"A map is a means of communication, and it is not the God-given truth. It's the way you design it. The mapmaker makes the map."

Suchi Gopal's maps don't just tell us where things happen; they tell us how and why

BY Barbara Moran

PHOTOGRAPH BY Jackie Ricciardi

Suchi Gopal's talent goes far beyond the science of data crunching. She is gifted in the unteachable art of weaving: bringing together seemingly unrelated ideas and people to attack thorny problems.

Suchi Gopal bursts into her classroom, grabs a piece of chalk, and draws a grid on the blackboard, filling in temperature data from points across the United States. "Aha!" she claps. "Today we will do some math!" Her 11 graduate students, parked in front of glowing computer screens, will soon learn an important lesson about geographic information systems (GIS)—making maps with computers.

Gopal, a College of Arts & Sciences professor of earth and environment, is a renowned expert (and devoted teacher) in the field. To Gopal, maps are power. A long list of statistics on bicycle accidents at BU, for instance, is just an inscrutable jumble of numbers. But insert the data into GIS, overlay a map of campus, and the computer builds a map that makes the data instantly understandable. In that case, it becomes clear that most bike accidents don't occur at intersections, as one might expect, but when the bike lane veers too close to parked cars and bicyclists get doored. Maps reveal things. They provide a deeper understanding of a problem, so people can choose the right solutions.

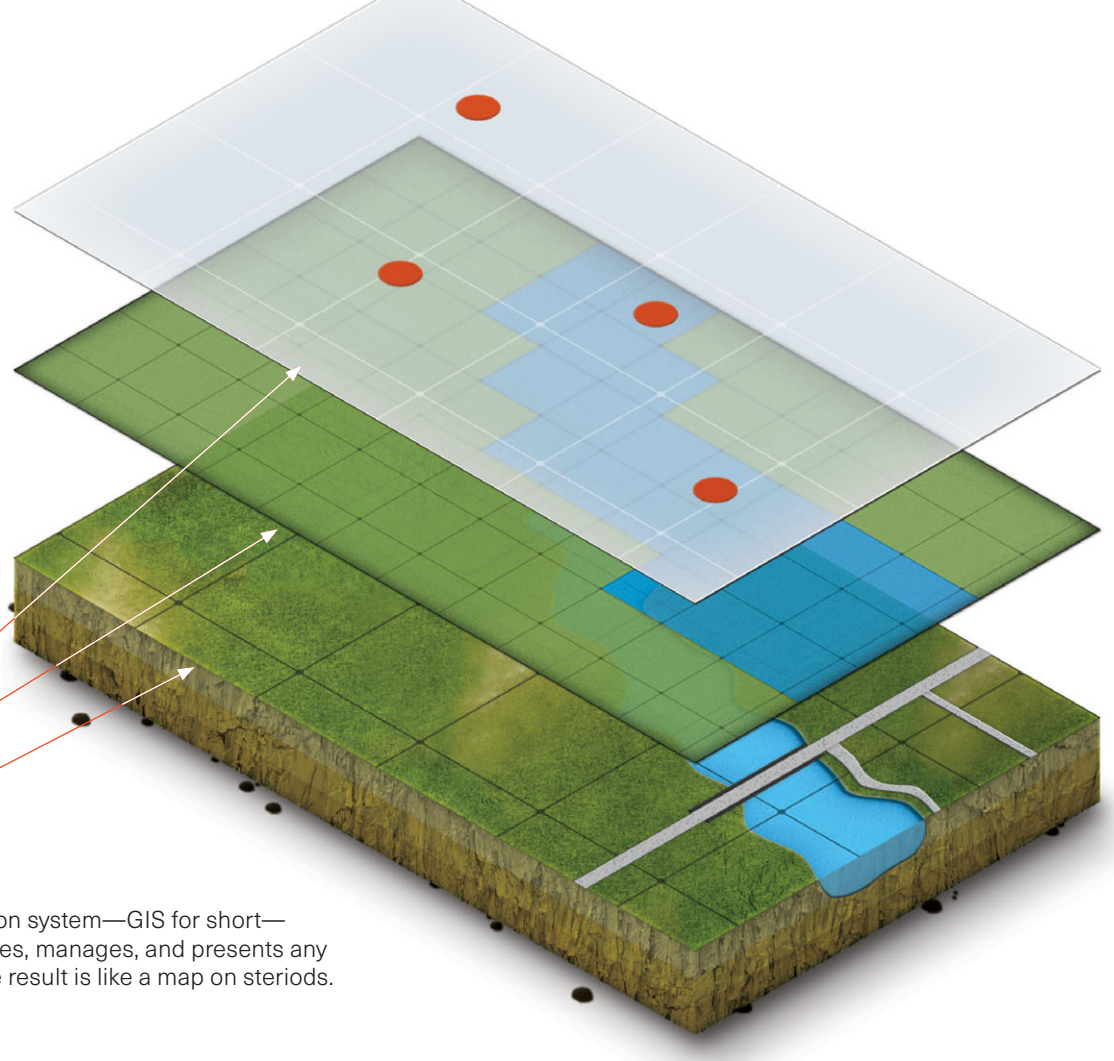
Over the past two decades, as computing power has increased, GIS has risen from an obscure tool for measuring the productivity of Canadian farms to a powerful technique that maps everything from the eating patterns of orangutans to health care access in Zambia. And Gopal, with her expertise in statistics and geography, as well as her wide-ranging scientific interests, rides the tip of this trend. Her students in Introduction to GIS come from public health, social work, geography, neuroscience, anthropology, and myriad other fields to learn how to turn their dry data into spectacular maps.

