Solving Singapore's urban heat island effect

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Singapore. Credit: Unsplash/CC0 Public Domain

According to Singapore's Meteorological Service, Singapore has been warming up twice as fast compared to the rest of the world.

Due to the effects of global warming, rising urban heat, and El Niño, 2023 was the hottest recorded year in Singapore.

Temperature increases can result in adverse climatic effects such as

increased frequency of heat waves, droughts, extreme rainfall, and floods.

Another factor that is contributing to rising temperatures is Singapore's densely built city and urban structures such as buildings, roads, and vehicles.

Urban structures can trap and release heat into the environment, especially at night.

The Urban Heat Island (UHI) effect or trapped urban heat explains why there are temperature differences of up to seven degrees Celsius between the urban and less built-up areas of Singapore.

The consequences of rising temperatures can be dire for human beings.

Other than thermal discomfort, health issues can exacerbate, resulting from heat stress or excess heat trapped in the bodies.

Heat stress occurs in the event when human bodies cannot adequately cool themselves or dissipate the built-up of excess heat.

"In an effort to cool down urban heat, the Cooling Singapore 2.0 project was initiated in 2021. This research project is in collaboration with ETH Zurich at the Singapore-ETH Centre," Research Assistant Graces Ching informed the Office of Research.

"Climate research has been my focus since my undergraduate studies. Since graduation, I've been involved in researching the effects of trees and vegetation on 'beating the heat' in Singapore," she added.

"When the opportunity to work on the Cooling Singapore 2.0 project was presented to me, I seized it for three reasons. My curiosity in climate

research was piqued from my earlier work. I had also developed an interest in understanding the interactions between the atmosphere, humans, and the environment. And I wanted to be a part of the team to develop one of Southeast Asia's pioneering computational projects for reducing urban heat," she continued.

"The focus of Cooling Singapore 2.0 is to build a Digital Urban Climate Twin (DUCT) system, which models urban spaces using a system of models. Different scenarios can be simulated on the system. For example, different sizes, shapes or density of vegetation can be modeled so that we can develop an in-depth understanding of how the different scenarios affect the microclimate in the surrounding areas," she elaborated.

About Digital Urban Climate Twin

The Digital Urban Climate Twin (DUCT) is essentially a digital representation and a copy of a physical climate system.

The DUCT incorporates all relevant computational models to account for environmental factors such as wind and sunlight, land surfaces, traffic, industrial and building energy models, as well as the movements of people.

It factors in previous findings along with the data and models of available UHI and outdoor thermal comfort (OTC) research. It can also simulate past historical data to the current data that is being collected. This ensures that the models produced are accurate, valid, and robust.

The DUCT can be used to isolate the effects of urban heat. It can quantify urban heat in selected areas so that climatic outputs such as temperature can be determined. It can also quantify mean radiant temperature, which is the exchange of heat between a human and the

surrounding environment, humidity, and wind speeds.

"Given that it is a powerful visualization tool, we wanted to design and develop the DUCT for urban planners and policymakers—for people who are responsible for urban planning yet who might not have the expertise nor in-depth knowledge of urban heat, so that they can make sound and informed decisions for urban planning for designing an environment that is more heat resilient and thermally comfortable for the residents of Singapore," said Ching.

Continued Ching, "We want them to use the DUCT to invent, design, simulate and test different scenarios for reducing urban heat. If the scenarios test well and there's high confidence that they will function well, then they can go ahead and build and turn the scenarios into reality."

Progress of the research

The project is progressing on schedule. Recently, a beta version of DUCT was released for testing by urban planners and policymakers.

In addition to gathering feedback from a selected team of users from the various Singapore government agencies, the researchers have embarked on the next phase of the project, which focuses on assessing the heat risks and impact of urban heat on human and biodiversity ecosystems.

Insights from the research

One key insight from the research thus far pertains to the impact of trees and parks.

While tree planting is perceived to be the perfect solution for reducing

urban heat, there appears to be a saturation point where temperature reduction is observed.

Additionally, poor management of trees, especially due to overcrowding, can reduce wind speeds, increase humidity, and trap air pollutants. This results in detrimental effects on thermal comfort.

That said, trees in a park contribute to cooler temperatures that can be felt in Housing Development Board (HDB) estates up to 300 meters away.

This effect, known as the park cool island effect, can reduce the mean radiant temperature during the day when the sun is most intense between 11 am and 3 pm .

Trees also provide the needed shade from the sun, and help to cool surrounding areas through evapotranspiration, which is the process of drawing heat from the environment and dissipating it through evaporation.

It has been found that trees and parks provide other ecosystem effects, such as improved mental well-being and carbon sequestration, which reduces greenhouse gas emissions.

Provided by Singapore Management University

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