Asia-Pacific Tech Monitor

Volume 41, No. 3, July-September 2024

Artificial Intelligence for climate change mitigation and adaptation
Opportunities and challenges

ESCAP
APCTT
Asian and Pacific Centre for Transfer of Technology

*The shaded areas of the map indicate ESCAP members and associate members.**

The Economic and Social Commission for Asia and the Pacific (ESCAP) is the most inclusive intergovernmental platform in the Asia-Pacific region. The Commission promotes cooperation among its 53 member States and 9 associate members in pursuit of solutions to sustainable development challenges. ESCAP is one of the five regional commissions of the United Nations.

The ESCAP secretariat supports inclusive, resilient and sustainable development in the region by generating action-oriented knowledge, and by providing technical assistance and capacity-building services in support of national development objectives, regional agreements and the implementation of the 2030 Agenda for Sustainable Development.

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Asia-Pacific
Tech Monitor
Vol. 41 No.3 ❖ July – September 2024

The **Asia-Pacific Tech Monitor** is a quarterly periodical of the Asian and Pacific Centre for Transfer of Technology (APCTT) that brings you up-to-date information on trends in technology transfer and development, technology policies, and latest technology innovations.

Web: https://apctt.org/techmonitor

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ASIAN AND PACIFIC CENTRE FOR TRANSFER OF TECHNOLOGY
C-2, Qutab Institutional Area
Post Box No. 4575
New Delhi 110 016, India
Tel: +91-11-3097 3700
E-mail: apctt.techmonitor@un.org
Website: http://www.apctt.org

ISSN: 0256-9957

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Foreword

Artificial Intelligence (AI) is emerging as a transformative force driving economic growth and productivity across diverse sectors. AI offers significant benefits in terms of increasing efficiency, fostering innovation and improving decision-making processes. Studies have also shown that AI holds immense potential to address climate change and accelerate sustainable development. The market of AI is rapidly expanding, which by 2030 might be contributing between $13 trillion and $16 trillion to the global economy, as per the *Technology and Innovation Report 2023* of UNCTAD.

For addressing climate change, Artificial Intelligence offers innovative solutions and applications in weather prediction, tracking pollution, improving sustainable agriculture practices, optimizing power grids, increasing energy efficiency, drafting disaster response plans, and preparing adaptation and mitigation strategies. Artificial Intelligence not only helps in precise and real-time predictions of extreme weather events, but also assists in managing and optimizing utilization of resources. With growing demand for sustainable and smart city applications, AI is increasingly becoming integrated into urban planning and systems across various domains including transportation, energy management, urban forestry, waste management, pollution control among others. For wider utilization of AI-driven technologies to address climate change, it is important for countries to strengthen their policies and capacity to facilitate innovation and scale up.

This special issue of *Asia-Pacific Tech Monitor* focusses on the theme “Artificial Intelligence for climate change mitigation and adaptation: opportunities and challenges”. It features articles presenting insightful discussions on innovative applications, case studies from the region and policy recommendations for leveraging AI-driven solutions to address the impacts of climate change. The articles discuss application of AI technologies in hydro-climatology and agriculture, integration of AI into urban forestry practices to enhance urban microclimates, and AI applications in mitigating and adapting to extreme heat conditions in densely populated Asian cities. The articles provide valuable insights for policymakers and planners advocating the incorporation of AI technologies to support climate change adaptation and mitigation measures.

We hope this edition of *Tech Monitor* will support relevant stakeholders in designing and implementing appropriate strategies to leverage innovative AI-solutions for climate resilience in the Asia-Pacific region.

Preeti Soni
Head, APCTT

Technology Market Scan

INTERNATIONAL

100% of electricity from renewable energy

Seven countries now generate nearly all of their electricity from renewable energy sources, according to newly compiled figures. Albania, Bhutan, Nepal, Paraguay, Iceland, Ethiopia, and the Democratic Republic of Congo produced more than 99.7 per cent of the electricity they consumed using geothermal, hydro, solar, or wind power.

Data from the International Energy Agency (IEA) and International Renewable Energy Agency (IRENA) also revealed that a further 40 countries generated at least 50 per cent of the electricity they consumed from renewable energy technologies in 2021 and 2022 – including 11 European countries.

Figures released by the IEA in January show that the UK generated 41.5 per cent of its electricity from renewable sources in 2022 – up 10.5 per cent from the year before. In Scotland, renewable energy technologies generated the equivalent of 113 per cent of the country's overall electricity consumption in 2022. While Scotland's electricity generation was dominated by wind power, researchers predict that solar will come to dominate global electricity supplies over the coming decades.

Significant progress has been made in recent years in improving efficiency rates for solar cells, primarily boosted by the so-called 'miracle material' perovskite. Commercial costs have also fallen, which led scientists at the University of Exeter and University College London to claim last year that solar energy has reached an "irreversible tipping point" that will see it become the world's main source of energy by 2050.

Their 2023 paper, published in the journal *Nature Communications*, found that technological and economic advances meant the transition to clean energy is not just reachable, but inevitable.

https://www.independent.co.uk

ASIA-PACIFIC

CHINA

Technology innovation hub

China's State-owned Assets Supervision and Administration Commission (SASAC) of the State Council recently launched the second phase of construction for original technology innovation hubs among centrally administered enterprises, in a bid to speed up the development of industrial upgrades driven by cutting-edge technology innovation. The move will support 40 centrally administered enterprises in establishing 52 original technology innovation hubs across 36 sectors such as quantum information, neuromorphic intelligence, and biomanufacturing, according to *Xinhua News Agency*.

Experts noted that state-owned enterprises possess scale and resource advantages, especially in technology research and development (R&D). The rapid progress in technological innovation by these firms serves as a pivotal driving force for fostering innovation in the private sector and propelling China's economic growth.

In the latest move, SASAC will urge central enterprises to bolster efforts in constructing innovation hubs and expedite 11 action plans to achieve original breakthroughs in fields such as quantum information, 6G, deep-sea exploration, controllable nuclear fusion, and advanced materials, *Xinhua* reported.

China has been vigorously pushing for its high-quality development, driven by new, high-quality, productive forces, and state-owned enterprises play a crucial role in advancing this process. Amid mounting global high-tech competition, it is imperative to encourage industrial innovation through policy and investment support, Li Chang'an, a professor at the Academy of China Open Economy Studies of the University of International Business and Economics, told the Global Times.

China's central government approved a guideline in February 2022 that required state-owned enterprises to enhance their innovation capabilities, promote the deep integration of industrial and innovation chains, and establish original technology innovation hubs.

SASAC's move marked the latest progress in this ambitious initiative, following the first batch of 29 key-supported technology innovation pilot projects launched since the plan was announced. Official data shows that centrally administered enterprises completed investments totaling 2.18 trillion yuan ($301.8 billion) in strategic emerging industries last year, representing a year-on-year growth of 32.1 percent, with a slew of key projects implemented in sectors such as photovoltaic hydrogen production, carbon fiber manufacturing, and automotive chips, according to media reports.

https://www.globaltimes.cn

R&D investment

Last year, China's annual R&D investment exceeded 3.3 trillion yuan ($458.4 billion), an increase of 8.1 percent over the previous year, said Yin Hejun, minister of science and technology. Yin made the remark in an interview following the opening meeting of the second session of the 14th National People's Congress on Tuesday. He added that among that, the funding for basic research was 221.2 billion yuan, an increase of 9.3 percent over the previous year. Last year, 950,000 new technology contracts were signed in China; authorized invention patents reached 921,000, an increase of 15.3 percent from the previous year, he said.

"New energy vehicles, lithium batteries, and photovoltaic modules, the so-called 'new three items' that everyone is focusing on, had very pleasing growth rates in exports last year. Technological innovation has not only enhanced the competitiveness of our country's traditional industries but has also solidified the foundation for developing new quality productive forces, injecting momentum," he said. Yin mentioned that last year, China achieved a number of major original achievements in quantum technology, integrated circuits, artificial intelligence, biomedicine, and new energy, including the official operation of the world's first fourth-generation nuclear power plant and the commercial operation of the C919 large aircraft.

In the future, China will further increase investment in scientific and technological research and continue to strengthen basic research, strengthen the power of national strategy, leverage the advantages of national laboratories and national scientific research institutions, and build a "national team" for the construction of a strong country in science and technology, he said. At the same time, China welcomes international cooperation to continuously inject new innovative power for high-quality development, he said.

https://www.chinadaily.com.cn

Green technology for carbon capture and sequestration

China is increasing its competitive edge in advanced technologies to combat global warming, a Nikkei survey shows, taking the global lead in patents related to the capture and sequestration of industrial carbon dioxide emissions. China's lead in the area is three times as large as that of second-place U.S. China is also the global market leader in batteries for electric vehicles and solar panels, giving it growing dominance in the decarbonization supply chain.

CO2 capture has been said to be a key to combatting global warming. The technology captures CO2 from factory and power plant exhaust and buries it underground or uses it as a raw material for chemicals. Companies in various countries are competing to develop the technology, for which the global market in 2028 is expected to expand to $15.24 billion, 6.5 times larger than in 2021. Working with the Mitsui & Co. Global Strategic Studies Institute, Nikkei analyzed patents granted or otherwise obtained in major countries from 2000 to February 2024.

The total number of patents in the field held by Chinese companies and research institutions have quadrupled from 2015 to 10,191, almost half the global total. Patent quality is also high, scoring second only to the U.S. in terms of attention they receive from competitors and other factors. It has rapidly closed the quality gap with the U.S. since the mid-2010s. Chinese companies and research institutes have advanced their technological capabilities in a wide range of fields, including CO2 separation and the conversion to hydrocarbons that can be used to produce chemicals.

The Chinese Academy of Sciences and China Petrochemical Corporation (Sinopec Group) also ranked top of the world in a number of patents by a research institute and a company. The Chinese Academy of Sciences excels in technology that converts CO2 into methane and other fuels. Sinopec started operating a large facility last year that can store more than 1 million tonnes of CO2 per year underground at an oil field.

https://asia.nikkei.com

INDIA

R&D to advance quantum communications networks

India's Department of Telecommunications (DoT) has urged the telecommunications industry to propose projects for an R&D initiative aimed at advancing the nation's quantum communications networks. In a statement, the DoT announced its intention to create "Quantum Standardization and Testing Labs" designed to foster innovation among quantum technology developers, manufacturers of testing equipment, and academic researchers. The DoT has invited applications from the communications sector to join these labs and contribute to the development of quantum technologies. Proposals must be submitted by August 5, 2024.

Quantum communications has emerged as a prominent research focus within the communications and internet sector. The IEEE Communications Society highlighted that leveraging quantum phenomena such as superposition and entanglement holds promise for enhancing the reliability, energy efficiency, and security of data networks. Moreover, the advent of a quantum-powered internet could unlock transformative applications in areas such as distributed computing and metrology.

As part of the standardization process, efforts will focus on defining benchmarks and protocols critical for incorporating quantum communication components like quantum key distribution, quantum state analyzers, optical fibers, and related elements into both current and forthcoming communication networks. "The main objective is to accelerate research and development (R&D) in quantum technologies, ensuring the interoperability, reliability, and security of quantum communication systems," the DoT press release stated.

https://telecomreviewasia.com

R&D partnership on decarbonization

Under its academic partnership, Open Innovation, Shell, the London-based oil and gas major says it has partnered with top Indian educational institutions to push deep research in various areas including decarbonisation to support its global energy transition. Ajay Mehta, VP, and Chief Engineer R&D, Shell India told *The Hindu,* "These partnerships aim to foster innovation and accelerate decarbonisation efforts in the energy sector to support the global energy transition."

