

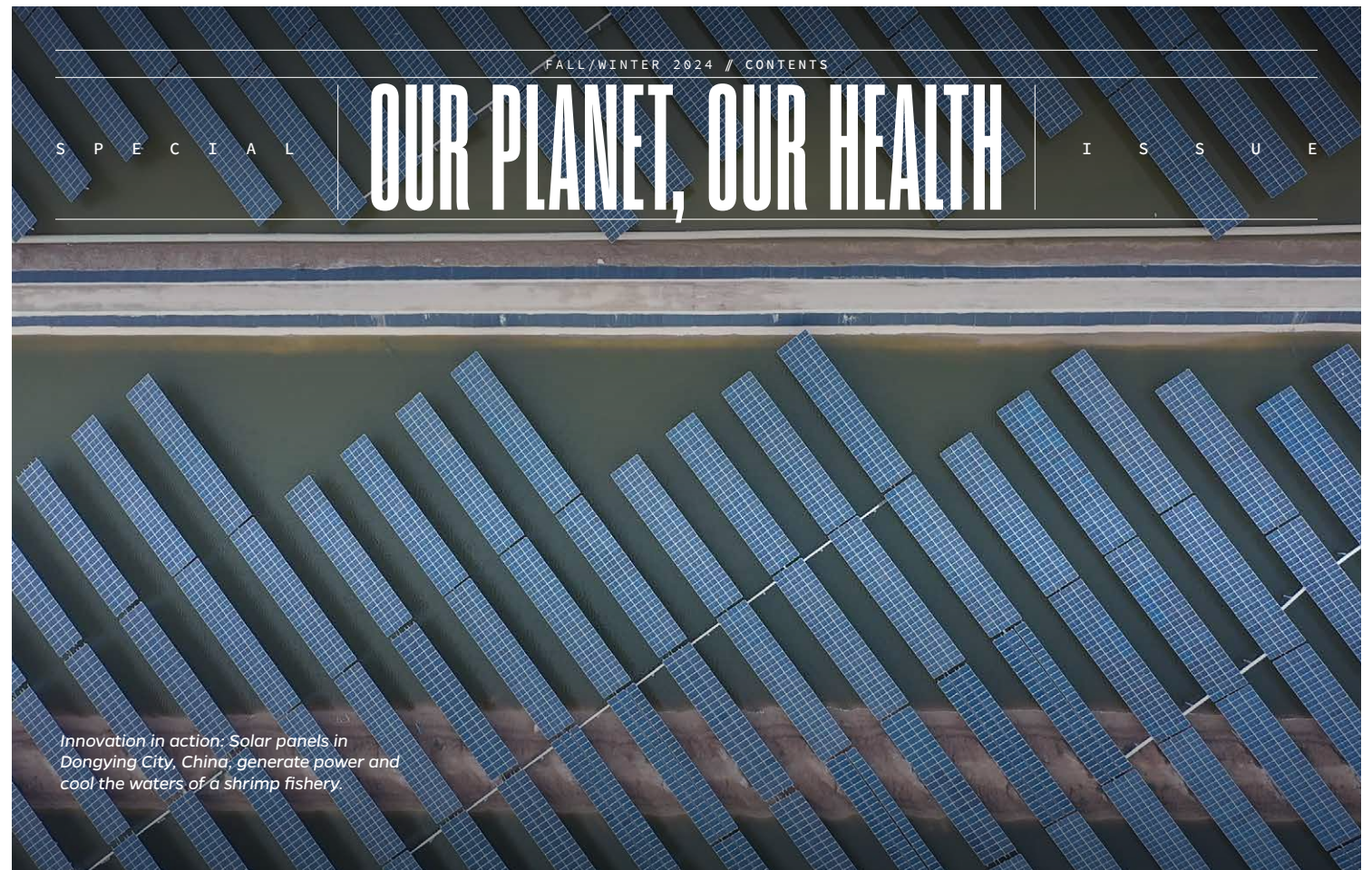


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Innovation in action: Solar panels in Dongying City, China, generate power and cool the waters of a shrimp fishery.

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A STORY OF NOW

The choices we make today will determine whether we have a livable future.

BY SAMUEL MYERS

We find ourselves actors in one of history's greatest dramas.

The story began when a trick of evolution allowed a lone ape species to develop an exceptionally large and complex brain. These brains have allowed us to bend Nature toward our will, unlocking an abundance of energy and resources that have fueled almost unimaginable improvements in human development. In the last 75 years alone, life expectancy nearly doubled, and child mortality and extreme poverty fell by a factor of five.

But the same advances in science and technology that drove these gains are also accelerating our destruction of Nature. To feed ourselves, we claim 40% of the world's land surface and nearly half its accessible fresh water. We have felled half the planet's temperate and tropical forests. Pollution from our enterprises contaminates air, water, and soil. And we are changing the planet's climate at a critical pace. Two-thirds of the birds, reptiles, amphibians, fishes, and mammals that used to share the planet with us are gone. A million species face extinction, many within the next several decades.

In pursuit of our ambitions, all of Nature has become collateral damage.

The field of planetary health tells us that these biophysical changes are interacting to erode the foundations of human well-being: the quantity and nutritional value of food we can produce, the quality of air and water, our exposure to infectious diseases and extreme weather events, and even the habitability of the places many of us live. Every dimension of human health is affected. The enormous health gains we have achieved over the last several decades

are now threatened by our degradation of Nature's life-support systems.

Nor are the health burdens distributed evenly or fairly. When warming brings malaria to the East African highlands, the poorest families who cannot purchase bed nets are most vulnerable. When pollinating insects decline and crop yields fall, the wealthy can purchase fresh fruits and vegetables while the poor suffer higher rates of heart disease, stroke, and certain cancers because they can't afford to eat these foods. Consumption patterns and value systems of the wealthiest people put the poorest people and future generations in harm's way. Indigenous knowledges that have long stressed our interdependence with natural systems have been marginalized or destroyed.

Here is where we find ourselves: Our cleverness may be our undoing. The same complex brains that subjugated much of Nature now recognize that the state of natural systems and the well-being of humanity cannot remain disconnected. People around the world are suffering. The wild, miraculous tapestry of life is coming unwoven. We are walking a charred path toward extinction.

As we awaken to the fierce urgency of this moment, we realize that our only way forward requires deep, rapid, structural change in how we live and a global commitment to protecting and regenerating Earth's natural systems. This understanding holds enormous promise.

Looking out across global food systems, energy systems, manufacturing, urban design, and green chemistry, we find a rich landscape of solutions. We can imagine a world, a hundred years from now, where the human population has stabilized by educating girls, creating economic opportunities for women, and providing greater

access to contraception. A world powered by renewable energy. A world where food and goods are produced with dramatically reduced ecological inputs. And a world where most of us live in cities that optimize physical, mental, and cultural health, while allowing Nature to regenerate. In this world, each passing decade offers more breathing room to the rest of the biosphere. It's called the Great Transition—and every person in every place has a role.

A million years of biological evolution and thousands of years of social evolution have brought us to this question: Can we change? As we awaken to this moment, can we rise to its requirements? Can we find the humility, the compassion, and the courage to acknowledge the need for a different path and collectively embrace it? How will we answer the only question that matters: How shall we live?

A hundred years from now, this could be our story: Once upon a time, on a stunningly beautiful planet, a young species with a very large brain woke up to find itself imperiled by its narrow self-conception and shortsightedness. And with eyes opened, it charted a new course in which selfishness gave way to collectivism, domination and extraction were replaced with regeneration, and extinction became renaissance.

The choice is ours. What story will we write? ◉



Samuel Myers, MD, MPH, is the founding director of the Planetary Health Alliance, the director of the Johns Hopkins Institute for Planetary Health, and a professor in Environmental Health and Engineering.

This essay was adapted from "The Wings of Herons," Constellation Project, 2022.

POWER PLUS

Solar panels in Dongying City, China, do more than generate 260 gigawatt hours of energy per year (power for 113,000 households). Perched above a shrimp fishery, the panels throw shade that cools water temperatures by 2°–3°C, per the World Resources Institute. Cooler water increases shrimp and sea cucumber yields by 50%.

OUR PLANET, OUR HEALTH
| FEATURE STORY |

The
MANY COSTS
~of~
CHEAP CHICKEN

Industrial food animal production exploits workers, poisons water sources,
and promotes the transmission of antibiotic-resistant superbugs.
Is there a better way?

BY MIKE FIELD



Broken clouds, dripping humidity, and a heat index of 101°F droop across Delaware's flat and sandy eastern shore on a midmorning in late June. At the southern tip of Georgetown in Sussex County, the Hispanic evangelical church *Iglesia de Dios de la Profección* stands in a sweltering parking lot surrounded by open fields of corn and soy. In the church's cool, brightly lit all-purpose room, Pastor Anastacio Matamoros, some congregants, and local community members sit with Bloomberg School researchers on folding metal chairs.

"We have come to hear what you have to say, what your concerns and experiences are," says associate professor of Environmental Health and Engineering Christopher Heaney, PhD, MS. He and his colleagues are part of a \$5.6 million National Institute of Environmental Health Sciences grant engaging local citizens to help identify links between environmental exposures and adverse health outcomes. Today, they want to hear from area residents who work for or live near the chicken growing and processing facilities that generate \$7 billion and 29,000 jobs across the small state.

Community activist Maria Payan of the Sussex Health and Environmental Network shares a Google map of the surrounding area. It's peppered with blue dots. Each typically represents an active poultry house twice the length of a football field and 60 feet wide, that crowds in 50,000 birds. Enormous fans at the end of each structure that blow air through the building also spew significant quantities of volatile organic compounds along with ammonia, bacteria, and fungi. This airborne "poultry dust"—made up of bird droppings, feathers, dander, and other materials—results in occupational asthma cases

at twice the national average across all industries.

Next, a retired couple shares their experience living within sight of a major chicken processing facility, where the birds are killed, plucked, butchered, and packaged for supermarket sales. The wells supplying clean water to their and their neighbors' homes are contaminated with nitrates from the processing plant. High nitrate exposure has been linked to ill health effects ranging from increased heart rate to nausea and abdominal cramping, with some studies suggesting an increased risk for cancer, especially gastric cancer. They can no longer drink the water from their taps. As part of a 2021 legal settlement, the couple and their neighbors rely on bottled water provided by the chicken processor for all their drinking and cooking needs.

Later, Bloomberg School researchers and community members travel to Ebenezer Haitian Seventh-Day Adventist Church in nearby Seaford. Church member Emanie Dorival, a registered nurse and founder and CEO of Ephphatha Medical Care Services, explains the brutal demands on the Haitian community members who work in local chicken processing plants. They receive little training yet must cut 14 pieces of chicken per minute or face penalties. "I have seen hundreds of work-related injuries. But it's hard to get them to report violations," says Dorival. "Many are undocumented workers, and they fear losing their jobs."

Air unfit for breathing. Water unsafe for drinking. Jobs that exploit marginalized workers. These and a host of other insults to human health are among the many impacts of industrial food animal production, or IFAP.

ONE DAY IN 1923, IN OCEAN VIEW, DELAWARE, farmer Cecile Steele ordered her customary 50 laying hens for the season. But 500 chicks arrived. It was a take-it-or-leave-it situation, according to industry trade group Delmarva Chicken Association, so Steele had her handyman build an 8-foot by 12-foot shed that she filled with the chickens and equipped with a woodburn-



ing stove. Eighteen weeks later, she had 387 surviving birds weighing about two-and-a-half pounds apiece. She sold them at 62 cents per pound (the equivalent of more than \$11 per pound today) and made a small fortune.

Steele's success evolved into the sprawling, global IFAP system that supplies almost all of our meat, eggs, and dairy today. The number of chickens, cows, pigs, and turkeys in the U.S. food system exceeded 10 billion in 2022, up from 5.2 billion animals in 1987, according to the USDA's Census of Agriculture. A snapshot in time reveals the enormous consumption these numbers reflect: The National Chicken Council, the industry's trade association, announced that Americans devoured 1.45 billion chicken wings while watching Kansas City and San Francisco battle in the 2024 Super Bowl.

“There are planetary, human, animal, and ecological costs associated with producing that cheap pound of chicken that are not reflected in what you pay at the grocery store.”

Yet all this plenitude comes at steep costs that are largely invisible to the average consumer, says Keeve Nachman, PhD '06, MHS '01, the Robert S. Lawrence Professor in Environmental Health and Engineering. "There are planetary, human, animal, and ecological costs associated with producing that cheap pound of chicken that are not reflected in what you pay at the grocery store," says Nachman, who is also associate director of the Center for a Livable Future.

In the U.S., most of those costs stem from the country's dominant model of animal production: the concentrated animal feeding operation, or CAFO. These came into use in the 1950s with chickens and in the 1970s with swine and cattle. The EPA defines large CAFOs as operations confining 1,000 or more "animal units"—comprising 1,000 beef cows or 700 dairy cows, for example, or 2,500

Three-quarters of chickens produced for meat in the U.S. in 2022 came from farms raising 500,000 or more chickens, per USDA. Such operations rely on massive poultry houses like these.

hogs, or 125,000 chickens—indoors for at least 45 days at a time. More than 21,000 such CAFOs were operating the U.S. in 2020, according to the EPA.

Raising large numbers of animals together in a confined space presents two related problems: food in and waste out. Federal subsidies support the production of soybeans and especially corn, which accounts for the vast bulk of total feed grain production. Globally, a third of all cropland is used to grow animal feed, according to the UN Food and Agriculture Organization (FAO). Devoting large areas of arable land to growing feed for animals deepens our reliance on corn and soy monocultures, with the associated problems of soil degradation, pesticide overuse, and biodiversity loss—while creating competition over a limited area that could instead be used to grow food directly for people.

Waste out is an especially difficult challenge. Livestock and poultry held in CAFOs produce 1.4 billion tons of manure annually—which, unlike human waste, is not treated. Poultry houses are typically cleaned once a year to remove manure, which is then stored in sheds or on open pads or in fields until it's applied as fertilizer. Cattle and swine excrement, however, is simply pumped into large open pits euphemistically called "lagoons." These methods often fail to contain the waste. After Hurricane Florence ravaged the swine-producing areas of North Carolina in 2018, for instance, the *New York Times* reported that more than 100 lagoons full of pig waste were either nearly or already overflowing and releasing untreated waste into local streams and waterways.

This is just one of the risks to human health, say critics of the CAFO system. Extreme concentrations of any single species provide a rich breeding ground for dangerous pathogens. "Imagine a classroom with a capacity for 200 people, and it's packed, and you introduce someone infected," posits Meghan Davis, DVM, PhD '12, MPH '08, an associate professor in EHE. "There's a lot of contact, a lot of transmission."

"The same thing is true when you think about an industrial scale animal production facility where you've packed

in all these animals and then introduce an infectious agent,” says Davis, who previously worked as a veterinarian caring for dairy cattle in Lebanon County, Pennsylvania. “It spreads like wildfire.”

To mitigate this risk, CAFOs have relied on an abundant use of antibiotics—both as prophylaxis and, until recently, to promote animal growth, a practice that the FDA began phasing out a decade ago but still persists. Recent data show that about 65% of medically important antibiotics currently sold in the U.S. go to food animal production. But frequent use of antibiotics among food animals directly endangers human lives. Past indiscriminate use of antibiotics in food animals has greatly increased the prevalence of antibiotic-resistant superbugs such as methicillin-resistant *Staphylococ-*

cus aureus, and, according to a 2019 CDC report, has led to an estimated 2.8 million annual infections and as many as 160,000 excess deaths. And that’s just bacteria. High concentrations of animals—especially birds—provide ample opportunity for viruses to mutate and spread through animal species, as evidenced by the highly pathogenic H5N1 avian influenza that has infected U.S. dairy cows and agricultural workers, as well as harbor seals, raccoons, deer mice, mountain lions, and other mammals. Experts are concerned about a pandemic of the disease, which has been reported in 23 countries since 1997.

THANKSGIVING WITH NO TURKEY ON THE MENU? For most Americans, it would be inconceivable. Food is more than sustenance;

it is deeply cultural. And that includes Americans’ love of chicken wings and hamburgers, bacon and turkey legs, ice cream and three-egg omelets. The U.S. is tied with Portugal for highest overall meat consumption per person, coming in at 328 pounds a year, according to the FAO.

“Our perspective is that while we certainly need significant reform, it’s not reasonable to advocate for ending all meat production,” says Center for a Livable Future senior program officer Patti Anderson, PhD ’14, MPH ’09. “This is particularly important because there are a lot of settings, especially outside the U.S., where animal-sourced foods can be produced sustainably and are critical to diet.” In calorie-challenged communities, for instance, goats and pigs can forage on marginal lands but provide much-needed protein to human diets. In the U.S., however, the challenge is bringing changes necessary for long-term sustainability to an entrenched system defended by rich and powerful interests.

The most effective leverage, as is so often the case, may lie in the power of the purse. “We can’t just flip a switch and start producing food the way we need to, but we can transition there,” says Nachman. “One powerful tool for moving in that direction is through procurement.” Large institutions such as schools and universities, governments, and the military are potentially effective agents of change. “If we can incentivize large institutions to source foods that are produced in a way that respects people, the planet, and animals, that can bring change,” he says. “And we can nudge—you know, encourage these institutions to put plant-based options front and center so that people default to the healthier and more sustainable choice.” In a buffet or cafeteria line, for instance, large platters of grains and legumes could be supplemented with animal protein side dishes and alternative protein meat substitutes (see sidebar) that would share equal billing with the traditional choices.

