Khalifa University Science and Tech Review

A quarterly science magazine published by Khalifa University

The Heat Issue

THE HEAT IS ON

Apocalypse wow!

Unforgettable journeys at the edge of climate change — **P12**

Flood insurance

'Sponge cities' harness nature to manage - and better use - rain from storms supercharged by climate change — **P32**

Blood, sweat and fears

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Nature's cool ideas

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Khalifa University Science and Tech Review

KUST Review is dedicated to publishing authoritative, reliable and accessible information about science, innovation and technology news and trends. Although we report on news from around the world, we highlight advances, innovators and topics of interest from the Middle East and North Africa region. Our mission is to spread knowledge of and enthusiasm for science and technology in the Arab world and beyond through responsible and trustworthy journalism.

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Khalifa University

Shakhbout Bin Sultan Street, Abu Dhabi,
United Arab Emirates

CONTRIBUTORS

Dean Everett
A professor of infectious diseases and lead for the Khalifa University Infection Research Unit. **Page 20**

Yousef Haik
Vice chancellor for academic affairs at the University of Sharjah. **Page 68**

Maria Machado
An affiliate consultant with Maverick Publishing Specialists. **Page 69**

Gustavo Patino
The associate dean for undergraduate medical education and an associate professor in the Department of Medical Education at the Western Michigan University Homer Stryker M.D. School of Medicine. **Page 70**

LETTER FROM
THE EDITOR

A scorching summer made the newspaper front pages and website home pages in 2024 with stories about record high temperatures, power grids struggling to keep up with the demand for air conditioning and more than a thousand heat-related deaths of pilgrims on hajj.

Sadly, 2024 wasn't an aberration. Soaring temperatures are expected to become ever more common. According to a Guardian survey of many of the world's leading climate scientists, 80 percent expect temperatures to rise at least 2.5 degrees Celsius above pre-industrial levels.

Half of these experts foresee at least a 3C increase. Only 6 percent thought temperatures would be held to the internationally agreed 1.5C limit.

Consequences could be severe and far-ranging as heat fuels famine, conflict, fires, storms and more.

In this issue of *KUST Review*, we look at a few of the looming dangers, such as how warming oceans feed the red tides that damage economies and even threaten national security.

Guest columnist and Khalifa University epidemiologist Dean Everett discusses how a warmer Earth might lead to more human diseases. And senior science writer Jade Sterling describes how climate change might affect locations around the world.

We also look at the ways science is helping to mitigate these dangers, with stories on how reflective surfaces might keep buildings cooler; why "sponge cities" work with nature to prevent floods and conserve water; and how artificial mangroves use the sun's heat to desalinate water.

You'll find even more in these pages, on our website, www.KUSTReview.com, and on Facebook, Instagram, LinkedIn, X and YouTube @KUSTReview.

So page, click, subscribe and follow to get the best of our coverage of science in the Middle East and around the world in English and in Arabic.

As always, be informed and stay curious.

Dr. Arif Sultan Al Hammadi
KUST Review Editor-in-Chief

IN THIS ISSUE

THE HEAT IS ON

This issue is bringing the heat.

We're talking about changing climates and the dangers they pose as well as some of the solutions scientists and engineers are working on.

For example: Changing temperatures mean sand dunes might soon encroach on human settlements. We also look at heat-resistant materials inspired by nature.

In other stories, we spend a day at the races with autonomous vehicles and our panel of experts discusses how AI might impact scholarship.

REGULAR CONTENT

SHIFTING DUNES

Desert dunes could encroach on towns and crops thanks to changes in global wind patterns

By: **Jade Sterling**

DESIGN: Anas Albounni, KUST Review
PHOTOS: Unsplash

Sand dunes form when wind blows sand into piles, creating shapes depending on the wind speed and direction. Sand blows up the windward side of a dune and slides down the leeward side. Like a game of leapfrog, the dune slowly moves.

This movement is glacial — incremental movements as small as a grain of sand each time — but over time these movements add up. And climate change could change their speed, shape and direction.

Deserts around the world are already encroaching on civilization, threatening farmland and infrastructure. The rate at which dunes move varies, depending on the velocity of the wind and the topography of the region.

“Sand dunes in arid regions are conspicuous mobile landforms that require adaptation and mitigation strategies to protect human infrastructure and economic assets from encroachment, and (they) play a substantial role in desertification and atmospheric dust emissions,” says Andreas Baas, professor of aeolian geomorphology at King’s College London.

“Desert dunes and sand seas cover approximately 20 percent of the world’s arid zones, and their morphology and patterning are an important diagnostic of environmental surface conditions, not only on Earth, but also on other planetary bodies.”

Baas’ latest research focused squarely on terrestrial sand as he and King’s College London colleague Lucie Delobel investigated how the shape, migration speed and direction of mobile desert dunes are projected to change by 2100 around the world in direct response to changes in wind patterns. »»

The researchers say a changing wind climate plays a key role in this — and climate change is in the driver's seat. "We were surprised to find many regionally significant future increases in potential sand drift and changes in wind regime, which can impact the migration and shape of desert dunes," Baas tells *KUST Review*.

"The general assumption previously was that global warming leads to smaller temperature differences around the world (because poleward regions are heating up more) and that these smaller temperature differences would lead to weaker winds.

We found that the poleward expansion of monsoon systems in particular will have a major impact on dunes in places like Oman and Mauritania." Baas points out that while most dunes around the world are unlikely to change their shape due to changes in winds, around 10 percent will, and some dune fields are likely to change their direction of movement.

"We found that 73 percent of the current desert dune areas are projected to experience a significantly different drift potential," Baas says. Drift potential is defined as the total amount of sand transportation by wind. "Around one-third of desert dune areas will see an increase, while the other two-thirds will see a decrease."

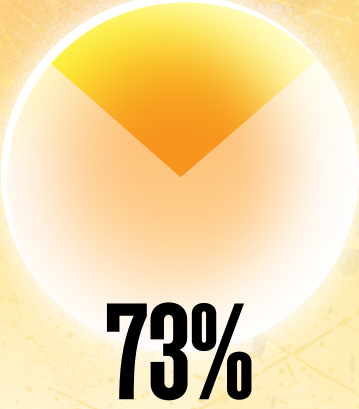
Dune movement will still be very slow and incremental, but over time it could cause serious problems to infrastructure and the fragile ecosystems surrounding areas of sand.

"In many desert countries, the layout of settlements and infrastructure has been historically adapted to the local dune shapes and dynamics," Baas says. "In the UAE, for example, there are many villages and infrastructure — even airports — that are built in between long seif dunes that run from west to east.

> **"Deserts around the world are already encroaching on civilization"**

20%

of the world's arid zones are desert dunes and sand seas



73%

of the current desert dune areas are projected to experience a different drift potential

If those seifs break up into smaller dunes, they may migrate towards a more southerly direction and those settlements will become buried by sand. In other places, such as Rajasthan, sand dunes may migrate faster and become a bigger problem to deal with where they're overrunning agricultural fields."

The researchers note that changes in dune behavior may need to be considered in planning and management efforts as mitigations designed for the current wind climate, such as sand fences and green belts, may become locally less effective — under a changing wind direction, for example — or even unnecessary, if dunes transform from a migrating to an elongating type.

More precise models are needed for site-specific recommendations. "The planet's history has seen many vast changes in deserts and dune fields in its long history, but now is the first time that humans have come along and have built assets in between the dunes," Baas says.

"Our projections based on a global climate-change model suggest that potential sand drift in the UAE may decrease somewhat in the future, but these global models are not good at representing regionally important weather events like the shamal.

"And other studies predict that such extreme events will become stronger, in which case future shamal winds may kick up more dust and move more sand."

Longer springs, warmer nights

The **arid and semi-arid regions in northern Africa and southwest Asia have been expanding**, exacerbated by rapid population growth and climate warming, according to a study in *Scientific Reports* from Khalifa University's Diana Francis and Ricardo Fonseca.

The study investigates atmospheric circulation changes and their effects on clouds, moisture, dust and radiation across northern and equatorial Africa, southern Europe, the Middle East and southwest Asia. The researchers note that **daily nighttime temperatures are increasing faster than daytime temperatures**, particularly in summer, due to higher atmospheric moisture and dust levels.

In winter, convective regions have shifted eastward in Africa, increasing low-level clouds in subtropical regions and shifting dusty areas southward. Future climate projections (2066-2100) suggest **longer springs and shorter autumns**.

The subtropical highs over North Africa and the Arabian Peninsula are projected to migrate polewards by 1.5 degrees in latitude, a trend statistically significant at 95 percent confidence level, in line with the projected expansion of the Hadley Cells.

The Hadley Cells are the convective cells over the tropics. As they expand, **the southern Arabian Peninsula (currently subtropics) may shift toward a tropical-like climate** with increased rainfall frequency per year. The study highlights the importance of accurate, high-resolution climate models that account for dust and pollutants in the MENA region.

Such models, the researchers note, are crucial for reliable climate projections and for supporting climate resilience and mitigation initiatives, including the transition to renewable energy sources.

⊙ **RIGHT:** These photos are not of tropical forests in Brazil nor the Italian country side, but of Saudi Arabia's South.

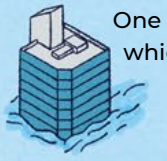
PHOTOS: Shutterstock

UAE protects its artificial islands and coastline from the effects of climate change

By: **Maggie Kinsella**

ILLUSTRATIONS BY: Abjad Design

The UAE is renowned for its ambitious engineering projects, including five sets of human-made islands. These islands, however, may become vulnerable to rising sea levels caused by climate change. That's why the UAE is working now to fortify these land masses and more.



Research in the UAE uses remote-sensing data, sea-level projections and coastal hydrodynamic models to assess the impact of rising seas along the country's coastlines. This research has identified the country's low-lying and shallow-sloping geography as particularly vulnerable.

"These models allow us to simulate the impacts of rising sea levels under various scenarios," says Maryam Rashid AlShehhi, who studies reefs and reef restoration at Khalifa University.

Research teams have identified two critical risk areas: displacement and economic instability due to flooding and erosion; and ecosystems and communities in low-lying areas, encompassing natural habitats and developed regions in low-elevation coastal zones.

"These areas face high risks of habitat loss, increased flood frequency and ecological degradation. For example, coral reefs, which rely on stable water conditions, face stress from both rising sea levels and potential increases in turbidity and sedimentation due to coastal erosion. Saltwater intrusion is another concern, as it can compromise freshwater supplies and agricultural productivity in coastal areas, leading to broader socio-economic effects," AlShehhi tells *KUST Review*.

To combat this, breakwaters have been constructed along the coasts of Ras al Khaimah and Fujairah, and Abu Dhabi is mandating seawalls for upcoming waterfront developments.

But sustainable methods will also be used.

One method involves mangroves, which not only act as a carbon sink, but also protect the coastline.

Their dense biomass and intricate root systems can withstand powerful waves, including those from hurricanes, and thrive in oxygen-poor coastal soils. Mangroves excel at trapping sediment from rivers and oceans, which is both a strength and a vulnerability.

While sediment accumulation around their roots helps build land, a disruption in sediment supply leaves the plants vulnerable.

In 2023, *Arabian Gulf Business Insight* reported that the Environment Agency – Abu Dhabi in partnership with environmental tech company Dendra embarked on a project to plant 27 million mangrove trees in Abu Dhabi by 2030. This is part of the UAE target of 100 million mangrove trees within the same timeline.

"The UAE also uses artificial reefs and 'living shorelines,' which combine vegetation, sand and other natural elements to create more resilient and eco-friendly shorelines," AlShehhi says. "Several projects have been supported on artificial intelligence-driven solutions for real-time monitoring and adaptive responses."

Other collaborations will address the challenge of rising sea levels. Khalifa University recently worked in conjunction with the Ministry of Climate Change and Environment (MOCCAE) and other universities and organizations to produce a national report on the impact of climate change on the environment.

Additionally, the UAE Climate Change Research Network, led by MOCCAE, brings together universities, research institutions and government agencies to share data, initiate research and develop policy focused on addressing climate challenges like sea-level rise.

Diana Francis of Khalifa University leads the network's Cluster on Climate Data and Modeling.

These are only a fraction of collaborations in action locally and regionally.

"By enhancing natural defenses, the UAE strengthens its resilience against rising sea levels and extreme weather, which aligns with broader regional efforts to prepare for climate impacts," AlShehhi says. "The UAE's focus on restoring mangroves, seagrasses and coral reefs promotes biodiversity, supporting marine ecosystems that are critical for fisheries, tourism and ecological balance, which is in line with regional priorities to preserve natural habitats.

"The UAE's sustainable practices set a regional example, encouraging neighboring countries to adopt similar approaches," AlShehhi says.

APOCALYPSE WOW!

Unforgettable journeys at the edge of climate change

By: **Jade Sterling**

Welcome to the *KUST Review* traveler's guide to the world.

If you're looking for a travel destination that either has been ravaged by climate change or is about to be, this is the brochure for you. 2023 was officially the world's hottest year on record. The average global temperature for the year was 1.48C warmer than the 1850-1900 pre-industrial average, according to the European Union's Copernicus Climate Change Service.

That's perilously close to the 1.5C limit set under the 2015 Paris Agreement — certainly close enough to make planning your post-1.5 world travel dreams a reality very soon. Beat the rush – if not the heat – with our guide to the top 6 destinations.

New England

Experience the magic of autumn, one last time

NY, USA

HIGH

From the fleeting magic of fall to the fall of the trees themselves.

As summer fades, New England transforms into a canvas painted with the fiery hues of autumn. From the rustic charm of Vermont's country roads to the coastal serenity of Maine, the journey promises a symphony of fall foliage.

A classic road trip surrounded by a kaleidoscope of red, orange and yellow leaves could be yours for as long as the trees stay standing.

Global warming-driven increases in hurricanes mean they might not be around for much longer.

Shersingh Joseph Tumber-Davila is a Dartmouth College terrestrial ecosystems ecologist studying the response of ecosystems to global environmental change. He says a single hurricane hitting New England might result in the release of more than a tenth of all the carbon stored in the area's forests.

As you wander through the autumnal beauty, look around and notice that woodland covers about 75 percent of the New England land area. Take a moment of gratitude for the trees that remove some 16 million tons of carbon dioxide from the atmosphere each year.

Tumber-Davila's team used computer models to calculate the carbon losses that would occur in storms with 8 to 16 percent higher wind speeds than those of the 10 biggest New England storms of the 20th century. These higher wind speeds are possible as a result of global warming. They found that even a storm of the same wind speeds as the Great New England Hurricane of 1938, which downed 70 percent of standing trees in some areas, could release 120 million tons of carbon if it were to occur today. Make the winds 16 percent faster and that number jumps to 250 million tons.

"The emissions are not instantaneous, however," Tumber-Davila says. "It takes approximately 19 years for the downed carbon to become a net emission, and 100 years for 90 percent of the downed carbon to be emitted."

Tumber-Davila also points out that these estimates are conservative, but no matter: 70 percent of the New England forest could end up on the floor, joining the soft rustling of leaves beneath your feet.

Let New England's fall beauty captivate your senses but maybe don't count on these forests being a carbon sink for your travel emissions much longer. »»

PHOTO CREDIT: Unsplash & Freepik

Siberia

The ultimate chill in sunbathing adventures

SI, RUS

38°C

Where the sun shines bright and the ice quickly melts.

Forget the Caribbean, the Mediterranean is so last season, and who needs the Maldives to stay above water anyway? Siberia is the hottest new destination to catch some rays.

The Arctic is warming faster than any other region on Earth, according to Rashit Hantemirov from Russia's Ural Federal University: "Siberia is among the regions with the strongest warming worldwide, and heatwaves have reached a disturbing new level in recent years, especially in 2020 when temperatures soared across Siberia to reach a record-breaking 38C inside the Arctic Circle."

Scientists say "disturbing" — we say "opportunity!"

Be among the first to experience the great Siberian tanning tour across the most sun-soaked, formerly frost-kissed locations the Arctic Circle has to offer.

And who says sunbathing is a midday activity? In the far north, the summer brings the midnight sun, giving you 24-hour opportunities to catch those rays.

Bask in record temperatures this summer for the low, low price of devastating, cascading effects on local ecosystems, human communities and the built environment.

Remember to get your Arctic zombie virus shots before you go!

Ancient viruses frozen in the Arctic permafrost could soon be released and unleash a major disease outbreak, and no one wants to be ill on holiday. Anthrax is a killer accessory to a nice tan.

Australia

A glimpse into tomorrow's oceans today

QLD, AUS

HIGH

Dive into the future in Australia with a trip to the bleached coral of the Great Barrier Reef. Welcome to the future of underwater adventure, where the vibrant colors of life meet the stark reality of change. Australia's coral reefs, once bursting with life, now offer a different kind of beauty — a ghostly, otherworldly landscape just beneath the waves.