Shell has so far collaborated with more than 15 Indian institutes on initiatives like decarbonisation, technology development, knowledge exchange, and start-up incubation. Indian Institute of Science (IISc), Bengaluru, IIT Madras, National Chemicals Lab, Pune, and TERI, New Delhi are some of these institutions. These partnerships focus on reducing greenhouse gas emissions and innovations such as low-carbon fuels, distributed electrification, carbon sinks, hydrogen generation, efficient power and refrigeration cycles using supercritical carbon dioxide, and so on.

With IISc alone, the British firm has 14 ongoing research projects as part of a Master Research Agreement ranging from computational science, catalysis, and biofuels, Mr., Mehta said. The partnership seeks to build on cutting-edge energy and environment-related research at the Interdisciplinary Centre for Energy Research (ICER) at IISc. Recently, the firm launched the Shell IITM Centre for Energy Research (SICER) in partnership with IIT Madras. This collaboration for five years is expected to promote innovation, research, development, piloting, and commercialisation of technologies in the energy sector.

https://www.thehindu.com

Auto R&D grows

India's automotive sector is making significant strides in research and development (R&D), yet global competition remains formidable. A new report entitled "State of Industry R&D in India" by the Foundation for Advancing Science and Technology India, in collaboration with IIFL Securities, shows both impressive achievements and areas needing improvement. The report highlights that India's automotive and components sector is a major player in global R&D, contributing to 40 per cent of the USD 31 billion spent on engineering and R&D. This sector accounts for eight per cent of India's total R&D expenditure. The primary focus areas for R&D include emission compliance and advancements in electrification technologies.

Global firms outperform Indian firms in R&D intensity and the proportion of PhD employees by 3.1 times and 3.4 times, respectively. Ferrari N.V. leads globally with the highest R&D intensity at 15.2 per cent and the largest number of PhD employees as a proportion of total employees. Among Indian firms, Mahindra & Mahindra stands out with an R&D intensity of 5.7 per cent and the highest R&D expenditure, amounting to USD 335 million, which is more than 3.5 times that of Maruti Suzuki, the second highest Indian R&D spender.

In terms of patents and publications, global firms produced 29.8 times more patents per USD billion revenue and 1.6 times more publications per USD billion revenue compared to Indian firms. BYD leads globally in patents per USD billion revenue. TVS Motors displays an exceptional number of patents relative to revenue, ranking second globally and first among Indian firms with 2,548 patents, which is approximately 6.2 times that of Mahindra & Mahindra. Bosch has the highest number of publications per billion USD revenue among Indian firms and ranks second globally, with 2.4 times more publications per USD billion revenue than Tesla.

High-revenue cluster firms such as Mahindra & Mahindra, Hero MotoCorp, and Maruti Suzuki show varying degrees of R&D intensity and PhD employee ratios. Bosch and TVS Motors, despite being in the low-revenue cluster, have significant achievements in publications per billion USD revenue.

https://businessworld.in

ISLAMIC REPUBLIC OF IRAN

Capacity of renewable power plants

The capacity of Iran's renewable power plants has reached 1,199.71 megawatts (MW), based on the latest data released by Iran's Renewable Energy and Energy Efficiency Organization (SATBA). Of the mentioned figure, the share of wind power plants is 31 percent with 366.3 megawatts and the share of solar power plants with 529.9 megawatts is 58 percent, according to the SATBA data for the end of the third Iranian calendar year of Khordad (ended on June 21). Small hydropower plants account for 9.0 percent of the country's total renewable power with 103.67 megawatts. Biomass power plants also have a one percent share with 12.5 MW, and the share of expansion turbine power plants with 9.6 MW is also one percent.

Over the past few years, the Iranian government has taken serious measures to accelerate the growth and development of renewable energies in the country. Diversification of financing models for renewable projects, increasing the ceiling of guaranteed electricity purchase, providing the possibility of buying and selling renewable electricity in the green board of the Iran Energy Exchange (IRENEX), and providing the possibility of exporting renewable electricity have been the most important measures taken for this purpose.

Iranian Energy Ministry has also put it on the agenda to add 10,000 MW to the capacity of the country's renewable power plants by the end of the current government's administration (August 2025). Considering the fact that the country's renewable power generation capacity stood at about 800 MW when the current government took office in August 2021, the mentioned increase in renewable energy capacity would mean a 13-fold rise.

Back in January 2022, the Energy Ministry and some of the country's private contractors signed memorandums of understanding (MOU) for cooperation in the construction of new renewable power plants across the country. The electricity generated by renewable sources increased by 28 percent in the third Iranian calendar month of Khordad (ended on June 20) compared to the same month last year. Renewable sources generated more than 230 million kilowatt hours of electricity, an increase of 21 percent in comparison with a month earlier. Wind power plants held the lion's share of the rise in the production of electricity by renewable sources.

Based on the Energy Ministry data, renewables currently account for nearly seven percent of the country's total electricity generation capacity. Of the country's total renewable capacity, 44 percent is the share of solar power plants while the share of wind farms stands at 40 percent and small-scalded hydropower plants generate 13 percent of the total renewable capacity.

https://www.tehrantimes.com

MALAYSIA

Innovation, commercialization ecosystem

The Ministry of Science, Technology, and Innovation (MOSTI) is optimistic about seeing more market-ready products emerging this year with the launch of Supercharger Series 2024, which aims to invigorate Malaysia's innovation ecosystem. With the launch of the Series, Minister Chang Lih Kang said, Mosti is hoping to see an increase in high-quality products ready for commercialisation this year.

The Series stands as a strategic initiative designed to foster collaboration, engagement, and knowledge sharing within Malaysia's research, development, commercialisation, and innovation ecosystem. Focused on facilitating the commercialisation journey from idea inception to market entry, the Series is set to revolutionise the pre-commercialisation phase of Malaysian innovations and, for 2024, it aims to create significant and far-reaching impacts through cultivating local technopreneurship champions, increasing Malaysia's commercialisation rate, improving economic growth through R&D commercialisation and high-skilled jobs creation.

This initiative provides invaluable opportunities for university spin-off companies, researchers, private sector entities, and agencies to not only gain essential knowledge but also to identify and address various challenges, which in turn, will drive economic growth and strengthen the innovation ecosystem, ensuring that emerging technologies and research breakthroughs can effectively reach the market and benefit society as a whole.

https://thesun.my

Initiatives for cloud and AI skills

The Government of Malaysia and Google have created two initiatives to equip Malaysian youth with AI skills and improve public service delivery with cloud-native, AI-driven productivity tools. Between the Ministry of Higher Education (MoHE) and Google, the first initiative aims to upskill Malaysian youth from different backgrounds by providing 161 institutes of higher learning with 500 Google Career Certificate scholarships in 2024. The certificates cover expertise across cyber security, data analytics, and IT support. They can be completed in three to six months via self-directed online training, without any prior experience. This initiative is an extension of Gemilang, which has benefited over 31,0000 Malaysians with 80 per cent of certificate graduates receiving positive career outcomes.

In collaboration with Jabatan Digital Negara (JDN), the second initiative equips 445,000 public officers with Google Workspace tools to increase productivity. This accelerates policy development, budget planning, and public consultations by enabling public officers to collaborate on tasks, easily find information across organizations, and use AI tools to streamline workflows and facilitate data-driven decision-making.

https://www.channelasia.tech

PHILIPPINES

Share of solar and wind in power output

The Philippines plans to boost the share of solar in power output to 5.6 per cent in 2030 from 2.4 per cent in 2024, and wind to 11.7 per cent from 3.1 per cent, according to a government presentation, potentially making the archipelago's grid among the cleanest in the region. The Southeast Asian nation expects a higher share of solar and wind to offset a decline in the share of other clean sources such as hydropower and geothermal energy, helping non-fossil sources account for 35 per cent of power generation by 2030.

Hydroelectricity's share is set to fall from 10 per cent to 9.1 per cent, while geothermal energy is expected to account for 7.7 per cent of overall output by 2030, compared with 8.9 per cent in 2024, Ms Mylene Capongcol, assistant secretary at the Philippines Department of Energy, said in the presentation, at the Renewable Energy Markets Asia conference.

The Philippines plans to achieve the targets by doubling solar capacity and tripling wind capacity over six years, Ms Capongcol added in the presentation, which was shared with Reuters. The country is betting on a rapid build-out of offshore wind farms, which have high upfront costs. Spiralling costs amid high inflation have resulted in some developers canceling or pausing projects in the US and Britain in 2023. The archipelago also expects to add 1,200 megawatts of nuclear capacity by 2032, Ms Capongcol said in the presentation, adding that the country plans to upgrade its transmission infrastructure to help manage the addition of renewables.

The energy department will also create a long-term programme to facilitate the voluntary early decommissioning or repurposing of over 3.8 gigawatts of coal-fired power plants which are more than 20 years old, Ms Capongcol said. The Philippines is targeting to reduce the share of coal in power generation to 47.6 per cent by 2030, from about 60 per cent currently.

https://www.straitstimes.com

National AI Strategy Roadmap

Taking a significant step towards a more innovative future, the Department of Trade and Industry (DTI) with support from the Asian Development Bank (ADB will launch the National Artificial Intelligence (AI) Strategy Roadmap 2.0 (NAISR 2.0) and the Center for AI Research (CAIR) on 03 July 2024. Building upon the foundation laid by the first AI roadmap in 2021, the NAISR 2.0 incorporates recent technological advancements, including Generative AI. This recalibrates the strategic actions, considering recent developments, and addresses emerging themes such as ethics and governance. In line with the country's science, technology, and innovation-driven Industrial Strategy, the new roadmap pursues the strategic mission to harness AI's transformative potential in boosting the Philippine economy and improving the quality of life for its citizens.

Anchored on a solid vision to be a Center of Excellence in AI R&D, CAIR will play a pivotal role in leveraging AI's transformative potential to address societal and industrial challenges, stimulate economic growth, and promote inclusive development. CAIR's mission is to transform the Philippines into a premier destination for AI-driven innovation and investments.

By creating AI solutions for regional concerns notably sustainable agriculture, urban planning, and disaster resilience, CAIR hopes to establish the Philippines as a leader in multiple AI application areas. Through technological innovation, multidisciplinary and cross-disciplinary research, and the development of full-time research scientists, engineers, and R&D personnel, CAIR aims to promote socio-economic R&D, improve scientific knowledge, and strengthen the competitiveness of science and technology in the country while balancing and ensuring responsible AI adoption to improve public services and the lives of Filipinos.

This groundbreaking launch marks the establishment of the first AI hub in the Philippines, housing pioneering AI experts who will be spearheading the Center's goals. The event will unveil the pioneering CAIR team and mark the Center's official commencement of operations.

NAISR 2.0 and CAIR present an opportunity for the government, academia, and industry to continue collaborating and guarantee that Filipinos will reap the most benefits from these AI advancements. These initiatives are in line with the Department's implementation of the Tatak Pinoy (Proudly Filipino) Act or Republic Act No. 11981, which fosters innovation to promote greater industrial sophistication, economic diversification, and industrial transformation.

https://www.dti.gov.ph

WIPO treaty adopted

The Intellectual Property Office of the Philippines (IPOPHL) on Wednesday shared that the Philippines has joined 193 other member countries of the World Intellectual Property Organization (WIPO) in adopting a landmark treaty on intellectual property (IP), genetic resources (GR), and traditional knowledge associated with genetic resources (ATK). The 194 member states of WIPO achieved a consensus after 25 years of negotiations to create a more inclusive global patent system.

