

# Technology Scan

## Focus: Technologies for climate-resilient cities

### ASIA-PACIFIC

#### AUSTRALIA

##### National index to combat urban overheating

In response to the growing threat of urban overheating, researchers at the University of New South Wales (UNSW) have created a National Heat Vulnerability Observatory Index (NaHVO) to measure and mitigate heat vulnerability across Australia's towns and cities.

The NaHVO provides a standardised approach to data collection and measurement of heat vulnerability, considering factors such as the built environment and population demographics. The index identifies areas where populations are more susceptible to the adverse effects of urban heat and informs effective cooling interventions. This data is then used to model the impact of various heat mitigation strategies, offering tailored advice to local authorities.

In its initial phase, the project has already demonstrated significant potential. Pilot studies in Dubbo Region and Maitland City have shown that implementing a combination of cooling strategies, such as cool materials for roads and roofs, increased urban greenery, and water-misting systems, could reduce air temperatures by up to 2 degrees Celsius and surface temperatures by over 10 degrees Celsius.

As urban planners, developers, and architects face the challenge of designing climate-resilient towns and cities, the NaHVO emerges as a crucial tool. It enables decision-makers at all levels of government to visualise and measure the effects of urban overheating while providing location-specific data on the impact of various cooling strategies.

<https://www.buildaustralia.com.au/>

### CHINA

##### Radiative cooling technology

City University of Hong Kong (CityU-HK) researchers have made a remarkable scientific breakthrough in developing next-generation passive radiative cooling technology. Their pioneering work on cooling ceramics, pavements, and textiles helps mitigate heat impacts without additional energy consumption. This innovation has promising application potential in buildings, roads, and clothing, addressing issues such as urban heat islands and greenhouse gas emissions to combat the challenges of climate change.

The team established the start-up i2Cool in 2021 under the incubation of CityUHK's HK Tech 300 programme and developed a cooling paint for roofs and walls. The recent approval of funding from the Hong Kong government's "Research, Academic and Industry Sectors One-plus Scheme" (RAISE+ Scheme) marks a significant step forward in accelerating the commercialisation and application of this groundbreaking innovation. The CityU-HK team plans to establish manufacturing facilities and production lines by the end of 2026.

A research team led by Professor Edwin Tso Chi-yan, from CityUHK's School of Energy and Environment, has been focusing on developing passive radiative cooling (PRC) technology. "PRC technology is a universal solution to global warming, as it leverages high solar reflectivity and high mid-infrared emissivity to cool surfaces naturally by reflecting incoming sunlight and emitting thermal radiation to the cold universe, potentially reducing the surface temperature by at least 2°C," explained Professor Tso. "This technology offers an electricity- and refrigerant-free cooling solution, mitigating the heat impact without additional energy consumption."

The innovation involves developing passive radiative cooling ceramics

(PRCCs) with high solar reflectivity and superb mid-infrared (MIR) emissivity. PRCCs have a porous structure that minimises solar absorption and resists degradation caused by ultraviolet (UV) radiation. Composed of pure inorganic materials that have low absorption of sunlight and heat, PRCCs offer excellent chemical stability and robust mechanical properties. These eco-friendly ceramics are suitable for long-term outdoor use, making them ideal for building envelopes, pedestrian paths, and public squares. They can reduce solar heat gain and enhance the thermal radiation to the universe, thereby reducing the need for air-conditioning.

<https://www.cityu.edu.hk/>

##### Radiative cooling coating for energy saving

Hong Kong Polytechnic University (PolyU) researchers have developed an environmentally friendly solar-driven adaptive radiative cooling (SARC) coating for building roofs and walls. This coating can reduce a building's surface temperature by up to 25°C and lower indoor temperatures by 2 to 3°C, all without consuming any energy. The non-toxic, metal-free, and durable coating can also be produced on a large scale, promoting an eco-friendly and energy-saving method to mitigate urban heat island effects and support the achievement of carbon neutrality.