An estimated 80 percent of the Great Barrier Reef has suffered severe bleaching in rising ocean temperatures, and you can now embark on a guided tour through the most famous underwater graveyard.

Our expert guides will narrate the tale of once-thriving coral ecosystems, now standing as silent sentinels of the sea. Since 2016, the Great Barrier Reef has experienced five mass bleaching events, say researchers at the Great Barrier Reef Marine Park Authority, which monitors the health of the coral.

In 2024, the latest event was caused by heat stress and affected two-thirds of the reef. The authority's chief scientist, Roger Beeden, says it's too early to say what the full consequences of this event are, but hopes that if conditions cool, much of what's bleached could recover.

In the meantime, glide over ghostly coral gardens, where the absence of color tells a thousand stories. For an optional extra, take part in one of our neon night dives. As the sun sets, dive into an eerie underwater neon party. Special UV lights reveal the fluorescent glow of the bleached corals, creating an unforgettable luminescent spectacle: nature's own discotheque! »»

An Amazonian Adventure

Sizzle in the jungle

SA

47°C

If an autumn trip isn't an option, you could summer in the rainforest and still experience the fall beauty.

Embark on the hottest journey of your life and forget the cool, lush canopies of yesteryear: This Amazonian adventure promises an up-close encounter with the sizzling future of the tropics.

Already, a small proportion of leaves in the canopies of tropical forests are dying from heat stress (about 0.01 percent), but Christopher Doughty at Northern Arizona University is far more pessimistic: "We are predicting total leaf death," he says. "Even a small change in temperature could greatly impact tropical plant species."

His team placed temperature sensors on leaves in the upper canopy of Amazonian rainforests. As temperatures increase, more leaves are affected, and the more leaves that are affected, the warmer the existing forests become.

After about 47C, leaves can't photosynthesize as the cells that capture energy from sunlight are too damaged. Plus, in hotter temperatures, the stomata on leaves close to prevent water loss. Without the cooling effects of evaporation — or plant sweat — the leaves get even hotter.

But hey! On this tour, glide through the treetops on a zipline, where the leaves are so sparse, you won't need to worry about the obstructed views! Witness firsthand — and at speed! — the impact of extreme heat on the rainforest's once-teeming biodiversity. What fun!

After your thrilling zip across the forest, find your way down to the banks of the Amazon River, now warmer than your average hot tub, not to cool off, but to catch a glimpse of the world-famous pink dolphins. Don't look too far out to water though: You're much more likely to spy one washed up dead on the shore.

The dolphins may be on the International Union for Conservation of Nature's red list of threatened species, but your chances are good to spy a carcass or two. The Amazon basin is experiencing its most intense dry season in more than a decade, and extreme temperatures could be picking off the wildlife.

At least 125 dolphins died in a single Brazilian lake in 2023, but with an estimated 13,000 left in the wild, there's still time to go dolphin-watching.

Antarctica

Experience the warmer side of the world's coolest continent

AN

38°C

Chill out in the new and improved Antarctica, now with less ice and even fewer penguins!

Leave the bulky parkas and cumbersome snow boots at home: Antarctica is warming up to tourists in a whole new way.

Welcome to the world's most exclusive destination, now more accessible than ever. Long gone are the chilly receptions of the past — say hello to a warmer, more welcoming Antarctic adventure.

Antarctica is melting faster than ever, according to the World Economic Forum, losing 150 billion tons of glacier ice a year. Warmer ocean temperatures melt the ice sheet but also thin the floating ice shelves that hold the ice sheet on the land. As ice shelves lose strength, more ice flows into the sea, raising the sea level and accelerating ice loss. Compared to 2016, the sea ice surrounding Antarctica in 2023 was missing an area the size of Libya.

In March 2022, the most extreme heatwave ever recorded on Earth hit East Antarctica: Temperatures were 38C higher than "normal." This came as no surprise to Edward Blanchard-Wrigglesworth, part of the research team investigating this event: "The heatwave was skillfully forecast, resulting from a highly unusual weather pattern which produced strong northerly winds and imported warm and moist air from Australia. Weather forecast models predicted the heatwave up to eight days in advance.

"We found that the heatwave was made 2C warmer by climate change, and we expect future end-of-century heatwaves to be 5 to 6C warmer."

Sunny days and comfortable nights bring barefoot strolls along the newly formed beaches of the Antarctic coast, where the only ice you'll find is in your drink. Enjoy the surreal experience of sunbathing where once only penguins dared to tread.

Speaking of penguins, capture the perfect, unobstructed landscape shots in our penguin-less paradise.

With these pesky crowds on the decline, you'll have uninterrupted views of Antarctica's stunning, changing landscapes.

In 2023, record sea ice loss caused a mass die-off of emperor penguin chicks, prompting concerns the world's largest penguin species could soon be extinct.

Emperor penguins breed on sea ice rather than on the land. In 2023, the sea ice broke up much earlier than expected, and the fledgling penguin chicks did not have enough time to grow the black waterproof feathers and muscles needed to swim.

They fell into the water and drowned or froze: Four out of five colonies suffered a total breeding failure, says British Antarctic Survey's Peter Fretwell.

"Emperor penguins are an iconic symbol of Antarctica threatened by climate change," Fretwell says. "Recent efforts to predict emperor penguin population trends from forecasts of sea ice loss have painted a bleak picture, showing that if present rates of warming persist, over 90 percent of emperor colonies will be quasi-extinct by the end of this century.

"Climate change is considered the only major driver of their long-term population change."

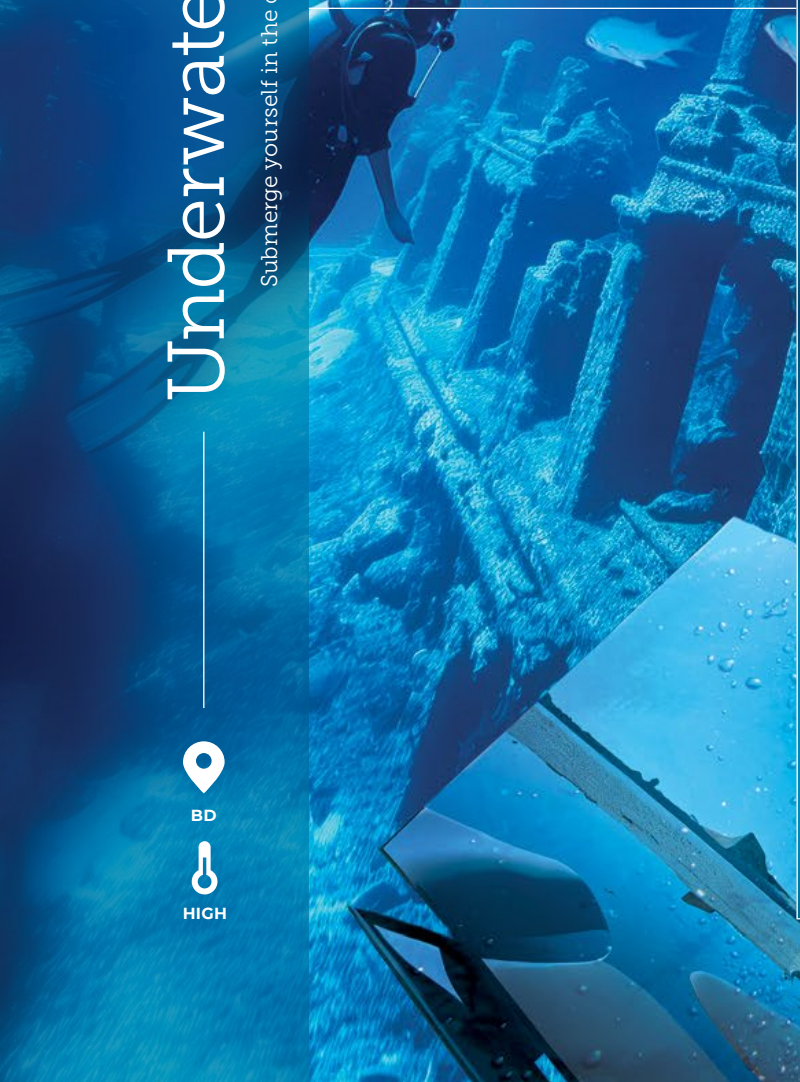
So grab your swimsuits and prepare to enjoy the new Antarctica with more comfortable temperatures and no pesky penguins underfoot. One dip in the world's largest outdoor heated pool and you'll soon forget you're in the once frozen wilderness. »»

Underwater Odyssey

Submerge yourself in the cities of the future today!

BD

HIGH



Embark on an unparalleled diving adventure where the treasures of civilization meet the mysteries of the deep. Our exclusive Underwater Odyssey takes you on a submerged journey to the splendors of Bangladesh and Vanuatu in a world tour unlike any other. These destinations are reimagined for a world post-sea-level rise. Strap on your scuba gear and dive into history, culture and the stark reality of our drowning planet.

One of the more dramatic potential outcomes in a warming world is the collapse of the Greenland ice sheet, which could be triggered by a 1.5C rise, and would cause a 7-meter rise in global sea levels. Chad Green, California Institute of Technology, found nearly every glacier in Greenland has thinned or retreated over the past few decades at a rate of 30 million tons of ice per hour. All that water has to go somewhere and that includes the tropical island nation of Vanuatu.

Formerly home to some 260,000 residents, the 82 volcanic islands now sit beneath the waves, creating an 800-mile diver's paradise. Discover the vibrant coral gardens that have overtaken the once-idyllic archipelago, navigate underwater bungalows and submerged villages, where the fusion of culture and coral creates a breathtaking underwater maze. For the more adventurous, dive into the depths to witness submerged volcanic landscapes, where the fire now dances with the ocean in a steamy, ethereal ballet. The warmth of thermal vents attracts an array of marine life, creating a vivid tapestry of color against the ghostly backdrop of lost lands — perfect for the aspiring underwater photographer!

Sensitive to sea water? Our stop in Bangladesh offers river-water dives through sunken mangrove forests and the drowned streets of Dhaka, where the hustle and bustle of the city have been replaced by the serene silence of the deep.

As monsoons intensified and glacial meltwater rushed down from the mountains, severe flood events became more common, hitting the world's eighth-most populous country. Voyage into the heart of the country that used to sit on the largest river delta in the world, at the confluence of the Ganges, Jamuna and Meghna rivers, and is now a must-visit for fans of ornate architecture home to schools of weaving fish.

If you want to give back, cultivate change in the land of the midnight sun at this unique Finnish voluntourism farmstay opportunity.

As the world shifts, so too does the landscape of Finland. Once known for its endless forests and frozen tundra, climate change is reshaping parts of this Nordic wonderland into burgeoning farmlands. Dive hands-first into the heart of Finland's emerging agricultural scene.

Alexandra Gardner, University of Exeter, says as the climate warms, crop production will increasingly shift into wilderness areas: "2.7 million square kilometers of wilderness will become suitable for agriculture within 40 years, equivalent to 7 percent of the total wilderness area outside Antarctica. The increase in potentially cultivable land in wilderness areas is particularly acute at higher latitudes in the northern hemisphere, where 76.3 percent of newly suitable land is currently wilderness. "

While Gardner's results don't account for whether our current crops could be grown in these new areas, you can give it a go as you experience the Finnish countryside like never before. Partake in the cultivation of crops from hearty root vegetables to more exotic produce and witness the green revolution in real-time. Don't worry about any biodiversity loss or natural habitat destruction: Your farming efforts can only contribute to a greener, more productive farm ecosystem. This isn't just a holiday: It's a hands-on contribution to a global challenge.

As climate change redraws the map of what's possible, your efforts in Finland will help sow the seeds of change.

Finland

Embrace the rustic life in the tamed wilderness

FI

HIGH

DESIGN : Rawan Ghonim, Khalifa University
PHOTOS: Shutterstock, Unsplash, Freepik

We must prepare for climate change's effects on human health

DEAN EVERETT: Professor of infectious diseases and lead for the Khalifa University Infection Research Unit.

The consequences of **human-caused** climate change are already seen across the world, with hotter temperatures, rising sea levels and more frequent and severe storms. **Climate change** is our planet's most immediate and biggest threat, and it will likely only worsen.

Among its numerous negative effects on human health, there is increasing evidence linking climate change to increased prevalence of infectious diseases and outbreaks.

Infectious diseases are caused by microbes that make us ill. Microorganisms prefer particular climate conditions.

Changes in weather patterns that favor the conditions needed by a pathogen, particularly in terms of average temperature, rainfall and humidity, for example, will only benefit its ability to survive and spread.

Conditions that favor vectors such as rodents, mosquitos and ticks that support pathogen reproduction and transmission will also help some infectious diseases spread. More and more studies are demonstrating the association between climate and the increasing threat of zoonotic (animal-to-human) diseases. Rising temperatures may increase the breeding rate of disease vectors such as mosquitoes and the infectious agents they carry, such as malaria, and expand their reach.

Chikungunya and dengue viruses, which are transmitted by mosquitoes or ticks, now occur in South Asia, South America and Europe in previously unaffected areas. Increased temperatures across North America, for example, are expanding the range of ticks that carry Lyme disease. They're also providing better conditions for bats and other suspected hosts of Ebola in Central Africa.

As global temperatures rise year on year so too have the number of outbreaks of infectious diseases. SARS, MERS, Zika, West Nile, COVID-19, and more recently monkeypox and polio, have all threatened public health in recent times.

A study in *Nature Climate Change* aimed to understand the relationship between major environmental changes such as global warming, rising sea levels, storms, floods, drought and heat waves and the outbreaks of 375 human infectious diseases.

It showed that 58 percent of these public-health threats were fueled by climate change. What seems to be happening is that the host animals the pathogens infect are affected by changing climates.

Increasing global temperatures, for example, mean that the geographic range for many pathogen-carrying animals, including insects like mosquitoes, is expanding rapidly.

So we can better understand what our future holds....

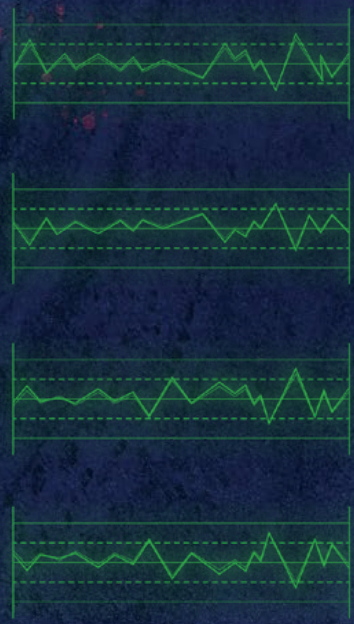
Experts say the world is not prepared for climate-driven outbreaks and call for more studies to:

1. **Better understand how pathogen survival and spread is affected by temperature and humidity.**
2. **Better understand how ecological changes and human behavior affect the spread of infectious diseases.**
3. **Model the interactions between infectious diseases and climate at regional or global and local scales.**
4. **Identify interventions that will reduce risks today and as the climate continues to warm.**

RED ALERT

WHY A COLORFUL PHENOMENON THREATENS YOUR HEALTH, THE ENVIRONMENT AND EVEN THE WATER YOU DRINK

By: **Suzanne Condie Lambert**



In 2008-2009, a deadly algae bloom struck the Arabian Gulf. The cluster of *Cochlodinium polykrikoides* was so large it threatened millions of residents, the ecology of the waterway itself and even national security.

In the years since, smaller blooms, also called red tides or harmful algal blooms, have hit the Gulf region. And warming waters seem to assure that such events will become larger and more frequent in the Middle East and around the world.

Algae aren't inherently bad, though, says Shady Amin, an associate professor of biology at New York University Abu Dhabi who studies the phenomenon in the UAE and the Gulf of Mexico.

"Algae are actually for the most part good and important," he tells *KUST Review*. "Without algae there would not be life on Earth. They make the oxygen we breathe. All the fish we eat is because of algae. There are good blooms that happen in the open ocean. If you go to the North Pacific, for example, very well known spring blooms enrich the food web and that's how you get whale-watching."

But bad blooms? The kind fed by warming waters and runoff from human activity like construction and agriculture? They can be catastrophic.

HUMAN HEALTH

Humans don't even have to be in the water to be harmed by a red tide.

The algae can produce toxins that build up in the food chain, so humans who consume the shellfish and other fish that eat these algae face serious health risks, Amin says.

"Not to mention that in areas that have a lot of wave action, a lot of these toxins can get spread into aerosols that people can inhale as they walk across a beach."

> **It's only because of us overdeveloping our coasts and dumping things in the sea water that leads to these harmful red tides.**
>
> — Shady Amin, an associate professor of biology at New York University Abu Dhabi

It's not just walking across a beach that can expose people to these risks. A study in the U.S. state of Florida found a spike in hospital visits involving respiratory distress during red tides.