This new treaty is the first to specifically address the connection between patents, genetic resources, and traditional knowledge, which includes provisions that recognize the rights of indigenous peoples (IP) and local communities. "The treaty showcases our collective effort to empower marginalized groups globally while maintaining a fair intellectual property system," IPOPHL Director General Rowel Barba said at the Diplomatic Conference in Geneva last May 13 to 24.

The adoption of the new treaty, now requires inventors to disclose if their patents are based on genetic resources and their associated traditional knowledge. This transparency is expected to prevent the misuse or theft of genetic resources and traditional knowledge.

https://www.pna.gov.ph

REPUBLIC OF KOREA

Digital technology adoption

According to a recent announcement by the Republic of Korean Ministry of Science and ICT, the Republic of Korea has been recognized for the highest adoption rates of leading-edge digital technologies among member countries of the Organisation for Economic Co-operation and Development (OECD). This information was derived from the 'Digital Economy Outlook Report 2024' published by the OECD, which now releases its findings biannually, spotlighting global digital trends based on statistical data and survey responses.

While cloud computing and the Internet of Things (IoT) are commonly embraced by OECD businesses, the uptake of big data analytics and) has been slower due to cost-related issues, with smaller companies particularly feeling the pinch. Yet, South Korea differentiates itself with impressive rates of digital tech implementation: a 53% rate for IoT, 40% for big data analysis, and 28% for AI technologies—all of which place the country at the top of the OECD rankings. Moreover, the country's cloud computing adoption is also remarkable, ranking fifth at 70%.

The report further sheds light on the economic growth experienced in the ICT sector among OECD members from 2011 to 2022, which was 2.5 times faster than the overall economic growth, averaging an impressive 5.3%.

https://elblog.pl

Semiconductor packaging R&D

The Republic of Korea will inject 274.4 billion won ($200 million) into a state-run R&D project for semiconductor packaging technology, a key to producing the high-performance, low-power chips essential for AI applications. The government spending aims to narrow the gap with Taiwan, China, and the US in the semiconductor back-end process market, where Korea controls less than 10%. In contrast, it commands 60% of the memory chip market as of 2022, according to the Ministry of Science and ICT.

The Ministry of Trade, Industry and Energy said the R&D spending plan had passed the preliminary feasibility test conducted by the science ministry. That means the government has given the go-ahead to the seven-year project running until 2031. The plan represents a follow-up to a 65-billion-won, state-run project on semiconductor packaging R&D undertaken between 2018 and 2022.

Packaging refers to assembling different types of semiconductor chips and providing them to customers in one piece. The process involves detaching chips through wafer sawing and mounting the chips on a module that will be installed onto a motherboard. The package allows the chips to be electrically and mechanically connected to external components. To meet the growing demand for high-end chips such as high bandwidth memory (HBM) amid the AI boom, chipmakers are focusing on improving back-end processing or packaging technology now that semiconductor miniaturization has reached its physical limits.

The advanced semiconductor packaging market is forecast to expand at a compounded annual growth rate of 10% to $78.6 billion by 2028, from $44.3 billion in 2022, according to research company Yole.

Samsung Electronics will launch three-dimensional (3D) packaging services for HBM chips within the year, according to the company and industry sources earlier this month. To do so, its advanced packaging team will vertically interconnect HBM chips produced at its memory business division with GPUs assembled for fabless companies by its foundry unit. 3D packaging reduces power consumption and processing delays, improving the electrical signal quality of semiconductor chips. Presently, HBM chips are horizontally connected with a GPU on a silicon interposer via the 2.5D packaging process.

https://www.kedglobal.com

Corporate R&D investment

Research and development (R&D) expenditures by major Republic of Korean companies hit an all-time high last year despite their falling sales amid an economic slowdown. The Ministry of Trade, Industry and Energy (MOTIE) and Korea Institute for Advancement of Technology (KIAT) announced on June 24 the top 1,000 Korean R&D investor companies of 2023. The sales of 1,000 top R&D investor companies declined 2.8% year-on-year in 2023, but their R&D investment increased 8.7% to KRW 72.5 trillion, up KRW 5.8 trillion compared to that of 2022. Accordingly, the ratio of R&D investment to sales advanced from 3.9% to 4.4%.

Of the 1,000 companies, 171 were large conglomerates and 491 were second-tier mid-sized companies. The remaining 338 firms were mid- and small-sized companies. In particular, major companies increased their R&D investment. Samsung Electronics R&D investment accounted for about 33% of the total, making it more dependent on Samsung Electronics for R&D than the combined R&D investments from the top 2nd to 10th, including Hyundai Motor, SK Hynix, and LG Electronics.

According to the "2023 Corporate R&D Scoreboard" released by MOTIE and KIAT, investments by the top 1,000 companies in the Republic of Korea's R&D investment reached KRW 72.5 trillion last year, up 8.7% from the previous year, the largest ever. Sales of these companies fell 2.8% last year, but the share of R&D investments to sales rose to 4.4% from 3.9% in 2022. The increase came despite their sales falling 2.8% on-year to KRW 1,642 trillion, and the proportion of corporate R&D investment out of sales rose 4.4% in 2023 from the previous year's 3.9%.

The top 10 and top 50 investor companies' R&D investment add up to KRW 45.5 trillion and KRW 56.6 trillion, respectively, each taking up 62.7% and 78.1% of the total 1,000 companies' R&D investment. Samsung Electronics, Hyundai Motor, SK Hynix, and LG Electronics are among the nine companies that invested over KRW 1 trillion, with Samsung Electronics' R&D investment (KRW 23.9 trillion) taking up 32.9% of the total R&D investment of the top 1,000 investor firms.

The top 1,000 list consists of 171 large corporations, 491 middle-market companies, and 338 SMEs. Compared to 2014, the number of mid-sized companies increased from 407 to 491, rising by 84, among the top 1,000 companies. Among mid-sized companies, NC Soft (KRW 467.1 billion, 17th) and Korea Aerospace Industries (KRW 408.8 billion, 19th) were included. The top 100 list includes 33 middle-market companies, indicating their increasingly central role in the innovation ecosystem.

A ministry official said, "The number of mid-sized companies that were among the top 1,000 major R&D investing companies has risen over the past years. The government will extend support for companies to increase investment for innovation." Last year, Samsung Electronics had the largest amount of R&D investment, with its investment reaching KRW 23.9 trillion, up 14.4% from the previous year. This accounts for 32.9% of the total investment of the top 1,000 companies. Samsung Electronics' R&D investment in sales was 14.0% last year. Leading carmaker Hyundai Motor Co. came next with KRW 3.7 trillion, which marked 15.6% on-year growth. R&D spending by chip behemoth SK hynix Inc. fell 10% on-year to KRW 3.6 trillion.

Home appliances giant LG Electronics Inc. increased its R&D expenditure by 10% to KRW 3.3 trillion, and Samsung Display Co. spent KRW 2.8 trillion on R&D last year, up 12% on-year. Kia Corp. was the fifth-largest R&D investor last year with KRW 2.2 trillion, the data showed. The top 1,000 companies expanded their average annual R&D investment by at least 6.6% over the last 10 years and the number of Republic of Korean firms among the top 2,500 global R&D investor companies is 47 in total as of 2022, ranking ninth by country.

Meanwhile, as of 2022, only 47 Korean companies were among the top 2,500 global R&D investment companies, making the Republic of Korea the ninth-largest R&D investment in the world. According to data from the European Union, only 47 Republic of Korean companies were among the top 2,500 companies in the global R&D standings in 2022. The Republic of Korea was behind the United States (827), China (679), Japan (229), Germany (113) and Taiwan (77).

https://www.koreapost.com

THAILAND

Climate technology platform launched

True Digital and Alibaba Cloud launched an AI-based platform aimed at supporting organisations in implementing sustainability goals. The two industry giants collaborated to build the Climate Technology Platform for businesses to tackle energy-efficiency challenges and implement technologies that can help guide businesses to reach their net-carbon goals.

The Thai government's draft Climate Change Act aims to reduce the country's greenhouse gas emissions by up to 40% by 2030 and reach carbon neutrality by 2050. Although many companies are trying to step towards being sustainable, Vice President of Alibaba Cloud Intelligence and General Manager for International Industry Solutions, William Xiong, said organisations lacked the tools to get there, stressing that being low-carbon is important and companies need to know how to manage their carbon footprints. "In our partnership with True Digital Group, we are introducing AI-driven sustainability solutions to Thailand, helping businesses with new capabilities to improve their energy efficiency."

True Digital Group developed the Climate Technology Platform, which integrates technologies such as cloud, IoT (Internet of Things), and big-data analytics with various data sources on

DataVisor, which is an integrated data management platform that provides in-depth analysis on how to lower and manage carbon emissions.

Ekaraj Panjavinin, Chief Digital Officer, True Corporation Plc. said these technologies empower the Climate Technology Platform to serve all dimensions of energy management requirements for enterprises. He explained that the platform transitions from traditional ways of turning physical labour into a digital system of sensors and IoT devices. The platform also connects various energy sources into a single energy management system and transits to renewable energy such as solar power, water power, and electricity from power grids.

https://www.nationthailand.com

Renewable power plan unveiled

The Department of Alternative Energy Development and Efficiency (DEDE) is forging multiple plans to maximise renewable energy benefits and align with global efforts to combat climate change. DEDE director-general Wattanapong Kurovat told Nation Group's Krungthep Turakij on Monday that it was updating this year's energy plan to meet clean energy requirements for Thailand to achieve carbon neutrality by 2050 and net-zero carbon emissions by 2065. He explained Thailand's energy policy planning has become increasingly complex amid the global focus on long-term environmental impacts.

Two draft plans – the Alternative Energy Development Plan (AEDP) and the Energy Efficiency Plan (EEP) – were set for a public hearing on Tuesday (June 18). Both will be included in the National Energy Plan 2024 alongside the Power Development Plan (PDP), Gas Plan, and Oil Plan.

The new energy plan aims to increase the production of electricity from renewable energy to over 50%, using solar, wind, and biomass sources generated from the agriculture sector. Although renewable energy costs more than fossil fuels, the Thai industry must adopt renewables to comply with new global trade regulations like the Carbon Border Adjustment Mechanism (CBAM), Wattanapong said.

Under the new Power Development Plan, the ministry aims to procure 77,407 megawatts (MW) of electricity to meet Thailand's forecasted peak of 56,133 MW in 2037. The plan must also factor in a drop in production capacity to 34,984MW as existing power plants expire. The plan includes sourcing 47,251 MW of new electricity, 12,957 MW from backup electricity generation, and 17,199 MW from power plants contracted to the ministry.

Of the new electricity, 34,851 MW will come from renewable sources: solar power (24,412 MW), wind (5,345 MW), biomass (1,045 MW), biogas (936 MW), floating solar (2,681 MW), industrial waste (12 MW), community waste (300 MW), hydropower (99 MW) and geothermal power (21 MW). The remaining 12,400 MW will come from combined-cycle power plants (6,300 MW), nuclear power plants (600 MW), overseas procurement (3,500 MW), and other sources like vehicle-to-grid systems (2,000 MW).