Coating a building in a reflective material enables the self-regulation of its thermal environment to minimize indoor temperatures. However, traditional passive radiative cooling materials cannot automatically adjust cooling capacity in response to environmental changes, which limits their applications.

To address this challenge, a research team led by Prof. Lu Lin Vivien, Professor of the Department of Building Environment and Energy Engineering at PolyU, along with key team member Dr. Quan Gong, Postdoctoral Fellow of the same department, has invented a carbon dots (CDs)-driven SARC coating that can

adjust cooling capacity based on solar irradiance. The work is published in the *Chemical Engineering Journal*.

However, traditional photoluminescent cooling materials typically rely on rare earth metals and perovskite materials, which pose environmental risks. To address these issues, the team has introduced groundbreaking, environmentally friendly polymer-based CDs as photoluminescent materials into the radiative cooling coating. Nano-sized CDs were embedded into polymers to create a biologically harmless material. The polymer CDs were uniformly coated onto hollow glass particles to create smart cooling beads, enabling the coating to effectively convert ultraviolet light into visible light photons and increase effective solar reflectance. This water-soluble SARC only requires the evaporation of water to form a coating on building surfaces without releasing any volatile organic compounds, thereby reducing air pollution.

Results have shown that compared to conventional radiative cooling coating, the new SARC coating improved effective daytime solar reflectance from 92.5% to 95% and increased the cooling effect by 10% to 20%. For example, it can reduce the temperature by up to 25°C when applied to concrete rooftops.

<https://techxplore.com/>

## INDIA

### New AI feature to tackle air pollution

In a bid to combat the rising air pollution woes of India, tech giant Google on Wednesday launched Air View+ -- an artificial intelligence-based solution that can help the government and the people with useful hyperlocal air quality information. Air View+ is powered by Google AI and works in collaboration with local climate tech firms. This can enable real-time hyperlocal air quality information, which includes local sustainability startups, researchers/climate action groups, corporations, city administrators, and citizens.

The ecosystem can provide "valuable air quality insights to government

agencies responsible for environmental monitoring and urban planning," said Google in a blog post. It will also provide "real-time hyperlocal air quality information in Google Maps for users across India," it added.

Air View+ empowers local municipal corporations with hyperlocal air quality data for their cities. This can be used to develop their in-house AQ dashboards via the researchers and sustainability partners. "These dashboards provide air quality data for unmonitored areas and help urban planners identify hotspots and make necessary interventions," Google said.

The capabilities of Air View+ were tested in a pilot run last year. The partnerships with municipal corporations including Navi Mumbai, Chhatrapati Sambhaji Nagar, and Greater Chennai have yielded hugely encouraging results, Google said. Further, Air View+ also helps common people access hyperlocal air quality information across the country in Google Maps.

The information garnered may help vulnerable populations such as young children or the elderly to take appropriate preventative measures and precautions for their health such as using N95 masks or reducing outdoor exposure. People can readily access AQI in Google Maps by selecting the Air Quality layer from the Layer button on the home screen and tapping on any location on the map. Clicking the Weather widget on the Explore tab on the home screen can help them access AQI info at their current location.

<https://morungexpress.com/>

### Pervious pavements to combat urban flooding

In a novel urban solution, researchers at the Indian Institute of Technology (IIT) Bhubaneswar here have developed pervious concrete pavements, a substitute for bituminous and concrete ones, that will help combat urban flooding and heat island effect in cities. According to the researchers of the School of Infrastructure at the institute, widespread construction and use of imperious pavements like bituminous and concrete surfaces exacerbate storm water runoff during rainfall, causing

flood-like conditions in cities. Additionally, these have led to significant depletion of groundwater reserves.

Recognising the issue, the researchers have come up with pervious concrete pavements with the objective of curbing storm water runoff and promoting groundwater recharge. Unlike traditional pavements, pervious concrete features interconnected voids with at least 15 per cent porosity, allowing storm water to percolate through the pavement and recharge the groundwater.