And some species may not be toxic, but they can still produce irritants that affect skin and eyes. That was the case in 2018 when Abu Dhabi authorities closed local and tourist favorite Saadiyat Beach to swimmers. »»

ECOSYSTEM DAMAGE

Fish and other marine animals suffer as well. Get a big enough bloom, and the algae consume the oxygen in the water, creating dead zones that suffocate other sea creatures.

Animals not in those dead zones can still be injured or killed, like humans, by consuming fish or shellfish tainted by the algae's toxins.

The results can be devastating.

The 2008-2009 event off the UAE coast, for example, wiped out thousands of tons of fish and damaged coral reefs, according to researchers who studied it.

And a 2018 red tide left Florida beaches littered with rotting fish, eels, porpoises, turtles and one nearly 8-meter whale shark.

Also in Florida, the same sort of respiratory problems that affect humans can afflict manatees, a threatened species, sometimes killing them.

The toxins can even produce a foam that fatally strips the weatherproofing from seabirds' feathers.

ECONOMY AND NATIONAL SECURITY

Human industries suffer as well, and not just the fisheries that rely on healthy waild and farmed stocks in the ocean.

In 1995, a *C. polykrikoides* bloom lasting eight weeks along the entire south coast of Korea resulted in economic losses totaling U.S.$95 million.

Refineries and other coastal industries take a hit when blooms clog seawater-intake systems.

Tourism, too, suffers when locations sold as escapes to the sun and the sea become unsafe – and unpleasant – to visit.

That 2018 red tide in Florida cost the state about U.S.$2.7 billion in tourism revenues, according to a study from the University of Central Florida.

But the UAE, which relies on desalination plants along its coast to supply most of its population with clean water, faces additional threats if harmful algal blooms force the plants' closure.

This happened in 2008-2009, when the red tide struck the Arabian Gulf, forcing Gulf Cooperation Council governments to order desalination plants to shut down.

The 70 plants in the UAE provide most of the country's potable water. And this alarms Athol Yates, who keeps an eye on civil-security matters as part of his work at Khalifa University. »»

ILLUSTRATION: Abjad Design
PHOTOS: Unsplash, Freepik, Shutterstock

A BETTER FILTER

High levels of nutrients sounds like a benefit to an ecosystem, but when an environment receives too many nutrients, otherwise known as eutrophication, algal blooms and hypoxic waters can kill fish and seagrass.

"The high accumulation of nutrients, including nitrogen and phosphorus, discharged into surface water, rivers and reservoirs can accelerate eutrophication and cause great damage to the aquatic ecosystem," says Shadi Hasan, director of the Center for Membranes and Advanced Water Technology at Khalifa University. "We need to control the levels of nutrients and develop innovative technologies to treat water and remove excess nutrients."

Treatment technologies already exist. However, chemical methods can introduce undesirable byproducts; and biological treatments take much longer and are inefficient in their use of nitrogen. Additionally, no available method offers complete water purification.

Novel membrane technology, however, may be the solution. Hasan's KU research team has developed a composite polylactic acid (PLA) and nanomaterial membrane to remove nutrients from wastewater. The membrane works via adsorption. The research team used a functionalized positively charged multi-walled carbon nanotube/graphene oxide hybrid nanomaterial to remove nitrogen (as ammonia) and phosphorus from wastewater while enhancing water permeability. The nutrients are filtered out by collecting in the pores of the nanotubes at the surface of the membrane.

But such a membrane needs to offer water permeability. As more nutrients adsorb and collect, the amount of water passing through decreases. The research team's membrane, however, offers high water flux even when filtering the nutrients.

The carbon nanotubes increase membrane tensile strength significantly, while the graphene oxide enhances thermal stability and tensile strength and provides antibacterial properties. This supports water flux and provides hydrophilicity to the end product.

While the effects of graphene oxide and carbon nanotubes in water purification are well-documented, studies are limited when it comes to combining the two as a nanohybrid.

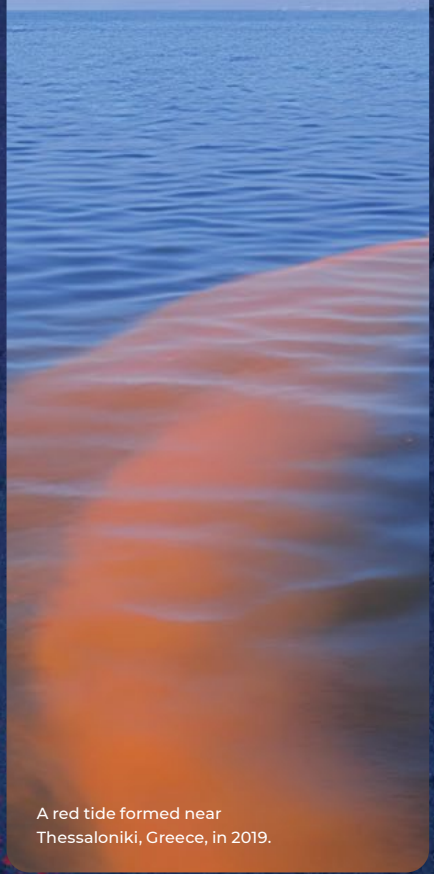
"After a comprehensive review of the literature, our research group is the first to report the fabrication of such composite PLA membranes for the removal of nutrients from synthetic and real wastewater," says Hasan, who adds that the team is investigating ways to scale up the membranes for larger applications.

By: **Jade Sterling**

WHEN IS A RED TIDE NOT RED?

Harmful algal blooms are often called red tides, but they can be other colors as well.

Some are brown, burgundy, orange, green, yellow or even bioluminescent depending on the pigment of the cells and weather conditions.



A red tide formed near Thessaloniki, Greece, in 2019.

"If you shut down the desalination plants, normally you have a supply for a day or two," he says.

"In general, virtually the only water you've got is in the water-distribution network, which starts with the desalination plant and ends with your tap.

"Of course, the bulk of that water is not used for drinking purposes but (for things like) watering gardens. If you can get a message out saying, 'Do not use the water for any other purpose, don't wash your car,' it will last longer. But the issue is how long will that message take to get out," Yates says.

The country has mitigation measures in place, he adds.

"The government has built a water network with redundancy, like an electricity network.

"So if (nuclear power plant) Barakah goes down, you still get electricity from other sources. Same with the water system."

There is also strategic water storage, Yates says, pointing to a depleted aquifer in Liwa that has been refilled to become a below-ground reservoir.

"If bad things happen to the desalination network, they can pump the water there to supply the networks."

It's a limited resource, however. And it's an expensive solution.

The Abu Dhabi Water Resources Master Plan estimates that desalination plants' decreased production during the red tide cost the industry more than U.S.$100,000 (Dh368,000) a day.

GULF CONSIDERATIONS

The UAE and the Gulf have other special concerns when it comes to harmful algal blooms.

For one, Yates points out, the current around the Gulf is particularly slow, meaning a red tide might linger longer.

"These long, slow blooms can shut down the (desalination plants') intake across a large area," he says.

"When you think about it, the (distance from) Abu Dhabi to Ras Al Khaimah isn't that long."

NYU Abu Dhabi's Amin has seen how long blooms can linger. His team watched "a really nasty bloom" in Abu Dhabi's Yas Bay for about a year.

The source is uncertain, but Amin suspects runoff from construction projects or other human activity.

Amin also notes that the Arabian Gulf in general is highly oligothrophic, meaning it is nutrient-poor.

"We came to realize this very recently," he says. "What that means is there's not a huge amount of biomass in the water relative to areas that have a lot more nutrients.

So if you have any kind of disturbance of that system, any runoff water, from, say, development or agricultural land or a monsoon, or some kind of weather event, that can really disturb the system and suddenly you get a bloom. These things are highly unpredictable."

The Gulf also makes observing blooms difficult.

"One of the easiest things that people use is satellite imaging. It's free. And it's always there.

"Unfortunately it doesn't work here very well because the Arabian Gulf, especially the UAE coast, is extremely shallow," Amin says.

"Satellites measure light reflected off the Earth. And when you're trying to approximate if there's a bloom in a given part of the ocean, you're measuring the wavelength that's reflected off the water and there are algorithms that can calculate how much algae is in the water.

The problem is that if you have a shallow area, you have also light reflecting off the bottom.

It's much more complicated in that case, and that's exactly the problem we have here. So relying on satellites here is not an option."

WATCHING THE WATER

Florida invests heavily in its red-tide defenses, Amin says.

"We work closely with the Gulf of Mexico and the State of Florida. They have a program funded by the state with hundreds if not thousands of state employees that go out almost every day, and they collect water.

"If it matches a certain threshold that they know a bloom is happening, they alert the public and start taking action."

The UAE does not yet have these kinds of resources, Amin says, "but we're making progress."

"That's what we aim to do."

Oman, meanwhile, in early 2024 launched a predictive model to help warn of incoming red tides.

An early warning system is indispensable for countries in the region, especially as climate change could make red tides more frequent and deadly, says Jauad el Kharraz, head of research at Muscat-based Middle East Desalination Research Center.

He stresses that further research is vital to evaluate the relationships between red tides, climate change, ocean acidification and human health.

Amin, meanwhile, suggests that we should be looking closer at ourselves.

"It's only because of us overdeveloping our coasts and dumping things in the sea water that leads to these harmful red tides," he says.

UAE WATER SECURITY STRATEGY 2036

21%
Reduction in total demand for water

$110/m³
Reduction in total demand for water

74 billion
Savings in AED to be achieved

95%
Increase in recycling and safe reuse of treated water

Source: The United Arab Emirates Government Portal Website

SOLAR IMPACT

Global warming makes photovoltaics less efficient; cutting-edge materials can help

By: **Maggie Kinsella**

ILLUSTRATION: Abjad Design
PHOTO: Shutterstock

In a 1931 conversation with Henry Ford, Thomas Edison said, "We are like tenant farmers chopping down the fence around our house for fuel when we should be using nature's inexhaustible sources of energy – sun, wind and tide. … I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that."

And tackle that we did with photovoltaic cells made up of materials called semiconductors, typically silicon, that convert sunlight to energy.

A warming planet, however, reduces the efficiency of solar-energy technology.

That's because solar-panel efficiency drops by .5 percent every time the temperature rises by 1 degree Celsius. Sun shining on a solar cell excites electrons to a higher energy level due to the charge it creates. But when the cell is hot from the start, electrons are already in this excited state, which in turn produces less electricity.

So, what now?

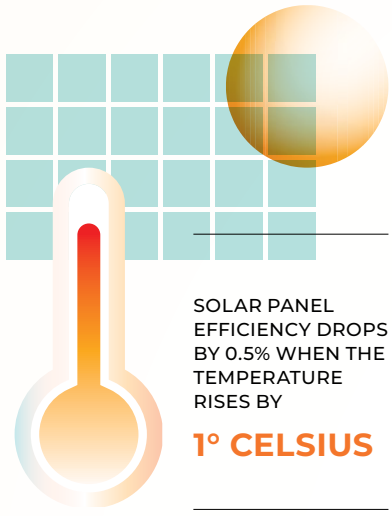
Solar technology is becoming more efficient, however. Researchers are developing cutting-edge materials and manufacturing models; multi-layer photovoltaic cells that absorb light from different parts of the spectrum like ultraviolet, visible light and infrared; and advanced technology like perovskites, whose specific crystal structure is highly efficient at converting sunlight to electricity.

Chinedu Ekuma, a physics professor at Lehigh University, sees the problem, particularly in the warmest climates, and possible new solutions.

"With rising global temperatures, solar panels are at risk of losing efficiency as excessive heat decreases their ability to convert sunlight into electricity. This can undermine solar energy's effectiveness in regions experiencing prolonged heat waves, pushing researchers to innovate materials that perform well even under extreme environmental conditions," Ekuma says.

Ekuma's research, funded in part by the U.S. Department of Energy, has produced a quantum material creating unparalleled solar-cell efficiency rates expected to contribute to next-generation, high-efficiency solar cells.

"Our newly developed quantum material, which incorporates intermediate band states, allows for a higher level of photon absorption and carrier generation. This innovation facilitates the generation of more than one electron per photon, pushing quantum efficiency beyond traditional limits, up to 190 percent, providing an exciting leap forward for photovoltaic applications," Ekuma tells *KUST Review*.



SOLAR PANEL EFFICIENCY DROPS BY 0.5% WHEN THE TEMPERATURE RISES BY

1° CELSIUS

This is especially significant because it implies the potential to exceed the Shockley-Queisser limit, which represents the theoretical maximum efficiency of a single-junction solar cell under standard conditions at 100 percent. In order to do so, the efficiency would have to exceed a maximum solar conversion efficiency of around 33.7 percent. »»

By 2050, solar energy is projected to supply nearly half of the Middle East's electricity needs.

This limit exists because not all sunlight has the right energy to be converted into electricity. Some bounces off without being absorbed. Some is lost as heat or is relaxed into lower energy states that aren't used. Some can't maintain the excited electron state and defaults to its original states before it can be used. And some photons simply don't have enough energy to boost the electrons.

Obstacles and applications

Ekuma's team doesn't foresee major obstacles to implementing its material into current solar energy systems. But scaling up to a commercial level of production and implementing the new material into existing technologies is going to take research and prices to come down, Ekuma says.

Ekuma's material could pose solutions for countries where the temperatures are among the highest.

These places include the Middle East, where more energy is used for cooling than anywhere else on the planet.

The region has over 300 days of sunshine each year. According to Rystad Energy, it is expected to reach solar capacity of close to 23 gigawatts of power by the end of 2024.

Solar energy is expected to reach close to 50 percent of the regional power supply by 2050.

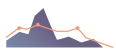
The Middle East and North Africa Region signed a pledge at the 2023 COP28 event hosted in Dubai to add 62 gigawatts of renewable energy over the following five years. Of that, 85 percent will be solar.

OVERCOMING THE HEAT:

A quantum leap in solar energy

> **The energy of the sun is the original source of almost all forms of energy on Earth."**
>
> — Nikola Tesla

THE CHALLENGE:



The reality: solar panel efficiency drops 0.5% For every 1°c temperature rise.

Why? Heat excites electrons, reducing energy production.

THE SOLUTION:

Quantum materials: Lehigh University's Chinedu Ekuma developed a quantum material.

QUANTUM LEAP

190%

Potential efficiency, surpassing the Shockley-Queisser limit (33.7%).

REGIONAL GROWTH:

23

GW solar capacity by 2024 (Rystad Energy).

50%

Regional power supply by 2050 (projected)

62Gw

COP28 UAE

COP28 pledge: 62 Gw renewable energy by 2028 (85% solar).

THE FUTURE

Overcoming obstacles: scaling production and integrating new materials are key.

A brighter tomorrow: Ekuma's research paves the way for more efficient, heat-resistant solar power.

SOLAR IN THE UAE

The UAE has a number of solar energy projects in progress and aims to triple its clean-energy contributions by 2050.

The largest of four major projects is in the Al Dhafra region about 35 kilometers south of Abu Dhabi. The largest single-site solar power plant in the world spans more than 20 square kilometers of open desert. It was operationally ready in June 2023 and was inaugurated just ahead of the COP28 United Nations Climate Change Conference in Dubai.

The plant, fitted with close to 4 million solar panels, can bring electricity to close to 200,000 homes and save 2.4 million tons of carbon emissions annually. This is equivalent to removing nearly half a million cars from the road for one year.

The panel efficiency broke records in January 2020 with its bi-facial technology. January in UAE is ideal for maximum solar panel efficiency as temperatures average 25 degrees Celsius, the optimal temperature for solar.

Summer months, however, can reach 50 degrees, reducing efficiency by 10 to 25 percent.

Khalifa University's Samuel Sheng Mao says the UAE is continuously working to develop innovative solutions to combat the heat issue.

"An innovation and research and development center under Mohammed bin Rashid Al Maktoum Solar Park is dedicated to testing and developing new solar technologies, including advanced cooling systems and materials adapted to the UAE's climate. The park is involved in testing bifacial panels, advanced cooling techniques and integrating phase-change materials to enhance efficiency during extreme heat."

Mao is also director of the ASPIRE Research Institute for Sustainable Energy, where Khalifa University researchers have been developing concentrated solar power and thermal energy storage technologies. They have also developed a passive cooling technology to mitigate the thermal loads for next-generation solar cells, he says.

Solutions to improve efficiency also include thermal storage units that can be used during peak demand periods. This balances the load, takes strain off the main energy grid and allows for better distribution management.

One thing is for certain, as the world continues its hot trajectory, solar technologies research will have to keep pace.

"Continuous advancements in materials science and thermal management are expected to enhance the performance of solar panels further, making solar energy a more viable and sustainable option even in extreme climates," Mao tells *KUST Review*.

UAE SOLAR ENERGY ADVANCEMENTS

JANUARY 2020

Record-breaking panel efficiency achieved using bi-facial solar technology.

January's average temperature of 25°C supports optimal performance.

JUNE 2023

The world's largest single-site solar power plant in Al Dhafra becomes operational.