The 2024 plan will boost the share of renewable energy in total electricity production to 51%, up from 36% under PDP 2018. The electricity price is expected to fall from 3.94 baht per unit under the previous plan to 3.87 baht. To reduce reliance on gas imports, the ministry aims to increase procurement of liquefied natural gas (LNG) from the Gulf of Thailand and Myanmar to meet the country's demand of around 4.8 billion cubic feet daily, as per the Gas Plan 2024. The ministry is also considering additional infrastructure to support LNG import, storage, and distribution to boost liquidity and support electricity production.

https://www.nationthailand.com

VIET NAM

Guidelines for innovation development

Viet Nam has issued major guidelines, policies, and orientations to develop innovation and startups, as the Party and State always consider science-technology and innovation as a "strategic breakthrough" and a "main driving force" to create improvements in productivity, quality, efficiency, and competitiveness of the economy. Over the past time, Vietnam's innovation activities have achieved many remarkable results. The country has continuously climbed up the Global Innovation Index (GII) from the 59th position in 2016 to the 46th in 2023, making it rank fourth in the Association of Southeast Asian Nations (ASEAN).

Viet Nam has always maintained the second position in the group of lower middle-income countries and is one of the seven middle-income countries that have achieved the most progress in innovation over the past decade. On March 12, 2024, for the first time, the Ministry of Science and Technology released the Provincial Innovation Index (PII). The 2023 index provided the grounds and evidence on strengths, weaknesses, potential, and necessary conditions for the country to promote socioeconomic development based on science, technology, and innovation of each locality.

The Government has also had many investment solutions to improve innovation indicators, including building a national innovation system that gathers experts and scientists, developing policies to encourage innovation, especially in businesses, and setting up the National Startup Support Centre. To date, framework conditions serving the development of the national innovation system have been formed such as policies to ensure intellectual property rights, and innovation of scientific and technological activities, simplifying administrative procedures, implementing support funds, and strengthening the linkages between scientific research and production and business.

National innovation and startup support centres are being formed in Hanoi, Da Nang, Ho Chi Minh City, and other localities, while innovation and startup centres have been set up in over 20 localities to connect local, regional, and national resources. As a result, enterprises are becoming more aware of the importance of innovation activities, putting this content at the centre of their production and business activities.

https://en.vietnamplus.vn

Human-centered artificial intelligence

The Science and Technology Ministry has issued guidelines for the responsible development of AI systems, promoting a human-centered society where everyone benefits from AI. Accordingly, the Ministry of Science and Technology has just released its Decision 1290/QD-BKHCN about guiding a number of principles on research and development of responsible AI systems that are aimed at a human-centered society where there is a reasonable balance between the benefits and risks of AI systems.

AI technology is now considered the core when digital technology is increasingly dominating social life as well as economic development. Many Vietnamese enterprises, such as FPT, Viettel, VNG, and VNPT have all affirmed that AI is the foundation and opportunity for Vietnam to develop technology on par with the world in the near future. AI can support and solve tough problems that people and communities are facing in the country at present.

Both domestic and foreign experts in the field agree that AI system research and development in Vietnam must fulfill the goal of creating a human-centered society, where everyone benefits from these AI systems while still ensuring a reasonable balance between benefits and risks.

The benefits of AI must be promoted via research, development, and innovation activities and minimize the risk of violating the rights or legitimate interests of organizations and individuals. This calls for the urgent need to form an ethical code to promote responsible AI development, which will in turn build user and social trust in AI systems that are being applied in all aspects of life in the face of unpredictable impacts and risks, as said by Prof Dr Andy Hall from the Commonwealth Scientific and Industrial Research Organisation (CSIRO – Australia). AI development is fraught with risks and uncertainties, so "responsible innovation" needs to be based on the proactive choice of safe, ethical, and socially appropriate technologies.

https://en.sggp.org.vn

Innovation Challenge 2024 launched

The Ministry of Planning and Investment announced the launch of the Vietnam Innovation Challenge 2024 with a focus on expediting the growth of Viet Nam's semiconductor and artificial intelligence (AI) sectors. With the theme "Innovation to accelerate the semiconductor industry and artificial intelligence to go global", the programme aims to create an intellectual playground, bringing together resources for collaboration, generating breakthrough ideas, leveraging the potential, and seizing the opportunities of the semiconductor and artificial intelligence industries.

Speaking at the event, Deputy Minister of Planning and Investment Trần Duy Đông emphasised the pivotal role of the semiconductor industry amid global economic competition and the strategic importance of AI in Việt Nam's development agenda. He reiterated the government's unwavering support for high-tech industries, aligning with the objectives of the VIC programme. "The programme not only reflects the vision and robust support of the Ministry of Planning and Investment in advancing these two promising sectors but also actively contributes to achieving the strategic objectives outlined by the Government," Đông said.

Việt Nam, with its strategic location, expanding digital infrastructure, highly skilled workforce, and abundant young talent brimming with creativity, is rapidly emerging as a key player in the semiconductor industry, poised for immense growth in the coming years. Projections from the SEMI Southeast Asia indicate that Việt Nam's semiconductor market is set to expand by over 6 per cent between 2022 and 2027.

With its two primary pillars focusing on optimising semiconductor processes and harnessing AI solutions for business development, the Vietnam Innovation Challenge 2024 seeks to foster collaboration, attract essential resources, and establish a multilateral cooperation platform. Through this, Vietnamese businesses are poised to enhance their value proposition and fortify their position within the global value chain.

https://vietnamnews.vn

RE firms to benefit from direct purchase agreements

Viet Nam's renewable energy developers, especially those with projects located near industrial parks, economic zones, and export processing zones, are likely to win big with the newly approved mechanism for direct power purchase agreement (DPPA), say analysts. On July 3, the government issued Decree No. 80/2024/ND-CP on the DPPAs between renewable energy generators and large electricity consumers.

Analysts with broker Saigon Securities (SSI) say that the DPPA mechanism can encourage more investment in domestic renewable energy projects, thereby promoting environmentally sustainable development and improving the efficiency of the power market in Viet Nam. The mechanism will create a better competitive environment for participants and has the potential to resolve state utility Vietnam Electricity's (EVN) financial problems, they add. They note that renewables play a key role in the roadmap drawn by the 2021-2030 National Power Development Plan (with a vision until 2050), or PDP VIII.

The plan targets expanding power generation capacity to over 150,000 MW by 2030 and nearly 600,000 MW by 2050, contributing to the nation's goal of achieving net zero emissions by 2050. Encouraging renewable energy production, especially in the North, can solve or at least reduce significantly Vietnam's electricity shortage problem in the long term; and the new mechanism will allow risk prevention through regulations on forward contracts, the SSI analysts say.

According to a study conducted by the Ministry of Industry and Trade at the end of 2023, out of 67 renewable power projects surveyed, 24 with a combined capacity of 1,773 MW wished to participate in the DPPA as sellers, while 17 others (2,836 MW) were considering participation. On the buyers' side, 20 out of 41 respondents wanted to join the mechanism.

https://theinvestor.vn

Technology Scan

Focus: Artificial Intelligence for climate resilience

ASIA-PACIFIC

CHINA

AI weather model

The Shanghai Academy of Artificial Intelligence for Science and Fudan University unveiled Fuxi 2.0, an upgraded AI-powered large model for climate and weather forecasting. Fuxi 2.0 boasts higher prediction accuracy than previous models and is 1,000 times faster, while also being cheaper and able to generate longer-term forecasts. It is expected to enhance early warning, risk management, and disaster prevention capabilities across China.

"The rising frequency of extreme weather events due to climate change necessitates improved weather forecasts," said Qi Yuan, director of the academy. "Fuxi 2.0 aims to mitigate the damage caused by such events by providing more accurate and timely predictions."

Li Hao, who leads the academy's earth science research team, highlighted Fuxi 2.0's significant leaps in forecasting extreme weather phenomena, surpassing the accuracy of the European Centre for Medium-Range Weather Forecasts' short- and medium-term models.

The first version of Fuxi was launched at the United Nation's COP28 climate change summit in December, becoming the first Chinese sub-seasonal climate model capable of generating forecasts for the next 15 to 60 days. Li said Fuxi 2.0 can deliver nationwide high-resolution forecasts with ground meteorological elements, providing hourly updates accurate to within a kilometer — a vast improvement over existing models with resolutions of 10 to 25 km.

For the new energy sector, Fuxi 2.0 offers more accurate wind speed, irradiation, and power generation predictions, allowing for optimized wind and solar power generation, improved grid load balancing, and reduced curtailment. "It acts like an intelligent navigation system for wind farms and solar power plants," Li said.

The aviation industry can leverage Fuxi 2.0's ability to predict low cloud cover and total cloud cover, aiding in forecasting ice, turbulence, and uneven light conditions — factors impacting flight experiences and costs. The academy and 12 other institutions, including meteorological services, research bodies, and industry leaders, have announced the formation of an ecological alliance for intelligent meteorological innovation. It will leverage Fuxi 2.0 and foster collaboration between the research, education, and industrial sectors to drive further technological advances in intelligent weather forecasting.

https://www.chinadaily.com.cn

AI-based model to address streamflow, flood forecasting

Chinese scientists have recently proposed a novel artificial intelligence (AI)-based model to address streamflow and flood forecasting at a global scale for both gauged and ungauged catchments which remains one of the long-standing challenges in hydrology, given that more than 95 percent of small- and medium-sized watersheds worldwide do not have any monitoring data.

In light of global climate change, the frequency and intensity of extreme rainfall events significantly increased, leading to more frequent flooding disasters and more intensive flooding risks. Thus, the effective prediction of flood discharge serves as a crucial factor for reducing the risks of flood disasters. Despite the significant progress that has been made in physical process-based flood discharge prediction over the past few decades, forecasting results using current methods still heavily rely on monitoring data and parameter calibration. Recent progress and expansion in deep learning have made the AI technology-based data-driven models an alternatively novel solution for streamflow and flood forecasting in hydrological science.

A research team led by Ouyang Chaojun, a research fellow with the Institute of Mountain Hazards and Environment from the Chinese Academy of Sciences, proposed an AI-based novel streamflow and flood forecasting model to solve the streamflow and flood prediction problems at a global scale for both gauged and ungauged catchments.

Data-driven models are critically dependent on the quality of historical data. The research team is leveraging historical data sets across 2,089 catchments from the US, Canada, Central Europe, and the UK with a data collection frequency of 24 hours and the time span between January 1, 1981, and December 31, 2009, to train the model, while also using historical data sets between January 1, 2010, and January 1, 2012, to verify the accuracy of the model's forecasting capability, Ouyang told the Global Times. According to Ouyang, generally speaking, examining a longer time span results in richer data sets, despite having higher training costs. The significant diversity in the distribution of the data across these catchments ensures data variety and tests the accuracy and reliability of the model in the predictions for future time periods.

The verification results show that the model yields a mean Nash-Sutcliffe efficiency coefficient (NSE) of 0.75 - a commonly used score to assess the predictive power of hydrological discharge models - across 2,089 catchments, highlighting improvements by the state-of-the-art machine learning over traditional hydrologic models. Based on the models pre-trained in the northern hemisphere, researchers conducted predictions on 160 entirely new river basins in Chile in the southern hemisphere without using any monitoring data, to test the model's prediction ability in ungauged catchments. The prediction results of different pre-trained models show strong spatial distribution consistency.

The model applied to 160 ungauged catchments in Chile shows that 76.9 percent of catchments obtain NSE higher than zero in the best situation, demonstrating the potential of deep learning methods to overcome the ubiquitous lack of hydrologic information and deficiencies in physical model structure and parameterization. The model was recently published online through the interdisciplinary journal *The Innovation*. This deep learning model can more effectively capture the spatial and physical attributes within the catchments.