Another avenue may be to let the sun shine in. “One of the pillars of change has to be around transparency,” says Anderson. “There is a deep, ‘out of sight, out of mind’ vein to how we raise and

FUTURE MEAT



FARMER, POET, AND ESSAYIST Wendell Berry noted “how we eat determines to a considerable extent how the world is used,” says CLF’s Brent Kim, MHS ’09, an EHE assistant scientist.

“There are important roles for animals in a sustainable food future, and there are also plenty of protein-dense options that don’t depend on animals at all,” says Kim. The key lies in efficiently producing more food for humans on agricultural land already in use with a fraction of the ecological burdens. Substitutes for milk and protein made from soy, peas, oats, nuts, and other plants are now commonly available in most grocery stores.

The student-led Alternative Protein Project at Johns Hopkins supports research and career tracks in emerging technologies within the field. Alternative proteins include cultivated meat, in which tissue engineering techniques are used to culture specific animal meat cells; precision fermentation, which uses microbes to influence food palatability and taste; and plant-based meat substitutes that have expanded significantly in recent years.

“We envision a food system that provides people with the foods they love—produced without conventional animal agriculture,” says Alternative Protein Project leader Vivian Su, a Materials Science and Engineering PhD student.

By hosting speakers, webinars, and social events featuring plant-based foods, the group advocates for alternative proteins as a way to alleviate public health, ecological, and ethical burdens associated with over-consuming animal-sourced foods while providing a positive impact on greenhouse gas emissions and planetary health.

“Hopkins is an international leader in medicine and public health, and we believe that the overlap between the tools and knowledge utilized for biomedical research and food manufacturing can be used to drive forward a future of a just and sustainable food system,” Su says.

And that’s not just a change of diet. It’s a change in how we use the world.

—MF

THE BIG PICTURE

Delaware’s chicken houses are just a cog in a global food system responsible for the majority of water use, biodiversity loss, land use change, and up to a third of all GHG emissions. The Earth crisis cannot be solved without addressing this foundational problem.



In poultry houses holding tens of thousands of chickens, enormous fans provide ventilation but also expel large quantities of volatile organic compounds, fungi, and bacteria.

process food animals in this country. When you get everything nicely packaged at the grocery store, you don’t have to think about how it got there.” Consumers can’t make good choices about what they eat unless they are actually informed. While package labeling that identifies eggs as coming from “free range” chickens is a start, USDA regulations do not require that those chickens spend time outside. Clear and accurate definitions of terms need to be determined and enforced, she says.

Prioritizing animal welfare could be yet another way forward, argues Alan Goldberg, PhD, an EHE professor emeritus who worked on a 2008 CLF and Pew Charitable Trusts report that examined the U.S. IFAP system. “It was a life-changing experience,” says Goldberg, who founded the

Center for Alternatives to Animal Testing at the School but had no prior experience with food animal agriculture. “I came away convinced that animal food systems can be intensified without being cruel.” He believes large and centralized animal farms can be humane. What’s missing, he says, is the 8,000-year-old agricultural animal tradition of husbandry, of proper care of and attention to farm animals. (“The rise of confinement agriculture in the 20th century broke this ancient contract,” he says.) Goldberg believes that raising standards of animal welfare through regulation—“providing for the animal to be able to express its natural behavior, essentially providing what the animal needs and what the animal wants”—would address most of the negative human health consequences of IFAPs.

A CHANGE OF CUSTOMER BEHAVIOR HERE, some additional transparency and greater respect for animals there, adjustments

to regulations, and enforcement of environmental rules regulating chemical and biological discharges already in place—some combination of these and similar approaches could bring about real and sustainable change, experts say.

“It’s about helping people understand that our current system of cheap food is actually not so good for them,” says Adam Sheingate, PhD, a professor at the Krieger School of Arts & Sciences who specializes in the politics of food and agriculture. “Whether it’s leading to diet-related disease, or increasing the risks of the next pandemic, or impacting people in rural areas who live near these operations, or the way air and water are seriously compromised, or the incredibly large volume of antibiotics used, these are the issues that matter to people,” says Sheingate. “We need to bring them to the personal level. That’s how we’ll get people to understand not just the science behind these things, but the policies that we need to change.”



Cities must rethink transportation infrastructure to reduce greenhouse gas emissions.

BY KELLIE SCHMITT
ILLUSTRATIONS BY PATRICK KIRCHNER

In a leafy Seattle neighborhood on the shores of Lake Washington, Nathaniel Henry, PhD, is explaining the 15-minute city concept by pointing exuberantly in all directions.

“There’s a convenience store over there, restaurants here, a bakery a block over there, a school a block over there,” says Henry. “There’s a park and an elementary school. There’s the bus line that goes to downtown Seattle, and a small library over there.”

The stroll along the Madrona neighborhood’s central shopping corridor vividly demonstrates how residents can easily walk, bike, or use public transit for most daily excursions in trips that

typically don’t exceed 15 minutes—improving air quality and increasing their physical activity in the process.

As he heads down a hill toward a grocery store, he notes “cool safety features” that encourage walking or cycling, like dedicated bike lanes and a pedestrian-only street during school drop-off hours.

Henry, a 31-year-old data geography consultant who does not own a car, believes in the transformative power of walkable neighborhoods like Madrona for residents’ health as well as the environment’s. In April, he launched a tool that maps 15-minute neighborhoods nationwide called Close, which has already had 2 million pageviews. ◀

“People understand more now about carbon footprints,” he says. “Just because the suburbs look greener doesn’t mean they’re the green choice.”

Indeed, transportation is the largest contributor to human-generated greenhouse gas (GHG) emissions in the U.S. At Johns Hopkins’ Center for Climate-Smart Transportation, researchers are exploring how the 15-minute city and other evidence-based approaches could help municipalities address such alarming issues and reshape how people travel. The Center, which is funded by the U.S. Department of Transportation and includes six institutions, has a key goal: Make climate change the center of every transportation decision.

“It’s extremely important to think about how we can reduce these emissions and move toward meeting greenhouse gas emissions target reductions,” says Shima Hamidi, PhD, MSc, the Center’s director. “What actions and policies can help? It starts with cities.”

CITIES AT THE FOREFRONT

Researchers at the \$10 million Center are investigating strategies that could make the transportation sector more environmentally friendly. While city-level climate action plans are widespread, the majority are falling short of their GHG emissions targets.

“We want to know the reason: Why did they fail to come up with actionable plans and policies?” Hamidi says.

The Center’s research can help city officials identify evidence-based approaches to meet their targets. For example, the Center’s 15-minute city project uses AI and anonymized data from millions of U.S. cell phones to better understand where people travel on a daily basis. Policymakers could use those findings to incentivize more commercial areas closer to neighborhoods, or to add public transit options along common driving routes.

“If you really want to switch from driving to environmentally friendly options, you have to give people the option, and most often the option isn’t available,” Hamidi says.

Findings from this research will be published in academic journals and shared in places like the upcoming World Health City Forum. That meeting, which will be held in South Korea in November, focuses on how cities can address challenges like climate change. The emphasis is urgent, says Seydina Fall, MBA, a senior lecturer at Johns Hopkins Carey Business School, who plans to attend the forum.

“Cities have the most impact in changing daily lives,” he says. “We don’t have a choice but to change.”

MAKING CLIMATE-SMART OPTIONS ACCESSIBLE

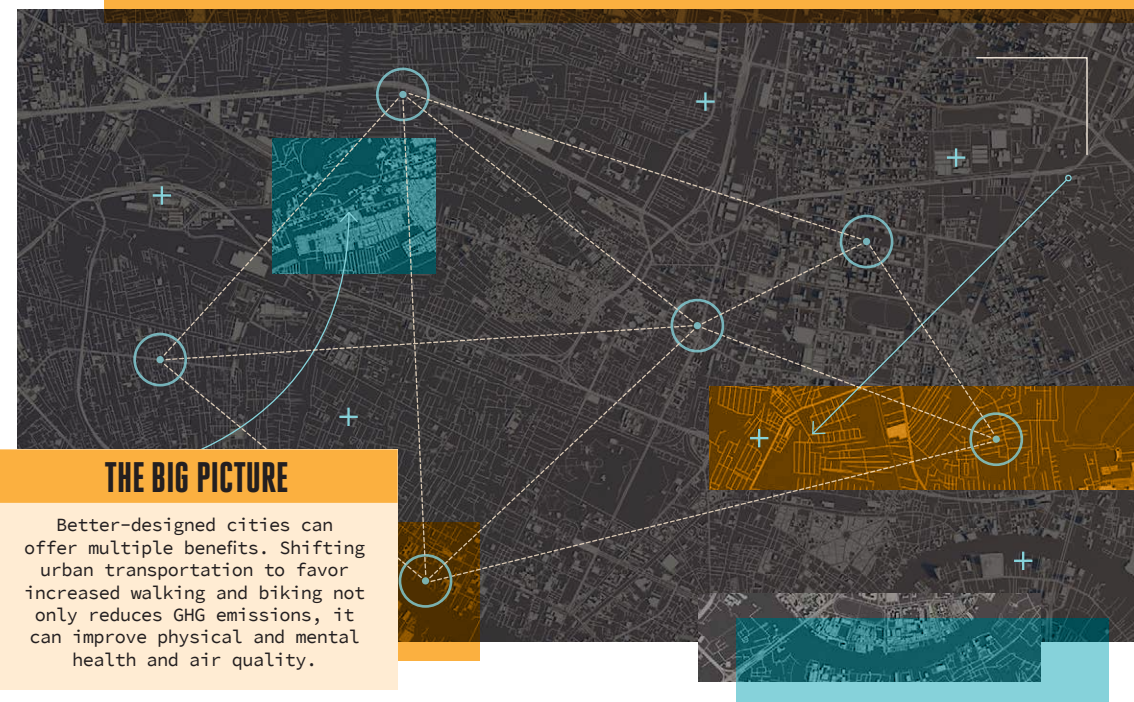
Many of the Center’s projects explore how changes to active transportation options like walking, biking, or public transit might increase adoption.

A striking example is the successful promotion of cycling in Bogotá, Colombia, says Francisca Rojas, PhD, MCP, academic director at the Bloomberg Center for Public Innovation at Hopkins. In Bogotá, the combination of clogged city streets, a temperate climate, and an extensive network of protected bike paths makes biking an appealing alternative to sitting in traffic. Even so, the city faced a gender gap among cyclists. Many women, who are often caregivers of elderly relatives and children, had little time to learn how to ride a bike, encountered cultural norms that discouraged female cycling, and didn’t feel safe on the roads. To change that, the city poured resources into community centers that could offer child care and bike education for women as part of their Care Blocks policy. They also invested in additional infrastructure to make cyclists feel safer.

“Once there are bike lanes and barriers from traffic, women get on bikes,” Rojas says. “If that doesn’t exist, there’s a heightened risk perception for women.”

The changes had a noticeable impact: Of all the trips women made in 2023, nearly 4% were on a bicycle, up from 1.6% in 2011, according to Bogotá’s travel survey.

Physical comfort also influences people’s transportation choices, notes Ales-



THE BIG PICTURE

Better-designed cities can offer multiple benefits. Shifting urban transportation to favor increased walking and biking not only reduces GHG emissions, it can improve physical and mental health and air quality.

sandro Rigolon, PhD, an associate professor of City & Metropolitan Planning at the University of Utah, one of the institutions in the Center.

“Cities are increasingly asking their residents to avoid driving to mitigate climate change,” he says. “But what are cities doing to adapt to climate change and create better conditions for active transportation?”

While there are widespread efforts to make biking safer, there’s less emphasis on making it comfortable to bike or walk in hot weather. So, he’s exploring strategies like planting more trees along common cycling routes or alongside sidewalks where families might walk to school. Shelters or tree shade near transit stops might encourage people to wait for the bus, even on a scorching day.

Morgan State University Professor Celeste Chavis, PhD, MS, also pays attention to the role of convenience through her work with the Center. If environmentally friendly options like public transit also reduce commute times, for example, people are more likely to choose them.

“Everyone understands the link between transportation and climate change,” she says. “But you have to understand the way people feel: How long does it take me to get to work?”

Likewise, when it comes to electric vehicles (EVs), finding a nearby charging station matters. It’s a major issue in cities

like Baltimore, where few rowhomes have dedicated driveways that allow people to easily charge their vehicle.

That prompted Chavis to map the city’s public EV chargers, monitor who is using those chargers, and survey current EV owners about where they charge. The ongoing project will examine whether existing public chargers in city parks and city-owned garages are serving city residents or outside commuters. The decision of where to place additional chargers may also depend on the city’s goals: Is it more important to encourage city residents to buy an EV or get more clean vehicles coming into the city?

TECHNOLOGY OFFERS POTENTIAL

As cities grapple with climate-smart policies and their challenges, technology offers some helpful tools.

At the University of Texas at Austin, another partner institution, Junfeng Jiao, PhD, is studying how a digital transportation model might guide sustainable transportation choices. This technology uses cameras to display traffic and commuter demand patterns in real time to help city planners create transit availability that better fits travelers’ shifting needs, such as adding extra buses during a particularly busy commute time. It could also predict

how events like a major sports game downtown might impact public transit demand or identify if a certain transportation hub needs more shared bikes or scooters.

“Many times, there’s a huge demand for public transit but there’s no train or bus going by,” he says. “If we can better meet demand and supply, we can significantly increase the usage of different transportation modes and reduce carbon dioxide emissions.”

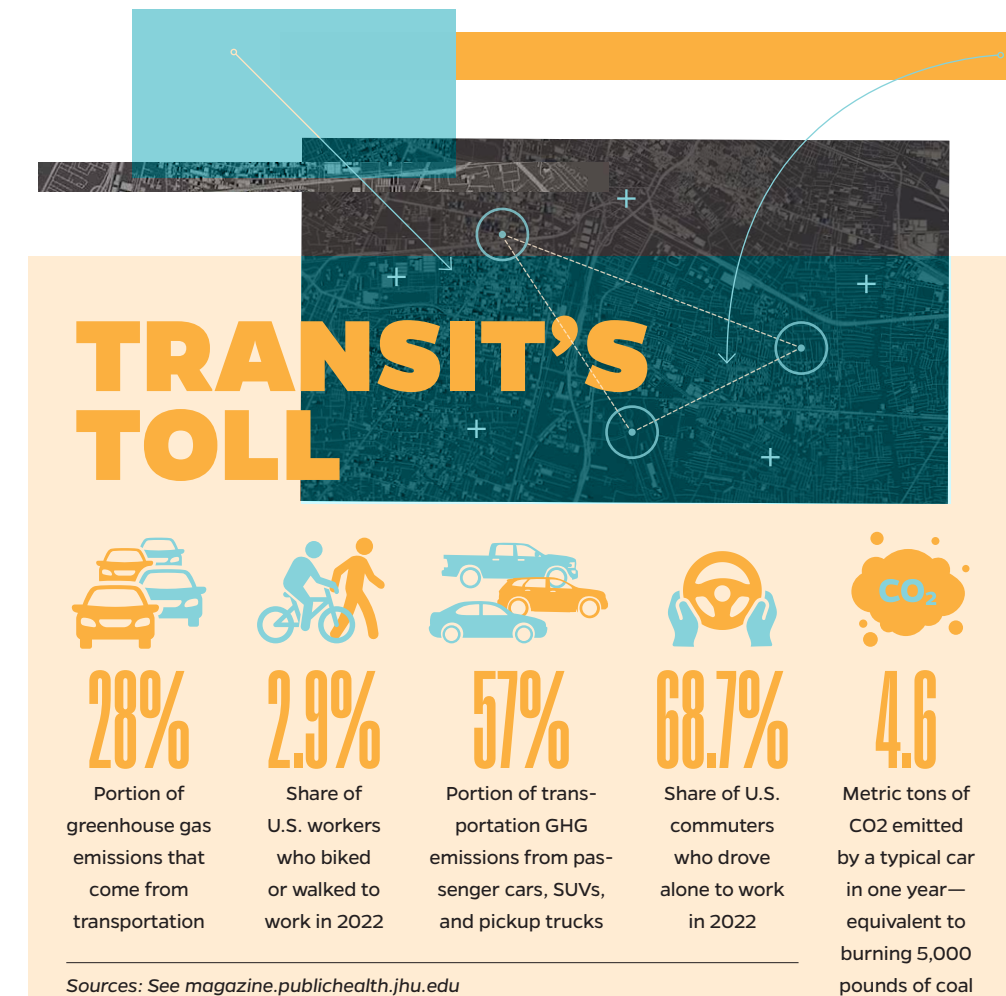
Jiao is also looking into the role of robots in reducing frequent, short consumer drives, such as running out to the grocery or drugstore. The pilot will test robotic delivery of soft drinks and other convenience store items from a central location on the UT campus.

“Smart transportation and smart cities in our country are lagging behind ... Europe or Asian countries,” he says. “I think there is a lot that can be done with our technology and our resources.”