Today, Gopal is teaching them the power of computing by snatching it away. She encourages two students to the board, where they begin to solve a series of tedious equations. When they find the answer, Gopal circles the number in blue chalk. "This is the temperature of just one unknown location," she says. "You see how much work that was? On the computer, everything is so sweet and quick."

The exercise is Gopal's work in a nutshell: years of research, thousands of data points, millions of calculations, all painstakingly collected, entered, checked, and finally hidden behind a beautiful, brightly colored map that anyone can understand intuitively. But Gopal's talent goes far beyond the science of data crunching. She is gifted in the unteachable art of weaving: bringing together seemingly unrelated ideas and people to attack thorny problems. Her colleagues describe her as equal parts mapmaker and matchmaker.

The range of Gopal's research is astonishing, from anthropology to public health. "All this data is only good if it addresses a societal problem," she says.

Mapmaking, Suchi Style



In this example, **a layer of data** *(such as malaria hot spots)* overlays **a land use layer** (like a levee) and **a topographical map**.

A geographic information system—GIS for short—captures, stores, analyzes, manages, and presents any kind of spatial data. The result is like a map on steriods.

"Suchi is very good at pulling in ideas from other disciplines and applying the tools of GIS. That's one of her hallmarks and she's very much a leader," says Curtis Woodcock, department chair and professor of earth and environment. "Suchi is one of the more freewheeling, quick-thinking, fast-associating people I know. The ideas just bounce out of her."

Maps Can Lie

Sucharita Gopal—known universally as "Suchi"—grew up in Chennai, India. With two doctors for parents, dinner conversations "were all about illness and sickness and health and wellness," says Gopal. "That's where the curiosity came from." In college, Gopal became entranced with the idea of how people move through their landscape, and the power of maps to help people make decisions, including choices about public health. "Everything happens in space," she says. "Health happens in space." She left India in 1983 for the University of California, Santa Barbara (UCSB), to pursue a PhD in geography.

UCSB was—and still is—a leader in GIS. Computerized mapping had sprung up in the early 1960s, as large mainframe computers became more widely available. The US Census Bureau wanted better maps, as did military spies, British botanists, and urban planners. But it was an English geographer named Roger Tomlinson who became widely known as the "father of GIS" for persuading the Canadian government to create the Canada Geographic Information System (CGIS) in 1966 to conduct a massive inventory of the country's land. Their goal: to see how much land was farmed and which farms were productive. They operated the system until the late 1980s.

When Gopal arrived at UCSB, commercial GIS systems were entering academia, but many scientists didn't know what to do with them. "Through the '80s, there were just a few people around the world who recognized the significance of GIS," says Michael Goodchild, a professor emeritus from UCSB who advised Gopal on her thesis. "We had the president of the Association of American Geographers on record as saying that GIS was a nonintellectual expertise."

Gopal held no such notions. Even then, she saw potential uses for maps in many fields. She also understood their power. A

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map is only useful, she says, if someone is using her brain to make it, and analyzing the data honestly. "Maps can lie," says Gopal. "Hitler lied to the German people by exaggerating the threat from Britain and France. A map is a means of communication, and it is not the God-given truth. It's the way you design it. The mapmaker makes the map."

