Gunn: Many people know of, or at least have heard of Lima, Peru, but few are aware of its capital and it's second largest city, Arequipa. Tim Filley is a professor of geosciences at Purdue University. I asked him, “paint us a picture.” Tell us about Arequipa and the Arequipa Valley of Peru.

Filley: Arequipa's both a city and a region. It is in a southern part of Peru, and it's in the desert-y area near Chile. It's abundant in natural resources—incredible geological, ecological, biological, and landscape diversity. In a little over a hundred miles, you can go from sea level to 20,000 feet. You can go from coastal desert to alpine meadows and lakes nestled under massive glaciers. It's astounding. It's got huge ore deposits—untapped resources—abundant fisheries on the coast, glaciers that provide life-giving water to the desert regions in the mid-altitude regions. It's got astounding natural beauty. Really deep cultural indigenous heritage that you can see in the architecture and the art and the music, and that also plays out really neat in terms of the cultural diversity because the food is astounding. It's just this this fusion of all these different cultures, and that's not to be missed.

Gunn: Now I know that people have been living there for as long as people have been there, but that there's been the Western influences for a number of hundred years. It goes back—

Filley: It does. You know, obviously, the Spanish were controlling it for quite some time, and the Viceroy is—I'm not pronouncing that correctly—but ran the southern Latin American region from Peru, so it was a main capital, and so when you go into these colonial cities—and Arequipa the city is actually referred to as the ‘white city’, and it's made from the volcanic rock deposits and the beautiful colonial architecture there, and you're just transported back hundreds of years. It's amazing.

Gunn: Now wherever humans go, wherever they've lived for a long time, there's always a big impact on the land. What's happened over these centuries to Arequipa?

Filley: Well you know because Arequipa is—and Peru and general—blessed with many natural resources—the glaciers, the copper, the zinc, the gold, the fisheries, right—there's been obviously massive extraction efforts to recover that and use it for growth. For example, the mining industry has been used for thousands of years, all the way back into the Inca. There's impacts of that locally when they mined it, but as you became more industrialized and extractive efficiencies became greater, and the ability to pull out more increased, you had greater and greater accumulated effects of some of these negative externalities, as you might call them. So right now, mining represents greater than what—sixty percent, I think—of the economy of Peru, and efficient mines, well-run mines, you know, obviously have a great effort in terms of environmental protection, water reuse, and such, but unfortunately there's also a lot of illegal mining that goes on in Peru.

Gunn: Really?

Filley: Oh my goodness, yes! The local impacts are devastating in terms of some of the mercury that comes out, the mineral exports as they're rolling down the streams, and that is a big problem. It kind of gets to a large part of the problem with Peru in terms of monitoring, measuring, and regulating many of these activities is that there's a large degree of informality in the economy in Peru.

Gunn: Give us a sense today how many people are spread over what kind of square miles, or however you want to spread that out, and then where are the mines in relation to that?

Filley: The nation of Peru has about 30 million people in it, and those are mostly concentrated in the north. In the southern part, where Arequipa is, the city itself has only about 1 million. It’s a small region. The population is concentrated in that Arequipa city-region, and there's vast tracts of desert in Arequipa where no one lives or works—no one lived until recently—this is actually an important part of the work that we're doing. What they've been doing to basically expand out of this valley that Arequipa’s in—to expand out agriculture—they're undertaking some of the most massive irrigation projects the world has seen—pulling water in from the glacial uplands, redistributing river waters up into the highlands, and creating—what they are looking to achieve is—it's an agricultural oasis.

Gunn: And where are the mines all in through these areas? Are they saying are scattered?

Filley: Yeah. The mineral reserves are scattered throughout Peru. Many of them are untapped, but if you look at Arequipa, well one of the largest mines is actually right outside of town.

Gunn: So it's hard to say what's “the problem here?” Is it the mining? Is it all this water being redistributed? Is it the impact of agriculture, which can be tremendous? Is it the fact there are more people here? Is that the fact that they're taking over what used to be desert—now they're making it arable land? And that's just the beginning.

Filley: The whole issue is that these problems are interrelated, and so you have competition for natural resources among major industries: developing agriculture, which may only represent, let's say 6% of the GDP of Peru, versus mining which is the major actually resource of Peru. But they compete for the same resource—water. They compete for, in some areas, land. They both bring benefit. They both helped Peru lower poverty rates enormously over the last few decades. In the cities that might be 20% now, and in the rural areas it is still quite high, in the upper 50s. But these new types of production, these new ventures that they're doing, are generating great good: new infrastructure, new resources for education. But they have negative accumulated impacts. What we're doing is to try to look at the conflicts between these developing sectors in the economy, seeing how we can develop tools to actually explore how to share resources and how to talk to the people who are the stakeholders who will be actually making the decisions about how these resources are monitored and measured and shared.