BETTER OPTIONS, BETTER CHOICES

Creating an environment that’s more conducive to active transport helps people make more climate-friendly choices, says Portland planning consultant Ben Schonberger, MCP. From his home, Schonberger can walk to a grocery store, a UPS store, and the elementary school his children attended. He bikes to work, using a route that has safety elements like speed bumps to slow down traffic and flexible posts at intersections that define the bike lane.

“Is it not more fulfilling and enriching to be able to walk your kid to school without being terrified of getting run down, or to have a grocery store within walking and biking distance?” he says. “If you can do more outside, it’s not just good for the planet, it’s good for individuals in terms of their health and happiness and ability to thrive.”



CHARMED

Protesting coal dust and half-burned medical waste, South Baltimore residents lead the way on environmental health research.

BY MELODY SCHREIBER
PHOTOS BY MOLLYE MILLER

Wind-borne coal dust from the Curtis Bay Coal Piers, which can handle 14 million tons of coal annually, has drawn protests from South Baltimore community activists.



VILMA GUTIERREZ IS A SHY, QUIET GIRL. WHEN SHE SPEAKS, OTHERS FIND THEMSELVES MOVING TOWARD HER, TILTING THEIR HEADS TO CATCH THE 17-YEAR-OLD'S GENTLE WORDS.



LEFT: Vilma Gutierrez fights against coal dust in Curtis Bay; MIDDLE: Gutierrez marches in a June protest; RIGHT: "Things always get attention when they explode," says Shashawnda Campbell.



But in June, she finds herself clutching a microphone in front of a crowd outside the Curtis Bay recreation center in South Baltimore, asking the international corporation CSX to stop polluting the area's marginalized and overburdened communities.

Nearby, children clamber onto a circus-colored playground glinting in the sun. A few hundred feet away, trains clank across a dozen crisscrossing tracks, looping around their nucleus: a series of four-story-high heaps of coal. The mountains of Appalachia gutted and reconstituted in South Baltimore.

When the wind lifts the dust in eddying clouds, it looks like ocean waves rolling across the sky, one resident says.

The dust blows from the massive coal piles and from the open cars of screech-

ing trains, and it settles on everything: plastering windows, coating water in children's inflatable pools, and slipping into homes when doors swing open. It's sucked into lungs, sending breathless children to the hospital. Residents have high rates of asthma, lung cancer, heart disease, and chronic lower respiratory disease, and their life expectancy is almost four years less than Baltimore's average.

Yet CSX denies the black substance is coal, arguing instead that it's diesel residue or other pollutants—or even soil or pollen.

The people of South Baltimore are pushing back.

Last summer, Gutierrez volunteered with the community group Free Your Voice, in partnership with Johns Hopkins'

Community Health Addressing Regional Maryland Environmental Determinants of Disease (CHARMED) Center and the University of Maryland, to understand what the dust really was.

CHARMED asserts that people are experts on their communities. They know, for instance, that air pollution might be lower on one street than another because of traffic patterns, and they can help researchers create better models and experiments based on this knowledge.

"Our role is helping the communities obtain scientific evidence and then advocating with them for some kind of action to be taken on a policy level," says Marsha Wills-Karp, PhD, MS, director of CHARMED and chair of Environmental Health and Engineering.

What Gutierrez and other volunteers did was disarmingly simple: They installed sticky strips of white poster tape and special carbon tape on residential buildings in the Curtis Bay, Lakeland, Brooklyn, and Mount Winans neighborhoods. For a month, the rough black dust accumulated on the strips; sometimes, it appeared on the strips within seconds.

CHARMED scientists used electron microscopy to confirm what members of the community knew all along: It was coal.

"We do have scientific evidence that it was detectable and we want to stop this—we want to stop it now," Gutierrez says at the protest.

"People like me, we don't have a big voice. We just don't have the power," Guti-

ierrez says, haltingly at first, but then her words start to gain momentum. "People don't really listen to people who come from low poverty. We are fighting against a lot of people who do have a lot of money, who do have a lot of connections. We are still always trying to fight back."

'WE'RE NOT LYING. YOU CANNOT GET OUT OF THIS.'

The Port of Baltimore is the second-largest export hub of coal in the nation, and shipments of sought-after Appalachian coal are soaring. When an explosion rocked Curtis Bay in 2021, all eyes turned toward the coal terminal.

"Things always get attention when they explode," says Shashawnda Campbell, director of environmental justice at the South Baltimore Community Land Trust.

Residents learned the explosion was caused by a buildup of methane in the coal piles. But no one came out to tell the community what was going on, Campbell says. They had to start asking questions, and once they started, they didn't stop. Why was all that coal piled up, uncovered, like that? Why was it allowed to blow over the homes and into the lungs of residents? How could they prove the negative effects it was having on their health?

"We know what the questions are, but we don't know how to actually do this research," Campbell says.

The faculty working at CHARMED had been involved in research in South Baltimore since 2013 or so, and community members approached them after the explosion. The community and the scientists developed several research questions about the coal terminal: Was it indeed coal dust blowing into the communities? How quickly was it accumulating? And did it create health and environmental burdens? In addition to the sticky strips, they also installed air quality monitors near the fence line of the facility. Their research indicated the coal dust was pervasive. "It basically went throughout the South Baltimore community," Campbell says.

The research with CHARMED wasn't just some "weird feel-good project," she says. "This was a real project that actually yielded these different evidence sources. ... We've been able to open doors we hadn't been able to get into for a while with this research." CSX and local leaders aren't just hearing anecdotes from residents. "There is research behind us. We're not lying. You cannot get out of this," she says. "Once you know something, you have to do something about it. If you don't do something about it, you're saying you do not care."

CSX uses water sprayers to try to keep some of the dust in place when the wind picks up, but residents haven't observed a difference. They're asking CSX to cover the terminal and the trains.

“They also ship it on open train cars, so it’s blowing all the way across the country, too,” Wills-Karp says. “They’re a \$30 billion company; you’d think they could spare a little bit of money to contain that coal. That’s all we’re asking at this point: Just don’t let it blow all over the community.”

ANOTHER KIND OF POLLUTION

When residents of Mount Winans heard about the community research partnership, they wanted in. The trains carrying coal rumble only a few feet from some of their houses, and the coal dust spreads into their community as well.

And they had more ideas for the researchers. They weren’t concerned only about air pollution. In fact, their biggest concern is the noise pollution from trains constantly roaring past their homes, idling and revving for hours in the middle of the night, and sounding ear-splitting horns.

“Can you imagine having a train going 25 feet from your house in the middle of the night?” asks EHE Professor Gurumurthy “Ram” Ramachandran, deputy director of CHARMED. That would be loud enough, he says, but train operators are mandated to sound their horns three times when they begin moving forward, “and train horns are incredibly loud.” Sleep duration and quality have major effects on cardiovascular health and cognition. The researchers are now setting up a project to measure noise and air pollution.

Because of the community leadership, researchers are now examining more nuanced scientific questions. “There is never just one issue that needs to be addressed, which is how scientific research traditionally got done. This is a much more complicated issue—and that’s how the science gets improved,” says Ramachandran, PhD, MS. “We got many perspectives that we had missed looking at it from the outside. I wish more science was done this way.”

“We’re not always, as physicians or researchers, exactly spot-on with what we think to be important,” says Nirupama Putcha, MD, MHS ’12, a pulmonary physician in the Johns Hopkins

HEALTH IN CURTIS BAY

69.7 YEARS

Life expectancy for residents of Curtis Bay, compared to 73.6 years for the rest of Baltimore

25%

Increased mortality rate in Curtis Bay compared to the rest of Baltimore

6.1%

Share of deaths in Curtis Bay caused by chronic lower respiratory disease, compared to 3.5% in the rest of Baltimore

>2X

More people hospitalized for asthma in Curtis Bay in 2011 than the state average

Sources: See magazine, publichealth.jhu.edu

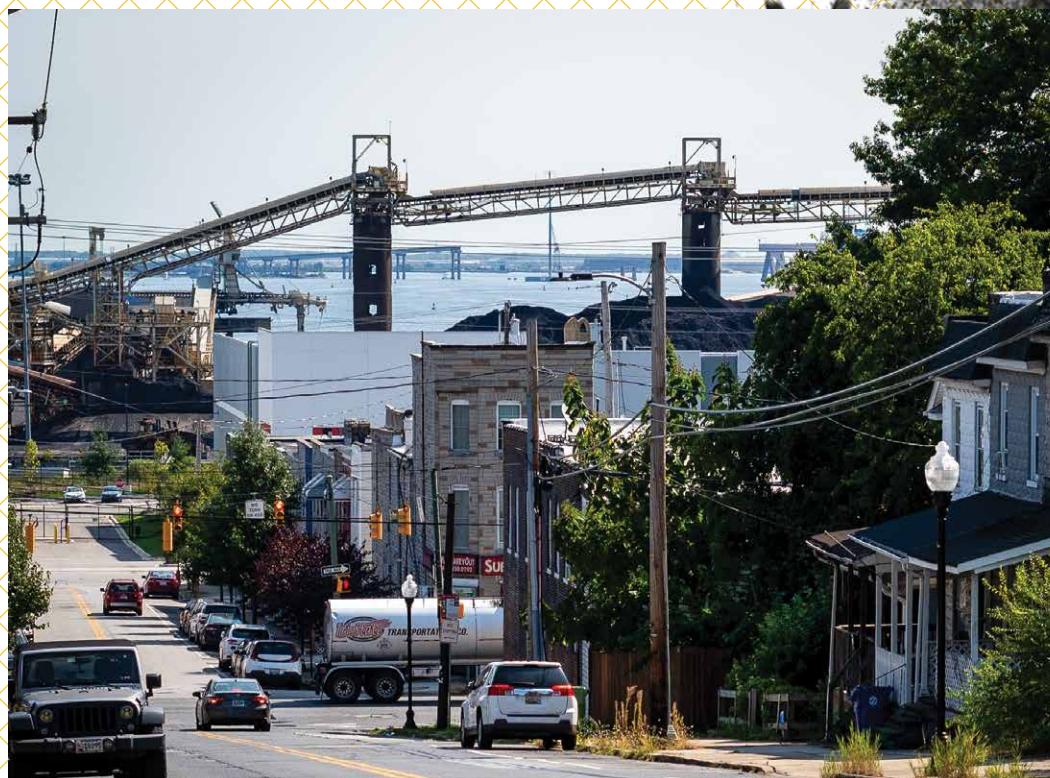
School of Medicine working to design these studies. “We may not really fully understand or recognize what a community is experiencing, and we really need those concerns to come primarily from a community.”

Communities in and around Baltimore have been disproportionately affected by adverse environmental issues like pollution, and the placement of industry within these neighborhoods further marginalizes the communities, says Ana Rule, PhD ’05, MHS ’98, assistant professor in EHE. Residents in these communities have worked for decades to understand how pollutants are affecting their health. “They know they’re exposed, they know this is a bad situation,” Rule says. Often, a few members of the community try to do as much research as they can, keeping everyone else informed and sharing resources. “So, they were really open to us coming in to help. It was like, ‘Oh, yes, we’ve been trying to learn about what the exposures are in our community.’”

And community members want to know how the results will help them. “That’s the goal of this type of research, to push academics to think more pragmatically,” Putcha says. “You’re getting pushed to really try to use the information you’re getting and be efficient about it. If you’re asking the communities for the privilege of gathering that information, you better use it, right?”

Citizen science is the only way they could accomplish as much as they have, Rule says, but more people—volunteers or paid workers—would be a huge help to take measurements, or to check on monitors, recalibrate them, and send them for repairs as needed. “We don’t have the number of hands and time in the day to do all the things that need to be done,” she says.

Frequently, the studies are done with relatively low-cost technologies. In Mount Winans, the researchers installed apps on residents’ cell phones to track noise variability, and they’ve also looked into noise detectors—the kind of devices used by people who manage properties, like Airbnb rentals, to see if tenants are having parties. “A lot of my research is: Can we use some of these lower-tech-



LEFT: Curtis Bay Coal Piers infrastructure looms over the community; CHARMED director Marsha Wills-Karp works with community advocates to amass scientific evidence.

nology solutions, accept their limitations, but also be able to take advantage of them?” says Kirsten Koehler, PhD, MS, professor in EHE and lead of CHARMED’s exposure characterization and modeling core.

17 HOURS OF HAZARDOUS SMOKE

But evidence of wrongdoing doesn’t mean problems will be fixed—at least, not immediately.

Less than five miles from the coal terminal, a medical waste incinerator puffs a cloud of smoke. The emissions are supposed to be white steam; dark smoke means the waste has not been fully incinerated and could pose health risks to anyone who breathes in the soot. “It’s medical waste, which means potentially it could contain harmful organisms,” says Ramachandran.

Yet the incinerator frequently emits a dark cloud, and sometimes debris floats down to the neighborhoods, scattering all over the ground.

Curtis Bay Energy, the incinerator’s operator, was criminally charged by the Attorney General of Maryland for not fully burning the potentially infectious trash, and the company pleaded guilty in October 2023. They were fined \$1.75 million. “It was just spewing all over the place. It’s pretty egregious,” says Wills-Karp.

But in early 2024, residents took researchers and EHE students on a “toxic tour” of Curtis Bay, and they pointed out the dark cloud billowing from the smokestacks. They asked CHARMED if they could gather proof that the incinerator was still violating regulations.

The community and CHARMED researchers set up video cameras to watch the incinerator for two weeks in February and March 2024. During that time, thick black smoke emerged from the stacks 27 times, for an average of 40 minutes each—a total of 17 hours of hazardous violations. Residents continued seeing the smoke after the cameras came down.

They believe the operators, in a bid to save money, turn the temperature down

on the incinerator. This would mean it doesn’t properly incinerate everything. “They know that’s not legal,” Wills-Karp says. “Even the attorney general knew this was just not acceptable. But they haven’t followed up on making them comply, and that’s why the community is so upset. ... We just want them to contain it so they’re not exposing people.”

Hopkins researchers shared their findings with the Maryland Department of the Environment (MDE) and presented the results at a city council meeting in March. Maryland is now seeking to impose additional fines on the incineration company.

The Curtis Bay incinerator, the largest medical-waste incinerator in the country, has the capacity to dispose of one-third of all medical waste in the U.S. The majority of the waste comes from outside of Maryland,

“We are fighting against a lot of people who do have a lot of money, who do have a lot of connections. We are still always trying to fight back.”

THE BIG PICTURE

Curtis Bay's coal problem is repeated and magnified across many countries. Global coal usage is the biggest energy source of CO2 emissions and a major cause of climate change and air pollution.



Railroad tracks encircle the Curtis Bay coal terminal, bringing coal cars to be unloaded. The community has asked CSX to cover the trains and the terminal to reduce coal dust.

including from Canada. But two local hospital systems contributed waste: MedStar and Johns Hopkins. While Johns Hopkins ended its agreement with the incinerator, MedStar did not.

When a company is found to be involved with environmental hazards like these, they may hesitate to admit wrongdoing, Wills-Karp says. But “the community already knows you put stuff there. So now you need to say, what can you do to be part of the solution?”

'THE SAME AIR WE ALL BREATHE'

After collecting and analyzing the dust in Curtis Bay, CHARMED, with the University of Maryland and MDE, released a report in December 2023 confirming the substance is coal dust and concluding that Curtis Bay and other neighborhoods bear a disproportionate burden of pollution. The authors pointed out that there are no safe levels of fine particulate matter like coal dust, according to the WHO and the U.S. EPA.

But instead of taking action, CSX challenged the state-backed findings. The company said in a statement that there's no evidence the coal dust is present in the community or that it has a significant effect on air quality, and said the research “relied on flawed approaches to draw unfounded conclusions.”

For U.S. Rep. Kweisi Mfume, the former NAACP president and CEO who has represented Curtis Bay since 2022, that was the hardest part to believe. “To discredit the studies that have been done, and by rep-

utable organizations, that's what I find so amazing,” he says.

“Coal dust has to be significantly reduced, if not eliminated, so that persons living in these communities can continue to breathe,” says Mfume. “I'm going to do everything that I can to represent their concerns here and to fight like hell to make sure that the federal government finds a way to protect individuals, their environment and, quite frankly, their life and their lifestyles by doing what's right.”

Mfume also wants to establish a federal standard for covering coal cars, which he compared to regulations on indoor smoking and auto emissions that have been proven to harm health.

On August 29, Maryland released a draft permit for two weeks of public comment. The permit would require CSX to construct a physical barrier around the coal heaped up at the terminal, but not a covering from above. The permit would also require CSX to spray water on the coal cars when they enter the facility.

Mfume says it doesn't go far enough. “CSX believes that they can construct a wall barrier that would prevent the problem that we have right now, and that was never requested,” he said. Instead, the community has asked for the company to cover the coal piles and the train cars.

Campbell, the community organizer, wants CSX to be fined for every day that it releases coal dust into nearby neighborhoods. “This is not a one-off event, like the explosion that happened,” she says, for which the company was fined. It's “a continuous event that they should constantly be paying for.” In September, for

instance, MDE issued a notice of violation after residents observed a cloud of dust generated along the railroad tracks near the terminal.

For Campbell, the fight isn't just about coal dust or noise levels or medical waste. It's existential.