Through this study, the model has demonstrated an enormous potential for streamflow and flood prediction across regions at a global scale. It is expected to enhance disaster prevention and mitigation efforts significantly if it is integrated with existing disaster forecasting systems to establish a real-time warning platform across various time scales, from days to hours to minutes.

https://www.globaltimes.cn

AI-enabled model to help mitigate ammonia emissions

An international research team led by the Hong Kong University of Science and Technology (HKUST) has achieved a significant breakthrough by developing an artificial intelligence (AI) model that can help mitigate global ammonia (NH_3) emissions from agriculture. The study, titled "Fertilizer management for global ammonia emission reduction", has been published in *Nature*.

A research team led by Prof. Jimmy Fung Chi-Hung, Chair Professor of HKUST's Division of Environment and Sustainability in the Academy of Interdisciplinary Studies and Department of Mathematics, and Prof. Zheng Yi from the School of Environmental Science and Engineering at the Southern University of Science and Technology (SUSTech), collected and compiled a dataset based on field observation data of NH_3 emission rates spanning between 1985 and 2022. They subsequently trained an AI-powered computer model to estimate global NH_3 emissions using the dataset while considering various geographical factors such as climate, soil characteristics, crop types, irrigation water, fertilizer, and tillage practices.

This model is capable of generating customized fertilizer management plans for different regions. For instance, in Asia, around 76% of wheat land is suitable for using enhanced-efficiency fertilizers (EEFs) to reduce NH_3 emissions due to the influence of global warming, as temperature plays a pivotal role in NH_3 emission from wheat land in Asia.

The AI model discovered that by optimizing fertilizer management, including adjusting the timing of fertilization, utilizing a specific blend of nutrients, and implementing suitable planting and tillage practices, it is possible to reduce global NH_3 emissions from the three crops by up to 38%, with Asia having the highest NH_3 reduction potential, followed by North America and Europe.

This finding holds particular significance as this work has projected a 4.0% to 5.5% increase in global NH_3 emissions from cropland over the 30-year period until 2060. Therefore, even achieving a fraction of this potential reduction would suffice to offset the projected increase.

https://phys.org

AI model for weather forecasting

A groundbreaking artificial intelligence (AI) weather forecaster has been released by the team behind China's Pangu-Weather prediction model, and it has a precision that has evolved from tens of kilometres to just a few kilometres. The newest iteration of the AI model, Zhiji, which focuses on regional weather, can give a five-day forecast with a precision that has been sharpened from 25km (15.5 miles) to 3km. Its launch came less than a month after Pangu-Weather, developed by Huawei Technologies, was named China's best scientific innovation of 2023. Since its release in August last year, Pangu has revolutionised weather forecasting, offering quicker and more accurate predictions than traditional meteorological methods.

Pangu-Weather first burst onto the scene in July 2023, when a paper detailing the AI model was published in the journal, Nature. A month later, it was launched on the European Centre for Medium-Range Weather Forecasts (ECMWF) website. The AI model hit a major milestone when it was able to complete a seven-day weather forecast in just 10 seconds – more than 10,000 times faster than traditional methods. Then on February 29, just months after its launch, Pangu-Weather was ranked first among China's top 10 scientific advances in 2023 by the National Natural Science Foundation of China (NSFC).

"In its recognition by the NSFC, Pangu had two major accomplishments: first, it improved the world's leading ECMWF weather forecasting system by about 0.6 days. This means it can predict extreme weather earlier and more accurately," Science and Technology Daily reported. "The second is 7-day predictions in 10 seconds, 10,000 times faster than numerical ones." According to a Huawei report in late February, Pangu delivered more accurate forecasts for crucial weather elements, such as temperature, pressure, humidity, and wind speed, than numerical simulations. Plus, its error margin for predicting the paths of tropical cyclones was 25 per cent lower than the ECMWF.

It is quite an achievement for the AI model, which has so quickly changed the face of global weather forecasting. By leveraging AI to predict weather patterns, scientists can bypass the complexities associated with traditional methods of forecasting. No mathematical physics knowledge or expert experience is needed for AI, something which has created a new avenue for weather prediction.

Now, researchers have used Pangu as a foundation to develop the new regional model, Zhiji. Created in collaboration with the Shenzhen Meteorological Bureau, Zhiji has been trained with high-resolution data from southern China.

According to the Huawei team, Zhiji can provide a five-day forecast with a precision of 3km for Shenzhen and its surrounding areas. While the Central

Meteorological Bureau already provides hourly forecasts with street-level precision, these are generally only available for the following 24 hours. “Zhiji is capable of forecasting core meteorological elements such as wind speed, temperature, humidity, and precipitation. Since its trial operation began in February, it has provided valuable insights to the Shenzhen Meteorological Bureau on multiple occasions,” Huawei reported in late March.

https://www.scmp.com

INDIA

IoT and AI-powered automatic weather station

Forecastro, a pioneering climate tech startup based in Pune, proudly announces the launch of WeatherWise-an IoT/AI-boosted Automatic Weather Station (AWS). This patent-pending and exclusively Made in India product harnesses the power of IoT, Machine Learning (ML), and Artificial Intelligence (AI) to deliver precise weather data collection. WeatherWise offers an extensive suite of measurements, including UV radiation, humidity, and climate change predictions, to help the government and businesses monitor and mitigate the impacts of climate change. This innovative solution aims to fight the extreme climate crisis with advanced technology and early warning systems.

WeatherWise is the culmination of over a decade of dedicated research by Forecastro’s founding team members, Somnath Varpe and Kiran Todekar. Varpe, with over six years of experience in embedded systems and microcontrollers, has previously worked on sophisticated systems such as telemetry and meteorological instruments for the DRDO Meteorology division of the Government of India. Todekar, a Data Scientist with a robust background in Machine Learning algorithms, Deep Learning, Computer Vision, and Image Processing, has served as a researcher at the Indian Institute of Tropical Meteorology.

https://www.business-standard.com

EUROPE

DENMARK

Using AI to develop early warning systems for flooding

Susanne Nielsen realizes that it is probably only a matter of time before her parents’ summer house at Slettestrand in North Jutland is affected by flooding. Because under the house, which is just 400 meters from the bay of Jammerbugt in the municipality of the same name, the groundwater level is now often so high that there is a risk that large amounts of rain will not be able to seep away, but rather enter the house.

To give residents and decision-makers the best chance to protect themselves against flooding in the area, researchers from DTU have helped Jammerbugt Municipality develop an early warning tool. It can provide 48 hours’ notice of local flooding along rivers, streams, and coastal areas in the municipality. It is the first of its kind to provide local flood warnings.

The tool—a so-called “wet index”—is based on artificial intelligence trained on freely available data on dynamics that influence the risk of flooding. Data comes from satellite imagery and weather forecasts, as well as information on ground and seawater levels and the topography of the landscape. However, the movement and accumulation of water in open landscapes are difficult to calculate because many parameters affect how water moves and accumulates. To handle this complexity, artificial intelligence was used in the development of the model behind the wet index.

By utilizing specific design principles in the construction of the model and feeding it with carefully selected data, the researchers have incorporated an understanding of water movement, distribution, and interaction with the surrounding environment, according to Roland Löwe. He is one of the developers of the wet index and an Associate Professor at DTU specializing in how water behaves.

Jammerbugt Municipality tested the tool in 2023. The results show better than expected predictions for the wet spring months. However, during the summer period, when Denmark was almost drought-stricken, the tool incorrectly predicted flooding in the same areas that had been flooded during the rainy spring.

https://smartwatermagazine.com

GERMANY

Highly resolved precipitation maps based on AI

Researchers of Karlsruhe Institute of Technology (KIT) have now developed a first method based on artificial intelligence (AI), by means of which the precision of coarse precipitation fields generated by global climate models can be increased. The researchers succeeded in improving the spatial resolution of precipitation fields from 32 to two kilometers and temporal resolution from one hour to ten minutes. This higher resolution is required to better forecast the more frequent occurrence of heavy local precipitation and the resulting natural disasters in the future.

Many natural disasters, such as floods or landslides, are directly caused by extreme precipitation. Researchers expect that increasing average temperatures will cause extreme precipitation events to further increase. To adapt to a changing climate and prepare for disasters at an early stage, precise local and global data on the current and future water cycle are indispensable. “Precipitation is highly variable in space and time and, hence, difficult to forecast, in particular on the local level,” says Dr. Christian Chwala from the Atmospheric Environmental Research Division of KIT’s Institute of Meteorology and Climate Research (IMK-IFU), KIT’s Campus Alpine in Garmisch-Partenkirchen.” For this reason, we want to enhance the resolution of precipitation fields generated e.g. by global climate models, and improve their classification as regards possible threats, such as floodings.”

Currently used global climate models are based on a grid that is not fine enough to precisely present the variability of precipitation. Highly resolved precipitation maps can only be produced with computationally expensive and, hence, spatially or temporally limited models. "For this reason, we have developed an AI-based generative neural network, called GAN, and trained it with high-resolution radar precipitation fields. In this way, the GAN learns how to generate realistic precipitation fields and derive their temporal sequence from coarsely resolved data," says Luca Glawion from IMK-IFU. "The network is able to generate highly resolved radar precipitation films from very coarsely resolved maps." These refined radar maps not only show how rain cells develop and move but precisely reconstruct local rain statistics and the corresponding extreme value distribution.

"Our method serves as a basis to increase the resolution of coarsely grained precipitation fields, such that the high spatial and temporal variability of precipitation can be reproduced adequately and local effects can be studied," says Julius Polz from IMK-IFU. "Our deep learning method is quicker by several orders of magnitude than the calculation of such highly resolved precipitation fields with numerical weather models usually applied to regionally refine data of global climate models." The researchers point out that their method also generates an ensemble of different potential precipitation fields. This is important, as a multitude of physically plausible highly resolved solutions exists for each coarsely resolved precipitation field. Similar to a weather forecast, an ensemble allows for a more precise determination of the associated uncertainty.

The results show that the AI model and methodology developed by the researchers will enable future use of neural networks to improve the spatial and temporal resolution of precipitation calculated by climate models. This will allow for a more precise analysis of the impacts and developments of precipitation in a changing climate.

"In the next step, we will apply the method to global climate simulations that transfer specific large-scale weather situations to a future world with a changed climate, e.g. to the year of 2100. The higher resolution of precipitation events simulated with our method will allow for a better estimation of the impacts the weather conditions that caused the flooding of the river Ahr in 2021 would have had in a world warmer by 2 degrees," Glawion explains. Such information is of decisive importance to develop climate adaptation methods.

https://www.preventionweb.net

UK

AI weather forecasts

Artificial intelligence (AI) can quickly and accurately predict the path and intensity of major storms, a new study demonstrates. The research, based on an analysis of November 2023's Storm Ciarán, suggests weather forecasts that use machine learning can produce predictions of similar accuracy to traditional forecasts faster, cheaper, and using less computational power. Published in *npj Climate and Atmospheric Science*, the University of Reading study highlights the rapid progress and transformative potential of AI in weather prediction.

Professor Andrew Charlton-Perez, who led the study, said, "AI is transforming weather forecasting before our eyes. Two years ago, modern machine learning techniques were rarely being applied to make weather forecasts. Now we have multiple models that can produce 10-day global forecasts in minutes.

To understand the effectiveness of AI-based weather models, scientists from the University of Reading compared AI and physics-based forecasts of Storm Ciarán—a deadly windstorm that hit northern and central Europe in November 2023 which claimed 16 lives in northern Europe and left more than a million homes without power in France.

The researchers used four AI models and compared their results with traditional physics-based models. The AI models, developed by tech giants like Google, Nvidia, and Huawei, were able to predict the storm's rapid intensification and track 48 hours in advance. To a large extent, the forecasts were 'indistinguishable' from the performance of conventional forecasting models, the researchers said. The AI models also accurately captured the large-scale atmospheric conditions that fueled Ciarán's explosive development, such as its position relative to the jet stream—a narrow corridor of strong high-level winds.