Covering 20 square kilometers, it features 4 million solar panels, powers 200,000 homes and saves 2.4 million tons of carbon emissions annually.

NOVEMBER 2023

The Al Dhafra plant is inaugurated ahead of COP28 in Dubai.

ONGOING

Khalifa University and the Mohammed bin Rashid Al Maktoum Solar Park focus on:

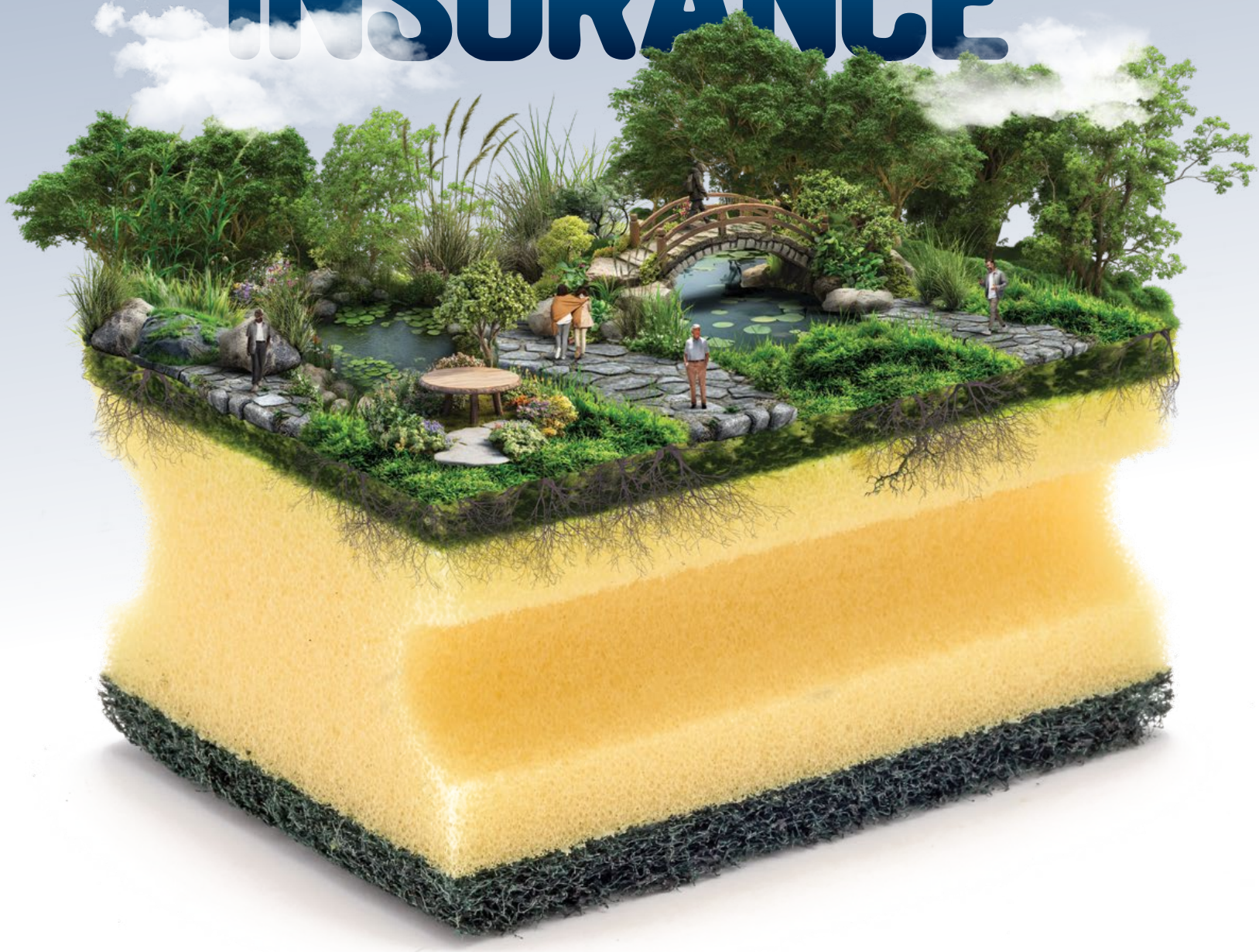
Advanced cooling systems and materials for extreme heat.

Thermal storage, passive cooling and next-gen solar cell technologies.

2050

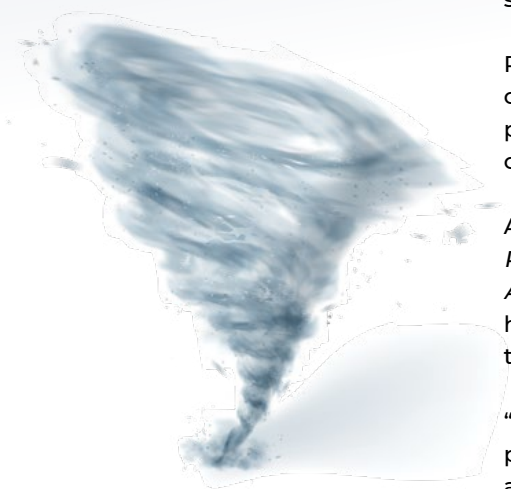
UAE aims to triple its clean-energy contributions, with solar as a key pillar.

FLOOD INSURANCE



‘SPONGE CITIES’ HARNESS NATURE TO MANAGE – AND BETTER USE – RAIN FROM STORMS SUPERCHARGED BY CLIMATE CHANGE

By: **Suzanne Condie Lambert**



⊙ **LEFT:** The design is inspired by Chinese landscape architect Kongjian Yu’s concept of “sponge cities.”

Storms are becoming stronger, wetter and deadlier. You can thank a warmer, moister atmosphere and heating oceans as the extreme storms they feed produce more rain, stronger winds and heavier flooding.

In 2024 alone, hurricanes Helene and Milton left hundreds of billions of dollars in damagesin the U.S. while flooding in Afghanistan and Pakistan was blamed for more than a thousand deaths. Cities, in particular, may be feeling the effects of these killer storms more intensely than the countryside.

For one thing, urban areas draw more rain: Skyscrapers often slow storms, letting them drop more precipitation in a relatively small area.

Pollution like auto exhaust seeds clouds. And heat rising from pavement and concrete creates convectional rainfall.

A study published in the *Proceedings of the National Academy of Sciences* says the effect has become more pronounced over the past two decades.

“This is everywhere,” Dev Niyogi, a professor at the University of Texas at Austin and paper co-author, tells the *Washington Post*.

“The magnitude of the impact will vary. But just the way we treat urban heat islands, we should start treating urban rainfall effect as a feature associated with urbanization.”

And some cities that have not previously been associated with flooding are finding that the changing climate may require a different kind of urban planning.

Exhibit A: Abu Dhabi, where record-breaking April 2024 storms brought a year’s worth of rain to the Gulf city in just a day.

FROM THE GROUND UP

Chinese landscape architect Kongjian Yu has been thinking about that different kind of urban planning for decades.

He won the Cornelia Hahn Oberlander International Landscape Architecture Prize (“Oberlander Prize”) in 2023 for his concept of “sponge cities,” which has inspired projects not only in China, but France, Russia, Indonesia, Thailand and the United States.

Yu’s company Turenscape has contributed to more than 600 projects in 200 cities.

The concept relies on nature – through trees, parks and ponds – and good design to protect cities from flood waters. In essence, rather than rely on concrete drainage systems and flood walls, it makes the city itself a “sponge” to better absorb rainfall.

“There’s a misconception that if we can build a flood wall higher and higher, or if we build the dams higher and stronger, (then) we can protect a city from flooding,” »»

SKYSCRAPERS OFTEN SLOW STORMS, LETTING THEM DROP MORE PRECIPITATION IN A RELATIVELY SMALL AREA

Yu tells CNN. "(We think) we can control the water ... that is a mistake."

The stakes are high. An Intergovernmental Panel on Climate Change report says 700 million people live in areas where rainfall extremes have risen. This number is expected to grow as global temperatures increase.

CELEBRATING THE WATER

Scott Hawken, director of the Landscape Architecture and Urban Design program at the University of Adelaide's School of Architecture and Civil Engineering, uses sponge city principles in his work. It's about celebrating the water on site, he says.

"This development of the sponge city is about the necessity to manage water in a more intelligent way. It allows water to infiltrate into the landscape and slow it down, to manage it on site rather than what has been done throughout most of the 20th century, which is to expel the water from the city rapidly," he tells *KUST Review*.

As Hawken tells it, preparing urban areas to better withstand flooding isn't just an issue with physical infrastructure, like swapping out concrete gutters for absorbent plants and sandier soils. It requires a change in social perspectives as well.

"The 20th century perspective (sees) water or flooding being a problem or a nuisance. That's one cultural perspective that inspired overengineered approaches which haven't really valued water in the way that it should be valued."

Instead, Hawken suggests looking to communities that consider flooding a part of life, like the cities and settlements of Southeast Asia that have weathered monsoon climates for hundreds of years and longer.

"Floods there are not viewed as a risk. But in the Western context we really fear floods. They're out of mind until they're around us, and then we panic rather than thinking into the future and planning to live with floods and work with them on site." And where you can't work with them?

"We've also built in a lot of areas which we shouldn't, like on flood plains."

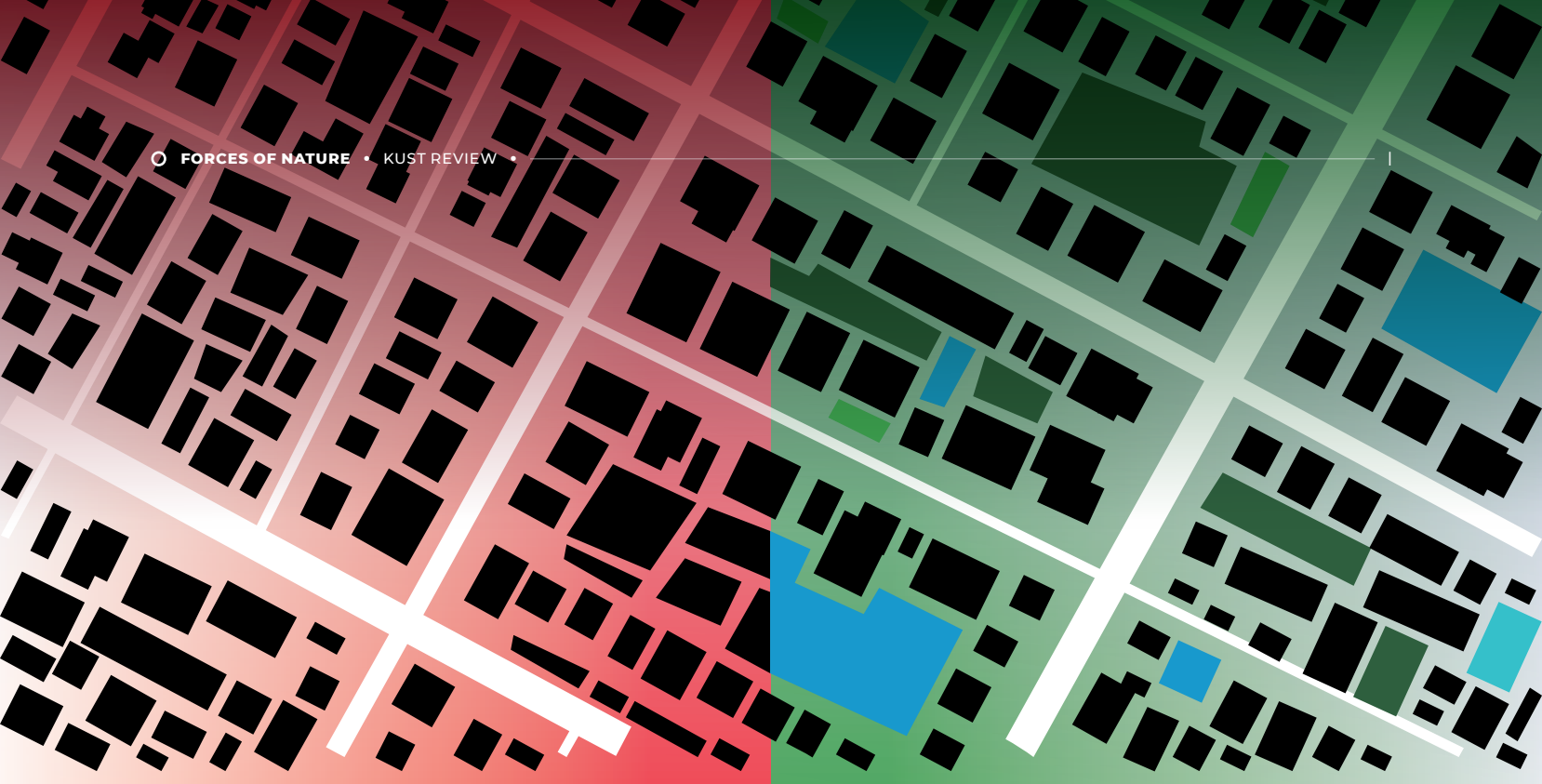
MANAGING THE WATER

Hawken isn't just concerned with creating a landscape that better absorbs water but cities that manage the rain wisely.

"The irony is often you have a very wet landscape that has a lot of water but also has to pipe water in because it's not using water in a smart enough way. It isn't recycled, filtered and reused.

"People have a resistance to that. But some of the traditional societies have been reusing and recycling water in intelligent ways for a long time. We need to get over that. »»

⊙ **BELOW:** Cities in particular, may be feeling the effects of killer storms more intensely than the countryside.



PROTECTION

FROM HEAT TOO

Sponge cities don't just protect residents from flooding. They also provide relief from extreme heat, says the University of Adelaide's Scott Hawken.

"In cities like Adelaide, heat waves are even more deadly than flooding. They kill a lot of people: the vulnerable, the young and the old. We need to think about how to keep our cities cooler during these extreme events and design parks and gardens to generate cool airflows and bring the surface temperature down," he says.

The best way to do that is to use well-watered and irrigated vegetation to set up cool airflows throughout the city, Hawken says.

"It's not just having a park here. It's strategic, like a natural air conditioner. We need to think of these larger park systems woven in amongst our cities. These parks need to be well-watered, but that shouldn't be a problem if resources are used wisely, he says.

"Most of the time there is plenty of water in our cities, but we just don't use it carefully," he says.

"Many cities around the world are running out of water, but those cities often don't take care of their water. It's only when the drought kicks in that the penny drops. But by then it's too late. We don't have the systems in place."

Urban oases in Abu Dhabi helped cool surrounding temperatures by up to 2.2 degrees Celsius, according to a study by Mohamed bin Zayed University of Artificial Intelligence and the tech giant IBM. Artificial intelligence-enabled technology helped analyze decades of satellite data and provided insights on how vegetation and water bodies make a significant impact on heat islands in the city.

Masdar Park in the Masdar City neighborhood had a 2.2-degree cooling effect in that area, the researchers found. Umm Al Emarat Park, one of the largest and oldest parks in the city, brought down the surrounding temperature by 1 degree.

The researchers suggest the technology can enable sustainable design and help urban planners identify other areas that could benefit from green spaces.

> **WE THINK WE CAN CONTROL THE WATER... THAT IS A MISTAKE.**
> — Kongjian Yu

DESIGNS: Abjad Design
PHOTOS: Envato, Freepik

The technology is certainly there. "The filtered and recycled water is often much cleaner than the water that's not," Hawken says.

Singapore, he says, is an example of a city that is successfully reusing and recycling its water resources.

"A lot of the technology that was developed in Australia has been exported to places like Singapore. Now they've taken those ideas and run with them, probably doing a better job than anywhere else."

DESERT SOLUTIONS

Dubai entrepreneur Chandra Dake has also been thinking about managing flood waters and collecting rain for reuse. His inspiration: the United Arab Emirates' desert sands.

Dake and his company, Dake Rechsand, use the plentiful sand to create permeable materials that not only allow water to pass through but filter it on its way to underground honeycomb storage tanks. These tanks keep the water fresh without chemicals or electricity.

"Every nook and corner, every junction, can become a storage house of water," he says.

"That reduces the burden of centralized storm management, which is normally implemented in advanced cities across the globe."

He points to a project in Beijing that used his technology to address chronic flooding problems that led to frequent traffic jams.

"This area that used to flood is now able to harvest every drop of water. The surface is now used for a recreational facility. All the rainwater goes underneath it. After implementing it for the last two, three years there's no more flooding, not even one traffic jam. And the water? It's literally like distilled water."

Saving the water from just one storm would be a huge benefit for UAE cities that rely mostly on energy-hungry desalination technology, he says.

That record-breaking 2024 storm? The water could have been used for two or three months cleaning roads, improving irrigation and watering greenery, he says. Instead, it went to waste.

"All of that water was discarded. Not even one cubic meter was used." Dake says his technology can easily be integrated into an existing infrastructure. "You can build a road. You can build paving. You can build anything. And these can be retrofitted as well."