There used to be three communities not far from Curtis Bay—Fairfield, Wagner's Point, and Hawkins Point—with long-standing traditions of fishing, harvesting pears from trees, and going to church together. When more industry moved in over the past few decades, the residents fought back. “People said no. People risked their lives,” Campbell says. But eventually, all of the residents had to leave; the last house was torn down in 2017. Now the region is entirely industrial—including a hazardous waste landfill, chemical manufacturers, and a Superfund site.

“If you go down there, you would never imagine that there was a pear tree, ever,” Campbell says—much less a vibrant community. She doesn't want Curtis Bay or Mount Winans or Brooklyn or Lakeland or anywhere else to have the same fate.

“It's affecting all of us. Even if you don't directly live in Curtis Bay,” Campbell says at the protest. “No matter where you live, the air is going to flow. You're breathing in the same air we're all breathing in. This is your fight just as much as it's ours.”

She is fighting corporate pollution, yes, but really she is fighting for the right to breathe. The right to live.

As Gutierrez, Campbell, and others march through the streets of Curtis Bay in June, holding giant drawings of blackened lungs and chanting “Shut it down,” people come out of their houses to watch. Most stay on their porches, watching the protest sweep by like a parade, but some begin trailing behind the protesters.

One woman standing on her porch spots a neighbor joining the march. “What are you doing?” she yells, her tone teasing.

Her friend grins back, a little embarrassed, but more defiant. “I'm marching! I want that coal factory gone!”

The woman shrugs. “It's been here forever.”

Her friend nods, but she keeps walking. She says: “It's only a matter of time.”

CHARMED ORIGINS

CHARMED was founded three years ago, one of 25 centers funded by the National Institute of Environmental Health Sciences. It is interdisciplinary, drawing from the Johns Hopkins schools of Public Health, Engineering, and Medicine, and collaborating with the University of Maryland and agencies like the Maryland Department of the Environment.

The scientists work with communities in Maryland, southeastern Pennsylvania, and parts of Virginia and North Carolina, focusing on how environmental issues—air, water, soil, and noise pollution; industrial farming; oil and natural gas; transportation and shipping—affect health.

At every step, scientists and community members work together, holding community meetings to identify the most pressing problems, conducting studies, and taking the results to decision-makers and leaders. —MS

THE MICROPLASTICS SCOURGE

BY BRIAN W. SIMPSON

Trillions of tiny plastic fragments have dispersed throughout the Earth—and most human bodies. It's one example of how humans have disrupted natural systems with devastating consequences.

2 TYPES OF MICROPLASTICS

Primary microplastics include cosmetic microbeads, abrasive cleaners, and nurdles (tiny plastic pellets that measure less than 5 mm). Nurdles are melted down to create plastic products such as textiles, air fresheners, paints, etc.

Secondary microplastics are fragments worn down from larger plastic products, like food containers, fishing nets, adhesives, artificial turf, etc.

ORIGIN STORY

In 1950, 2.3 million tons of plastic were produced. By 2022, that had soared to 600 million tons.

Nearly all plastics are made today from fossil fuels.

3 UBIQUITOUS THREAT

Microplastics are approaching ubiquity in global ecosystems and can be found in arctic deep-sea sediments, the air above Dongguan, China, and the snow on Mount Everest.

Animals that ingest microplastics can pass these particles through the food chain to humans. More than two-thirds of marine mammals in a 2023 study had microplastics in their fats and lungs.

5 IMPACT ON HUMAN HEALTH

The effects on human health are still being determined, though early studies are cause for concern. Example: A March 2024 study found that microplastics in the carotid plaque of heart disease patients increased the risk of heart attack, stroke, or death by 4.5 times over a three-year period.

4 IN PEOPLE

Microplastics have found their way into humans via drinking water, sugar, honey, rice, milk, fruits and vegetables, mussels, table salt, air, etc.

Each American ingests an estimated 39,000–52,000 microplastic particles per year, per a 2019 meta-analysis of 26 studies.

Microplastics have been found in human breast milk, placentas, testicles, hearts, livers, kidneys, lungs, and colons.

SOLUTIONS

Solutions begin with the obvious—produce less plastic. Alternatives to current plastics include new bio-based materials that degrade in months rather than centuries, and zero-waste strategies that emphasize product reuse. ○

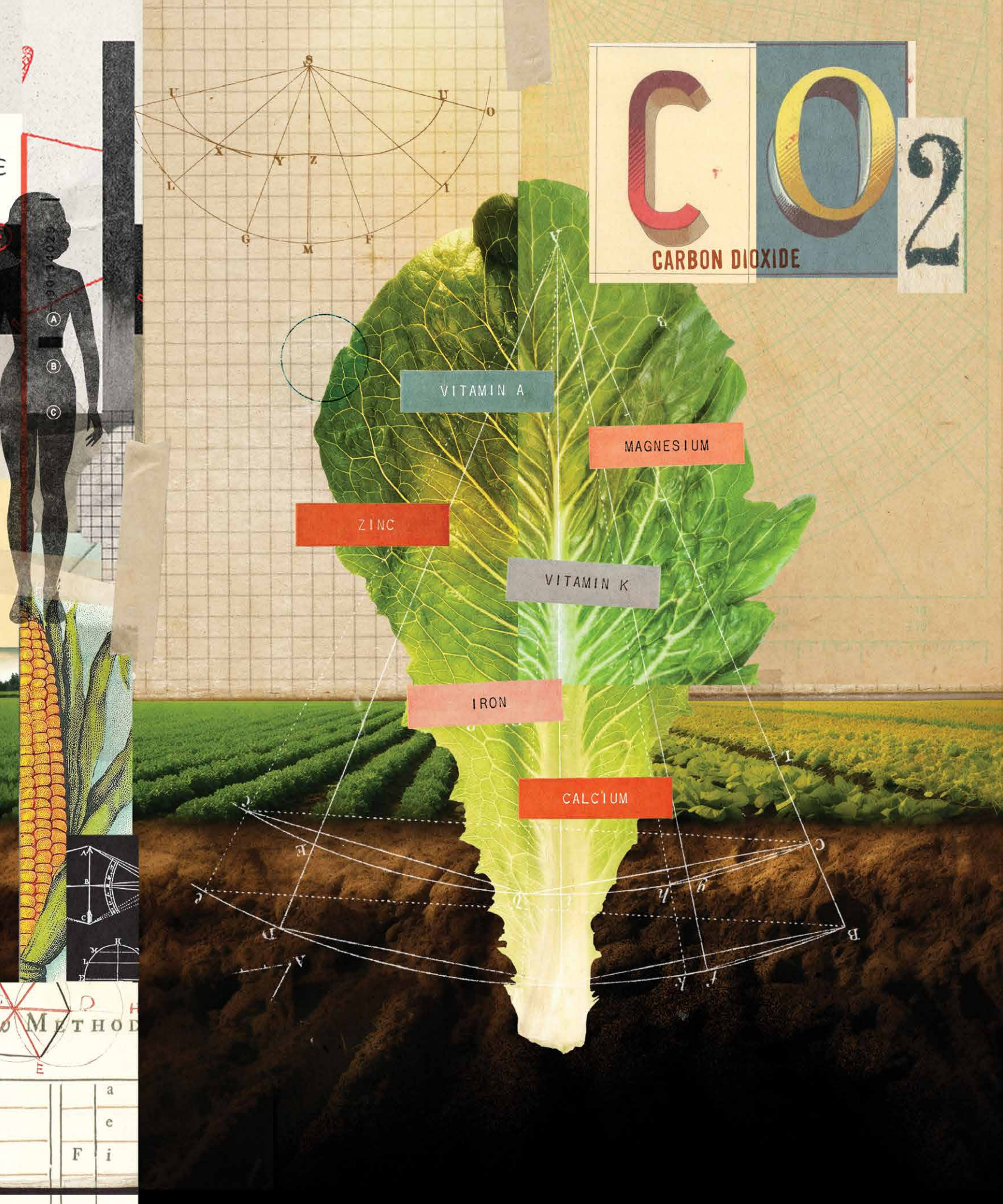
Editor's note: Microplastics and other objects not to scale. Sources: See magazine.publichealth.jhu.edu

SPECIAL ISSUE | OUR PLANET, OUR HEALTH

REMOTE SENSOR

Pinpointing the sources of carbon dioxide and methane emissions is an important step toward eliminating such threats. The Carbon Mapper Coalition's Tanager-1 satellite, which was launched in August, is the first of an expected web of satellites that will surveil the Earth for "super emitters" like oil and gas wells, landfills, etc.





CRUISE HARVEST

Rising carbon levels are eroding nutritional values of staple crops, threatening millions with hidden hunger.

BY KELLIE SCHMITT
ILLUSTRATIONS BY DUNG HOANG

FROM HIS 10-ACRE PROPERTY in southern Mississippi, farmer Timothy Robb knows that invisible nutrients matter—for the health of plants and the humans who consume them.

The right balance of vitamins and minerals will make the salad greens he supplies to New Orleans restaurants darker in color and chock full of nourishment. If the proportions are out of balance, though, the plants may suffer in both nutrition and appearance. Take, for example, potassium deficits. ●

“You’ll see it on a head of lettuce,” Robb says. “The outer leaves on the lowest part of the tip will burn. There’s a black, brown, or wilting effect along the leaf margin.”

Robb can sprinkle chicken manure and study soil composition in the hopes of righting the ratios. But there’s another disrupting force he and other farmers can’t control: rising atmospheric carbon levels.

Scientists investigating the impact of increasing carbon dioxide on global staple foods like rice and wheat have made some concerning findings: Higher CO2 levels make many foods less nutritious, reducing protein, vitamins, and critical micronutrients like zinc and iron.

Micronutrient deficiency, or “hidden hunger,” is already a pervasive problem globally as a result of poor and restricted diets. A lack of crucial vitamins and minerals can affect humans in a number of ways, from increasing child and maternal mortality to impairing growth and development. More than 2 billion people worldwide currently face micronutrient deficiencies, including more than half of preschool children and about two-thirds of non-pregnant women of reproductive age, research has estimated. Declines in

crop nutrients as a result of rising CO2 could exacerbate these threats to human health, especially for children and pregnant people in low-income countries.

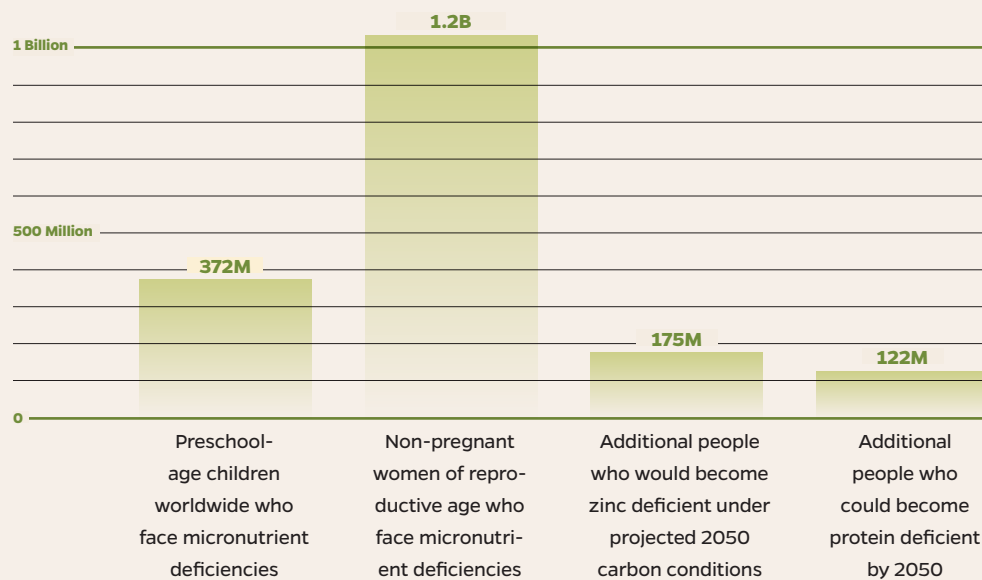
“It’s a really strong example of planetary health: Something that we’re doing to the environment is impacting health,” explains Samuel Myers, MD, MPH director of the Johns Hopkins Institute for Planetary Health and a professor in Environmental Health and Engineering. “As we change these complex systems, we’re seeing unintended consequences and unanticipated results.”

AS PEOPLE HAVE BURNED FOSSIL FUELS FOR energy, Earth’s CO2 levels have risen steadily. Today, atmospheric CO2 is about 50% higher than pre-industrial levels, according to NOAA. Scientific research and news accounts often focus on the most visible effects of those increasing levels, says Lewis Ziska, PhD, MS, an associate professor of environmental studies at Columbia Mailman School of Public Health.

“A lot of attention is placed on ‘biblical outcomes’—sea level rise, to superstorms, to the end of the world as we know it,” he says. “I come at it from a botanical lens.”

MORE CARBON, MORE DEFICIENT

How increased CO2 impacts nutrition in populations across the globe



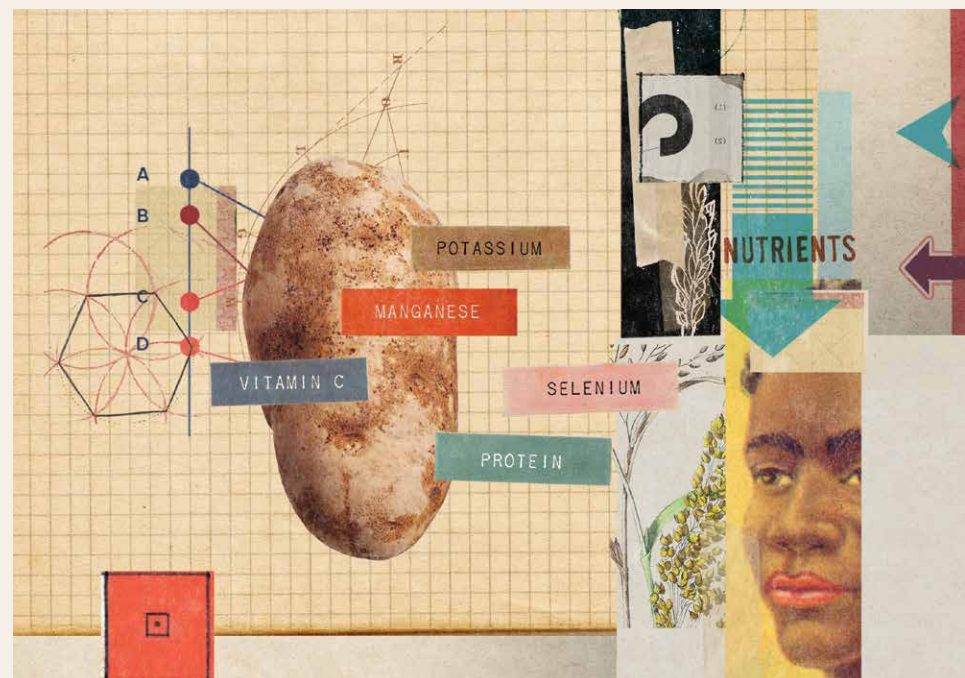
From that perspective, Ziska and fellow researchers have investigated the impact of additional carbon on plants’ chemical components and the potential human health consequences. While atmospheric carbon can fuel plant growth, the effects of the additional carbon are more complex than just bigger plants. Crops grown under higher-carbon conditions increase the synthesis of sugars and starches while decreasing the concentrations of protein and nutrients. These findings are evident in global staple foods including rice, wheat, potatoes, and barley. (A much smaller percentage of plants like corn and sugarcane use carbon differently and haven’t demonstrated the same changes.)

The amount of nutrient decline varies by experiment and plant, and most experiments double the current CO2 levels. A 2018 review of 50 articles published in *Frontiers in Plant Science* found that when carbon levels rise, protein levels drop by nearly 10%, iron by 16%, zinc by about 9%, and magnesium by about 9%.

The precise mechanisms fueling the decline are still a mystery but likely have roots in the imbalance created by additional CO2, which the plant takes from the air and uses in photosynthesis. As plants pull water from the soil, they bring along nutrients like iron and manganese which help the plant grow. Adding more CO2 shifts the proportions, much like adding more of just one ingredient to a recipe.

“We’re seeing this imbalance in elements that make up plant growth, and the plant is adapting to that,” Ziska says.

Initially, scientists conducted the research in greenhouses and growth chambers with small sample sizes, says Myers. That led to some doubts as to whether the findings simply stemmed from the artificial growing conditions. To address those concerns, Myers led research combining 41 selectively cultivated varieties of six staple food crops grown across seven different locations on three continents over 10 years. These experiments were performed in open field conditions in which a ring of jets pumped out CO2 while sensors ensured that consistent concentrations would settle over the field. They mimicked the level of CO2 the planet will likely face in the next 30 to 80 years.



“It is a very specific way to reproduce real-world growing conditions, where identical cultivars experience the same soil, weather, pests, and pathogens, but differ only with respect to the CO2 concentration,” Myers says.

ONCE THE STUDIES DEMONSTRATED THE WIDESPREAD plant nutrient decline, scientists investigated the implications.

“From a human health standpoint, there was a big ‘so what?’ question,” Myers says. “What does that mean for our risk of nutrient deficiency, and what are the health impacts going to be?”