Smarter Satellites

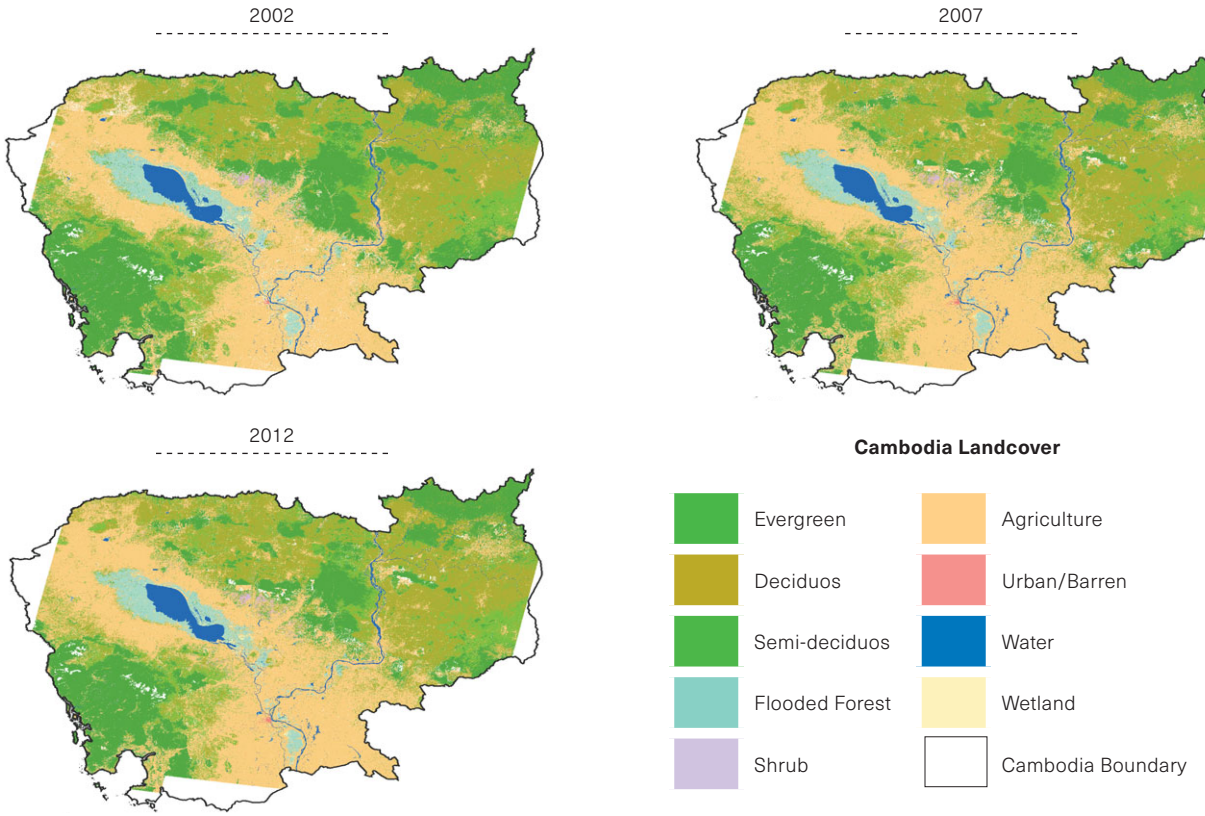
After finishing her PhD, Gopal joined BU's geography department in 1989 and soon embarked on an unusual collaboration with neural modeler Gail Carpenter, who was studying pattern recognition. Gopal had done related work at UCSB, building an artificial intelligence model to study how people use patterns and landmarks to navigate through space. The geographer and the neuroscientist thought their combined understanding of brains and mapping might help solve a growing problem: data overload.

"Back then, everyone was already saying that they were overwhelmed by data," says Carpenter, a CAS professor of cognitive and neural systems and of mathematics. "It's nothing like it is today, but even then people were already overwhelmed."

Gopal and Carpenter were looking at a particular set of data: thousands upon thousands of ground images from Landsat satellites. It was a classic case of Too Much Information: the photos were great, but it took humans months—if not years—to analyze them. The scientists wanted to make the satellites more like people: choosier about the data they collect.

"One of the things that makes us different from satellites is how we pay attention," says Carpenter. "We know what to ignore." Take driving: "You don't notice every single tree, but you notice the fire truck coming. We filter out the unimportant stuff. That's how we handle lots of data with a pretty narrow bandwidth."

Could satellites be taught to do the same? Carpenter and Gopal developed a computer learning system—a series of algorithms that would allow a computer to look at Landsat images and discern mixtures of land cover, finding percentages of, say, wetland, conifer forest, and grass. Their system took minutes to churn through a photo that humans needed six months to analyze, with results of the same accuracy. "We developed methods



Mapping Cambodia's Biodiversity Gopal's doctoral student Xiaojing Tang examined how deforestation affects biodiversity in Cambodia's Tonlé Sap Lake. The maps show significant forest loss between 2002 and 2007, and less striking changes between 2007 and 2012.

that Suchi and her students still use all the time," says Carpenter.