The materials are suitable for both hot and cold climates, Dake tells *KUST Review*. "And one important element is these materials are made from desert sand. Desert becomes a solution for global problems.

"We will see enormous social, environmental and economical benefits," he predicts.

Here's how athletes are improving performance and maintaining health in extreme heat

By: **Maggie Kinsella**

ARTWORK: Abjad Design
PHOTOS: Shutterstock

BLOOD, SWEAT, AND FEARS

During the 2022 summer U.S. Open, world-ranked No. 3 singles tennis player Daniil Medvedev looked into a courtside camera and said, “One player is going to die, and they’re going to see.”

He was speaking of the extreme heat he and his opponent suffered during the nearly three-hour match in which he cooled himself with towels full of ice.

Medvedev wasn’t the first athlete to complain. Two years earlier at the Tokyo Summer Olympics, tennis player Paula Badosa of Spain was helped off the court in a wheelchair due to heat stroke. Medvedev also suffered there: The umpire at his Olympic match asked if he was OK to continue. Medvedev replied, “I can finish the match but I can die. If I die, is the ITF (International Tennis Federation) going to take responsibility?” (He won that match.)

And Jamie Farndale, a U.K. rugby player, shared his experience training for the Dubai Rugby Sevens in *Rings of Fire — Heat Risks at the 2024 Paris Olympics*, a report prepared by Australian advocacy group FrontRunners and released as extreme heat broke records around the world.

“I remember we prepared for Dubai Sevens one year by doing heat chamber sessions at our training base in Scotland. … You just couldn’t cool down all day, you were tense and angry — fights would break out in our sessions, which never ever happened normally. It was pretty scary to see the effects! On the pitch I remember just wanting to get through the match — which is crazy! Something you dedicate your life to because you love it so much and here you are on the world stage willing it to end!

“What we do is push ourselves to our limits, and if we have to do so in conditions that are unsafe, I don’t think the athlete would hold back. It is not in an athlete’s DNA to stop and if the conditions are too dangerous, I do think there is a risk of fatalities.”

This fear is not unfounded.

“Oppressive environmental conditions — temperature, humidity, radiation and wind speed — are one of, if not the greatest, risk factors for exertional heat illnesses,” says Samantha Scarneo-Miller, who studies heat injuries at West Virginia University.

“As these environmental conditions worsen, it makes it difficult for our body to dissipate heat. When we produce more heat than we are able to dissipate, we can eventually reach ‘uncompensable heat stress,’ which can lead to exertional heat illnesses.”

Heat-related illnesses, some life-threatening, are increasing and can impact major organs.

Skin deep

The skin is the largest of the human organs, and it plays a vital role in cooling the body. It protects internal organs, communicating with the brain to regulate body temperatures When skin temperatures spike or fall, the skin's thermoreceptors signal the hypothalamus in the center of the brain, which produces hormones to regulate heart rate, hunger and temperature.

Blood vessels relax, increasing blood flow that carries excess heat to the skin's surface. Sweat allows that heat to leave the body and cool us down. The body's optimum internal temperature is 37.1 degrees Celsius. And the internal thermostat will always work to return the body to this temperature.

> **You are an engine, and if the engine is hot, it burns faster, so it'll slow you down. The number one thing you can do is train your body to be a little less bothered by the heat."**
>
> — Rory Linkletter

But what if it can't? "From a thermoregulation standpoint, the pre-optic area of the hypothalamus (POAH) is the area that controls temperature for the body," Scarneo-Miller tells *KUST Review*.

"At some point during extreme exercise in the heat, the POAH is affected and is unable to effectively regulate the body, though the specific mechanism and timing for this is not well known.

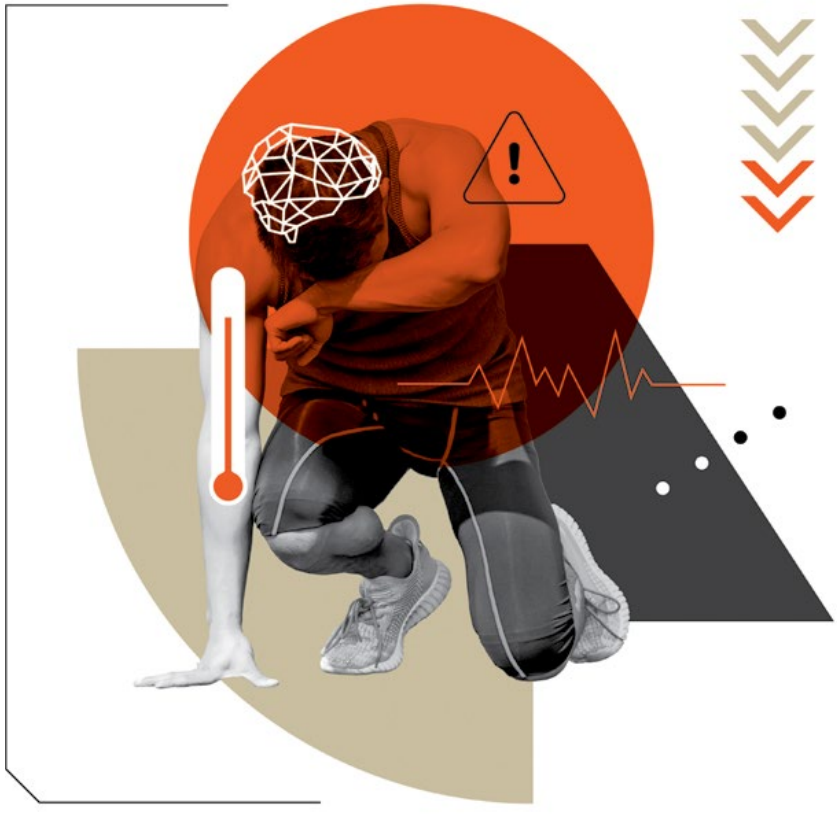
"As these physiological changes continue to worsen, it affects our body's ability to thermoregulate, eventually leading to exertional heat illnesses," Scarneo-Miller says.

A body unable to cool itself due to extreme heat can experience heat exhaustion. Symptoms include nausea, headaches and cramps. Most can be alleviated by releasing the heat, resting, replenishing fluids and cooling down.

Athletes, however, as rugby player Farndale noted, are often hard-wired to never give up. The problem is heat exhaustion can develop into heatstroke. Results can include traumatic brain injury or death.

One way to minimize these illnesses, experts say, is by adapting to higher temperatures. This is better known as heat acclimation or reducing the impact on heart rate and body temperature via training.

Though "there are no validated technologies to monitor and prevent completely exertional heat-related illnesses," Scarneo-Miller says, preventative measures like heat acclimatization are necessary. »»



> **Oppressive environmental conditions — temperature, humidity, radiation and wind speed — are one of, if not the greatest, risk factors for exertional heat illnesses."**
>
> — Samantha Scarneo-Miller

"Heat acclimatization is the process of gradually increasing the intensity of physical activity in the heat. Intensity is inclusive of duration of activity (e.g., time), when the activity is performed (e.g., time of the day when it is hottest), equipment worn (e.g., football helmets), among other elements," she adds.

Diving in

Some athletes travel to the competition site weeks in advance to train.

According to the Gatorade Sports Science Institute, for highly fit athletes this might take one to two weeks of 90-minute daily heat exposure.

If moving to training locations isn't in the cards, some athletes simulate the heat where they are. The Belgium field hockey team, for example, set its heat chamber to 50C to prepare.

Marathoners will also train for hotter climates. Some spend time in a sauna post-training or wear outfits over their clothes to raise their body temperature during training.

Canadian marathoner Rory Linkletter says he wears extra clothing during some of his training runs. "You are an engine, and if the engine is hot, it burns faster, so it'll slow you down. The number one thing you can do is train your body to be a little less bothered by the heat," he tells the *New York Times*.

Putting it to the test

Athletes are capable of pushing their bodies to extremes. But how much further can they push themselves in the heat? What is the human limit?

Every human is different, so results vary. Testing can also pose ethical questions. Therefore, until recently, this type of human testing had never been done.

But as global temperatures soar, it's something athletes and everyone else on the planet needs to know for their own safety.

That's why a team of researchers at the Heat and Health Research Centre at the University of Sydney, Australia, tested humans in a heat chamber set to a wet-bulb temperature (heat combined with humidity) of 54C and 26 percent humidity – a threshold a research

HOT WHEELS

By: Jade Sterling

team 15 years ago proposed no human could survive for six hours.

One study participant runs 100 kilometers per week, is 31 years old and spent a week acclimatizing prior to his time in the climate chamber. The experiment, intended to last three hours, ended at the 2.5-hour mark after the participant's core temperature reached 39C — the max allowed.

The experiment was done several times under different temperatures and conditions. This was the first time the subject was unable to withstand the three-hour mark.

The first-of-its-kind experiment is ongoing and aims to answer the question how much heat is too much?

Turning to tech

In the meantime, to help athletes keep a cool head, some are turning to technology.

Current wearables on the market track heart rate, blood pressure and respiration rate. But for those training to withstand extreme temperatures, body-temperature readings need to be part of the mix.

Core wearable by Zurich-based company Greenteg tracks every element of athletes' performance. The device monitors heat entering and exiting the skin, allowing it to track the core body temperature.

This helps athletes to not only ensure thermoregulation for safety, but enhance performance: Thermoregulation in athletes enables maximum performance without the risk of overheating.

"Thermoregulation is also used in targeted heat training to continuously extend time to »»

Didier Pironi gave the most to win the 1978 24 Hours of Le Mans race for his team. He took the last two stints of the race, driving for four hours in a non-air-conditioned cockpit under a Plexiglas roof in June.

He took the checkered flag, parked up and promptly collapsed. The race doctor unzipped his fire suit and covered him in ice. In 2005, Stephane Sarrazin said his cockpit reached 80 degrees Celsius. Air conditioning became a requirement in 2007.

Racing drivers are no strangers to feeling the heat in competition but racing is definitely heating up.

The Formula One Singapore Grand Prix is renowned as the most difficult race of the year as ambient temperatures stick around 40C — at night, when the race is run — and the 2023 Qatar Grand Prix saw many drivers seek medical attention for either dehydration or heat exhaustion after a race run in 30C and high humidity.

A warming planet and higher ambient temperatures only exacerbate the conditions racing drivers experience.

Many formulae see the drivers sat directly in front of the engines, surrounded by electronics heating the cockpit. Brakes can reach 1,000C and even catch fire.

Drivers must wear fire-retardant, long-sleeved safety clothing, topped with a race suit, gloves, balaclava and helmet, all of which store heat and prevent any heat exchange. Thermoregulation becomes very difficult even on cooler days.

Studies have found the peak post-race core temperature of V8 supercar drivers was 39.7C and 38.6C for NASCAR drivers. A reminder: Normal body core temperature generally ranges from 36.5 to 37.5C. Hyperthermia is considered anything over 38.5C. Another study found drivers in closed-cockpit races were halfway to their peak temperature after just 10 minutes of racing.

Any rise in temperature can see fatigue and impaired mental performance start to creep in, the last thing you want at 220mph.

Cool Threads

Scientists are working hard to keep us cool with just the clothes on our backs.

A group of researchers at the University of Massachusetts have created a natural film that can be added to clothing, and the results show that this coating of calcium carbonate — the main ingredient in limestone, marble and chalk — helps reflect the sun's energy back into the atmosphere and still allows body heat to escape.

"We see a true cooling effect," says Evan Patamia, a chemistry graduate student on the project. "What is underneath the sample feels cooler than standing in the shade."

The resulting temperature reduction under clothing is approximately 4.5 degrees Celsius.

There is no electrical component, less need for carbon-intensive cooling measures and zero environmental impact.

"What makes our technique unique is that we can do this on nearly any commercially available fabric and turn it into something that can keep people cool," Patamia says.

The team is working with a start-up company that may provide scalable production.

fatigue without risking injury," according to the company website.

The data also includes skin temperature; heat strain, which tells us how hard the body works to cool itself; and temperature zones, which train the body and can improve performance. Finally the device tracks thermal load, or how long the athlete remained within the heat training zone.

For team sports with breaks, cooling technology is helping with thermoregulation.

A 2022 study about the need for face-, head- and neck-cooling technology that can be worn during and after training mentions that after the human face, the hands are the next on the cold thermosensitivity scale, particularly the palm and sole.

A 2023 study from the University of North Dakota concluded that cooling the palms led to increased endurance.

Hands out

But why the palms? The palms contain a high number of arterio-venous anastomoses (AVA), which are located below the skin and provide a shortcut for the blood to quickly move from arteries to veins.

It's this shortcut that lets the body release heat efficiently. So, when you're overheating, more blood is flowing through the AVA, bringing heat to the skin's surface.

This means the palms are an effective heat-offloading site.

Sports tech company Apex Cool Labs says the technology used in its palm-cooling device, Narwhals, reduces heat stress and accelerates recovery time, allowing for

> **If you can eliminate fatigue, you can increase the work volume, you get a huge conditioning effect”**
>
> — Craig Heller

enhanced performance not only for endurance sports but also for strength training.

Stanford University’s Craig Heller studied human temperature regulation and found that the primary heat exchange surfaces of human bodies are the hairless skin of the palms, soles and face. This led to the development of CoolMitt, which some U.S athletes used to cool core body temperatures at the 2024 Summer Olympic games.

“If you can eliminate fatigue, you can increase the work volume, you get a huge conditioning effect,” Heller tells CBS News.

While there is tech that helps us cool and prevent heat injury, West Virginia University’s Scarneo-Miller says updated policy should be part of the solution.

“Sport organizations need to be very cognizant that as the environment continues to warm, we need to make policy changes to protect our athletes.

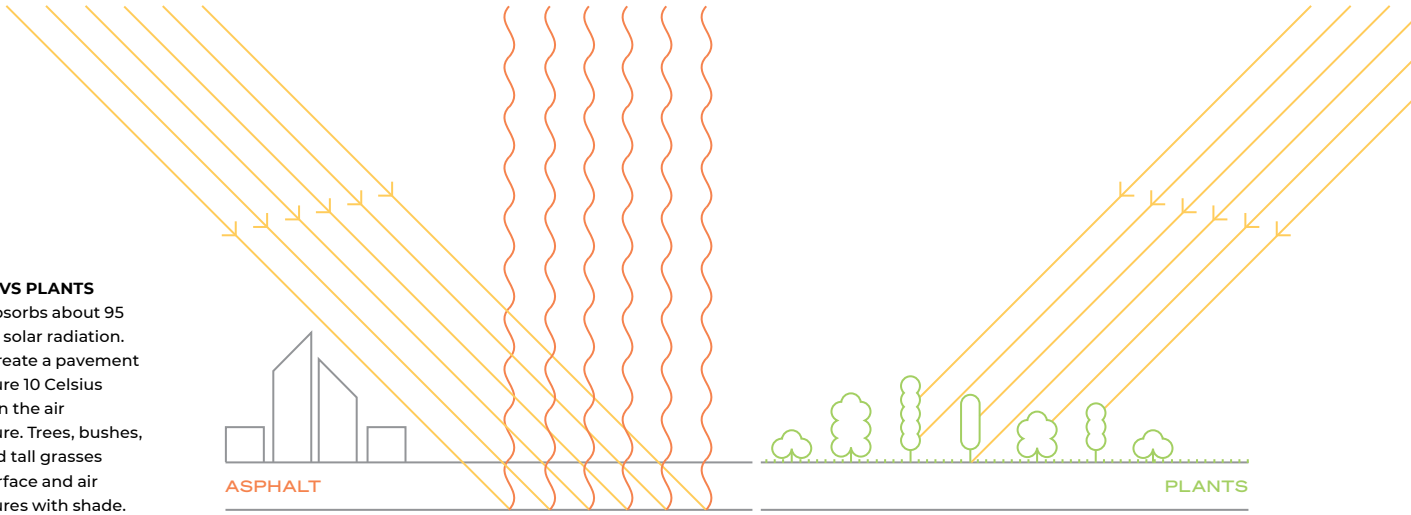
Developing strong and proactive policies now will allow us to be better prepared for these worsening environmental conditions.

“Policies such as requiring heat acclimatization, an athletic trainer at every sports organization, cold-water immersion tubs available within five minute of all venues, and emergency action plans all can help recognize and manage a patient suffering from exertional heat illnesses, especially exertional heat stroke, which can be fatal,” Scarneo-Miller tells *KUST Review.*

FLOOR IS LAVA

Urban heat islands are turning cities into searing concrete jungles — but help is on the way

By: **Maggie Kinsella**



ASPHALT VS PLANTS
Asphalt absorbs about 95 percent of solar radiation. This can create a pavement temperature 10 Celsius hotter than the air temperature. Trees, bushes, shrubs and tall grasses reduce surface and air temperatures with shade.

THERE ARE STUNNING CITY SKYLINES AROUND THE WORLD. BUT DON'T LET THE SMOOTH GLASS FACADES FOOL YOU – IT'S A HOT MESS INSIDE.