Those were tricky questions to answer. For example, how could they gauge how much zinc a 6-year-old girl in Mali gets from her regular diet, and how these declines would impact her total zinc intake and individual health? Myers and colleagues constructed a global database to estimate, for the populations of 152 countries, the per capita intake of dietary nutrients by age and sex for more than 200 different foods.

While all nutrients matter, protein and zinc are particularly vital for human health. Zinc deficiency impacts the immune system, which could make someone more vulnerable to malaria or diarrheal diseases. Insufficient protein can increase infant mortality and lead to stunted growth and development. The changes will disproportionately

impact people who are already at the highest risk for nutrient deficiency in the world’s poorest regions, places like South and Southeast Asia, Africa, and parts of the Middle East.

The impact of rising CO2 on food nutrient levels could exacerbate health inequities globally, says Saskia de Pee, PhD, the World Food Programme’s (WFP) senior nutrition adviser.

“In countries with the least diverse and least quality diets, this will further deepen the gap,” she says.

RESEARCHERS INVOLVED IN THE EXPERIMENTS point to reducing CO2 emissions as the best strategy for addressing the predicted nutrient declines later in the century. Barring that, one way to address declining nutrient levels could be fortification, de Pee says. Much like how iodine is added to salt or B vitamins to bread flour, nutrients can be added to rice. India recently piloted a program to fortify rice as part of a broader effort to improve nutrition. They distributed the rice, which was fortified with vitamins and minerals like iron and zinc, to people participating in food assistance programs. The pilot was deemed so successful that India began a rollout throughout the country in 2023, according to the WFP.

Other strategies may include sprinkling micronutrient-rich powder over a

meal, an approach often used to fortify foods for young children, or selecting different crops to plant. Since the additional CO2 doesn’t impact all plants equally, farmers could plant varieties that may be less susceptible to the changes.

As public health experts grapple with solutions, additional research is exploring even more puzzling consequences of increased carbon on plants.

For one, increased carbon doesn’t seem to impact all vitamins and minerals equally. Even though vitamin B12 levels in rice drop significantly, vitamin E levels rise. Another emerging area of research will investigate whether the shifting balances could increase toxins such as arsenic in rice, or the potency of poisonous plants like nightshades. What is the effect on pollinators if the plants they visit have less protein? From a pharmacology perspective, the changes could alter the efficacy of medicinal plants like *Artemisia annua*, or sweet wormwood, which is used as an antimalarial.

“Not everyone goes to the corner Walgreens to get their prescriptions,” Ziska says. “Over a billion people rely on plant-based sources of medicine.”

At University of Washington, Global Health Professor Kristie Ebi, PhD, who worked on a paper relating to the rice field studies in China and Japan, is curious about the health implications of consuming more carbohydrates in plant-based foods because of rising CO2 concentrations. If the relationship between declining micronutrients and rising carbon is linear, that may mean our food today is already less nutritious than what our grandparents ate.

“The question is whether this mechanism is feeding into the obesity crisis if people are eating more carbohydrates and less of other types of nutrients,” she says. “No one knows.”

Back in Mississippi, Robb says he wants to learn more about what this all means for the rows of baby arugula, lettuce, kale, and mustard he’s cultivating.

“For me, and people who do small-scale agriculture, what inspires us is healthy, nutrient-dense food,” he says. “It’s alarming to hear that atmospheric carbon can have this effect.”



FEELING THE EXTREME HEAT

In New Orleans' urban heat islands, too few green spaces, poverty, and inadequate cooling options make residents vulnerable to heat's health risks.

BY MELBA NEWSOME

August greeted New Orleans with a spate of extreme heat alerts warning of successive days of brutal heat with a triple-digit heat index and little relief even after sundown. The city's heat problem is both chronic and multifaceted, says Julia Kumari Drapkin, founder and CEO of ISeeChange—an online platform for climate data and weather tracking.

"We're one of the oldest cities in America with homes that were designed before air conditioning. Many [homes] have been storm-battered, and our low- to moderate-income homeowners are really having a hard time maintaining their homes with such extreme costs and stresses," she says. "One out of every three people in the South cannot afford their utility bills." Some residents report seeing their energy bills double or even triple during the summer months.

Many of the New Orleanians who logged their experiences on ISeeChange this summer wrote of high energy bills and inside temperatures as high as 89°F, even with the air conditioner running nonstop.

In the summer of 2023, Bloomberg School epidemiologist Jaime Madrigano, ScD, MPH, partnered with ISeeChange on a five-year, NIH-funded project designed to estimate the health burden of heat in New Orleans. It aims to identify individual and neighborhood characteristics, as well as behavior patterns, that increase vulnerability to heat, particularly for people who can't afford to adequately cool their homes.

"The home environment can actually be a substantial risk in and of itself," says Madrigano, associate professor in Environmental Health and Engineering, who researches environmental and climate-related stressors with the goal of informing equitable health policies. "We know that people are often dying right in their homes. If you're financially constrained or on a fixed income, you're that much more subject to these kinds of weather and climate stressors."

Madrigano and her research team combined information gathered over two weeks from temperature and humidity sensors in the bedrooms of 70 mostly Black residents of the city's Upper Ninth Ward. This summer they collected data from residents of the Hollygrove and Hollygrove-Dixon neighborhoods. Additional data from the Louisiana Department of Health will help to provide a picture of the most impacted communities, based on heat-related hospitalizations, and the greatest contributing factors to those hospitalizations.

photo PEETERV // GETTY IMAGES

A preliminary analysis of the Upper Ninth Ward data showed that indoor temperatures averaged 80°F but approached 90°F at certain times in a quarter of the homes sampled, because either air conditioning units couldn't keep up or residents, worried about electric bills, didn't run the units enough to keep their homes at safe temperatures. The granular data gathered over a two-week period will supplement climate and satellite data.

The consequences of extreme heat go well beyond financial stress and physical discomfort. Extreme heat is the most deadly of all weather-related events, and is associated with mental health issues, heat strokes, dehydration, and myriad cardiovascular, kidney, and respiratory disorders. Societal impacts include increased violence, declines in worker productivity, and poor school performance.

Extreme heat poses an unequal burden for certain racial and income groups, according to a 2021 study published in *Nature*. People of color and those living below the poverty line are more likely to live in urban heat islands like much of New Orleans' Upper Ninth Ward. There, impervious surfaces, pollution, traffic, and sparse greenery can increase temperatures by at least 8° compared to greener, less developed areas.

During her time as a postdoctoral research fellow at Columbia University and before joining the Bloomberg School in 2022, Madrigano found solid proof of the dangers of extreme heat for vulnerable populations. She collaborated with the New York City Department of Health and Mental Hygiene and the Mayor's Office on a two-year study to better understand the most extreme impact of extreme heat on the city's population.

"I looked at who was dying during heat waves," she says. "We found that people that lived in poor neighborhoods and in neighborhoods that had less trees, Black New Yorkers, are more likely to die during heat waves. The results were not shocking, but it was good evidence there were great inequalities."

Madrigano's findings had the desired impact of influencing city policy. Following the 2015 publication of the study, the city used the heat map she created to guide the

photo ARGONNE NATIONAL LABORATORY // FLICKR

implementation of its \$100 million Cool Neighborhoods NYC heat resiliency initiative. The plan included over 500 cooling centers, increased the city's tree canopy, developed climate-risk training programs, and installed more cool roofs in the most heat-vulnerable communities.

Similarly, the city of New Orleans has several efforts underway to increase climate resilience. In January, the work of ISeeChange and other advocates contributed to the city's introduction of the Healthy Homes ordinance which requires rental property owners to provide cooling systems capable of maintaining a maximum bedroom temperature of 80°F to three feet above the floor. Madrigano hopes that the results of her study will prove useful to policymakers looking to update this ordinance or consider other adaptive measures to protect the public's health during extreme heat events.

As more data about the health impacts of extreme heat and who is most affected by it become available, Madrigano hopes that researchers, environmentalists, and government officials will increasingly view extreme heat as an environmental justice issue in need of targeted, equitable solutions—particularly when it comes to protecting vulnerable people in their homes.

"Residents who can't afford to stay cool at home are left with few options to protect themselves from dangerous temperatures," Madrigano says. "That's why it's so important to ensure people can stay safe at home. During an extreme heat event, it can be a matter of life and death." ◉



OPPOSITE: The summer sun sets over the skyline in New Orleans. BELOW: Cool roofs deflect the sun's heat, keeping buildings cooler to increase energy efficiency and make indoor climates more comfortable.

~1,500

Annual heat-related deaths in the U.S.

10°

The temperature variability in urban microclimates between coolest and warmest sites at the same time

6,700

Number of premature deaths caused by urban heat islands in 93 European cities in summer 2015

Sources: See magazine. publichealth.jhu.edu

THE BIG PICTURE

Extreme heat threatens anyone in an urban heat island who's living in substandard housing and lacking proper cooling. Groups considered at highest risk include older adults, people with disabilities or chronic conditions, and children.

PLANETARY HEALTH'S FRONT LINES

How humans navigate a world out of balance.

Manufacturing, agriculture, transport, and other sectors of the global economy consume natural resources on an immense scale. Individuals, however, are left to endure consequences like heat poverty, saltwater intrusion of water sources, pollution, and extreme weather events. The following four reports, originally published by *Global Health NOW*, share human insights from India, Kenya, Bangladesh, and the U.S. ♦

Extreme heat created by climate change disproportionately impacts poor communities in India.

HEAT POVERTY GROWS IN INDIA

BY CHEENA KAPOOR

SITTING ON THE CONCRETE FLOOR IN HER AIR-CONDITIONED one-room house in a densely populated west Delhi slum, Maya Devi worries about her husband and children who have to step out every day in the scorching heat to go to work or school.

Devi works as a maid for a middle-class family and earns \$50 per month, bringing the family's monthly income to about \$120. After enduring several summers of extreme heat, she borrowed \$215 from her son's employer last year to buy a secondhand air conditioner. She wanted to avoid another round of annual heat-related nausea, headaches, and dehydration among her children.

"Some nights, we would all stay awake because the heat was unbearable, and humidity from the small water-run cooler would make it difficult to breathe," Devi explains. "My three sons missed school [or] work several times after falling ill due to the heat, thus losing several days' worth of daily wages. That's why we decided to take a loan."

The employer now deducts \$15 per month from her son's already low salary, pushing the family more into debt.

Devi's husband, Om Prakash, returns home from his rickshaw work in peak afternoons to rest in his air-conditioned room. However, to avoid further debt in electricity bills, he only runs the air conditioner for a half hour during the day and about an hour at night.

Of the 800-odd shanties in the slum, Prakash estimates that 150 now have air conditioners—all bought on loan or consumer credit schemes. Such purchases are leading many into heat poverty—a now-common term in India—as people are forced to take high-interest loans (up to 15%) to buy air conditioners.

During India's record-breaking heat wave between March and June this year, at least 100 people died, and 40,000 suffered heat stroke—more than 19,000 of them in May alone as the temperature soared to a national record high of 126°F.

"I have not seen such overwhelming numbers in my over two-decade career," says Ajay Chauhan, head of Internal Medicine at Ram Manohar Lochia Hospital in Delhi.

Chauhan notes that most of those who are brought in for treatment are men ages 30–50 who work outdoors: "We hardly get any women patients, which shows that the lower income group men, who work as laborers, rickshaw pullers, are more at risk of getting a heat stroke," he says.

The risks of heat-related illnesses will only grow as "climate change fuels longer, more frequent, and more intense heat episodes" says Ritika Kapoor, a climate scientist at Natural Resources Defense Council India. "Thus interventions and vulnerability assessments are much needed to build climate resilience."

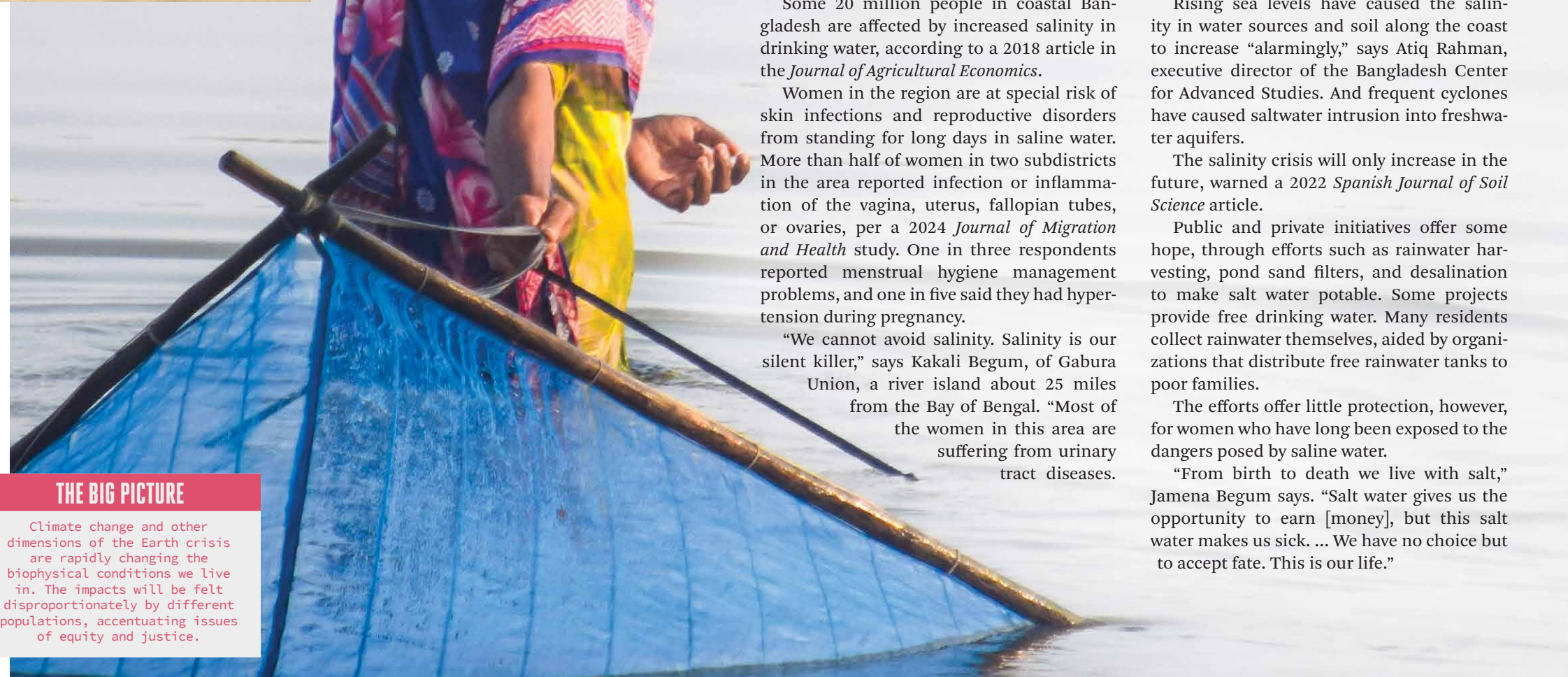
Meanwhile, air conditioner sales are soaring—especially in Delhi. The high number of personal loans since last year forced the Reserve Bank of India to caution lenders.

"It is a vicious cycle. Either we avoid loans, suffer in heat, and miss work, or we take loans, stay healthy, and work to pay off the debt," says Devi.



THE BIG PICTURE

Climate change and other dimensions of the Earth crisis are rapidly changing the biophysical conditions we live in. The impacts will be felt disproportionately by different populations, accentuating issues of equity and justice.



A 'SILENT KILLER' IN BANGLADESH

BY RAFIQU L ISLAM MONTU

IT'S A SUNDAY AFTERNOON IN SEPTEMBER 2023, AND HUNDREDS OF WOMEN AND CHILDREN THROUGH THE banks of the Kholpetua River near Burigoalini village. Each wields a blue net to catch baby shrimp, called fry. They survive on the income they earn selling the fry to shrimp farmers.

Most stand in the salty water for nine to 10 hours per day. The same scene is repeated across much of coastal Bangladesh.

Jamena Begum fishes with her 10-year-old daughter until a storm begins to roll in. As the tide rises and the river swells, they leave for home.

Their health, however, is threatened not just by the storms that frequent southwestern Bangladesh, but by the salt water intruding into the Kholpetua—and their lives.

Some 20 million people in coastal Bangladesh are affected by increased salinity in drinking water, according to a 2018 article in the *Journal of Agricultural Economics*.

Women in the region are at special risk of skin infections and reproductive disorders from standing for long days in saline water. More than half of women in two subdistricts in the area reported infection or inflammation of the vagina, uterus, fallopian tubes, or ovaries, per a 2024 *Journal of Migration and Health* study. One in three respondents reported menstrual hygiene management problems, and one in five said they had hypertension during pregnancy.

"We cannot avoid salinity. Salinity is our silent killer," says Kakali Begum, of Gabura Union, a river island about 25 miles from the Bay of Bengal. "Most of the women in this area are suffering from urinary tract diseases.

Many women are having sores, skin diseases. Excessive use of salt water is causing miscarriages."

Santosh Kumar Majumder, a gynecology consultant, estimates that 60% of the people in the region drink salt water, which can be especially harmful to pregnant women. "It causes high blood pressure which in turn may cause eclampsia or seizures during pregnancy. These may lead to miscarriages or an underweight and malnourished baby," Majumder says.