Gunn: Now usually when a professor says to me, “we're working with these people” or “we're doing this,” we're talking about a professor's individual research, at best a couple of colleagues, some graduate students, but, as I understand it, Purdue University, as a much wider basis, is working with the people in Arequipa.

Filley: Yeah and actually the whole way that this process developed was actually quite fascinating. There is the university we're working with, which is the National University of St. Augustín. Their president and vice-president really are quite visionary, and they were looking to transform their university into a beacon in Latin America for sustainable use of natural resources. And they had developed a way, a mechanism, to access some of the tax dollars that had been accumulating from the mining industry and to use them to actually get into a technical alliance with a university to develop capacity in their program for soil monitoring, for research, for social sciences in the sustainability area. They had made a connection with a not-for-profit organization called Core Foundation, and Core Foundation contacted Purdue, and it actually started off sort of peer-to-peer. They talked to a few faculty members one on one, and nothing was ever clicking. Everything was too hyper focused in one particular area, so they then talked to the director of Discovery Park Tomás Díaz de la Rubia, and—

Gunn: What’s Discovery Park?

Filley: Discovery Park is a program that doesn't exist in any particular college within Purdue. It is outside of that, and it is a collection of centers and institutes that are geared towards promoting innovation and research and commercialization areas of nanotechnology, sensor application, cancer research, defense, food security, climate change.

Gunn: Anything the university does, you'll find in Discovery Park, in some level.

Filley: Well, yes, but it what it does is it's a space that is designed to gather expertise across the university and to address really grand-challenge problems—things that really require multidisciplinary, transdisciplinary ideas that really can't be developed within a department, or even two departments. Discovery Park provides that home. It provides resources. It provides the ability to incubate and catalyze new ideas, and so it was at that point that the idea of like, let's pull together everything that Purdue has to offer in relation to the social sciences, environmental awareness, holistic watershed management, and soil sustainability and health, tech development in arid environments—pull it together, and create an institute-level program with our partner UNSA, now, to solve these challenges.

Gunn: And UNSA is the name for the university in Arequipa, yes?

Filley: UNSA is the acronym that we use for “Universidad Nacional de San Agustín.”

Gunn: You're listening to Tech Nation. I’m Moira Gunn, and my guest today is Tim Filley. He's a professor at Purdue University and head of the Filley Lab in the department of Earth, Atmospheric, and Planetary Sciences. He also co-directs the scientific programs at the Arequipa Nexus Institute for Food, Energy, Water, and the Environment at Peru’s San Agustín National University. Now here we have the Arequipa Nexus Institute and your co-directing the scientific programs. What kind of science will you do here in Arequipa?

Filley: We have a number of different scientific engagement levels that we're doing. We're first starting off with infrastructure projects where we are looking across large-scale tracts of land, large watersheds, and taking tools—modeling tools we've developed at Purdue that actually help people to make decisions about how to better manage that land. We're taking these models and transforming them into an Arequipa-specific model, co-developing them with modelers at Arequipa to incorporate issues of climate, incorporate issues of resource management, incorporate issues of geography, and making them specific for the stakeholders of that region. Some of the other things we're doing is directly addressing some of the inefficiencies and problems with irrigation in the region. We have programs that are looking at robotic systems for continuous monitoring and delivery of water, fresh water, using irrigation systems, so taking our tech development programs working with UNSA’s tech development programs, and looking at how we can take these robotic systems into these desert environments to maximize efficiency of water delivery and minimize contamination.

Gunn: What do the robots do?

Filley: A couple of things. One of those systems is going to be designed for looking at monitoring of highly contaminated water where you might not actually want to send someone because it might be too dangerous, so these will have sensors on them. They will be automated systems that can go into highly contaminated water. That's one of them. The other system will be actually looking at delivery systems for irrigation. You can have time systems, institute monitoring of water quality, water amounts—it will check for leakage—and so to maximize the input of water to minimize loss, because remember again, this is a desert region. You don't to lose water. You want to put just what you need on.

Gunn: I keep thinking that if suddenly we're going out into a desert region, and we're turning it into an agricultural region, what's the impact on that?

Filley: Well, the world's got a lot of experience with this. We've done this—

Gunn: We do it all the time.