As part of the experiment, IIT-BBS used pervious concrete pavements in the cycle parking area, covering 150 square metres with 18 slabs produced at a ready-mix concrete (RMC) plant. Students from the Transportation Engineering section participated in it, placing 150 mm thick pervious concrete slabs of 3.5X2.5 metre over a 250-300 mm reservoir layer atop the subgrade. The system was found capable of storing over 20 cubic metres of water without a runoff.

To assess pervious concrete pavements' efficiency, rainfall data from June 27 was also obtained from the GMAG lab of the School of Earth, Ocean, and Climate Sciences. It was found that the pavement infiltrated 6.8 cubic metre of storm water per hour during 47.24 mm/hr rainfall from 1.30 pm to 4.00 pm without any runoff.

<https://www.newindianexpress.com/>

## JAPAN

### Machine learning model enhances urban resilience

To make cities more resilient to the effects of liquefaction, Professor Shinya Inazumi and his student Yuxin Cong from Shibaura Institute of Technology in Japan have been developing machine learning models that predict how soil will react during earthquakes. These models use geological data to create detailed 3D maps of the soil layers, identifying stable areas and those more prone to liquefaction. Unlike manual soil testing methods, which cannot cover every location, this approach offers a broader and more detailed view of soil behaviour.

In their recent study published in *Smart Cities* on 8 October 2024, they used artificial neural networks (ANNs) and ensemble learning techniques to accurately estimate the depth of the bearing layers, a crucial indicator of how stable the soil is and how likely it is to experience liquefaction during an earthquake.

Predicting areas with deep and stable bearing layers helps identify locations where the soil can provide better support for buildings, especially during events like liquefaction. The researchers collected bearing depth data from 433 points in Setagaya-ku, Tokyo, using standard penetration tests and mini-ram sounding tests. In addition to the depth of the bearing layer, they also recorded key information about each location, such as longitude, latitude, and elevation.

The data was used to train an ANN to predict the bearing layer depth at 10 locations, utilizing the actual site measurements to evaluate the accuracy of the predictions. To improve the accuracy of these predictions, the researchers applied a technique called bagging (bootstrap aggregation), which involves training the model multiple times on different subsets of the training data. This approach resulted in a 20% improvement in prediction accuracy.

Using the predicted values, the researchers created a contour map illustrating the depth of bearing layers within a 1 km radius around four selected locations in Setagaya Ward. This map is a valuable visual aid for civil engineers, helping them identify suitable construction sites with stable soil conditions. It also assists disaster management experts in pinpointing areas that are more vulnerable to soil liquefaction, enabling better risk assessment and mitigation strategies.

<https://www.eurekalert.org/>

## SINGAPORE

### Digital solutions to address urban land scarcity

As the global population continues to grow, land and resource limitations

are becoming increasingly urgent concerns, particularly in densely populated megacities. In response, researchers from Nanyang Technological University's (NTU) School of Civil and Environmental Engineering (CEE) are working on solutions that focus on utilising underground space and strengthening coastal protection measures.

Underground development presents a potential solution to urban land scarcity, offering new opportunities for social, economic, and environmental advancements. Coastal cities, meanwhile, face the growing threat of rising sea levels and erosion, making it essential to implement measures that protect shorelines and low-lying areas.

At NTU, the Centre for Urban Solutions (CUS) plays a key role in addressing these challenges. This multidisciplinary initiative focuses on integrating digital technologies, including artificial intelligence (AI), to improve urban planning and construction. One of CUS's main areas of research is underground engineering. With land becoming increasingly scarce, cities are expanding upwards with high-rise buildings and downwards. This approach creates additional space while ensuring cities are prepared for future growth.