Gopal and Carpenter have remained friends and colleagues over the intervening decades, collaborating on research and lecturing in each other's classes. "It takes a long time to establish interdisciplinary research, and she's great at that," says Carpenter. "But her best quality is generosity. Some people never learn the importance of being generous, but she just shines there."

This generosity has given Gopal a web of connections stretching from her childhood pen pal in California (who she still keeps on speed dial) to scientists across disciplines and around the world. The range of her research is astonishing, and now it often loops back to the questions of health that originally drew her to geography. She helped Susan Proctor of the US Army Research Institute of Environmental Medicine on a School of Public Health study mapping the incidence of Gulf War Veterans' Illnesses. She helped James McCann, a professor of history at BU's African Studies Center, find hot spots of malaria in Ethiopia. And she's working with Davidson Hamer, an SPH professor of global health and medicine, to understand how pregnant women access health care in Zambia. Gopal is also the principal investigator on a five-year, $2.9 million National Science Foundation grant that integrates STEM research into the science curricula of local schools, by pairing BU graduate students with teachers. The grant has impacted more than 2,000 middle school students so far.

"I want to solve real-world problems. I don't want to write something that's buried in a journal. I want to work with actual people to make a difference," says Gopal. "All this data is only good if it addresses a societal problem."

The Movie of What Has Happened

The power of Gopal's research is evident in an interactive map called MIDAS, developed with Les Kaufman for an ambitious project in Belize. In 2005, Kaufman, a CAS professor of biology with Boston University's Marine Program, received a $12.5 million grant from Conservation International to examine ocean zoning projects. Belize had "protected" certain ocean and coastal areas from fishing, but were the protections actually working? What could the country do better? Where should they spend their money? To answer these questions, Kaufman needed data. And maps. And people. He needed Suchi Gopal.

"She has an excellent formal background in spatial mathematics and map theory, and she's, of course, very skilled at GIS," says Kaufman. "But she also understands people. Because Suchi is empathic, she can relate to people better than most geeks. And that was one of the biggest missing elements of the team I was trying to build."

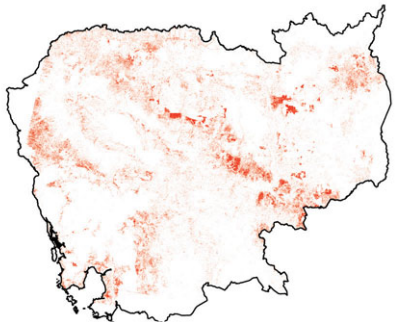
Kaufman approached Gopal and asked her to build a map. Not just any map, but something new: an interactive tool that could help people make decisions, sort of like SimCity for the coast of Belize, but with real data. "People in Belize had no access to complete and accurate maps of their natural resources and marine habitats," says Gopal. "How do you give them the best science that we know? How do you help them make a decision? That was the tool that Les asked me to make. And we needed people to use it. Otherwise, it would be worthless."

Over three years, Gopal built MIDAS, which demonstrates the power of GIS in the hands of a master mapmaker. The interface is simple and instantly usable. By sliding tabs, you can see how a change in habitat quality or species abundance will affect overall ecosystem health. Or you can see the effects of an oil spill over hours or days. Or what happens if you destroy a swath of mangroves. It remains hugely popular and useful among stakeholders in Belize. "GIS is the movie of what has happened," says Kaufman. "It's also the projection of what could happen, depending on what decisions we make."

For Gopal, building the map was only the beginning. The bigger goal was getting people to use it. And that was where Gopal, always the teacher, had her proudest moment. During the final presentation of MIDAS to stakeholders in Belize, she made an extraordinary gesture of trust and generosity, turning the podium over to a young woman from the Fisheries Department who had learned the system only the night before.

"She did the whole thing in front of this huge audience of 100 people, most of them from Belize, who were tired of gringos and Americans talking to them," says Gopal. "She did the mangrove stuff, she did the oil spill stuff, she totally took ownership. It was huge.

"I think of all the things that I've ever done, that little thing was the biggest. It was so powerful. I'll never forget it. We were blown away." ■



Cambodia's Deforestation
The red areas show deforestation in Cambodia from 2000 to 2014, a total forest loss of 7.6 percent.

Gopal built a new kind of map: an interactive tool that could help people make decisions, like SimCity for the coast of Belize.