Daryl Lovell:

Hello, and welcome back to the 'Cuse Conversations podcast. I'm Daryl Lovell, Associate Director of Media Relations at Syracuse University.

Elizabeth Carter:

I think the message of hope that I have and the reason why I do what I do is that a lot of the legacy problems that we deal with now in managing natural disasters, mainly how our storm sewers have been built, how our flood control infrastructure is laid out, how we structure our responses, a lot of these policies and infrastructure were developed at a time when we didn't have a lot of observations. We didn't know. We didn't have a lot of measurements of stream flow or precipitation that would let us know what the actual risk of flooding looked like in this area, or drought looked like in that area.

Daryl Lovell:

Extreme weather events, like hurricanes, floods, and droughts are becoming more frequent in many places and more severe. These events can cause widespread damage and displacement, and they can be very difficult to recover from. Elizabeth Carter is an Assistant Professor of Civil and Environmental Engineering, whose research interests include disaster response and mitigation. She joins me today. Thank you, Professor Carter, for being on the 'Cuse Conversations podcast.

Elizabeth Carter:

My pleasure.

Daryl Lovell:

So I want to start off by, I've worked with you before, but I know one of the things I think about you is with the study of hydro climatic extremes, and I thought maybe you can talk a little bit about what this is and what kind of events or scenarios that really refers to.

Elizabeth Carter:

Yeah. So hydro is water, and climatic means the variability of our climate system. So I study natural disasters that happen at the intersection of where bad weather meets the water cycle. So pretty much any event that will result in either a flood or a drought, and the flood and the drought would be the impacts that we're trying to ameliorate. So examples could be extreme rainfall events, either too much rain or not enough rain. Things like tropical storms and hurricanes are other big drought generating forces that we have in the United States. They bring in a lot of precipitation, but they also cause storm surges from the ocean, which can cause flooding. So I work kind of in that space.

More people are impacted globally by droughts and flooding than all other types of natural disasters combined. And I have some stats here. So since 1980, droughts and floods and associated events like tropical storms have cost the United States over $2 trillion, and the impacts of these events are getting worse. So according to the NOAA, National Centers for Environmental Information, the cost of drought in the United States adjusted for inflation has increased by 476% since 1980. The cost of extreme weather has increased by 718% since 1980, and the cost of flooding has increased by 1567% since 1980. So we're seeing both the frequency and the severity of these water associated natural disasters are getting worse, but the human impacts are getting worse as well.

Daryl Lovell:

That leads well to the next question I had, because as I was thinking about this, I was like, it certainly feels like, from a public perception standpoint, that we hear about back to back natural disasters with flash floods, hurricanes, wildfire, severe drought, and I wondered where do your interests lie when it comes to these large scale events? What are you studying? What are you talking about with your students when these events are happening? Or after these events are happening?

Elizabeth Carter:

So I think it does... I feel like especially in the last couple of years, it's been almost difficult to be in this field and looking at the news, because there are so many different directions you can get pulled in. So first of all, why we think these events are having greater impacts, there's kind of two sides of it. The first, I'm going to call the climate change side of the equation, and then the second one, I'm just going to call it the global change side of the equation. So all of the things that humans are doing to the environment independent of modifying the climate.

So with the climate change side of things, we know that greenhouse gases are causing an increase in the average air temperatures. The simplest way to describe how that would kind of translate into the water cycle is that warm air holds more water than cold air. You can kind of think about it how in the winter your skin will get really dry, but in the summer, you might not experience that symptom as much. That's just because that cold air is not able to hold as much moisture as warmer air is. So if air temperatures are going up, on average, that means that the atmospheric column is going to be holding more water on average. So when it rains, more water will come down as precipitation from that single rain event. And when we have the inverse of that, when it's a really dry situation, we would imagine that moisture that's stored in soil and implant is going to get sucked into the atmosphere a little bit more quickly. So we call this wet gets wetter, dry gets drier. It means that we can predict, and we are seeing an increase in hydro climatic extremes.

Climate change also does this other thing that, beyond making our wet and dry events more extreme, it makes them a little bit more difficult to predict. So there are kind of complex circulation patterns in the atmosphere that take moisture from the oceans and bring it onto the land surface so that us people can enjoy it. Those circulation patterns are getting modified by climate change as well. So we have an increase in extremes and a reduction in the ability to predict when and where those are extremes are going to happen. So the other... That's the climate change side of why things are getting worse.