The machine learning technology underestimated the storm's damaging winds, however. All four AI systems underestimated Ciarán's maximum wind speeds, which in reality gusted at speeds of up to 111 knots at Pointe du Raz, Brittany. The authors were able to show that this underestimation was linked to some of the features of the storm, including the temperature contrasts near its center, that were not well predicted by the AI systems.

To better protect people from extreme weather like Storm Ciarán, the researchers say further investigation of the use of AI in weather prediction is urgently needed. The development of machine learning models could mean artificial intelligence is routinely used in weather prediction in the near future, saving forecasters time and money.

https://phys.org

AI-led innovation protects communities hit by climate change

The United Nations World Food Programme (WFP), Oxford University Physics Department, IGAD Climate Prediction and Applications Centre (ICPAC), and various national forecasting and meteorology agencies across East Africa are joining forces to pioneer a transformative initiative that is revolutionising extreme weather forecasting and early warning systems in the region.

In East Africa, where deadly floods have succeeded the worst drought in decades, climate change is accelerating the frequency and severity of extreme weather events, and the need for precise and timely forecasts has never been more critical. In an era marked by escalating weather variability, accurate weather predictions are essential to safeguard lives and livelihoods.

Climate scientists at Oxford University Physics have developed a ground-breaking AI-based weather model that enhances the accuracy of rainfall forecasts, offering high-resolution predictions without the need for additional costly supercomputers. “We believe the approach we have pioneered and are using here is a game-changer for parts of the world which have previously suffered from a lack of resource and infrastructure but nonetheless find themselves bearing the brunt of climate change,” said Dr. Shruti Nath, a climate scientist at Oxford University Physics.

This initiative was made possible with the support of Google.org to World Food Program USA, in support of WFP’s efforts to mitigate the impacts of climate change. The funding and in-kind contribution of computational resources from Google Cloud are crucial in overcoming the resource constraints faced by many forecasting organisations in Eastern Africa.

The success of this initiative in East Africa sets a precedent for broader application. The vision extends beyond this region, aiming to replicate this model in other parts of the world facing similar challenges. By continuing to refine AI-based models and expanding our partnerships, the goal is to build a more resilient global community capable of withstanding the worsening impacts of climate change.

https://www.ox.ac.uk

NORTH AMERICA

CANADA

Predictive AI models to protect cities from climate damage

Canadian cities can use artificial intelligence to save millions while predicting and protecting themselves against climate change, say two McMaster engineering researchers behind a new virtual modelling system. “We’re already seeing the impact of climate change and extreme weather on our municipal infrastructure,” explains Moustafa Naiem Abdel-Mooty, a researcher and instructor in the Department of Civil Engineering.

He used machine learning to predict the impact of climate change on infrastructure systems but soon realized he could do more using what’s called “digital twins” technology — creating an evolving virtual model of something based on real data and subjecting it to projected influences to predict how its physical version will be affected. Naiem created a virtual, self-updating replica of a city that continuously exchanged data with what was happening in real life.

With his former PhD advisor Wael El-Dakhakhni, a professor in the Department of Civil Engineering, and postdoctoral fellows Maysara Ghaith and Ahmed Yosri, Naiem founded a business called Resilio Climate Solutions, to help bring Canada up to date. Using a digital twin, they can now play out “what-if” scenarios and employ different measures to predict the best ways to reduce the impact of extreme weather events. That includes protective actions such as building levees beside rivers or improving other flood-proofing measures to protect critical infrastructure.

The Resilio team virtually went back in time to before the flood to create a case study to test their model. They were able to predict the flood with 85 per cent accuracy and to suggest ways in which Calgary could have mitigated its physical and financial impact.

“Our digital twin tool is a game changer in climate adaptation and resilience building. It is designed to empower government and business leaders to optimize their adaptation budget spending while also educating community stakeholders on possible impacts of future climate extremes,” says El-Dakhakhni.

https://brighterworld.mcmaster.ca

AI to improve building energy use and comfort

A new study from Waterloo researchers creating climate change-proof buildings with deep learning-powered inspections. University of Waterloo researchers have developed a new method that can lead to significant energy savings in buildings. The team identified 28 major heat loss regions in a multi-unit residential building with the most severe ones being at wall intersections and around windows. A potential energy savings of 25 per cent is expected if 70 per cent of the discovered regions are fixed.

Building enclosures rely on heat and moisture control to avoid significant energy loss due to airflow leakage, which makes buildings less comfortable and more costly to maintain. This problem will likely be compounded by climate change due to volatile temperature fluctuations. Since manual inspection is time-consuming and infrequently done due to a lack of trained personnel, energy inefficiency becomes a widespread problem for buildings.

Researchers at Waterloo, which is a leader in sustainability research and education and a catalyst for environmental innovation, solutions, and talent, created an autonomous, real-time platform to make buildings more energy efficient. The platform combines artificial intelligence, infrared technology, and a mathematical model that quantifies heat flow to better identify areas of heat loss in buildings.

Using the new method, the researchers conducted an advanced study on a multi-unit residential building in the extreme climate of Canadian prairies, where elderly residents reported discomfort and higher electricity bills due to increased demand for heating in their units. Using AI tools, the team trained the program to examine thermal images in real-time, achieving 81 percent accuracy in detecting regions of heat loss in the building envelope.

“The almost 10 per cent increase in accuracy with this AI-based model is impactful, as it enhances occupants’ comfort as well as reduces energy bills,” said Dr. Mohamad Araji, director of Waterloo’s Architectural Engineering Program and head of the Symbiosis Lab, an interdisciplinary group at the university that specializes in developing innovative building systems and building more environmentally friendly buildings.

The new AI tools helped to remove the element of human error in examining the results and increased the speed of getting the data analyzed by a factor of 12 compared to traditional building inspection methods. Future expansions to this work will include utilizing drones equipped with cameras to inspect high-rise buildings.

https://uwaterloo.ca

USA

New AI model for weather, climate

Working together, NASA and IBM Research have developed a new artificial intelligence model to support a variety of weather and climate applications. The new model – known as the Prithvi-weather-climate foundational model – uses artificial intelligence (AI) in ways that could vastly improve the resolution we'll be able to get, opening the door to better regional and local weather and climate models.

Foundational models are large-scale, base models that are trained on large, unlabeled datasets and can be fine-tuned for a variety of applications. The Prithvi-weather-climate model is trained on a broad set of data – in this case NASA data from NASA's Modern-Era Retrospective Analysis for Research and Applications (MERRA-2)– and then makes use of AI learning abilities to apply patterns gleaned from the initial data across a broad range of additional scenarios.

"Advancing NASA's Earth science for the benefit of humanity means delivering actionable science in ways that are useful to people, organizations, and communities. The rapid changes we're witnessing on our home planet demand this strategy to meet the urgency of the moment," said Karen St. Germain, director of the Earth Science Division of NASA's Science Mission Directorate. "The NASA foundation model will help us produce a tool that people can use: weather, seasonal, and climate projections to help inform decisions on how to prepare, respond, and mitigate."

With the Prithvi-weather-climate model, researchers will be able to support many different climate applications that can be used throughout the science community. These applications include detecting and predicting severe weather patterns or natural disasters, creating targeted forecasts based on localized observations, improving spatial resolution on global climate simulations down to regional levels, and improving the representation of how physical processes are included in weather and climate models.

"These transformative AI models are reshaping data accessibility by significantly lowering the barrier of entry to using NASA's scientific data," said Kevin Murphy, NASA's chief science data officer, Science Mission Directorate at NASA Headquarters. "Our open approach to sharing these models invites the global community to explore and harness the capabilities we've cultivated, ensuring that NASA's investment enriches and benefits all."

Prithvi-weather-climate was developed through an open collaboration with IBM Research, Oak Ridge National Laboratory, and NASA, including the agency's Interagency Implementation and Advanced Concepts Team (IMPACT) at Marshall Space Flight Center in Huntsville, Alabama.

Prithvi-weather-climate can capture the complex dynamics of atmospheric physics even when there is missing information thanks to the flexibility of the model's architecture. This foundational model for weather and climate can scale to both global and regional areas without compromising resolution.

"This model is part of our overall strategy to develop a family of AI foundation models to support NASA's science mission goals," said Rahul Ramachandran, who leads IMPACT at Marshall. "These models will augment our capabilities to draw insights from our vast archives of Earth observations."

Prithvi-weather-climate is part of a larger model family– the Prithvi family– which includes models trained on NASA's Harmonized LandSat and Sentinel-2 data. The latest model serves as an open collaboration in line with NASA's open science principles to make all data accessible and usable by communities everywhere. It will be released later this year on Hugging Face, a machine learning and data science platform that helps users build, deploy, and train machine learning models.

https://science.nasa.gov

AI to create carbon-capturing plants

A unique partnership at Salk leverages the deep learning software known as SLEAP to study plant characteristics, speeding up the development of plants that can combat climate change. Scientists in Salk's Harnessing Plants Initiative are using a sophisticated new research tool called SLEAP—an easy-to-use artificial intelligence (AI) software that tracks multiple features of root growth. Created by Salk Fellow Talmo Pereira, SLEAP was initially designed to track animal movement in the lab. Now, Pereira has teamed up with plant scientist and Salk colleague Professor Wolfgang Busch to apply SLEAP to plants.

In a study published in *Plant Phenomics*, Busch and Pereira debut a new protocol for using SLEAP to analyze plant root phenotypes—how deep and wide they grow, how massive their root systems become, and other physical qualities that, prior to SLEAP, were tedious to measure. The application of SLEAP to plants has already enabled researchers to establish the most extensive catalog of plant root system phenotypes to date.

What's more, tracking these physical root system characteristics helps scientists find genes affiliated with those characteristics, as well as whether multiple root characteristics are determined by the same genes or independently. This allows the Salk team to determine what genes are most beneficial to their plant designs.

"This collaboration is truly a testament to what makes Salk science so special and impactful," says Pereira. "We're not just 'borrowing' from different disciplines—we're really putting them on equal footing in order to create something greater than the sum of its parts."

Prior to using SLEAP, tracking the physical characteristics of both plants and animals required a lot of labor that slowed the scientific process. If researchers wanted to analyze an image of a plant, they would need to manually flag the parts of the image that were and weren't plant—frame-by-frame, part-by-part, pixel-by-pixel. Only then could older AI models be applied to process the image and gather data about the plant's structure.

What sets SLEAP apart is its unique use of both computer vision (the ability for computers to understand images) and deep learning (an AI approach for training a computer to learn and work like the human brain). This combination allows researchers to process images without moving pixel-by-pixel, instead skipping this intermediate labor-intensive step to jump straight from image input to defined plant features.

"We created a robust protocol validated in multiple plant types that cuts down on analysis time and human error while emphasizing accessibility and ease-of-use—*and* it required no changes to the actual SLEAP software," says first author Elizabeth Berrigan, a bioinformatics analyst in Busch's lab.

Without modifying the baseline technology of SLEAP, the researchers developed a downloadable toolkit for SLEAP called *sleap-roots* (available as open-source software here). With *sleap-roots*, SLEAP can process biological traits of root systems like depth, mass, and angle of growth.

The Salk team tested the *sleap-roots* package in a variety of plants, including crop plants like soybeans, rice, and canola, as well as the model plant species *Arabidopsis thaliana*—a flowering weed in the mustard family. Across the variety of plants trialed, they found the novel SLEAP-based method outperformed existing practices by annotating 1.5 times faster, training the AI model 10 times faster, and predicting plant structure on new data 10 times faster, all with the same or better accuracy than before.