Rising sea levels have caused the salinity in water sources and soil along the coast to increase "alarmingly," says Atiq Rahman, executive director of the Bangladesh Center for Advanced Studies. And frequent cyclones have caused saltwater intrusion into freshwater aquifers.

The salinity crisis will only increase in the future, warned a 2022 *Spanish Journal of Soil Science* article.

Public and private initiatives offer some hope, through efforts such as rainwater harvesting, pond sand filters, and desalination to make salt water potable. Some projects provide free drinking water. Many residents collect rainwater themselves, aided by organizations that distribute free rainwater tanks to poor families.

The efforts offer little protection, however, for women who have long been exposed to the dangers posed by saline water.

"From birth to death we live with salt," Jamena Begum says. "Salt water gives us the opportunity to earn [money], but this salt water makes us sick. ... We have no choice but to accept fate. This is our life."

TRANSPORTATION JUSTICE IN MUSIC CITY

BY SARAH HAYS COOMER

HISTORY AND A BOOMING PRESENT ARE CONSPIRING IN NASHVILLE, TENNESSEE. POLLUTION FROM TRAFFIC SNAKING THROUGH THE CITY'S URBAN CORE disproportionately impacts historically marginalized communities, exposing residents to high concentrations of airborne toxins.

Most of the city's major roads and highways run through neighborhoods that mortgage lenders deemed "hazardous" for loans beginning in the 1930s because of concentrated populations of racial and ethnic minorities—a racist practice called redlining.

Today, Music City has the toughest commute in the U.S. because of long drive times and a lack of walkability, bikeability, and public transportation options, according to a Forbes analysis. More than 30,000 people move to Nashville every year, which increased average time lost to traffic congestion to 56 hours in 2023 from 41 hours in 2022. That means more pollution in city neighborhoods. People living within 300 to 500 meters of heavily trafficked roads are at the highest risk for negative health outcomes, according to a 2010 Health Effects Institute report.

Outdoor air pollution is responsible for 4.2 million deaths globally each year, per the WHO, from heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and other causes.

Underserved neighborhoods are also less likely to have access to healthy food, safe places to exercise, and medical care, says Mark Yancy, CEO of the nonprofit NashvilleHealth. Without trans-

portation, resources that could benefit residents are often out of reach, he adds.

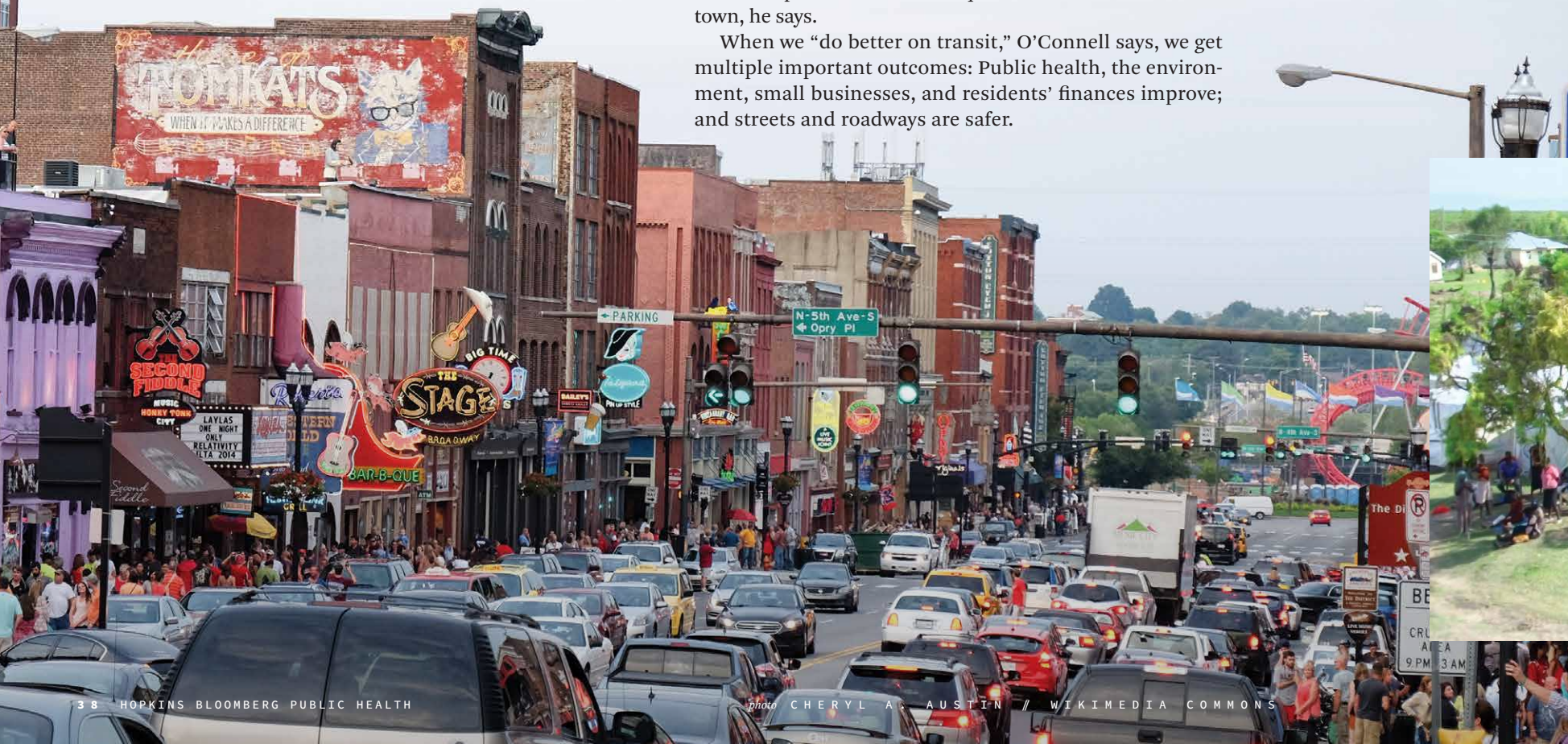
Nashville Mayor Freddie O'Connell, who lives in one of those neighborhoods, is on a mission to "reverse the effects of environmental racism." His engine of choice: transportation infrastructure.

O'Connell wants to establish economic equity and reduce pollution-related health threats through cutting-edge technology and natural resources.

But, without funding, progress is incremental. Of 50 major metropolitan areas in the U.S., Nashville is one of four that has not accepted federal funds from the Bipartisan Infrastructure Law and Inflation Reduction Act. To claim it, voters must approve a referendum in November establishing matching funds for transportation through a temporary 0.5% surcharge on sales tax.

If the referendum is approved, O'Connell aims to replace two-thirds of the city's traffic lights with smart signals capable of adjusting traffic flows on demand while reducing commute times and stop-and-go fuel emissions. The initiative would also construct bike lanes, 86 miles of new sidewalks, and 12 new transit centers with 24-hour bus service, allowing riders to bypass an "antiquated hub-and-spoke model" that required all routes to intersect downtown, he says.

When we "do better on transit," O'Connell says, we get multiple important outcomes: Public health, the environment, small businesses, and residents' finances improve; and streets and roadways are safer.



AN EARLY WARNING IN KENYA

BY SCOVIAN LILLIAN

WHILE CHILDREN RUN AND PLAY OUTSIDE A TIGHT CLUSTER OF THREE DOZEN WHITE TENTS, MOST OF THEIR PARENTS ARE SEARCHING for food or clean drinking water not easily accessible in the camp.

The white tarp shelters, stamped with "IOM • OIM" and the UN's migration agency's logo, are crammed on perhaps an acre of land in southwestern Kenya's Kisumu County. They house families displaced by last April's floods, which killed 294 people, left 162 missing, and decimated 650,000 acres of farmland, according to the Kenya Red Cross. More than 30 cholera cases were reported in Tana River County alone.

Months after the deluge, three villages in Kisumu County—Nduru, Kadhiambo, and Ugwe—remain unlivable, and 1,000 families are still stuck in evacuation camps, according to Jeremiah Odongo, the area's chief.

"Floods swept away my home and I lost everything, including my livestock," says Hellen Anyango, a flood victim and single mother of four. "My biggest fear is that the rainy season is here again."

The Kenya Meteorological Department had issued warnings about the onset of floods and the need for people to move to higher ground for safety—but most people didn't evacuate. They were reluctant to leave their homes because the government hadn't announced plans for designated safe places or temporary housing.

“

Floods swept away my home and I lost everything, including my livestock. My biggest fear is that the rainy season is here again.

The Milken Institute, which has been working since 2020 to help improve early warning systems (EWS) for pandemic preparedness and health security, published a report last May that identified a significant gap in the integration of environmental factors into Kenya's EWS and disease surveillance systems. By including meteorological data, especially during flooding, authorities can better anticipate outbreaks of waterborne diseases like cholera and vector-borne diseases like malaria. In turn, health authorities can preemptively distribute cholera kits, mosquito nets, and other disease-prevention resources.

Collaborations between climate change scientists and health professionals are essential, says Yun Fu, co-author of the Milken Institute report. By sharing data and expertise, professionals can develop models that forecast health risks related to climate events, boosting preparedness and response times.

In Mozambique, for example, local community brigades have been trained to educate and alert communities about impending hazards from extreme weather events—a method embraced after Cyclone Freddy hit the country in February 2023. Since then, it has proven an effective early warning method.

John Recha, PhD, of the International Livestock Research Institute in Nairobi, notes that EWS are crucial for timely alerts and information about impending climate change risks.

"Communities ought to be trained and educated on climate change risk responsiveness and safe evacuation procedures, as well as managing climate change health threats," Recha says, adding that national and county governments should collaborate to strategize better ways of handling floods to save lives in the future. ○



Habitats FOR Humanity

As people disrupt ecosystems and the climate changes, infectious disease risks rise.

BY TOMAS WEBER
ILLUSTRATIONS BY DAVIDE BONAZZI

Cases of mpox are surging. In August, the WHO declared an international emergency due to the dramatic rise in incidence of the disease, which can be fatal to people who are immunocompromised. Since 2022, around 100,000 cases of mpox have been reported, and hundreds of people have died. First detected in a human in the Democratic Republic of Congo in 1970, the virus is now quickly evolving, and mpox strains are spreading rapidly in and beyond Africa. ●



While human-to-human transmission is now the main driver of the spread, the mpox virus first spilled over to humans from rodents and monkeys, largely because of human-caused changes to the environment. For example, deforestation in West Africa, fueled by logging, brought humans into closer contact with infected animals. Climate change, too, may be extending the breeding season of rodents that carry the virus.

The mpox outbreak is part of an alarming trend. From COVID-19 and Lyme disease to Ebola and dengue fever, every year pathogens carried by animals sicken 2.5 billion people, killing 2.7 million. Over the past century, 60% of all new infectious diseases were the result of animal-to-human spillovers.

And the risk of zoonotic diseases is ballooning. Researchers have estimated that over the next 50 years, more than 15,000 viruses will spill over to a new species—with increased global temperatures and land-use changes driving the increase. Some of these viruses will likely be just a few random mutations away from pandemic potential.

“The problem is big,” says Meghan Davis, an associate professor in Environmental Health and Engineering. “And it’s getting bigger.”

HUMAN ACTIVITIES HAVE DIRECTLY AND INDIRECTLY fueled the spread of zoonotic diseases. Long-distance travel, for example, has transported not just people but diseases to new locations. “Think back to the earliest cases of Ebola in the 1970s,” says Davis, DVM, PhD ’12, MPH ’08. “They tended to be in very remote areas, with populations that were geographically cut off. So it would flare up and burn out. But now, people are moving globally all the time—and the risk [of transmission] is that much greater.”

Our decimation of the environment is another cause of the increase. Deforestation means humans can more easily venture into habitats where they might encounter animals that are acting as disease reservoirs, and the destruction of biodiverse areas for large-scale monoculture farms allows pathogens to spread more quickly.

Deforestation in the Amazon basin, which brings human settlements to the edge of the rainforest, increases malaria transmission, with disease risk increasing by 3.3% for every 10% increase in forest clearing. And in sub-Saharan Africa, irrigation schemes, which create standing water, as well as dam construction, have also intensified the malaria threat.

“We have abundant evidence that our destructive use of nature is catching up with us,” says Felicia Keesing, PhD,

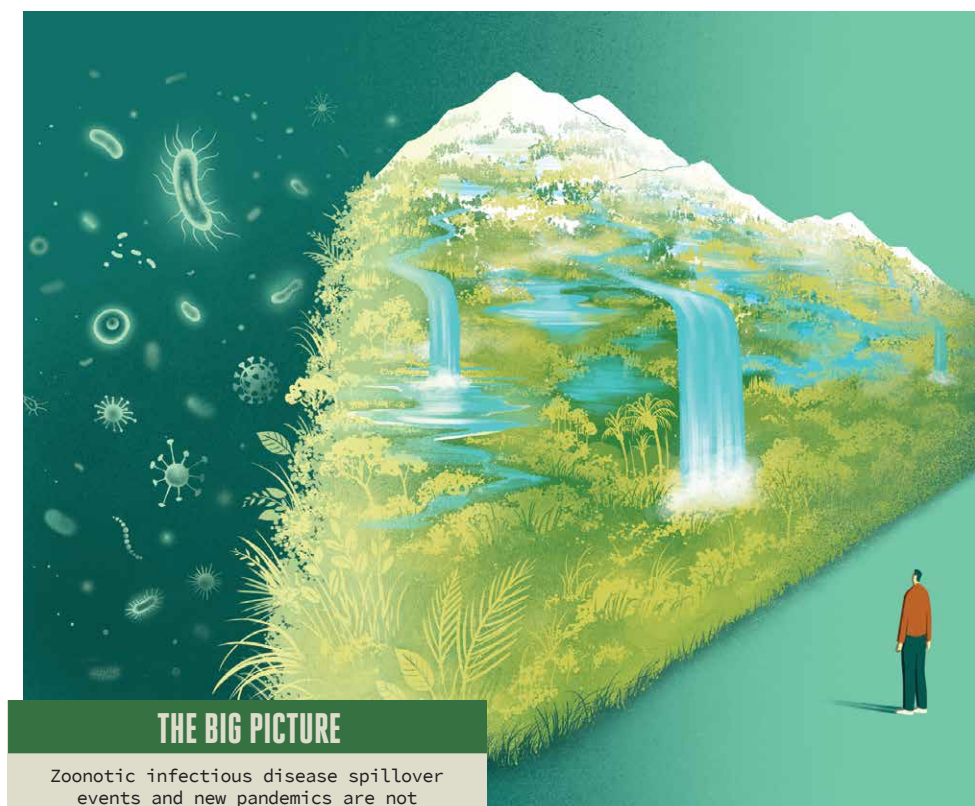
an ecologist at Bard College. “Zoonotic disease risk is one more reason why we should be reversing course.”

Climate change is a powerful threat driver. As global temperatures rise, disease vectors can spread into regions newly favorable to them. Malaria-carrying mosquitoes, for example, are now showing up in high-altitude parts of Africa, such as the Kenyan highlands, where the frequency and intensity of outbreaks have increased over the past 15 years.

In the U.S., meanwhile, disease-bearing ticks are thriving in places they used to find too cold. “Twenty-five years ago, if you didn’t want to get Lyme disease, you could just go to Maine,” says Douglas Norris, a professor in Molecular Microbiology and Immunology. “There were ticks in Maine, but the season was so short that they couldn’t complete their transmission cycle. But now it’s warm enough, and Maine has the highest incidence of Lyme disease in the U.S.”

The warming climate also brings more frequent and more extreme weather events that exacerbate vector-borne disease threats. In July, Hurricane Beryl sparked a surge of West Nile virus in Houston. “The floodwaters created standing water for mosquitoes,” says Norris, PhD, MS, who is a co-principal investigator on a National Science Foundation-supported project in Houston that is developing an enhanced surveillance system for detecting and predicting mosquito-borne diseases like malaria and West Nile. “Now, they’re going to have to spray the bejesus out of the city.”

Not all zoonotic diseases are intensified by recent environmental changes, though. Epidemiologist Emily Gurley, who studies the bat-borne Nipah virus, which has a mortality rate between 40% and 75%, believes that land-use changes likely played a role in creating the context for outbreaks of that virus. But in Bangladesh, “almost all the forests were cleared 300 years ago,” says Gurley, PhD ’12, MPH, distinguished professor of the practice in Epidemiology. And climate change, she says, might actually reduce outbreaks. Nipah outbreaks are driven by humans drinking contaminated date-palm sap, and people drink more of it in colder years. “So as the planet gets warmer,” says Gurley, “then maybe you’ll see fewer spillovers” of this virus.



THE BIG PICTURE

Zoonotic infectious disease spillover events and new pandemics are not the only threats arising from human disturbance of natural systems. Changes in land use can expand exposure and transmission of other diseases like malaria and schistosomiasis.

And while Lyme disease is creeping northward, it’s moving south, too. “That’s not consistent with climate change,” says Richard Ostfeld, PhD, a disease ecologist at the Cary Institute of Ecosystem Studies, who has studied Lyme disease with Keesing for many years. In theory, the Southern climate has long been hospitable to the disease-carrying ticks, so “there must be other factors involved as well. And, to a great extent, we don’t know what those other factors are.”