We're talking about urban heat islands. And according to the U.S. Environmental Protection Agency, cities run about 1-3 degrees Celsius hotter than surrounding areas. This may not sound like much, but it doesn't just make cities more uncomfortable places to live, it can also be dangerous. That's why researchers are investigating ways to keep humans safe and bring the temperatures down.

THE MAIN OFFENDERS

Roadways, buildings and other structures have environmental consequences. Asphalt, for example, absorbs about 95 percent of solar radiation.

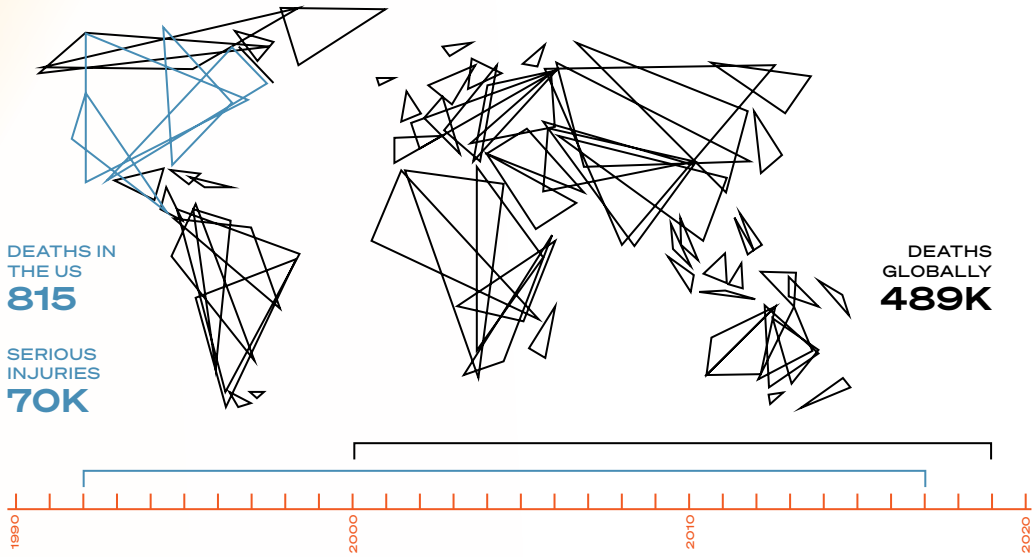
This can create pavement temperatures 10 degrees Celsius hotter than the air temperature. These surfaces heat rapidly in the day and slowly release heat over night — making the air temperatures hotter as well.

The same goes for concrete, valued for its strength and low cost. As a result most buildings are made up of about 60 percent concrete. These schools, hotels, restaurants, office buildings and hospitals also take in the day's heat and breathe it out slowly at night.

And it isn't just adding these heat sponges to our infrastructure that creates the heat-island effect. Something needs to be removed to make space. Like vegetation.

Trees and other plants such as bushes, shrubs and tall grasses reduce surface and air temperatures with shade. When the plants are removed, so is the shade, as well as the natural cooling system provided by natural processes like evaporation and transpiration

Cars, refrigerators and even the cellphones in our hands create additional waste heat that becomes trapped in urban environments. »»



DEATH TOLL DUE TO HEAT
Between 1992 and 2017, 815 American workers died and another 70,000 were seriously injured from heat stress. From 2000 to 2019, the global average of annual heat-related deaths was 489,000.

HUMAN HEALTH

It's not only the environment that suffers — heat can have a major effect on the human body. Kevin Foster, director of burn services at the Arizona Burn Center in the United States, saw the proof of just how dangerous surfaces can become when he treated patients, some with life-threatening injuries, who fell on scorching sidewalks.

Even a few seconds contact can be enough to cause injuries, he says, adding that asphalt can reach 82 degrees Celsius on extremely hot days. That's some serious heat.

There are also a plethora of heat-related illnesses that could become extremely serious conditions. Heat exhaustion and heat stroke, for example, can be deadly and often go unrecognized until it's too late. Many of these illnesses occur on the job.

Between 1992 and 2017, 815 American workers died and another 70,000 were seriously injured from heat stress, according to the U.S. Occupational Safety and Health Administration and the Centers for Disease Control.

A 2021 study published in *The Lancet* estimates that from 2000 to 2019, the global average of annual heat-related deaths was 489,000.

Other deaths are due to extreme heat exacerbating existing health conditions like cardiovascular and respiratory issues. These often affect the elderly, children and low-income populations.

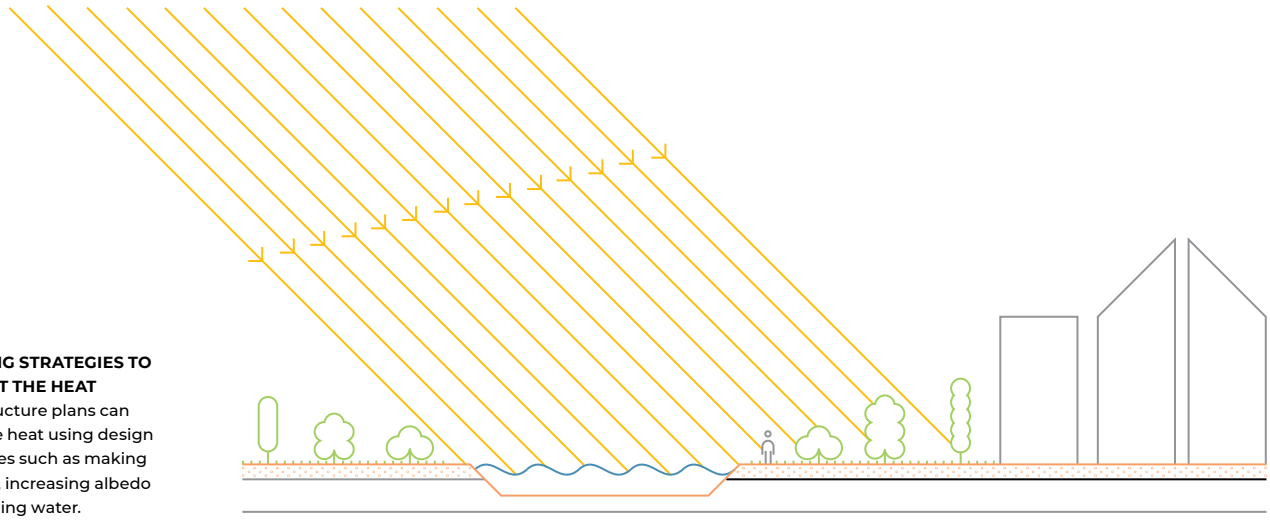
So how do we protect the most vulnerable? Researchers at Arizona State University for the past eight years have looked at how the built environment impacts human thermal exposure in cities using MaRTy, a biometeorological instrumentation platform that can measure the heat load on the human body, says ASU researcher Ariane Middel.

MaRTy was used to determine the benefits of different kinds of shade on the human body.

It has now teamed up with ANDI — a thermal mannequin that was developed by Thermetrics, a Seattle, Washington-based thermal technology company. It sweats like a human and simulates temperature regulation to help researchers understand the city heat on the body.

"ANDI is the first thermal mannequin that can be used in living laboratory outdoor conditions," Middel tells *KUST Review.*

MaRTy and ANDI are part of a National Science Foundation-



WINNING STRATEGIES TO COMBAT THE HEAT
Infrastructure plans can mitigate heat using design strategies such as making it green, increasing albedo and adding water.

sponsored project. MaRTy measures the heat load under different types of shade and ANDI reflects how the body responds to the load with things like sweat volume and skin and core temperature. ANDI's responses will also help researchers develop cool clothing materials.

Middel's research ultimately aims to determine the best outcomes for humans based on strategic methods of cooling that will assist urban development and planning in the future. She says it all lies in the fundamentals.

WINNING STRATEGIES

Infrastructure plans can mitigate heat using design strategies:

Make it green: Cities can be cooled by implementing as much greenery as possible, like trees, shrubs, and grass. Through evapotranspiration they cool the environment and provide shade, which can reduce the impact on the human body by up to 30 degrees.

Increase albedo: Albedo is the amount of energy such as light or heat a surface can reflect back into the atmosphere. Painting roofs white or using cool pavement technologies help reflect solar radiation.

Add water: Playground splash pads, fountains and misting systems can be built in areas where tree planting isn't possible.

Middel says it's not a matter of a one-size-fits-all scenario — each strategy depends on the build area.

Most work best with a combination of the above that suits the environment. For example, cool roofs and reflective pavements reduce the surface heat but don't provide shade for humans.

And while they provide an immediate benefit (trees take time to grow), they also diminish over time. So, a multi-faceted approach is the way to go.

"Policy and urban planning are key when it comes to cooling our cities," Middel says.

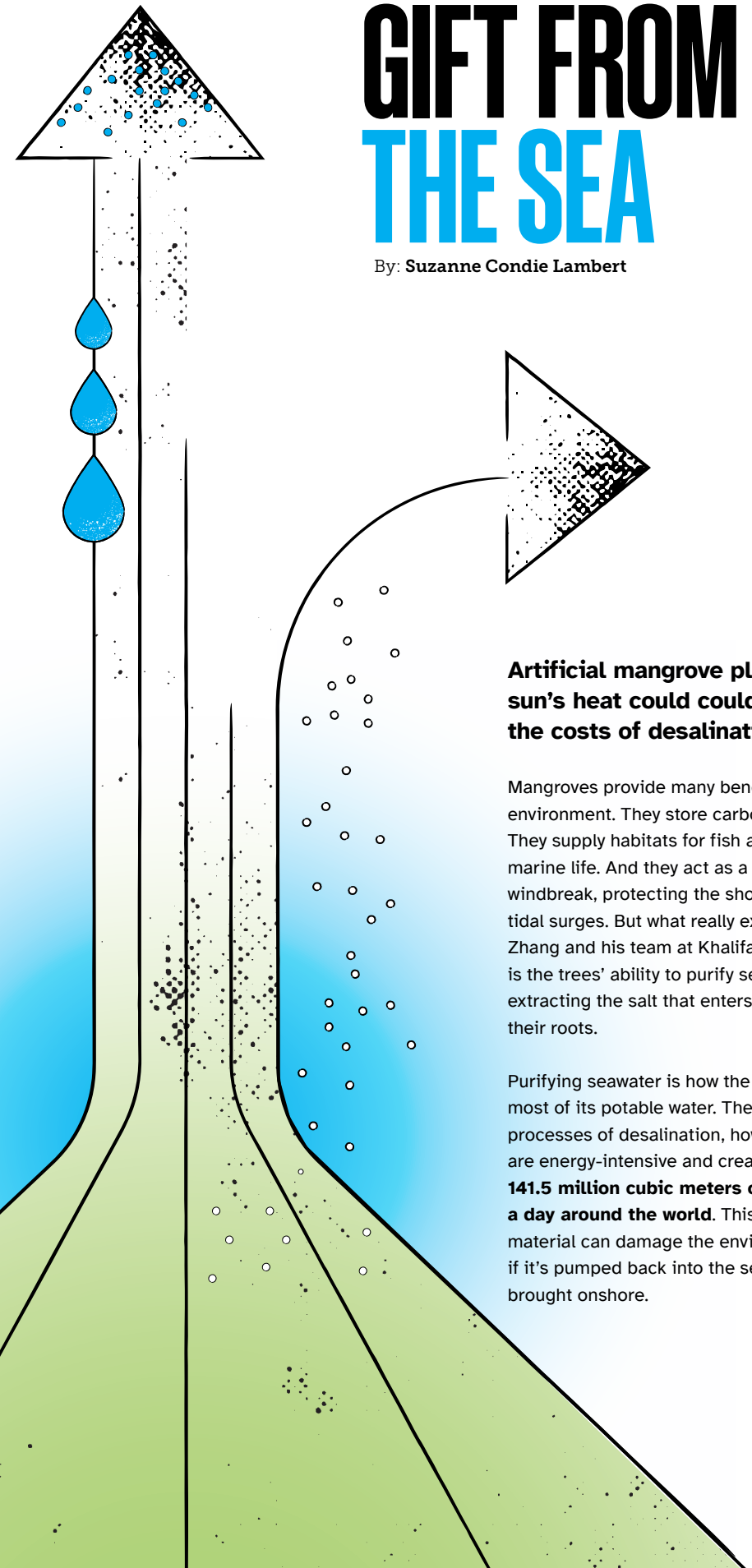
"Local governments can help create sustainable and heat-resilient cities by integrating cooling strategies that work in their geographical and climatic context into urban planning frameworks, such as urban forestry plans, heat action plans and climate action plans.

"Cities can also engage the communities through outreach and education campaigns to raise awareness to protect people from extreme heat," she adds. ●

GRAPHICS: Abjad Design

GIFT FROM THE SEA

By: **Suzanne Condie Lambert**



Artificial mangrove plus the sun's heat could could slash the costs of desalination

Mangroves provide many benefits for the environment. They store carbon dioxide. They supply habitats for fish and other marine life. And they act as a natural windbreak, protecting the shore from tidal surges. But what really excites Tiejun Zhang and his team at Khalifa University is the trees' ability to purify seawater by extracting the salt that enters through their roots.

Purifying seawater is how the UAE gets most of its potable water. The traditional processes of desalination, however, are energy-intensive and create about **141.5 million cubic meters of brine a day around the world**. This waste material can damage the environment if it's pumped back into the sea or brought onshore.

Zhang's bioinspired artificial mangrove, however, could be the inexpensive breakthrough a thirsty world needs without the caustic waste products.

The process is simple, Zhang says, and it's powered entirely by the heat of the sun to evaporate water and leave the salt behind. The sun's heat draws liquid up through a nanostructured titanium mesh using passive capillary action. The salt separates from the water and precipitates on "leaves," then at night falls onto the floating foam disc that keeps the device upright in water. The process collects about **2.2 liters/m2 of water a day.**

"The initial device is small," Zhang says, "but we can make it much bigger depending on how much water you need." As a bonus, the researchers are investigating how the collected salt could be separated and used for other purposes.

"Sodium chloride is edible," he says. "Calcium chloride, magnesium chloride, those are more for industrial processes. Our current technology proves that we can collect the salt. If we pull everything in a mixture, it's not very valuable.

"If we can separate (the salts), refine them, and make them pure, then that would be very valuable." Zhang thinks the device might eventually be able to draw other valuable materials from seawater, even lithium.

But the applications aren't just industrial, he says, pointing out that the device is small enough to carry in a backpack. Hikers and people who live off-grid might be able to use the artificial mangroves to purify water for personal use.

And the simple design, featuring titanium mesh and chemical etching to create a nano structure, makes it easily reproducible. "A high school student could make it," Zhang says. In the meantime, Zhang and his team are investigating start-up opportunities.

ILLUSTRATION: Abjad Design

Municipal waste could help fuel the future

By: **Jade Sterling**

Today more than half the world's population lives in cities, and this is expected to rise to nearly 70 percent by 2050. Rapid growth in urbanization has also led to an increase in municipal solid waste — all the trash, garbage and rubbish thrown away every day. This typically includes common household waste, newspapers and plastic packaging, office and retail waste but also used tires and furniture.

The issue of municipal waste is exacerbated by the relentless rise in plastic waste. Estimates project a daunting 1.1 billion tons of plastic burden by 2050, meaning sustainable waste-management solutions are a priority for cities around the world.

Researchers are investigating ways to turn this plastic waste into hydrogen. Hydrogen is billed as the energy source of the future, but its production is hindered by scalability, environmental impact and economic viability. Despite hydrogen's reputation as green fuel, current methods of producing it rely on fossil fuels and steam-methane reforming, which is energy-intensive and creates carbon dioxide as a byproduct.

Gasification, on the other hand, could be the hydrogen production technique we need to produce hydrogen at the scale we want it. Expose plastic waste to temperatures high enough and the hydrogen present in the plastic vaporizes, leaving behind an additional valuable byproduct: graphene.

Plastic is, after all, a hydrocarbon: polymers of hydrogen and carbon atoms. Heating the plastic quickly enough reorganizes the chemical bonds, with the carbon atoms combining to graphene and the hydrogen atoms becoming hydrogen gas. Flash joule heating is a technique for rapidly heating materials to extremely high temperatures with a jolt of electricity. Electricity converts into heat, achieving temperatures of thousands of Kelvin for a small energy cost and a large valuable product output.

Research led by Pau Loke Show, professor of biochemical engineering at Khalifa University, has applied machine learning techniques to the process to improve efficiency.

He says integrating hydrogen production from unconventional feedstocks, bolstered by machine learning and advanced storage, can contribute to a sustainable and pollution-free future: "Machine learning emerges as a critical enabler in optimizing gasification processes, enhancing efficiency and reducing emissions. Moving forward, these integrated approaches are key to advancing carbon-neutral energy solutions and fulfilling global environmental goals." ●

IMAGE: Freepik

NATURE'S COOL IDEAS

ILLUSTRATIONS: Abjad Design

Biomimicry offers lessons about energy efficiency we could apply to the built environment

By: **Jade Sterling**

While we can't grow larger ears like the desert fox or elephant to radiate heat, we could learn from nature to solve some of the problems of a warming world.