The global change side of why things are getting worse is that we just have more people, and people like to live close to water bodies. They're good for economic productivity, they're easier to develop around. And when we move in and we settle landscapes, we kind of do some characteristic things that change the water cycle. We put up roofs, and we pave the ground. Both of those things make it so that precipitation that's landing on that spot can't infiltrate into the soil, it all gets run off into rivers and streams. So kind of the human development, we have more people living close to in flood prone areas. And as people are moving in there, we're doing things that actually exacerbate flooding, despite developing the land surface.

Daryl Lovell:

Well, that was part of it was that I was thinking about, we talk so much about the actual... You hear about the science of the climate change, but there's humanitarian aspect to many of the stories we hear about coastal erosion and just the changes that we're seeing because the earth is getting warmer. I wonder, how much does your work intersect that between overlooking at the climate side, the science, but also the real life human impact?

Elizabeth Carter:

Sure. So the work that I do mostly involves bringing new data to the table when we're designing solutions to these climate problems. So we live in a built hydrosphere. Almost every river in the world has some type of human infrastructure on it that is either routing water for use, things like irrigation canals and water supplies for municipalities and industrial areas. Or we have flood control infrastructure all along all of our natural surface water bodies, things like levees and flood walls that aren't going to necessarily change the amount of water that's available at a location. They're not going to make floodwaters go away, but they change where it's located on the landscape.

So when we talk about how flood risk, for example, intersects with basic questions of equity and justice, what we're looking at is, how has this infrastructure been designed? And how has it redistributed risk within our communities with regards to lots of different socioeconomic variables? So there's this phrase called infrastructure inequity. We know that public infrastructure disproportionately benefits more affluent members of our society and can disproportionately exclude demographics that are just broadly excluded from our economy in general.

In water resources engineering, I think there are kind of two data sides of this infrastructural inequity. The first one is called, I call it the squeaky wheel grease. A lot of hydroclimatic extremes are actually kind of difficult to observe on the ground. If you think about, for example, flooding in the city, something called pluvial flooding, just the rain fell too fast, and it's ponding up in certain places, we don't exactly have, in our cities, a sensor network that's going to be sending off alarms and saying, "Hey, the neighborhoods in this basement are all filled with backed up sewage," or, "Hey, this intersection has standing water on it and has over and over again." The only way that we know about the impacts of something like urban flooding is if people are reporting it. And the mechanisms that a lot of communities have for reporting those types of impacts are going to lead to more impacts being reported in certain areas than in other areas, even if there are equal amounts of risk in those two areas.

So one of the ways that I look at improving equity in just the distribution of our response to these things is by seeing if we can improve better data about where they're happening. So can we generate something like a flood map that's going to give equal volumes of information for every neighborhood in the city so that we're not getting more information and therefore prioritizing more resources to certain communities?

The other reason why we see infrastructure kind of redistributing risk along socioeconomic gradients has to do with how we make decisions about how we're going to prioritize limited kind of spending interventions within communities. So if you think about something like, imagine that you've got a river, and that river is frequently flooding, and it's impacting thousands of people that are living on its shores. We might have enough resources from the federal government to come in and build a two kilometer stretch of a levee system.

We have to go through, and we have to decide where that two kilometer stretch of levee system is going to be placed. It's going to be protecting some property, and it's going to be excluding other property. Some of the data that we use to make decisions about where we're going to place infrastructure and how we're going to prioritize repairing infrastructure is biased along socioeconomic gradients. The biggest thing that we use is just property values. So if you take that into the context of all of the weighted history that we have around redlining, you can see how that would be problematic and how that would compound the legacies of inequity that stem from our housing markets.

So both of those things require... My main focus is, how can we use globally available data, the types of data streams that we get from satellites and things like that where we're collecting equal volumes of information everywhere, to improve our characterization of risk and do so in a way that is agnostic to

socioeconomic inequities? We don't want to be collecting more data on flood risk for certain people than for other people. Something that I am interested in is figuring out how we can make our algorithms more fair so that when we're working on these kinds of complicated problems of resource allocation, how can we make sure that data that equally represents where the problems are gets translated to equal distribution of solutions?

Daryl Lovell:

How difficult is it to take on something with equity and algorithms? I've done other reports about just some of the bias that we think wouldn't exist in algorithms, and it does. Because obviously, humans are making algorithms, they're setting them up, and we have our own biases, each of us carry those. But how big of a challenge is that alone?