Filley: We do it in Southern California, alright? The city of Los Angeles. There's some very interesting things that have been going on in the Arequipa region, and so we've created a very lush environment. People are benefiting greatly. You're able to produce avocados, grapes, pomegranates, and people are making money, but the problem is sometimes the water source is contaminated, and so you have river water that maybe shouldn't be used for irrigation being used for irrigation in some places. That needs to be monitored. You have water that's being added in a very inefficient way. Flood irrigation has just drenched over the surface of the water and what happens is massive amounts of water goes through, leeches out salts, but that water doesn't go away. It travels through the ground, and it hits a boundary—let's say maybe it's fifty feet below ground, forty feet below ground—and then starts to move out into the valley. And what's pouring out is saltwater. Even though you're doing this wonderful thing in terms of creating agriculture on these uplands, the valleys now are getting this influx of very salty water, which is changing their whole ecosystem. There are these negative externalities for what we're doing, and that what we're trying to do is to model all of that, to look at it into the totality and to talk to the people who are working there so to find out exactly what's going wrong, what's going right, and then how to basically have creative solutions. This also brings up a point of how the social sciences are so integral in our research. We need to talk to the stakeholders. We need to talk to the practitioners. We're sending our scientists—our social scientists—out there, looking at ways of addressing these problems, looking at new methods of bringing people together to form models of how to address conflict because you have people in the uplands who are creating agriculture in a new area but potentially contaminated the lowlands. Those communities need to be brought together to find potential solutions. The fascinating thing about this example is—I've spent the last three weeks in Peru, and we went visiting farms looking for potential collaborators among the farmers there, and we met a farmer, Mr. Bustamante, and he took us out for about an hour. He showed us all his great new vineyards, all his new agricultural tracts he's put in, and we were asking, “what are the problems that you have? How can we help you? What can we do for you in this relationship?” We piled into his car and we drove to the edge of an escarpment—a large valley—and he pointed out to the horizon, and as far as you could see, about 40 feet down on the cliff, was all new green lush things, and plants, and riverlets of water flowing out. He said “we're wasting water, and it's hurting the valley.” He said, “look what I'm doing,” and he showed us tens of hectares of land where he put in drip irrigation—small tubes where the water is delivered precisely by the roots. He says, “I'm the first one to put that in in this region. I want other people to do that.”

Gunn: Now, that's a farmer what about the miners, both legal and illegal? What's happening there? They're being told to shut down? What can you do?

Filley: There is a lot of local opposition to new mines, and people have actually shot down the development of new mining production. There's a lot of opposition particularly when mines start to talk about how they're going to use water resources in a very dry region. UNSA itself is actually setting up a number of different institutes in relationship to the different universities. Some of them will specialize in, actually, sustainable mining practices, and we'll be partnering with them down the line. Right now, the Nexus Institute that we are running is going to be focusing on more watershed development, monitoring of contamination, monitoring of soil health and clean water, and providing solutions in the form of these holistic models and how to work in the context of where they are right now.

Gunn: Meanwhile, back in Indiana, you're the interim director for the Center for the Environment at Discovery Park.

Filley: Correct.

Gunn: But in the Department of Earth Atmospheric and Planetary Sciences, there is the Filley Lab, and I have to say, I thought, “oh this is really great! I'll be able to figure out what you really do,” you know, when you're left alone to your own devices. Unfortunately, it's called “terrestrial stable isotope biogeochemistry.”

Filley: Sorry.

Gunn: We could work with you on this. I don’t even want you to parse it. I want you to tell me what it means.

Filley: Alright—

Gunn: Because there's a whole lot of people you have there, working as we speak.

Filley: I am a professor of geochemistry and agronomy. That means I work in the terrestrial environment. I work on land. My group blends principles and tools from those two systems—geochemistry and agronomy.

Gunn: And I think a lot of people don't know what geochemistry and agronomy is.

Filley: Okay, let me step back a little further. So what I try to do is, I try to look at what controls the health of soil. I look at what controls the destruction of soil, and I look at all the influences from different types of land use—let’s say agriculture or forestry: changes in climate, erosion changes, and contaminants, and how those control how soil evolves, how soil devolves, and how you can maintain it in a healthy way.

Gunn: I think what I'm hearing is soil is actually created and evolves and erodes and comes back together.

Filley: Soil is very dynamic, and soil is really not a renewable resource. We have to be very careful with soil. Soil takes a long time to evolve in most environments, and so that's kind of the research that we focus on. We look at what makes up the soil—the minerals, the organic matter, the microbes in it—and how they respond to things that promote good soil production, or how they respond to stresses that actually break apart that soil and cause sometimes irreparable damage to it. Soil is something that's quite precious, and we have to protect it because in some places soils take thousands and thousands of years to develop. In a matter of decades, you can destroy all of that work over time, and it won't come back in our lifetime or your grandkids’ lifetimes.

Gunn: Hence the Dust Bowl.

Filley: Hence the Dust Bowl…

Gunn: …in the thirties in Oklahoma.

Filley: It can take generations to rebuild soil, but it won't come back to what it was. It's still useful, it's still usable, it still gives you your maize or your soy, but it's not the same as what it was, and it requires more energy, more emphasis to get from it what we need, than when we started with it.

Gunn: Meanwhile back in Peru—back in Arequipa, we have a whole new land out here that, in the past, just sat there forever, for millennia. It was desert.