Together with massive genome sequencing efforts for elucidating the genotype data in large numbers of crop varieties, these phenotypic data, such as a plant's root system growing especially deep in the soil, can be extrapolated to understand the genes responsible for creating that especially deep root system.

This step—connecting phenotype and genotype—is crucial in Salk's mission to create plants that hold on to more carbon and for longer, as those plants will need root systems designed to be deeper and more robust. Implementing this accurate and efficient software will allow the Harnessing Plants Initiative to connect desirable phenotypes to targetable genes with groundbreaking ease and speed.

https://scitechdaily.com

AI model for weather prediction

Researchers from private sector companies like Nvidia and Google have started developing large artificial intelligence (AI) models, known as foundation models, for weather forecasting. Recently, scientists at the U.S. Department of Energy's (DOE) Argonne National Laboratory, in close collaboration with researchers Aditya Grover and Tung Nguyen at the University of California, Los Angeles, have begun to investigate this alternative type of model. This model could produce in some cases even more accurate forecasts than the existing numerical weather prediction models at a fraction of the computational cost. Some of these models outperform current models' prediction capability beyond seven days, giving scientists an additional window into the weather.

Foundation models are built on the use of "tokens," which are small bits of information that an AI algorithm uses to learn the physics that drives the weather. Many foundation models are used for natural language processing, which means handling words and phrases. For these large language models, these tokens are words or bits of language that the model predicts in sequence. For this new weather prediction model, the tokens are instead pictures — patches of charts depicting things like humidity, temperature, and wind speed at various levels of the atmosphere.

"Instead of being interested in a text sequence, you're looking at spatial-temporal data, which is represented in images," said Argonne computer scientist Sandeep Madireddy. "When using these patches of images in the model, you have some notion of their relative positions and how they interact because of how they're tokenized."

The scientific team can use quite low-resolution data and still come up with accurate predictions, said Argonne atmospheric scientist Rao Kotamarthi. "The philosophy of weather forecasting has for years been to get to higher resolutions for better forecasts. This is because you are able to resolve the physics more precisely, but of course, this comes at great computational cost," he said. "But we're finding now that we're actually able to get comparable results to existing high-resolution models even at coarse resolution with the method we are using."

While reliable near-term weather forecasting seems to be a near-term achievable goal with AI, trying to use the same approach for climate modeling, which involves analyzing weather over time, presents an additional challenge. "In theory, foundation models could also be used for climate modeling. However, there are more incentives for the private sector to pursue new approaches for weather forecasting than there are for climate modeling," Kotamarthi said. "Work on foundation models for climate modeling will likely continue to be the purview of the national labs and universities dedicated to pursuing solutions in the general public interest."

The introduction of Argonne's new exascale supercomputer, Aurora, will help researchers train a very large AI-based model that will work at very high resolutions. "We need an exascale machine to really be able to capture a fine-grained model with AI," Kotamarthi said.

https://www.newswise.com

Urban intelligence for extreme heat mitigation and adaptation

Experience in Asian cities

Yuan Lai, Edward Lai, Jiatong Li, Jingyi Xia

Tsinghua University School of Architecture, Beijing, China
Tel: 86-10-62783328
Email: yuanlai@tsinghua.edu.cn

Abstract

As urbanization accelerates globally, cities play a pivotal role in addressing the environmental and socio-economic challenges associated with rapid population growth, particularly in the context of climate change. This research focuses on a critical concept of urban intelligence and relevant AI applications in mitigating and adapting to extreme heat conditions, a critical issue in densely populated Asian cities. Extreme heat exacerbates public health risks, infrastructure degradation, and socio-economic inequalities, particularly in informal settlements with inadequate cooling resources. Leveraging AI, cities such as Singapore, Seoul, and Kuala Lumpur are pioneering innovations in real-time heat monitoring, predictive analytics, and climate-adaptive urban design. These efforts include the integration of AI with digital twin technologies for simulating urban heat islands, optimizing green and blue infrastructure, and enhancing smart building operations. This paper also discusses the opportunities and challenges of implementing AI-driven urban intelligence in Asian cities, highlighting the need for equitable access to technology, preservation of local historic architecture, and integration of traditional knowledge with modern innovations. The findings suggest that while AI holds significant promise for enhancing urban resilience to extreme heat, successful implementation will require careful consideration of local contexts, regulatory frameworks, and the socio-economic dynamics of rapidly urbanizing regions.

Introduction

Cities are central to achieving the sustainable development goals outlined in UN Sustainable Development Goal 11. The UN estimates that by 2050, the global population will reach 10 billion, with 68% residing in urban areas (United Nations, 2018). Meanwhile, cities also intensify environmental pressures and socio-economic conflicts, consuming over two-thirds of the world's energy and producing more than 70% of global carbon emissions (Luqman et al., 2023). Among the challenges, extreme heat poses a significant threat to urban areas, worsening health issues such as heat-related illnesses and respiratory conditions, increasing energy demand that strains power grids, damaging infrastructure through thermal expansion and contraction, degrading air quality by elevating pollution levels, and threatening water supplies due to higher evaporation rates. Extreme heat events can further lead to substantial economic costs, especially the ones related to healthcare and infrastructure repairs while exacerbating social inequalities by disproportionately affecting lower-income neighborhoods with fewer green spaces and limited cooling resources.

Asian cities are particularly vulnerable to the challenges of extreme heat due to their rapid urbanization and dense populations. The Intergovernmental Panel on Climate Change (IPCC) projects that many parts of Asia will experience more frequent and severe heatwaves by 2050, with the number of days exceeding 35°C expected to rise significantly in cities like Karachi, Delhi, and Ho Chi Minh City. (World Resources Institute, 2021). Urban areas, such as Tokyo, Bangkok, and Manila, are already several degrees hotter than nearby rural regions due to the concentration of buildings, roads, and other heat-absorbing infrastructure. (Chapman et al., 2017). In densely populated cities like Dhaka, Mumbai, and Jakarta, the impact of extreme heat is further exacerbated, particularly in informal settlements that lack adequate infrastructure. (Rashid et al., 2013). These conditions pose significant public health risks, with studies indicating the percentage of heat-related deaths attributed to human-induced climate change in Southeast Asia is between 48% to 61%, which is the second highest after Central and South America. (Medicine, 2021). In response to these challenges, cities are actively exploring and implementing planning interventions, policies, and technological solutions to mitigate and adapt to the growing impacts of extreme heat.

AI and urban intelligence

With growing urban big data and smart city applications, Artificial intelligence (AI) is increasingly becoming integrated into our urban environments, giving rise to urban intelligence as a comprehensive capability that leverages big data computing and information technology to enhance urban systems

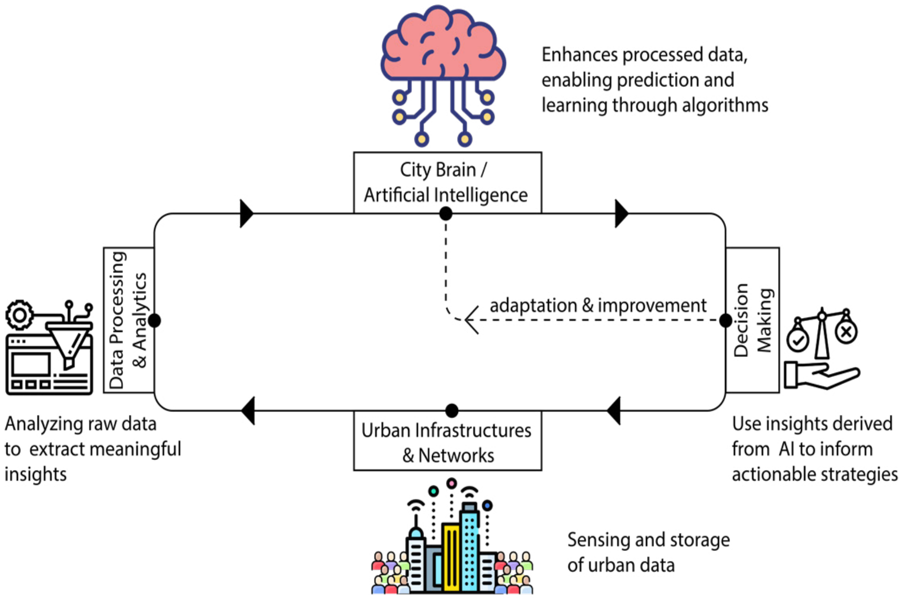

Figure 1: Anatomies and processes of urban intelligence (Source: Author)

Figure 2: Capacities of urban intelligence (Source: Author)

across various domains. AI enables computers to perform tasks traditionally associated with human cognition, such as perception, comprehension, and decision-making. These tasks rely on computing that involves data processing, analytical modeling, and outcome generation aligned with predefined objectives. AI's effectiveness largely depends on the quantity and quality of data and algorithms inspired by the human brain's decision-making processes with reasoning, learning, and problem-solving capabilities (Figure 1).

Urban intelligence plays a critical role in climate change resilience by providing real-time monitoring, predictive analytics, and automated responses that help cities anticipate and mitigate the impacts of extreme conditions (Lai, 2021, 2022). Urban infrastructure networks handle the sensing and storage of urban data. AI-powered infrastructures, such as intelligent transportation networks and waste management systems, can significantly improve urban operational efficiency. Then, data processing and analytics involving analyzing raw data to extract meaningful insights. Machine learning enhances the processed data, enabling prediction and learning through various algorithms. Ultimately, decision-making and adaptation use the insights derived from AI to inform actionable strategies. For instance, urban intelligence can advance urban health through everyday applications like personalized health monitoring and automated suggestions (Figure 2). These capabilities can greatly enhance climate resilience by utilizing predictive analytics and automated response systems to anticipate, mitigate, and adapt to extreme heat conditions.

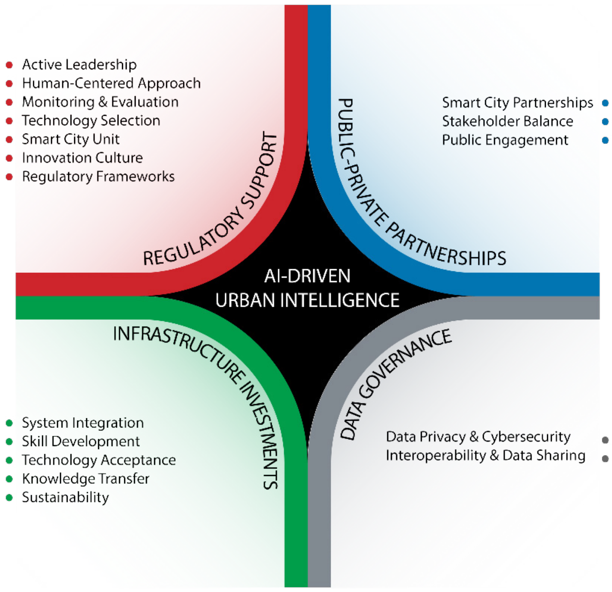

Figure 3: Government Roles in AI-driven Urban Intelligence (Source: Author)

As cities and companies are still experimenting with the capacity and use cases of urban intelligence due to the complexities of real-world urban scenarios and environment, there are already early-stage implementations across Asia for urban heat sensing, mitigation, and adaptation into the existing smart city ecosystems and frameworks. In Asia, researches have shown that responsibility and involvement in planning and implementation of smart city initiatives still largely falls on municipal governments. Hence, city governments and policymakers play significant roles in promoting and integrating the development of AI-driven urban intelligence (Figure 3). The key policy contributions are active regulatory support, inclusive public-private partnerships, sustainable infrastructure investments, and secure data governance. For example, AI for Urban Cooling, a joint grant call launched by AI Singapore and the Institute for Information and Communication Technology Planning and Evaluation, South Korea funds the research on AI-Assisted Multi-scale Microclimate Models. It is a scientific and technological cooperation between Singapore and South Korean researchers to develop AI-assisted models as a solution to satisfy the analytic, simulation and design recommendation needs to mitigate urban heat island effect and improve thermal comfort in urbanized areas. In addition, China aims to achieve global leadership in AI theory, technology, and applications, establishing itself as a key global innovation hub for AI by 2030, according to the comprehensive plan for the development of artificial intelligence (AI) by the State Council of China.