WHAT WE DO KNOW IS THAT BIODIVERSITY IS A barrier against disease. Flourishing ecosystems safeguard humans from a panoply of zoonotic illnesses. But as those ecosystems become less diverse—primarily because of habitat loss and fragmentation—that barricade begins to crumble.

Take Lyme disease. “The general hypothesis is that where there is a more diverse array of animals for ticks to feed on, that dilutes the intensity of the patho-



We have abundant evidence that our destructive use of nature is catching up with us. Zoonotic disease risk is one more reason why we should be reversing course.

ALONG WITH UNCOVERING THE SIZE AND THE shape of the risk, researchers are addressing the threat. Norris, for his part, has helped develop sophisticated monitoring techniques for detecting the next outbreak of mosquito-borne diseases. Using robotic traps, Norris’ team can identify specific species of mosquitoes, which gives a clue as to which diseases they might be carrying. Then, using genomic analysis, Norris and his team also search for the genetic codes of any new pathogens that the mosquitoes might be carrying.

Some of the problems we create, though, are more intractable. Ostfeld and Keesing recently wrapped up the Tick Project, a five-year study of a community-based model to prevent Lyme disease. A 2016 CDC study had shown that spraying peoples’ yards with pesticides did not reduce tick encounters, so Ostfeld, Keesing, and collaborators distributed almost 10,000 bait boxes, for killing ticks, to 24 different neighborhoods across Dutchess County, New York. They saw a 50% reduction in the number of tickborne diseases—suggesting that more research is needed to understand where and how humans encounter infected ticks.

Above all, says Rohr, we urgently need “to minimize the impact that we have on the natural world.” Reducing carbon emissions and conservation efforts to halt biodiversity loss will help, as will buying local goods since transporting food products across long distances risks introducing pathogens into new areas.

Flourishing, diverse ecosystems are the most effective safeguard against viral spillover, says Rohr. “We need to appreciate the value that the natural world offers to humanity, from an infectious disease-mitigation standpoint.”

STARVING SCHISTO, FEEDING CROPS

The human disruption of natural systems amplifies the threat of non-zoonotic diseases, too. In the 1980s, the Diama Dam was constructed to reduce saltwater intrusion into the Senegal River and to facilitate irrigation in the region. The increased freshwater provided more habitat for a snail that hosts parasitic flatworms that cause schistosomiasis, a serious disease that affects 240 million people worldwide. And increased fertilizer use in the burgeoning agricultural landscape also meant more food for the snails—and more parasitic flatworms and more schistosomiasis. One promising solution: Remove the invasive freshwater plants where snails thrive. In a 2023 *Nature* study, Jason Rohr and colleagues found that this approach not only reduced *Schistosoma* infection rates in children at sites where the vegetation was removed, but also provided a cost-effective source of feed for livestock and compost for plants.

SPECIAL ISSUE | OUR PLANET, OUR HEALTH

SMART SHIPPING

Beginning in 2019, the U.S. President's Malaria Initiative completely revamped its distribution strategy. Air freight of rapid diagnostic tests, antimalarial medicines, and other products was replaced by ocean and land freight. The project saved \$66 million and reduced transportation-related GHG emissions by 85%.



SOLUTIONS FOR A LIVABLE EARTH

OUR PLANET, OUR HEALTH
| FEATURE STORY |

From innovating ways to preserve glacial ice to predicting climate-driven migration shifts to building resilient cities, researchers are exploring scalable solutions to safeguard a planet in peril.

BY GABRIEL MULLER

REFREEZING THE FUTURE

As summer temperatures continue to rise every year, glaciers in Greenland and Antarctica are faster to melt and form puddles of water that accelerate ice loss. These pools, without sufficient time to refreeze overnight, contribute to rising sea levels and diminish ice's crucial role in reflecting sunlight back into the atmosphere.

Jaafar El-Awady, PhD, a professor in Mechanical Engineering at Johns Hopkins, along with colleagues across the University, are pioneering an innovative solution: ice nucleation proteins. These microscopic catalysts occur naturally in certain organisms and can accelerate the freezing process of water. When placed in melt pools, they can speed up the freezing process overnight "such that we can reduce the melting during the day," El-Awady says. His team also plans to weigh the feasibility of cloud seeding—"basically dispersing these ice nucleation proteins into clouds over glaciers to induce snowfall"—as a scalable means of application.

Preserving ice coverage would reinforce Earth's natural cooling mechanism and create a positive feedback loop: More ice means more reflected sunlight, further cooling the planet and slowing melt. "If we're able to increase ice mass," he says, "then you're going to actually start reversing the process of global warming."

The project, still in early stages, faces challenges. "Very detailed studies are still required to ensure these agents are not affecting the environment in a negative way," El-Awady says. But with machine learning aiding the research, El-Awady is optimistic. "AI and machine learning will help almost every aspect of this problem," he says, citing applications in designing more efficient proteins, predicting weather patterns, and modeling ice sheet mechanical behavior.

In a warming world, El-Awady and his colleagues' research offers some hope for a cooler future—not just a patch on the problem, but a way to potentially turn back the clock on ice loss.



FORECASTING THE CLIMATE EXODUS

In the arid landscapes of southern Iraq, rising temperatures are pushing people northward in search of water and arable land. Meanwhile, in Mali, shifting rainfall patterns are altering traditional herding routes. These movements, seemingly disparate, are part of a global phenomenon that Paul Spiegel and colleagues at the Center for Humanitarian Health are working to anticipate and mitigate.

Spiegel, director of the CHH at the Bloomberg School, has long studied conflict-driven displacement. Now, he's turning his attention to a force that's reshaping migration patterns worldwide: climate change.

"Climate change will cause movement, but will also cause conflict that will then cause increases in death and movement," explains Spiegel, MD, MPH '96. To unravel these dynamics, Spiegel and his team hope to develop models that analyze decades of climate data, migration patterns, and health outcomes.

This approach, which Spiegel refers to as "anticipatory action," combines big data analysis with on-the-ground interviews of recent migrants to develop models that can predict future population movements, identify migration drivers, and help governments and aid organizations prepare for future population flows.

In Iraq, this could mean designing climate-proof health systems that can accommodate significant population increases. In Mali, it might involve preparing health systems to tackle new disease vectors as both climate and human populations change.

Spiegel acknowledges the challenges, particularly in conflict-affected areas where data may be piecemeal, but emphasizes the potential benefits, from updating infrastructure to implementing new protective measures in climate-stressed areas. "We don't know if we will be successful," he admits, "but it has to be attempted."



FROM ER TO EARTH

During the chaotic early days of the COVID-19 pandemic, Johns Hopkins emergency medicine physician Chris Lemon found himself on the front lines.

Exhausted after long shifts, Lemon, MD, would find himself scrolling through his phone, seeking distraction. As he pushed pandemic news aside, he encountered a cascade of troubling stories about floods, fires, and climate change.

"During COVID, we felt incredibly vulnerable," Lemon reflects. "It made me see how changes to our planet could similarly affect our health and safety." This realization encouraged him to undertake a career transition—from full-time ER physician to champion for planetary health at the Johns Hopkins Institute for Planetary Health.

Lemon now balances his ER duties with coursework, teaching health care providers to think about global environmental challenges by developing new curriculum and educational programs. He envisions a future where a patient's environment is as crucial to diagnosis as their family history.

"It's about incorporating environmental factors into our standard health questions," he explains. "Beyond asking, 'Do you feel safe at home?' we might ask, 'Do you live near the Great Salt Lake?' which is now exposing people to heavy metals as it recedes and creates dust." Soon, asking if a patient lives near a pollution source could be as routine as inquiring about their smoking habits.

Lemon believes health care providers have a central role in communicating these issues, and to train them, he and his colleagues are developing a clinical fellows program at Hopkins. This program aims to create a "super track" for clinicians to immerse themselves in planetary health concepts, allowing them to become pioneers in this field regardless of their specific medical specialty.

"The med student who starts this semester is not going to be a boarded physician in the U.S. for at least seven years," he says. "How do we retool our health care workforce to operate in this space? The problems are here now. We can't wait any longer."



APPETITE FOR CHANGE

At a Baltimore school cafeteria, students discard uneaten food. Across town, a grocer removes slightly blemished produce from shelves. These scenes, played out countless times across America, illustrate a pervasive food waste issue that Roni Neff and her team are tackling head-on.

Neff, PhD, '06, ScM, associate professor in Environmental Health and Engineering, and her colleague Kaitlyn Harper, PhD '22, MS, assistant scientist in EHE, are studying solutions at multiple levels. In partnership with the World Wildlife Fund, they're testing interventions in school cafeterias. "We're measuring how much food students are throwing away and testing 'share tables,' where kids can leave unopened items for others to take," Harper explains.

Neff and Harper, along with Nicole Labruto, PhD, MA, assistant research professor in Anthropology at the Krieger School of Arts & Sciences, are also collaborating with workers at Albertsons grocery stores to reduce food waste and increase donations. They've created eye-catching posters with clear guidelines on what can be donated, and even proposed in-store events where local food banks can connect with employees and customers.

"These projects, and others we work on, are rooted in the idea that every food item in a landfill is the end result of a long list of missteps," Neff says. "Rather than focusing on wasting food as an individual and blameworthy action, we want to find the system levers we can pull."

But the impact goes far beyond lost meals. Food waste is a significant contributor to climate change, accounting for about 8% of global greenhouse gas emissions. When food decomposes in landfills, it releases methane, a potent greenhouse gas, Neff points out. And that's just the end of the story. "Consider all the resources—water, energy, labor—that went into producing that food in the first place," she says.

"When we waste food," says Neff, "we're not just missing an opportunity to feed others—we're actively harming our planet."



THE NEW URBANISM

Cities are at a crossroads. As office buildings sit half-empty and malls struggle to attract visitors, urban planners face a crucial question: How can we reimagine these spaces to benefit both the economy and the environment?

Seydina Fall, MBA, program director for real estate infrastructure at Johns Hopkins Carey Business School, believes the answer lies in sustainable urban development. "We're clearly facing transition risk," Fall explains, referring to the challenge of adapting urban spaces to meet new environmental regulations and changing societal needs.

Fall's solution centers on high-density, mixed-use zoning—a model where homes, offices, and amenities coexist within walkable distances. While not a new concept, Fall advocates for scaling up this approach using cutting-edge technology. "Can AI analyze population trends, income patterns, and consumer behavior to determine the best use for a piece of land?"

Crucially, Fall sees technology as a means to enhance urban resilience—a city's ability to withstand and recover from environmental challenges. By leveraging AI and other digital real estate innovations, cities can make more informed decisions about sustainable materials, energy-efficient designs, and adaptive reuse of existing structures. "Planetary health is very pro mixed-use," he notes.

Integral to this vision, however, are stakeholders with sometimes competing incentives: property owners hoping for an office space comeback, developers seeking profit, and environmentalists pushing for sustainability.

"If you're a long-term investor, it's a no-brainer," Fall argues, pointing out that buildings with sustainable features often have higher tenant retention and lower operational costs. "You need a 10–15-year investment period to really see accretion to your bottom line," he adds.

By demonstrating these long-term economic benefits, he aims to unite stakeholders behind creating sustainable, economically viable urban spaces. In Fall's vision, economic growth and planetary health are complementary goals—all starting at the city level. ☉



CLIMATE CHANGE'S PSYCHOLOGICAL IMPACT

Extreme weather is amplifying mental health crises across the world. Solutions are needed now.

BY MARILYN PERKINS

Early one morning in March 2019, armed hunters from the Dogon ethnic group surrounded the small village of Sobane-Kou in Mali, West Africa. Tensions were mounting between the Fulani and Dogon groups, who were at odds over how to use the village's surrounding lands. The Fulani were herders, whereas the Dogon tended to farm, and a centuries-long conflict was boiling over as extreme heat, drought, and flooding made it more difficult to do either.

By the next day, the Dogon hunters had burned swaths of the village and killed 175 Fulani residents.

The damage doesn't stop there. Global mental health advocates say these traumatic events can echo through a lifetime, fueling psychological distress and exacerbating underlying conditions like anxiety and depression. And some people go on to develop post-traumatic stress disorder.

The Fulani massacre led International Health associate Molly Lasater to investigate the layered consequences of a warming planet on psychological well-being. These effects will be felt most strongly in low-resource countries where climate change can worsen existing conflicts and humanitarian situations, and where mental health needs already often go unmet.

To mitigate some of global warming's worst psychological effects, researchers like Lasater and others are now pushing for mental health to be a focus in climate policy and interventions.

A 'THREAT MULTIPLIER'

A longtime resident of California, Lasater, PhD '18, MPH '14, is no stranger to the effects of climate change. She has seen friends lose their houses to wildfires and how such devastation can impact a person.

"You always have this looming fear," she says. Survivors of California's 2018 Camp wildfire were diagnosed with PTSD at a rate on par with war veterans.

But slower-onset climate change effects—like drought, rising sea levels, land cover change, and increasing temperatures—can cause stress over time that can ignite into violence like the 2019 Fulani massacre.

What's more, growing research shows that extreme heat can provoke aggression and increase suicide risk. In this way, climate change becomes a "threat multiplier" for mental illness, says Lasater.

"Where poverty, unstable employment, fragile infrastructure, conflict, geographic vulnerability to extreme weather events, or food insecurity exist, there's a greater likelihood of loss of livelihood, loss of life, or loss of a sense of control, which can lead to negative mental health consequences for survivors," adds Department of Mental Health chair Pamela Collins, MD, MPH.

Yet scientific research currently offers few solutions. Lasater and Mental Health adjunct assistant professor Jura Augustinavicius are collaborating with researchers at the University of Sciences, Techniques, and Technologies of Bamako in Mali to change that.

"Social, cultural, economic, and other environmental factors all sit in that pathway between climate change exposures and mental health outcomes," says Augustinavicius, PhD '17, MHS '14, the principal investigator on the project and also an assistant professor at the School of Population and Global Health at McGill University.

To untangle those influences, the research group is using system dynamics—an engineering approach that involves understanding complex systems through the relationships of their interconnected parts—to analyze the layered mental health impact of factors like farmer-herder conflicts, land use changes, weather patterns, and food availability in Mali. Lasater and Augustinavicius are working with local stakeholders to identify data on weather, physical and mental health, social and health services, and resource access to advance the work.

Their aim is to begin to tease out how climate-related factors contribute to feedback loops of displacement, conflicts, and migration in the region that threaten physical and mental health. With the

data, the researchers hope to better understand how these environmental changes ripple out to mental health and, ultimately, to incorporate interventions.

NEW POLICIES AND INTERVENTIONS

"My long-term goal is to think about integrated programs," Augustinavicius says. These might directly address psychological well-being—such as a campaign to raise awareness of mental health impacts of climate change—or support well-being through more indirect routes, such as ensuring that people with psychosocial disabilities can access to early warning systems.

Still, mental health and climate policies are "very nascent," says Alessandro Massazza, an adviser at United for Global Mental Health and an honorary research fellow at the Centre for Global Mental Health at the London School of Hygiene & Tropical Medicine. For example, the action plans for reducing emissions and adapting to climate impacts submitted every five years by parties to the Paris Agreement rarely mention mental health.

Massazza urges governments and policymakers to consider mental health when drafting climate policies. He points to South Australia's heat warning system as one success story. The region's action plan mandates notifying those with existing mental conditions of extreme heatwaves, via a phone call, and conducting a welfare check if there is no response. It also provides free mental health support to emergency workers involved in climate-related disasters.

On a local scale, Lasater advocates for strengthening physical and mental health services, promoting community support, and destigmatizing mental health—services that are best accompanied by other efforts, like vaccination, nutritional support, and climate change mitigation and adaptation programs.

WHY MENTAL HEALTH MATTERS

With climate change threatening people's physical safety, lives, and livelihoods, focusing on mental health may seem like a Band-Aid solution.

But "the distinction between physical and mental health is, to a degree, quite arbitrary," says Massazza. An oft-cited example is that depression can make people with HIV less likely to take their HIV medication, or make it harder for them to access HIV services. Connections like these make climate change's status as a "threat multiplier" even more acute, as the mental health impacts could also influence physical health.

And all of this comes with a hefty price tag: A 2023 *Annals of Global Health* study found that mental disorders due to climate, pollution, and environment-related causes could cost the global economy \$47 billion annually by 2030.

But more importantly, says Augustinavicius, preserving mental health is key to staying resilient in the face of a changing planet. "Mental health and well-being are really at the core of our humanity," she says. "And that means they're also at the core of our ability to address this problem." ❖

LASTING
DAMAGE

21,770

Projected additional suicides by 2050 in U.S. and Mexico without attention to climate change

3%

Share of countries that mention mental health in Paris Agreement climate action plans

\$537 BILLION

Cost to global economy by 2050 from mental disorders due to climate, pollution, and environment-related causes

Sources: See magazine.publichealth.jhu.edu



Ellen's Take | Special Q&A

COURSE CORRECTION

“We need to be ambitious and speak uncomfortable truth to intransigent power,” says planetary health leader Tan Sri Jemilah Mahmood.