Filley: What we're trying to do is, again, look at the system in its totality. How much do we have to put in to keep getting out what we need? What are the negative aspects of what we're doing? Sometimes we don't know yet. We need to figure that out in terms of contaminants, in terms of salination of groundwater, and then looking to see how we can sustain it because in reality, what they're doing is pushing up and even exceeding the limits of what that geology, that climate, that environment, can provide you, putting in massive amounts of energy moving that water and dumping it in, the fertilizer. All of that is needed to get that agriculture, but is it sustainable? That's the question.

Gunn: I've been speaking with Purdue University professor Tim Filley, co-director of the scientific programs at the Arequipa Nexus Institute for Food, Energy, Water, and the Environment. We'll talk more after a break.

[break]

Gunn: You're listening the Tech Nation. I've been speaking with Purdue University professor Tim Filley, co-director of the scientific programs at the Arequipa Nexus Institute for Food, Energy, Water, and the Environment in Arequipa, Peru.

Gunn: How well do we know the answer to sustainability in that framework, ever? Are we really hip to the beat on this? Like, you show us an area, and “we can tell you what is sustainable?”

Filley: Well, so you can think about this. 70% of the world's high-altitude equatorial glaciers are in Peru. They have lost—

Gunn: What?

Filley: Yeah.

Gunn: “High-altitude,”—

Filley: High altitude—around the equator, right? “High altitude” meaning that you're talking 3,000 meters above sea level and above, and they are around the equator. Most of those are locked in Peru. Well, as the water comes out over the Atlantic Ocean, it reaches these high mountains and dumps on all its water out and forms these glaciers, and all the air that comes out towards the Pacific has no water in it. That's why there's a desert on that side. Now, those glaciers have lost 30 plus percent of their mass in the last few decades. Peru is looking at a water crisis by mid-century. The farmers know that. Mr. Bustamante—one of the first things he told me is he's worried about the future of his water. He's thinking about putting in deep wells so he can get water from the ground because he knows eventually, those glaciers will be gone, and then the farming is gone.

Gunn: Seems to me they're pretty clear that climate disruption is happening.

Filley: Oh, it's very clear. They know that they know they're working against planetary limits right now.

Gunn: Because of their interesting situation, it's not fogged by while I'm in a city or I can go to the market and I can turn on the tap and the water is here, they can actually see these things change.

Filley: Yeah. You can see the changes in water movement down the rivers. Those fluxes are changing. They're diminishing in some areas. In some areas, they’re actually increasing because so much melt is happening now, it's a boom for agriculture. But they also know that that will go away.

Gunn: That's a short-term boom.

Filley: It’s a boom, then bust.

Gunn: Part of that is what the Nexus Institute is studying as well.

Filley: It is. It’s to look at the system right now and to see what you cannot waste. Right now, the types of irrigation that is most dominant there is flood irrigation—just drenching the land. There are other technologies that you need to be thinking about to maximize conservation of that water, but they're going to have to do this in a big way. They're going to have to re-engineer all the sectors of their economies. The nutrient sector wastes it from livestock. They're going to have to re-engineer the biomass sector—waste from agriculture. They're going to have to couple all the streams out of their economies so there is no waste. Make it restorative; add that biomass back in the land to rebuild soil, or actually, in this case, build soil because it wasn't actually a productive soil before. Take the nutrient waste from the animals. Bring that back into the soil to create those soil structures. And make sure you're not wasting water. They need to make their economies regenerative, restorative for their land.

Gunn: Something that is part of this, but we frequently forget about, is food, and what we now call “food security.” How does this play a role?

Filley: Food security encompasses many things. It encompasses distribution systems, it encompasses food safety. Is your food contaminated? It encompasses food nutrition. Poverty is a big part of it. Insecurity in terms of whether you can afford to buy food, coupled to global markets. Are there pressures on your local economy to produce things that you don't eat but you ship off to another country? Food security wraps all those things in there and, actually, this is one of the main emphases of the Nexus. Our Food Security center within Discovery Park, led by a Gebisa Ejeta, who is a World Food Prize winner, is heading one of the projects to actually develop an international food security center at UNSA to address these issues.

Gunn: Well Tim, this is terrific. I hope either you bring that wonderful farmer back or you take me there. I want to drive around in the car with him!

Filley: He will sit you down, and he will pull out a very large bottle of something called “pisco,” which is a brandy he makes from his grapes, and you will love it.

Gunn: I will, I will. Thank you for joining us, and I hope you come back and see us again.

Filley: Thank you.

Gunn: My guest today is Purdue University Professor Tim Filley, head of the Filley Lab in the Department of Earth, Atmospheric, and Planetary Sciences and co-director of the scientific program at the Arequipa Nexus Institute for Food, Energy, Water, and the Environment, a joint alliance of Purdue University and Peru's National University of San Agustín. I'm Moira Gunn. You're listening to Tech Nation.