Assoc Prof Wu Wei, who leads the Underground Engineering Cluster at CUS, oversees teams developing digital solutions to improve the safety and efficiency of underground construction. "Digging up to 100 metres deep poses significant engineering challenges, such as managing costs and controlling surface settlement to prevent accidents like the ground collapsing," he explains, referring to cases where sinkholes have formed during construction. His team employs AI-driven methods to map underground structures more accurately. By using machine learning, they can detect anomalies such as hidden cavities or boulders, improving precision while reducing costs and minimising the need for human supervision.

Similarly, Assistant Prof Shi Chao is applying digital technologies to underground and coastal engineering. His team uses digital twins—virtual models that simulate underground conditions—to optimise construction plan-

ning. These models enhance predictive analysis, reducing the reliance on physical site testing.

"We harness emerging AI technology to combine geological knowledge and site-specific data to automatically build and update digital twins," says Assistant Professor Shi. Accurate underground modelling is crucial for mitigating safety risks and preventing project failures. His team has successfully implemented digital twin technology in Hong Kong, which has been used to assess slope stability and seabed conditions for land reclamation and tunnelling. In cities with limited land availability, these tools can help engineers navigate challenging soil conditions while reducing construction risks.

Beyond underground expansion, researchers are also addressing the challenges posed by rising sea levels. According to Singapore's latest national climate study, sea levels could increase by up to 1.15 metres by the end of the century, surpassing previous projections.

<https://theindependent.sg/>

## EUROPE

### UK

#### IoT and AI to combat urban flooding

The University of Bath has unveiled an IoT solution aimed at tackling urban flooding by combining smart cameras with AI. The software, called 'AI on The River,' identifies blockages in culverts by detecting debris and waste. Culverts, critical for enabling waterways to flow under urban infrastructure, are fitted with trash screens to avert debris penetration. However, blockages at these screens can swiftly lead to flooding. By leveraging IoT capabilities, this system offers proactive monitoring and alerts. The system is attracting global interest, particularly from nations like South Africa where data scarcity hampers similar technological developments.

The system underwent trials at a site in Cardiff, achieving nearly 90% accuracy

in spotting potential obstructions. Traditionally, culverts have been manually monitored via CCTV, necessitating continuous human intervention.

Incorporating IoT with AI ensures local authorities can optimise resource allocation, focusing on genuine issues and enhancing immediate response capabilities. This facilitates safer, more efficient interventions without exposing teams to hazardous conditions.

With climate change increasing flood risks globally, this IoT-focused research marks a significant advancement in managing urban water challenges. The system's flexibility paves the way for a sustainable, intelligent approach to flood forecasting, setting a new benchmark for IoT applications in infrastructure. The study, 'CCTV Image-based classification of blocked trash screens,' is published in *The Journal of Flood Risk Management* and supported by the Engineering and Physical Sciences Research Council (EPSRC).

<https://iottechnews.com/>

## Molecular trap to clean pollution from water

Scientists from The University of Manchester have developed a new material that could help reduce water pollution caused by harmful chemicals, such as from leftover medicines and hygiene products, that end up in rivers and lakes. The research, published in the journal *Cell Reports Physical Science*, describes a new method using a molecular structure called a metal-organic cage (MOC). These tiny cages act like traps designed to catch and hold harmful molecules commonly found in our water supplies.

While MOCs have been studied before for gas and chemical capture, they are most commonly studied in chemical solvents where their performance differs significantly from that observed in water. Being able to demonstrate the capture of established wastewater pollutants in water is thus a step towards the application of these cages for real-world applications.

Jack Wright, a researcher at The University of Manchester, who completed the research as part of his PhD, said:

"Being able to use MOCs in water is a really exciting development. We know how valuable MOCs are for capturing unwanted substances, but until now researchers have not been able to apply them to real-world water systems.

"Many harmful chemicals are difficult to remove from water, and with water pollution becoming a global crisis, this new MOC technology could provide a valuable tool to help clean up water systems and prevent pollutants from entering our ecosystem, particularly in rivers and lakes near urban or industrial areas where wastewater discharge is most common."