Here are five ways nature has inspired methods to beat the heat.

From beetle to ultra-white ceramic

Basic physics tells us that lighter colors absorb less light than darker ones, and therefore remain cooler. While ultra-white paints exist and reflect over 95 percent of the sunlight that hits them, regular paint suffers from durability issues when exposed to the elements on the outside of buildings.

Researchers at City University of Hong Kong developed a passive radiative cooling ceramic that can drastically cool buildings by reflecting sunlight and heat. The ceramic makes it tough and hardy, and the team says it should be relatively easy to scale up for mass production.

"Our work on cooling ceramic takes inspiration from the bio-whiteness observed in the whitest beetle," lead author Zuankai Wang says. "Nature offers us an abundance of intricate designs, efficient systems and sustainable solutions that have evolved over millions of years."

The ceramic is based on the exoskeleton of the *Cyphochilus*, a genus of beetles with unusually bright white scales. The filaments that make the scales are just a few micrometers thick and tightly packed, which scatters almost the entire spectrum of light efficiently. Copying this structure allows the team's ceramic to achieve a solar reflectivity of 99.6 percent. »»

Termites invented air conditioning

If you compare the height of some of the biggest mounds with the termites that build them, **it would be the equivalent of four Burj Khalifas stacked on top of each other compared with humans**.

Much like the Burj Khalifa would be unbearable in the desert heat without air conditioning, so too would the termite mound. To combat this, the insects build a series of air pockets throughout, creating ventilation via convection.

A shopping mall in central Harare, Zimbabwe, copied the design of a termite mound in its architecture to develop a self-cooling system. The Eastgate Center has no conventional air-conditioning or heating systems and uses less than 10 percent of the energy of a conventional building the same size.

As termites constantly open and close a series of heating and cooling vents in the mounds throughout the course of the day, so too does the Eastgate Center as outside air is drawn in through vertical ducts on the first floor and either warmed or cooled by the building mass depending on which is hotter, the concrete or the air.

Petal to the metal

Anna Laura Pisello, University of Peurgia, Italy, thought the botanical world might offer solutions toward mitigating urban heat island effects. "**We first discovered several similarities between building systems and botanical systems, in particular flowers**," Pisello says. "***Galanthus nivalus* is a bell-shaped 'hanging flower' with white oblong flowers that bend to the ground.**"

Pisello says urban geometry plays a particular role in establishing energy consumption and heating and cooling. The denser an area, the hotter it gets. Flowers and their pollinators benefit from the warm air in the center of the flower, an observation at odds with the experience of residents in an urban heat island at the center of a city, but a study in light-colored flowers found that *Galanthus nivalus* exhibits a cooling effect.

Infrared cameras showed a uniform temperature across the flower of 2.7 degrees lower than ambient. While researchers aren't sure why this happens, the directional reflective property of the petals has been suggested as a possible contributor.

"A building envelope (all the building components that separate the indoors from the outdoors) is similar to flower petals," Pisello says. "Buildings surrounded by buildings in close proximity are like the layout of petals and building occupants interact in and among buildings, while pollinators forage inside flowers."

Pisello thinks these flowers may have microstructures in the petals that reflect solar radiation out and keep the intra-floral area cool. When she took a picture of the flower, she observed a shiny lighting effect across the curving flower petals from the camera flash and says materials with such optical features could be possible solutions for building applications.

Copy the chameleon

"Architects spend a lot of time and effort trying to solve their design problems. Actually, they just need to look at and learn from the surrounding environment," says Yasmin Eid of Sinai University. In looking at biomimicry, she points to the hexagonal-shaped building façade that drew inspiration from the chameleon and took first place in a competition for a mixed-use office building in Dubai.

Designed by Wanders Werner Falasi consulting architects, the building's façade is made of hexagons that mechanically adapt to the sun's trajectory. If they get too hot, they close. Each hexagon has fixed solar nano-cells in the exterior walls that collect sunlight during the day. Any energy that isn't used to run the building during the day is used to illuminate thousands of LEDs at night, like a chameleon changing color.

After all, chameleons don't change color due to their mood, but for thermoregulation and camouflage. Eid says the chameleon can avoid about 45 percent of sun rays simply by changing colors. The cells in the skin that can do this are called chromatophores and are roughly hexagon-shaped, inspiring the hexagon façade of the Dubai office building.

Forestation to fenestration

Mark Edward Alston's research draws inspiration from trees and natural systems to improve glass building materials. Specifically, the University of Salford Manchester researcher's work focuses on designing intelligent glass surfaces that can manage solar absorbance and fluidic conductivity for better energy management, in a similar way that tree leaves manage sunlight.

His composite glass material absorbs solar energy to reduce heat gain inside buildings in the same way leaves absorb sunlight for photosynthesis but minimize the heat absorbed. An adaptive layer in the glass dynamically adjusts to different environmental conditions to maximize efficiency. Just as plants use a vascular system to distribute nutrients and water, the glass uses a fluidic network to manage heat, circulating a cooling fluid in real time based on the external temperature and sunlight intensity.

His approach aims to transform building facades into more adaptive and responsive energy systems, mirroring the multifunctional and self-regulating properties of trees.

"**To truly create pioneering smart cities, at the forefront of low carbon production, could we embrace new bio-inspired technology solutions?**" Alston asks. "These principles to actively manage the surface temperature of glass could change our buildings into climate modifiers and contribute to city resilience in an increasingly unpredictable climatic world."

By: **Jade Sterling**

Reflective films to cool cities are a potential solution to rising urban temperatures

Eugenia Kargbo is Freetown's "chief heat officer," an unusual title for a government employee.

Freetown, capital city of Sierra Leone, has always been hot, but it's getting hotter. Climate change is making the mercury rise, and the urban heat island effect exacerbates the problem: On average, cities are 5 to 9 degrees Celsius hotter than rural areas. Kargbo says the data shows everywhere in Freetown is getting hotter, but some communities stay hotter throughout the day.

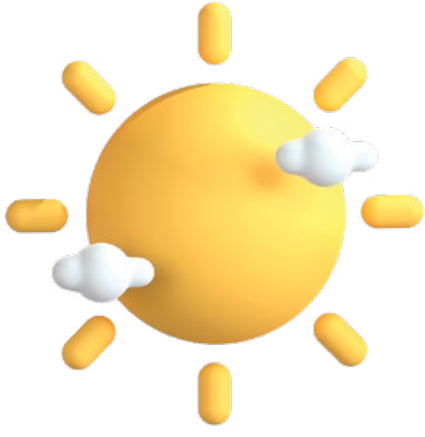
Freetown's Climate Action Strategy reported 94 percent of residents said the city was hotter in 2022 than five years earlier. They're not wrong. Sierra Leone is the 18th most climate-vulnerable country in the world, according to the Notre Dame Global Adaptation Index. And Adrienne Arsht-Rockefeller Foundation Resilience Center data says by 2050, around 120 days every year in Freetown will be as warm as the hottest 10 days currently.

In the city's numerous informal settlements, those living with uninsulated concrete walls and corrugated iron roof panels feel the heat even more. Kargbo had experimented with planting trees throughout the city and installing shading structures made of reflective plastic, but the real improvement was felt when a team of researchers approached her with an ambitious plan: Cover roofs with mirrors to reflect the sun.

Mirrors for Earth's Energy Rebalancing (MEER) was founded by Harvard University's Ye Tao. His theory? Develop "nontoxic surface-based reflectors that can redirect solar radiation back into space."

This isn't actually so crazy. We know that ice- and snow-covered areas offer the albedo effect, where light-colored surfaces return a large part of the sun's UV rays back to the atmosphere. It's why skiers and pole-trekkers need sunglasses and sunscreen. The planet has a natural "surface-based reflector" mechanism in snow and ice.

But with climate change come increased global temperatures and a dramatic loss of sea ice at the poles, snow in the mountains and glaciers in the north. »»



⊙ Cities are **5 to 9 degrees Celsius hotter** than rural areas

Darker surfaces absorb a larger fraction of the incoming solar radiation, creating a vicious cycle.

MEER's project aimed to cover buildings in Freetown with **a reflective film made out of recycled PET plastic and aluminum**. They started small: Two buildings got the film, another one was painted white and a fourth had a new metal roof installed.

The two mirrored buildings were 15 degrees cooler than the surrounding buildings without the film, while the white-roofed building experienced a 3 degree cooling effect. MEER says if the entire neighborhood were covered, the cooling effects would be even greater.

Researchers at the University of Maryland are taking a similar approach. They developed a reflective coating using glass and aluminum oxide particles that can be painted onto roofs and roads.

⊙ Two buildings in Freetown, Sierra Leone, got covered in film and were **15 degrees Celsius cooler** than the surrounding buildings without the film

> **It's simple to paint roofs white or light gray to increase the albedo effect — in theory. In reality, if this happens at a large enough scale it could have an unintended regional side effect.**
>
> — George Ban-Weiss

"This 'cooling glass' is more than a new material," Xinpeng Zhao, lead author, says. "It's a key part of the solution to climate change. This could change the way we live and help us take better care of our home and our planet."

The team's "cooling glass" is environmentally stable — able to withstand up to 1,000 degrees — and uses finely ground glass particles to recycle and avoid polymers.

The particle size maximizes infrared emissions and reflects sunlight through the atmosphere back into space. The glass paint also comes in four colors. George Ban-Weiss, an environmental engineer at the University of Southern California, says it's simple to paint roofs white or light gray to increase the albedo effect — in theory. In reality, if this happens at a large enough scale, Ban-Weiss says it could have an unintended regional side effect.

In coastal cities, for example, the urban warmth contrasting with the ocean drives a reliable sea breeze. Bring the temperatures closer to each other, and there could be less of this wind, which would mean less clean air and a reduced natural cooling effect.

Not just where roofs are but their shapes matter too. Covering flat roofs would project the rays straight back to space, but slanted roofs could shine on the ground or the city's inhabitants, heating them instead of the buildings.

One skyscraper in London is notorious for this. 20 Fenchurch St. is covered in glass — normal glass, not cooling glass — and its shape concentrates and reflects the sun's rays into a beam of light that hits the pavement and makes it hot enough to fry an egg.

Spot temperature readings at street level reached 91 degrees during summer 2013. The building's architect, Rafael Vinoly, also designed the Vdara hotel in Las Vegas, which had a similar refraction problem. That glass has since been covered with a non-reflective film.

"It's kind of a tug of war," Ban-Weiss says. "You've got a reduction in air temperature to make people more comfortable."

But at the same time, he adds, sunlight reflecting off the side of a building could make pedestrians less comfortable.

Portland State University's Vivek Shandas studied the heat island effect in over 100 U.S. cities.

He says thinking about heat reduction is still very novel in urban planning:

"When we're talking about a place that's designed in a particular way, how has the climate system been brought into the design of that place?

"How has the infrastructure been brought into its ability to mediate or moderate the amplifying temperatures? These are the kinds of questions I think we're really up against here."

94%

of Freetown residents said the city was **hotter in 2022 than five years earlier**.

By 2050, around **120 days every year** in Freetown to may be as warm as the hottest 10 days currently.

Sierra Leone is the **18th** most climate-vulnerable country in the world.

MEER: Mirrors for Earth's Energy Rebalancing

Reflective film is made out of recycled PET plastic and aluminum.

Cooling glass uses finely ground glass particles to recycle and avoid polymers. The particle size maximizes infrared emissions and reflects sunlight through the atmosphere back into space.

PHOTOS: Freepik
ILLUSTRATIONS: Abjad Design

THE FAST & AUTONOMOUS

Driverless cars take to the track for the inaugural vehicle showdown

By: **Jade Sterling**

Peering through the gap in the catch fence, the members of the Fly Eagle team held their breath. A whine emerged from the distance, an engine noise that grew louder as anticipation built for the Dallara Super Formula car to round the corner and scream down the pit straight.

In the blink of an eye, the car whipped past its spectators, crossed the timing beam and turned the corner at the end of the straight. The Fly Eagle team whooped; they'd set their best time yet.

Abu Dhabi's Yas Marina Circuit is no stranger to racing cars. It hosts events throughout the year, including the season finale of the Formula One World Championship since 2009. But the track has never seen racing like this before. It's not the speed or the car that makes it special: It's the drivers. The Fly Eagle car is driven entirely by artificial intelligence. There's no driver in that car. Yet, the drama, the speed, the precision, the passion — all remain.

The Abu Dhabi Autonomous Racing League (A2RL) is the first of its kind in the region, shaping the future of motorsport as we know it. Eight university teams were invited to take part in the "challenge," going head-to-head for a prize fund of U.S.$2.25 million.

Each team races using identical Super Formula SF23 cars, the fastest open-wheel race car after those used in Formula One, capable of reaching a maximum speed of 300 km/h. They're also manufactured using sustainable bio-composite materials, an important factor we'll get into later.

Each car is equipped with seven cameras, four radar sensors and three lidar units to navigate its way around the track, with the only difference between the teams lying in how they use their coding skills, algorithms and machine learning techniques to teach the cars to drive. »»

"Just because it's a machine, doesn't mean there aren't human elements in it," said Tom McCarthy. He's executive director of ASPIRE, the "technology transition arm" of Abu Dhabi's Technology Research Council. "Remember that it's people doing the programming here."

HOW DOES IT WORK?

The AI needs to be able to turn in to corners at the right moment, know when to brake, accelerate, change gear and recognize its surroundings at all times. To get the most out of the car, it needs information on how hot the tires and the brakes are, what the wind is doing in each turn, how much grip the tires have left — all the information a human driver gets from sensors and intuits from experience.

You'd think that the fastest way around the track would be to train the AI on an "ideal lap" set by an actual racing driver, an expert, and then have the car follow that data to the letter.

And indeed, there is training data for the algorithms, but every 50 milliseconds, the AI decides whether to listen to that training data or the live data it receives from its sensors. Sometimes, when it relies on its own inputs, the car shaves time off its previous best lap. Sometimes, it turns too soon and smacks into the wall.

Lakmal Seneviratne is director of the Khalifa University (KU) Center for Robotics and Autonomous Systems. With Majid Khonji, who leads the research activities in the KU Autonomous Vehicle Laboratory, the university entered the A2RL event with team Fly Eagle, a collaboration with Beijing Institute of Technology. They spoke to *KUST Review* in the team garage on qualifying day.

"The optimal trajectory is pre-computed," Khonji explained. "The code is then based on the information you get about your location on the track, and you try to accurately follow that path."

> THE FLY EAGLE CAR IS DRIVEN ENTIRELY BY ARTIFICIAL INTELLIGENCE. THERE'S NO DRIVER IN THAT CAR. **YET, THE DRAMA, THE SPEED, THE PRECISION, THE PASSION — ALL REMAIN.**

"In a simulator, your car would run perfectly using this method," Seneviratne added. "And do 10,000km perfectly. But in real life, errors creep in. If not corrected, these errors build up and the car goes wrong."

When asked if the team was correcting these errors or the AI was handling it, both Khonji and Seneviratne were quick to jump in: "The system is doing it. We set it up, but the system is doing all the learning, all the work."

There's plenty of run-off area at Yas Marina Circuit, but the barriers around the track are unforgiving, and there were many times during the practice runs that cars ran afoul of the track limits. Sustainable manufacturing came in handy as front wings were replaced regularly. And thankfully, the organizers had plenty of spare wings.

"We had some good runs but some technical hiccups, of course," Seneviratne said on qualifying day. Race events are rarely without hiccups for any race team, no matter the category, but for Fly Eagle, the biggest issue was signal around the racetrack. Their car was finding it difficult to communicate with the GPS system localizing it around the circuit.

"We get a very high-quality 3D map of the track and then the car has lidar sensors which it uses to localize itself on this map," Seneviratne explained. "The teams that are doing well here are using that technique successfully, and that's what we'll do next time too."

"To give an analogy, imagine it's a Formula One race and you've blindfolded the driver," Khonji added. "That's what our car is experiencing without the GPS."

Elite racing drivers practice each track before they arrive by putting in lap after lap on a simulator. It's common to hear them say they could drive a circuit with their eyes closed.

Seneviratne laughed when *KUST Review* put this to him: “In a straight line, sure, you could probably do it with your eyes closed, but corners, no way.”

This statement could not have been timed better: This is the point where attention was drawn from the garage back to the racetrack as the Kinetiz team car turned for Turn 12 too early and struck the barrier. Unfortunately for Kinetiz, Turn 12 is directly visible from the support pitlane where the teams were hosted for the event. The car was recovered, and a new front wing quickly supplied.

WHAT’S THE POINT?

Motorsport is often referred to as the “cradle of innovation”: Many innovations that found their way onto our roads originated in different motorsport categories.