Elizabeth Carter:

I think that that's actually why I got into water resources engineering to begin with. So algorithmic decision making, if you look back over the history of it, I feel like it was... It's at this idea of cost benefit analysis, using some measurement of something on the ground to kind of prioritize resource allocation, something called asset management. How are we going to make a complex decision about, "who gets what," has its legacy in kind of civil infrastructure.

In France, actually, and in the United States, the Army Corps of Engineers really pioneered and set the precedent for how we were going to use cost benefit analysis to decide how we were going to make complex decisions about civil works. I feel like algorithmic bias, that idea has gained a lot of traction in a lot of popularity as we're using more data and more privatized algorithms to make decisions in everything from sentencing to healthcare, to education. But we've been using data and models to make decisions about who gets what in public infrastructure engineering since the field's been around.

So in my field, I really do think that I love teaching engineers, because we could talk about these problems. In my water resources engineering class this year, we had Dr. Emanuel Carter, who's a landscape architect, a Professor of Landscape Architecture at SUNY ESF, come in and talk to students about redlining. And he showed all of the students the original redlined maps that were made for the federal government when they were moving to back private mortgages in the 1930s, and were just flipping by city, by city, by city. And students are from these cities, and they're able to see in real time how those literally redlined maps have played out over time. And we can also talk about how, "Hey, when you guys have your first clients and you're putting together budgets and you're trying to demonstrate why your project has value to a community, make sure you're talking more about just the dollar value of the properties in the neighborhood that you're serving." Talk about some of the ways that they can factor those things in.

So from an education side of things, I think that students have tools available to them that they can use right now that they can, as entry level engineers, start thinking about these things differently, start thinking outside of the box about how we value things within a community in terms of how difficult it is to change patterns. I mean, we're kind of at a frontline in terms of history with that.

One thing that I think about is one of my projects involves using satellite data to see if we can map flooding impacts in real time, so building flood maps for cities immediately after a natural disaster and making those available. As a scientist, my hope in generating data like that is that policy makers will see that information, and they will distribute resources based on actual risk, not filtering it through any of these other cost-based constraints that we see lead to inequities and how those resources are redistributed. But I don't know if having better data necessarily means that we will have less socially

biased models. I think that it's kind of a time will tell how that data's used and whether it's used to make the world better, or it's further weaponized against people who are often at the... Yeah.

Daryl Lovell:

Definitely. Yeah. If it helps level the playing field, like you said, or we just keep being in this cycle of disenfranchisement for certain groups, unfortunately. At least it's hopeful that people are making efforts, I think, to try and level the playing field, or even understand, how do we get here? How do we change things? I think that that's a step in the right direction.

And I was going to ask, as we think about next steps and the future, I'm doing this right around Earth Day, so it's a time when everything kind of goes into the larger conversation about our environment and being better, doing better. What kinds of things do you think about? What kind of messages do you have? Maybe something we can focus on this Earth Day, related to all the things that you do with studying climate disasters, mitigation, predictability, anything like that around Earth Day as well?

Elizabeth Carter:

Yeah. I think the message of hope that I have, and the reason why I do what I do is that a lot of the legacy problems that we deal with now in managing natural disasters, mainly how our storm sewers have been built, how our flood control infrastructure is laid out, how we structure our responses, a lot of these policies and infrastructure were developed at a time when we didn't have a lot of observations. We didn't know. We didn't have a lot of measurements of stream flow or precipitation that would let us know what the actual risk of flooding looked like in this area, or drought looked like in that area.

As of right now, there's over 300 earth observing satellites and observations that are collecting repeat pass imagery of everywhere on earth all the time. This is an amazing untapped data field for us in water resources management. We can now directly observe lots of different components with the water cycle everywhere on earth, and that makes it possible for us to manage those systems better. We have seen a trillion fold increase in computing power since the seventies. And one of the things that, that has enabled us to do is build these really complicated coupled earth systems models that let us do things like make predictions about what local weather and climate will be like under climate change. I think that we have a tremendous amount of information that we can be using to make smarter decisions about how we want to situate our build environment in the natural world that can help mitigate a lot of the impacts that we're seeing, especially with natural disasters.

Daryl Lovell:

Liz, thank you so much for just joining me on the podcast and sharing a little bit more about your work. It really is so timely as we think about Earth Day and Earth Month.

Elizabeth Carter:

Thank you for having me.

Daryl Lovell:

Thanks for checking out this week's episode. Be sure to subscribe to our podcast by searching 'Cuse Conversations on your favorite podcasting platform. I'm Daryl Lovell, signing off for the 'Cuse Conversations podcast.