In 2019, Tan Sri Jemilah Mahmood, MD, made a radical career change. After two decades managing health crises in disaster and conflict settings, she shifted her focus to planetary health. She wanted to stop responding to crises and start pursuing systems solutions. Now a respected global leader in planetary health, she is professor and executive director of the Centre for Planetary Health at Sunway University in Malaysia, where she leads efforts to advance education and research to benefit the health of people and the planet. In this discussion with Dean Ellen J. MacKenzie, Mahmood shares her perspectives on planetary health’s mission and its challenges.

I think you know better than anybody that environmental threats disproportionately affect people with the fewest resources. How can we ensure that those most at risk are our greatest priority in the years to come?

I don’t have the absolute answer, but the way I look at it is, if we are serious about protecting the vulnerable people and communities, we’ve got to find a way of making them less vulnerable. So we’ve got to start from that point.

My humble opinion is that we academics need to get a lot more strategic and less competitive. There’s so much collaboration that needs to happen now, and we need to really accelerate the work on planetary health. We need to be ambitious and speak uncomfortable truth to intransigent power. It’s quite straightforward. We need to just keep going at it, and we need to coordinate, cooperate, advocate, and help shift the dial.

Getting governments and the private sector on board is so critical. How do we do that?

I always talk about the three P’s. The first is political will. The second is solid policies, and the third is pressure. And pressure comes from people—consumers, or young people standing up to say, “We demand this from you.” Because ultimately, this is what moves the political will, and this will is what might shift the policies. Don’t underestimate the power of people.

What’s your message to national governments who are facing so many pressing needs—why should they prioritize planetary health?

I always talk about family. I talk about my two sons, and my new grandson, and my vision for them. And I talk about my parents—one was a civil servant and the other was a housewife who later on became an entrepreneur—and how they worked so hard to give me a bright future. And yet I cannot leave the same hope for my children because my generation is also guilty of what’s happened in the Anthropocene era that we live in now.

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My humble opinion is that we academics need to get a lot more strategic and less competitive. There’s so much collaboration that needs to happen now, and we need to really accelerate the work on planetary health.

The second thing I say is, it’s possible for us to succeed because planetary health brings together all the major challenges that we face. John Muir, a real early advocate of wilderness preservation in the U.S., said something like, when one tugs at a single thing in nature, one finds it attached to the rest of the world. The only way we have to find some way of balance and solution is to come back to where we came from, and that is nature.

What do most people not understand about planetary health?

Perhaps the right question is more likely to be, what is it that planetary health practitioners and advocates do not understand about the way humans think and act that currently prevents us from changing the course? What are we doing wrong because we’re not getting the traction that we so desperately need today?

I think we need to deliver key planetary health messages in ways that people understand.

The Global Planetary Health Roadmap and Action Plan were launched last April. They were really meant to help answer the question—and I love this question—how do we do planetary health? Well, how do you do planetary health?

Firstly, we need to be able to get our facts and figures right. How do we measure and prove that we are in trouble? Secondly, the global agreements and frameworks are fragmented as well. So we need to be looking at global governance. Thirdly, we need to revolutionize education to include in most national curricula proper respect and care for the environment. Fourthly, CEOs are only being encouraged—rather than pressured—to think about how the way in which they operate affects our health and the health of everyone on the planet, and the planet itself. We need to engage with these CEOs. Fifthly, all of us need to bring together the best minds in communications and coordinate our messages to politicians.

We’ve got to get out there and court controversy, argue, debate, and confront. We cannot just stand on the sidelines anymore.

You’ve done a great job at Sunway lifting up planetary health as a major initiative. What advice would you have for our effort here at Johns Hopkins to develop the Planetary Health Institute?

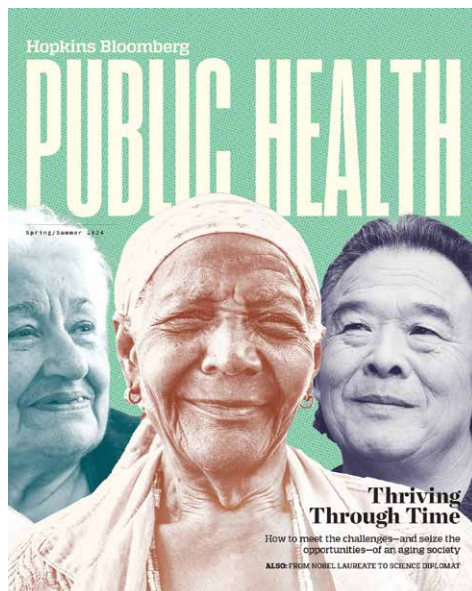
I think all of us need to have humility. We need to learn from each other and to be able to invest in coordination and connection. The world today, compared to the world in which I started as a medical practitioner, is so different. Everything is available at our fingertips, and I think there’s no excuse for us not to connect and coordinate. It’s not going to be easy. What I did was I doggedly showed people that it’s a win-win situation if we collaborate.

My advice to Johns Hopkins, as a very renowned institution, is to use your evidence now to drive policy change. ☉

Ellen J. MacKenzie, PhD '79, ScM '75, is the 11th dean of the Johns Hopkins Bloomberg School of Public Health.

THRIVING THROUGH TIME

Readers respond to our reporting on aging in America and other stories from our Spring/Summer 2024 issue.



By 2060, nearly 95 million Americans will be 65 and older. Last issue's writers explored the challenges facing our aging population, including reliance on family caregivers, racial disparities in dementia, and the health toll of social isolation—as well as solutions, from the molecular to the societal. Other reporting covered *Dobbs'* impact on OB-GYN training, biological causes of cancer disparities, adolescent food insecurity, the dangers of counterfeit drugs, and more.

If you missed any of these stories, they're all available—along with our full digital archive—at magazine.publichealth.jhu.edu.

You made many good points about family caregivers, but you left a significant part out of your article. The most ignored and valuable unpaid caregiver of all is the spouse. I have been my husband's caregiver for about 25 years. It started small and was mostly wound dressing changes. I was able to work outside of the home.

Then he had a stroke. It was more debilitating than we were ready for. His doctor told me that he would require full-time care. The only option we had was for me to stop working and be that full-time caregiver.

America's hidden heroes quietly serving. We stay while others leave. We run into the fire. —*Alies Dalton via web, in response to "Health Care's Hidden Workforce"*

I've looked into the pay that "companions" receive, and it's really low for what they will be asked to do. If that scale increases, there will be more people willing to pursue this as a career that they can actually make a fair living at. —*makosmom4ever via Instagram, in response to "Health Care's Hidden Workforce"*

I was fortunate enough to be a research assistant in some of the earlier stages of this work during my first year as a doctoral student, and what a way it's come since! It's certainly not often that you get to see formative research turn into impactful community change within the span of six years. —*Emma Clare Lewis, PhD, MS, via LinkedIn, in response to "The Hunger Gap"*

Following a plant-based diet, I had to relearn how to cook, shop for healthier ingredients, and discern food labels. Also revamped my family's favorite Italian recipes to incorporate more fresh vegetables, variety, new ingredients, and less fat. Still working on this!

I continue to educate myself on new cooking and meal prep techniques, power foods, and immune-boosting choices. Here's to healthier living! —*Gina M. Wilson, MS, via LinkedIn, in response to "The Missing Ingredient"*

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America's hidden heroes quietly serving. We stay while others leave. We run into the fire.

While improving food access is critical, we also must find a way to facilitate community cooking instruction. Recently, I launched an educational website to encourage new home cooks to batch cook with economical, highly nutritious ingredients. I have also begun some outreach classes with local nonprofits. It's challenging to scale but such a necessary part of changing habits for improved health. —*Lorraine Lippolis via web, in response to "The Missing Ingredient"*

It's fascinating to see the international reach of Peter Agre's scientific diplomacy. His efforts undoubtedly contribute to global scientific collaboration and knowledge exchange in diverse geopolitical contexts. —*Raffaele Di Giacomo, PhD, via X, in response to "Peter Agre's Third Act"*

In the dance of science, where nations meet, Borders dissolve, collaboration's heartbeat. Peter Agre's vision shines, clear and bright, Uniting minds for health's noble fight. Through shared knowledge, discoveries unfold and transform lives. We are thankful for you, Peter. —*Bakunda Louis Emmanuel via X, in response to "Peter Agre's Third Act"*

Some patients might perish without their prescribed medications. What about an accredited service patients can pay for that analyzes what is in a sample of the medication they have purchased from a foreign country? I think in probably a huge number of cases it would be well worth it to test their foreign-filled medications periodically to make sure their purchased medications are of the same quality. —*Adrian Zolkover via web, in response to "Fake Drugs, Real Dangers"*



Make a Lasting Impact

PUT A STUDENT'S PUBLIC HEALTH CAREER ON A FLIGHT PATH TO SUCCESS!

A Bloomberg School scholarship and a modest stipend set Gertrude Huster, MS '84, on a path to success, one that included working at the Naval Air Station at Patuxent River while she prepared for a biostatistics career in public health.

Huster never forgot how other people's generosity set her professional life in motion, which is why she and her family decided to create a bequest to endow a scholarship in the Department of Biostatistics just before she passed away from breast cancer in June 2023.



Nora Elhaisouni

Today Nora Elhaisouni is a master of science student in Biostatistics and the first Gertrude A. Huster (née Russell) Scholarship recipient. As a first-generation college student, she is grateful for Huster's gift which is helping her build a career in data analysis focused on infectious disease and maternal and child health.

Planned gifts such as Huster's provide scholarship and stipend support. Think about how you can

turn a student's dream into a career and open up exciting professional opportunities.

To make a lasting impact on public health—and the world—contact Richard Letocha, JD, CFP, director of gift planning, at rletocha@jhu.edu.



Journeys

INDIGENOUS ANSWERS

Ancient wisdom supported my people for thousands of years—
and can heal the polycrisis threatening the modern world.

BY SIONE TU'ITAHU

While planetary health may be new and novel to many, it is as ancient as the land to Indigenous people like me.

Growing up on our small island of Ha'ano, in Tonga, in the middle of the Pacific Ocean, we learned early on from our grandparents and other elders that we humans are inextricably one with the Fonua—Mother Nature.

So central is the concept of Fonua to our physical and spiritual reality that the womb, this physical plane of existence, the grave, and the hereafter are all called Fonua. Fonua is the inseparable connectedness of the web of life. It is the basis of our knowledge system and its values within.

“You are the Fonua, the Fonua is you. Look after the Fonua, and the Fonua will look after you,” Grand Uncle Masoe, a master navigator and farmer who adopted me, used to say.

Whether spending time at home, working in the garden, or fishing at sea, Grand Uncle Masoe and other elders—both male and female—would teach us the sustainable, ecological circle of life, and how we should take enough for our needs but not for our greed.

Masoe, as people called him, taught us how planting yams, kumara, and other crops within certain phases of the moon provides the highest yields. Based on the same lunar calendar, he showed us how choosing the right season and weather can help us catch a few big fish for our needs and leave the young ones to flourish.

He learned the wisdom of the Fonua from the village elders, not from any European-based school. But it is a dying knowledge because of Eurocentric knowledge that came into our world with coloniza-

tion. That is why I am working hard to preserve and advance Indigenous wisdom.

Our ancestors' knowledge and vision were beyond the lessons of this planet. We looked to the stars, the sun, the sea, and the wind as our guide for thousands of years when we navigated the Moana, the biggest ocean in the world (known later as the Pacific Ocean). The pathway of the moon and other celestial elements informed all human activities from fishing and farming to cultural festivals and recreational activities.

We Indigenous peoples in small Pacific nations have been living in harmony with Mother Nature and not against her. Her biodiversity flourished until Pacific Rim nations and the major powers brought unsustainable whaling and deep-sea trawling. They also dumped their rubbish and left their nuclear waste in our collective home. Environmental crises and global warming are a matter of life and death for us.

My Indigenous education and the impact of global environmental crises prompted me and my team at the Health Promotion Forum of New Zealand/Runanga Whakapiki Ake I Te Hauora o Aotearoa to co-organize the 23rd World Conference on Health Promotion with the International Union for Health Promotion and Education (IUHPE) in Aotearoa (New Zealand) in 2019.

Our twin Legacy Statements from the conference have shaped the strategic direction of IUHPE and informed our contributions to the WHO's Geneva Charter for Well-being in 2021. The statements refer to Indigenous knowledge systems as solutions to the unprecedented decline in the well-being of the planet and humanity. For example, our socio-ecological and spiritual knowledge and values of being one with

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We Indigenous peoples in small Pacific nations have been living in harmony with Mother Nature and not against her.

Mother Nature can inform public policies to become more environmentally conscious. Our systemic way of knowing that all beings are interdependently connected can shape social and economic systems to become more sustainable. It can also help our fellow humans to be more compassionate to each other and Mother Nature, and live a happier life in a healthy world.

The 476 million Indigenous people of the world are already making a significant contribution to the well-being of the planet and humanity. The planet's biodiversity is decreasing rapidly, but 80% of the remaining land biodiversity is in lands for which Indigenous peoples are custodians.

While we must urgently address the environmental crisis, we also must recognize it is part of a bigger, human-induced polycrisis that includes geopolitical conflicts, obsolete economic systems, and health challenges such as COVID-19.

We humans have lost the plot. We value material prosperity at the expense of spiritual well-being. We have lost our balance. Our crisis is ethical and spiritual and can only be addressed effectively if we include those missing dimensions of holistic well-being. ◉

Sione Tu'itahi is executive director of the Health Promotion Forum of New Zealand and president of the International Union for Health Promotion and Education.

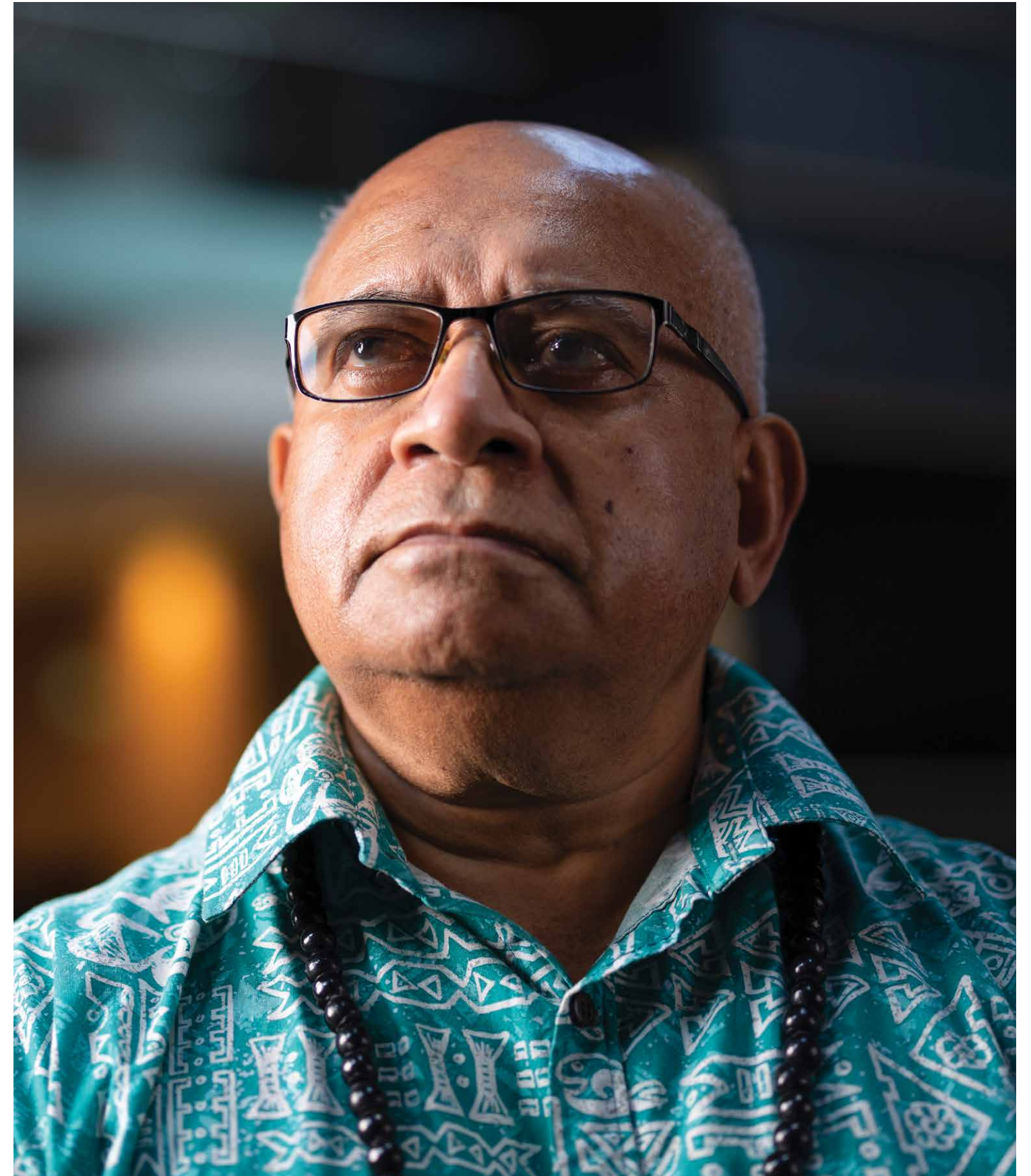


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