Disc brakes won the 1953 24 Hours of Le Mans Grand Prix for Team Jaguar and two years later debuted on Citroen road cars.

Carbon fiber was first used in Formula One in the 1980s to reduce weight and can now be found on high-performance road cars. »»

⊙ **IMAGE:** Seven cameras, four radar sensors and three lidar units are the eyes and ears for these AI racing drivers.

Push-to-start reduced the start-up times for racing drivers in the pit lane — hardly a modern car lacks it now. Anti-locking brake systems originated on the Ferguson P99 racecar in 1961, the kinetic energy recovery system first tested in Formula One in 2008 led the way for hybrid vehicles and all suspension systems in cars today trace their roots to NASCAR or Formula One.

Even rear-view mirrors were first found in motorsport. At the first Indianapolis 500, driver Ray Harroun attached a mirror to his car so he could keep track of the cars behind him. By 1914, this was standard practice for all production cars. ASPIRE says by stress-testing autonomous technology on the racetrack, it's easier to identify key challenges and areas of improvement and rapidly address them:

"We believe there is potential in autonomous robotics and AI to combine these with the average driver to bring about greater safety on our roads," said ASPIRE's McCarthy. "We thought the best way to do it is to demonstrate its capability in the most extreme conditions you can, in the fastest, most well-designed race car in the world."

Stress-test may be the operative word for the event. A race car lapping the circuit at speed with no driver but a computer was seriously impressive, but a full lap with no incidents was a rarity.

During qualifying runs, many of the teams struggled to set a lap. The cars seemed to randomly swerve, spin or turn into the barriers. Sometimes, they even pulled off to the run-off area and simply stopped.

Seneviratne explained the random stopping was the AI making a prudent safety choice: When it wasn't sure what to do, rather than risk anything, it just came to a halt. Fly Eagle, however, was not one of the teams that made it into the final.

"We're on a learning curve but we're really happy with what we've done," Seneviratne told *KUST Review*.

"For us, it was more about establishing a platform to go onto the next stage. This was the first time we've competed in any racing event. High speed is new for us."

IMAGE: Motorsport has long been a testing ground for innovations that later make their way into road cars.

LIGHTS OUT

Four teams lined up for the final, hosted in front of a capacity crowd.

Even this didn't go to plan: The leading car spun, the second car passed by without incident, but then the race officials displayed a yellow flag to the competitors.

Racing rules dictate no passing under a yellow flag, but this means no passing moving vehicles: i.e. no overtaking. Humans get this. Computers did not.

The algorithms knew they weren't allowed to pass, so they didn't. They stopped on track. The safety feature is perfect for incidents on a real-life road, but it's not so impressive for a racing event if all the cars grind to a halt.

After a restart, the eight-lap race was completed. For reference, Formula One drivers do a lap in about 90 seconds. They'd complete eight laps in 12 minutes or so. The A2RL cars took 16 minutes.

They weren't far off once they got going but these lap times were slower than teams had achieved earlier in the week during their practice sessions.

Once they'd reached the final, there may have been a subconscious unanimous decision to exercise a little more caution. All race teams watch nervously as their cars compete – few must be as nervous as those watching a computer.

In the end, the inaugural event was won by the team from Technical University of Munich as its car correctly turned the hairpin on the last lap, while the lead car misjudged its entry.

It was a clean move and was just as dramatic for a driverless car as it would have been for human drivers.

The gap between human and robot persists for now, but if these events keep happening, and teams keep pushing the boundaries of what AI can do, things may change very quickly. A2RL plans to be back in November 2025.

IMAGES: AI generated, KUST Review.
GRAPHICS & PROMPTS: Anas Albounni, KUST Review.


EDUCATION IN
AI

Tools will help scholars of the future. Here's how.

There's no question that AI is changing the landscape of business and government. But how will it affect scholarship? This issue's panel of experts has thoughts. »»

Yousef Haik is vice chancellor for academic affairs at the University of Sharjah.

Are we heading toward an AI divide?

The rapid pace at which generative AI is reforming higher education teaching and learning and creating career paths is breathtaking. Personalized AI tutors and advisors are now accessible anytime and anywhere, and AI educational tools have penetrated learning spaces in so many ways.

Literature review of massive scholarship has become much easier. Emerging jobs such as prompt engineer, AI developer, AI analyst and AI system automation specialist are in high demand.

However, equitable access to the data used for large language models, which is often protected by copyright, as well as access to the necessary hardware, is crucial to avoiding the "AI divide."

Many low-income communities have suffered from similar digital divides, as witnessed during the COVID-19 pandemic. A report by UNESCO, UNICEF and the World Bank disclosed that students without access to the internet and learning resources lost about a year of education during the pandemic.

I argue that AI should be fully deployed in higher education, despite concerns from academics about the integrity of education and the rigor and credibility of higher education being compromised by students using AI.

As a disruptive technology, AI is not meant to replace humans. AI will continue to require the creation of new knowledge, which is undoubtedly entrusted to humans. AI grants us the power of speed but not the power of creation — not original creation, at least. This is why we have ample opportunities to use AI as a tool to empower teaching and research.

We need to incorporate it with the understanding that it is a tool, not an end in itself. AI can help us solve problems, but it cannot identify them or consider them in broader societal terms. It still needs creative people inputting content and making larger connections.

As AI capabilities evolve at a rapid pace, those without the capabilities or access to the technology will fall further behind, leading to another divide akin to the digital divide. To avoid the catastrophe of an AI divide, we must address two key issues:

Internationalization of copyright law exceptions: There is a need to attain transboundary exceptions to copyright laws to allow access to copyrighted materials for feeding large language models. This would enable more inclusive use of AI technologies, ensuring that all communities can benefit.

International development fund for AI access: Establishing this to ensure equitable access and the development of necessary infrastructure is vital. This fund could support low-income communities and developing nations in participating fully in the AI-driven global society.

The international communities can harness AI's full potential while ensuring that no one is left behind. The deployment of AI in higher education and beyond must be guided by principles of equity and inclusivity, fostering a future where everyone has the opportunity to benefit from technological advancements. This approach not only prevents an AI divide but also promotes a more just and prosperous world.

Maria Machado shares peer-review expertise at Stories4Sci and Cactus Communications and is an affiliate consultant with Maverick Publishing Specialists.

Tools could improve peer-review processes

At the 2024 London Book Fair, over 28 sessions discussed the impact of AI on the publishing industry.

Nick Lindsay, the director for journals and open access at the MIT Press, talked about the impact that predatory journals and paper mills have exerted on the public's trust in science.

Jay Flyyn, executive vice president and general manager for research and learning at research-content provider Wiley, argued that the mismatch between academic careers and publishing times has been underestimated.

Indeed, the waiting time imposed by traditional peer review is one of the main weaknesses of this process. The rise in fraudulent papers being published and subsequently retracted (as in the highly publicized case of Hindawi Special Issues, which I worked on) cannot be solely explained by the globalization in the use of large language models.

I was particularly interested in the discussions mentioning peer review. Automating editorial processes upstream of peer review is needed, especially for data-availability-statement and ethical-board-approval checks, together with automated fraud detection for images.

For publishers not to stifle the dissemination of knowledge, Harsh Jegadeesan, the chief publishing officer at major academic publisher Springer Nature Group, supports moving from a content pipeline to a research platform. Its in-house team has developed a tool called Snapp to integrate the author, editor and reviewer processes.

The trend to de-atomise the research article by sharing data, methods and other components independently (such as the possibility offered by Figshare) is still not scalable or commercially minded, as this would require expanding the pool of potential reviewers.

David Clark at Oxford University Press recognized that reviewers are under increased pressure to assess a whole range of formats including text, images, audio and video. Thus, motivating researchers to accept volunteer and unpaid labor could be less frustrating and time-consuming for journal editors if the process were streamlined.

Reviewer Credits arose as a publisher-independent platform that enables journal editors to find the best-fit peer reviewers, while also providing rewards for reviewers.

How equity and inclusivity can be improved within the peer-review process still causes a head-scratching motion. All discussions I participated in recognized the need to diversify opinions by recruiting reviewers from traditionally excluded communities. Notwithstanding, projects that advocate enhanced discoverability and inclusivity, such as AfricArxiv, are still in their infancy.

Although PRErveview was conspicuously absent, training these reviewers and developing metrics to assess the quality of research peer review seems to be the next logical step.

Jointly with colleagues in the academic publishing world, we have put together an initiative and invite you to collaborate! »»

Gustavo A. Patino, M.D., Ph.D., is the associate dean for undergraduate medical education and an associate professor in the Department of Medical Education at the Western Michigan University Homer Stryker M.D. School of Medicine. His research focus includes neuroscience education and the application of quantitative methods in biomedical research.

Humans still own responsibilities

Artificial intelligence (AI) methods have been impacting many facets of our life, and large language models (LLMs) have recently supercharged this impact. In LLMs, the prediction the digital system learns to make is "given this string of words, what is the next word that will come after?"

The examples they learn from are millions of online digital documents. LLMs receive a user's query or prompt and produce a narrative response by trying to predict the appropriate next work in an iterative process.

In the world of academic scholarship, the power of LLMs to leverage such vast amounts of information and produce written products (the currency of the realm in academia) has found many applications promising to increase productivity: writing the initial draft of a manuscript, correcting the grammar of a human-produced draft, summarizing existing literature, creating code to produce the user-specified data analysis and suggesting the appropriate analysis for the data available.

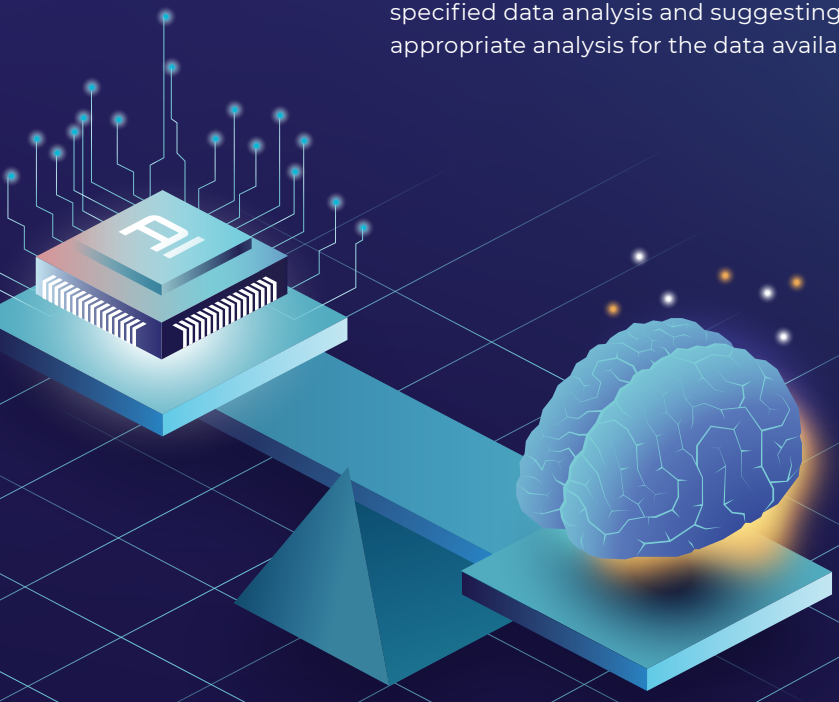


ILLUSTRATION: Abjad Design

It is important to emphasize that the success of each of these applications depends heavily on the user prompt.

Such wide applications require us to address important questions about scholarship and authorship, chief among them "Can an LLM be considered an author in a paper?"

To answer it, we must remember that AI systems are capable only of memorizing associations. As someone whose work and passion is medical education, I am very aware of the difference between memorizing facts and higher order mental abilities like applying those facts to solve problems; using parallel thinking to apply them to novel situations; or coming up with new hypotheses for discovering new facts.LLMs are capable only of memorizing facts as strings of words and depend on the prompts for what strings of words to produce.

Furthermore, the words themselves do not mean anything to the system, all it knows is that those words are correlated with each other in the documents it has learned from. Thus, LLMs are simply tools, very powerful tools, but tools nonetheless.

Even if they write the draft of a paper, LLMs are not capable of coming up with a novel idea, can't take responsibility for the content or review it critically, all key requirements for authorship.

If LLMs are simply tools, the responsibility of the content in the scholarly product still lies solely on the human authors. This is particularly important because LLMs can create word sequences with biased or false information (hallucinations) given their probabilistic nature and/or misinformation in their training data. The authors take responsibility for the accuracy of the content and referencing the sources of information to avoid plagiarism.

If LLMs are used in scholarly products they should be described like any other method to allow a review of the validity of the results and allow replicability. LLMs can help in each of these tasks, but humans still bear the full burden for what is shared with others.

NEXT ISSUE

WE'D LIKE A WORD

From the way natural language processing is changing the way we talk with machines to how AI might resurrect dead languages, communication is on our minds in the next issue of **KUST Review**.

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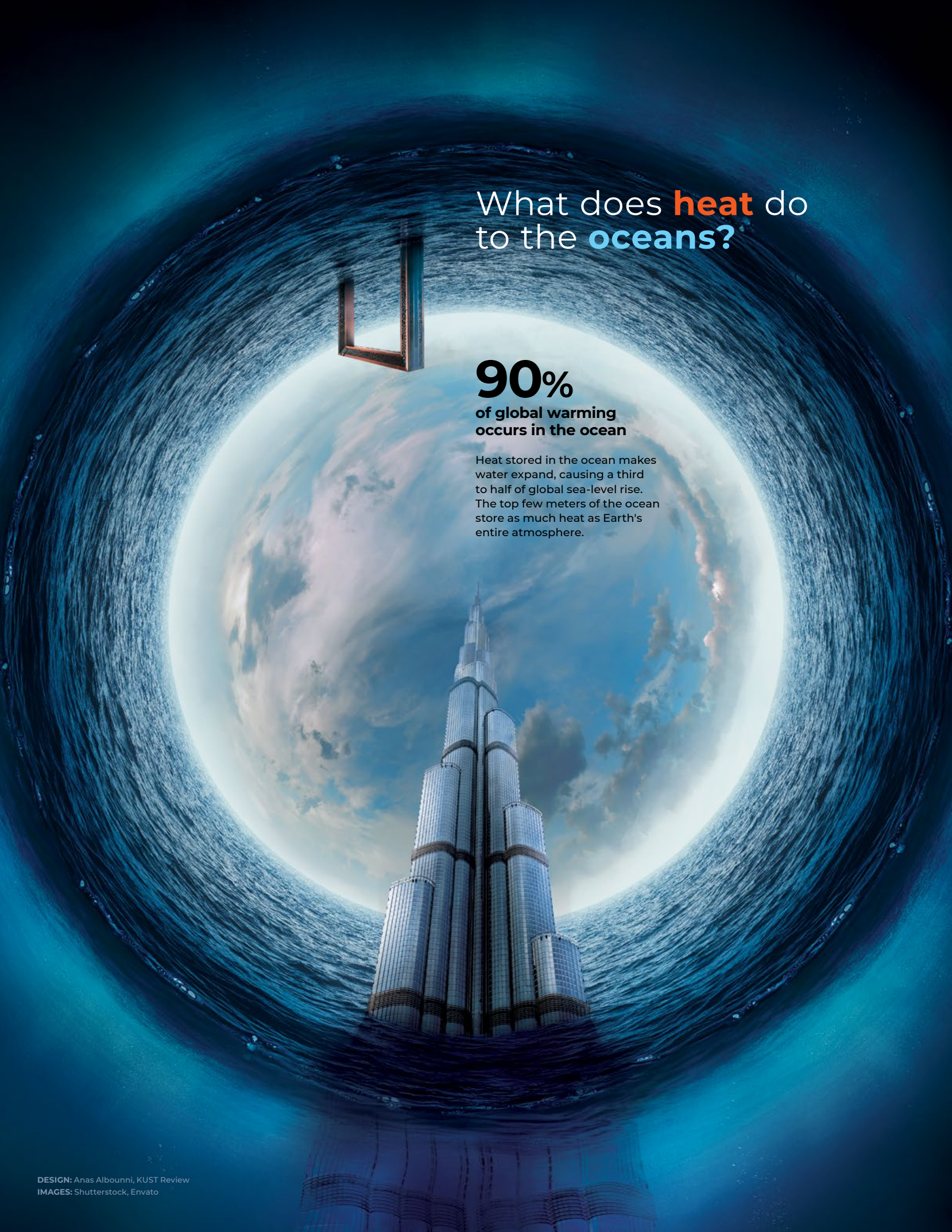

What does **heat** do to the **oceans?**

90%

of global warming occurs in the ocean

Heat stored in the ocean makes water expand, causing a third to half of global sea-level rise. The top few meters of the ocean store as much heat as Earth's entire atmosphere.

DESIGN: Anas Albounni, KUST Review
IMAGES: Shutterstock, Envato