the plan has been met with skepticism.

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