The cages are made up of metal ions connected by organic molecules, forming a hollow pyramid-like structure. These hollow spaces at the centre of these structures are where the MOCs trap specific molecules, like pollutants or gases. The new structure incorporates chemical groups called sulfonates to make it compatible with water, allowing it to function in real-world water systems, like rivers or wastewater.

It uses a natural effect called hydrophobic binding, where contaminant molecules preferentially "stick" to the inside of the cage rather than staying in the water. This allows the material to selectively capture and hold pollutants, even in challenging water environments.

Dr. Imogen Riddell, PhD supervisor and researcher at The University of Manchester said: "One of the real strengths of this method is its flexibility. The approach we have developed could be used to design other water-soluble MOCs with different sizes or properties. This opens the door to many future applications, including cleaning up different kinds of pollutants, development of green catalysts, or even development of drug delivery strategies."

Now, the researchers will look to further expand the water-soluble cages, to enable the capture of more, different contaminants, and are working towards the development of robust routes to recycling the cages to support their development as sustainable water purification aids.

<https://smartwatermagazine.com/>

## NORTH AMERICA

### USA

#### AI system models urban trees to tackle climate change

Tree-D Fusion, developed by MIT, Google, and Purdue researchers, uses AI to create 3D models of urban trees, predicting growth under climate scenarios. These models aid city planning by anticipating challenges like branch interference and improving urban cooling. The technology also addresses environmental equity by mapping urban tree canopies with unprecedented detail.

The novel "Tree-D Fusion" system developed by researchers at the MIT Computer Science and Artificial Intelligence Laboratory (CSAIL), Google, and Purdue University merges AI and tree-growth models with Google's Auto Arborist data to create accurate 3D models of existing urban trees. The project has produced the first-ever large-scale database of 600,000 environmentally aware, simulation-ready tree models across North America.

Tree-D Fusion builds on previous urban forest monitoring efforts that used Google Street View data but branches it forward by generating complete 3D models from single images. While earlier attempts at tree modeling were limited to specific neighborhoods or struggled with accuracy at scale, Tree-D Fusion can create detailed models that include typically hidden features, such as the back side of trees that aren't visible in street-view photos.

The technology's practical applications extend far beyond mere observation. City planners could use Tree-D Fusion to one day peer into the future, anticipating where growing branches might tangle with power lines, or identifying neighborhoods where strategic tree placement could maximize cooling effects and air quality improvements. These predictive capabilities, the team says, could change urban forest management from reactive maintenance to proactive planning.

The researchers took a hybrid approach to their method, using deep learning to create a 3D envelope of each tree's shape, and then using traditional procedural models to simulate realistic branch and leaf patterns based on the tree's genus. This combo helped the model predict how trees would grow under different environmental conditions and climate scenarios, such as different possible local temperatures and varying access to groundwater.

While Tree-D fusion marks some major "growth" in the field, trees can be uniquely challenging for computer vision systems. Unlike the rigid structures of buildings or vehicles that current 3D modeling techniques handle

well, trees are nature's shape-shifters – swaying in the wind, interweaving branches with neighbors, and constantly changing their form as they grow. The Tree-D fusion models are "simulation-ready" in that they can estimate the shape of the trees in the future, depending on the environmental conditions.

<https://www.technologynetworks.com/>

### AI to predict climate-change related diarrheal outbreaks

A study published in *Environmental Research Letters* by an international team of investigators led by a senior author from the University of Maryland's School of Public Health (UMD

SPH) Amir Sapkota, offers a way to predict the risk of such deadly outbreaks using AI modeling, giving public health systems weeks or even months to prepare and to save lives.

The multidisciplinary team, working across several institutions, relied on temperature, precipitation, previous disease rates, El Niño climate patterns as well as other geographic and environmental factors in Nepal, Taiwan province of China, and Viet Nam - between 2000 and 2019. Using this data, the researchers trained AI-based models that can predict area-level disease burden with weeks to months ahead of time.

<https://www.preventionweb.net/>