Urban heat sensing

Real-time heat monitoring and forecasting

Urban intelligence provides comprehensive sensing capacity that enables cities to monitor, measure, quantify, and analyze local heat-related factors. Cities like Tokyo and Singapore deploy IoT sensing networks to collect real-time temperature, humidity, and air quality data, which are essential for identifying heat hotspots and microclimatic variations within the city. (Nurmadiha Osman et al., 2021). AI models can leverage historical data, urban infrastructure, and satellite imagery to predict extreme heat events. For example, Seoul uses AI-driven models to forecast heatwaves and provide early warnings, helping authorities and citizens prepare in advance. (Asadollah et al., 2021). In Singapore, the local city agencies collaborated with ARUP on UHeat, a tool for identifying local urban heat effects. (ARUP, 2023). This tool leverages machine learning to analyze large volumes of satellite images by tagging building materials like glass, steel, tarmac, vehicles, air conditioning units, data centers, and other urban developments that may raise local temperatures (Figure 4).

Urban heat simulation

In large and densely built urban areas, AI can pair with digital twin technology to simulate extreme urban heat conditions at finer spatial resolution and nearly real-time frequency. Singapore has been utilizing various urban intelligence tools to improve building inspections with image processing and thermal sensing to monitor facade defects in buildings, identify types, and respond to repair costs (Figure 5). The city further invested in its R&D on a new technology that can simulate and assess building energy loss. By thermal scanning, it would be easier to locate the inefficiency of insulation in buildings and identify where action is needed. Real-time temperature sensing and heat distribution simulation across cities can help identify hotspots and implement targeted cooling strategies. By leveraging predictive analytics, AI models can forecast heatwaves, create real-time heat maps, guide proactive measures to protect vulnerable areas and the local population, and allow cities to prepare and respond proactively.

Figure 4: The UHeat tool analyzes the city's temperature between different locations in Singapore
(*Source*: https://www.arup.com/insights/from-urban-heat-to-biomimetic-design-how-digital-tools-can-support-greener-cities/)

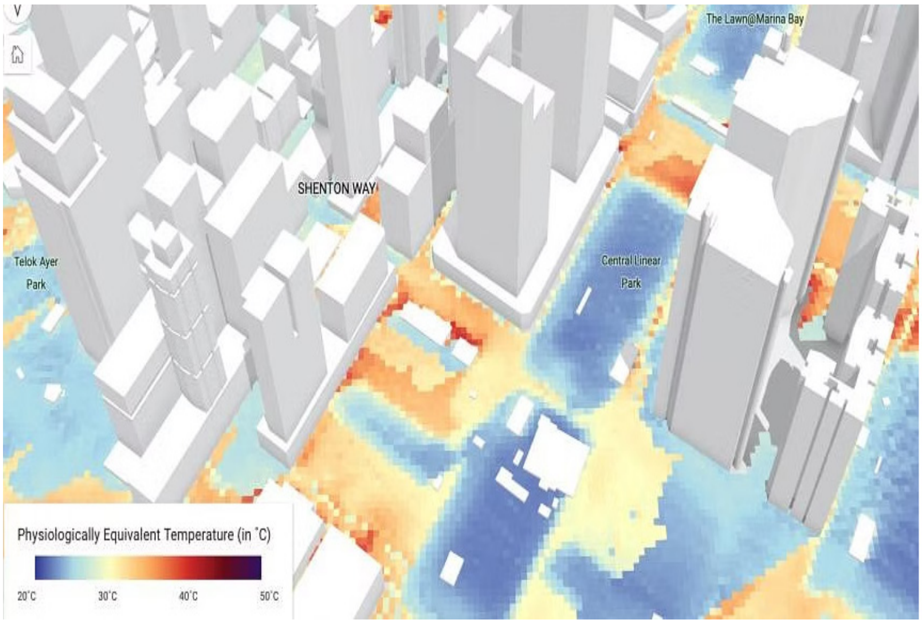

Figure 5: Digital twin of local temperature in the Central Business District, Singapore

(*Source*: ARUP)

Urban heat mitigation

Green & Blue infrastructure optimization

Urban heat mitigation refers to strategies and actions taken to reduce or counteract the extreme heat effects in cities. (Martilli et al., 2020). The goal is to lower urban temperature, improve thermal comfort for residents, reduce energy consumption for cooling, and enhance overall urban sustainability and livability. Urban heat mitigation can be done through various stages and processes in the optimization of urban green and blue infrastructures. Beginning with stakeholder engagement which ensures that local businesses, communities and residents have involvement in the early phases of co-designing and co-planning, this is followed by a feasibility study, which involves conducting cost-benefit analyses and identifying heat-vulnerable areas for targeted interventions. After examining both co-benefits and dis-benefits, the next step involves designing and integrating suitable measures into long-term urban planning and policies. The implementation phase ensures partnerships, proper resource allocation, and the use of progress tracking

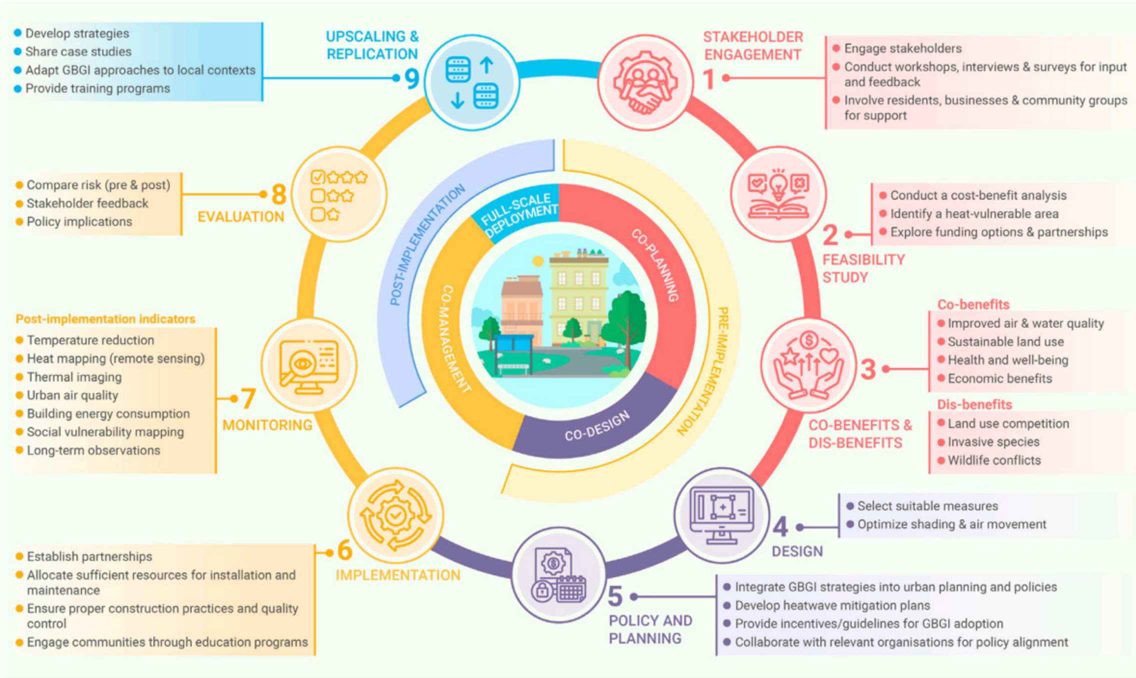

Figure 6: Urban green and blue infrastructure to mitigate extreme urban heat
(*Source*: Kumar, P., Debele, S. E., Khalili, S., Halios, C. H., Sahani, J., Aghamohammadi, N., ... & Jones, L. (2024). Urban heat mitigation by green and blue infrastructure: Drivers, effectiveness, and future needs. The Innovation, 5(2).)

tools; monitored by post-implementation indicators to provide insights into various urban metrics. Lastly, successful strategies are scaled and replicated to fit local contexts, spreading best practices through shared case studies and training programs.

Urban intelligence aids heat mitigation by leveraging data-driven decision-making, predictive analytics, and generative design to optimize spatial layout and infrastructure management. For instance, it can optimize the placement and maintenance of green and blue infrastructure, such as parks, green roofs, and water bodies, to maximize their cooling effects and reduce the urban heat island effect (Saaroni et al., 2018) (Figure 6).

Smart building operation

AI-empowered tools can enhance building energy efficiency through smart systems that adjust HVAC (heating, ventilation, and air conditioning) operations based on real-time data, further mitigating heat impacts and improving overall urban resilience. In China, cities are putting special emphasis on utilizing AI for optimizing building energy efficiency and carbon reduction. At the individual building level, intelligent analytical tools along with IoT networks can monitor, simulate, predict, and control HVAC systems, customize energy consumption strategies in real-time, and visualize energy efficiency improvement and cost reduction to support better decision-making. In Wuxi, China, the local city agency cooperated with Schneider Electric to launch SpaceLogic AI BOX, a comprehensive tool that combines AI technology with digital energy management, creating an AI application for building HVAC management (Electric, 2023). This intelligent solution relies on four functions that include digital twinning, modeling verification, system optimization, and energy-saving monitoring (Figure 7).

Urban heat adaptation

Climate-adaptive urban design

Urban heat adaptation involves making adjustments in the ecosystem, infrastructure, buildings, or public space to minimize the negative impacts of climate change and to protect residents, especially vulnerable groups, from health risks. (Chen & He, 2022). Common actions include establishing cooling facilities, enhancing electricity utility capacity, reducing solar radiation absorption with reflective materials, improving building thermal insulation, promoting green roofs, increasing air circulation in an urban environment, and providing more urban green space. Climate-adaptive urban design, particularly in the context of extreme heat, involves creating urban spaces that can effectively reduce and adapt to rising temperatures and the urban heat island effect. This approach integrates green infrastructure, such as parks, green roofs, and urban forests, alongside blue infrastructure (for example, water bodies) to cool urban areas, improve air quality, and create more comfortable living conditions. Appropriate building layout and land use planning will also help to improve urban ventilation and thermal environment.

Urban intelligence leverages AI and IT technology to enhance climate-adaptive design by optimizing cooling elements' placement (Eslamirad et al., 2020; Yoo et al., 2023), predicting heatwave patterns (Mustafa et al., 2020),

Figure 7: SpaceLogic AI BOX solution for smart building management

(*Source*: Schneider Electric)

and enabling real-time adjustments in urban infrastructure (Qi et al., 2022). By leveraging climate data and smart technologies, cities can implement targeted heat mitigation strategies, monitor their effectiveness, and dynamically adapt to changing climate conditions, ensuring that urban environments remain resilient and livable (Cheong et al., 2022). Extreme heat-adaptive urban design integrated with urban intelligence has important value for cities in South and South-East Asia. In Kuala Lumpur, Malaysia, the city uses AI to analyze airflow patterns and optimize the placement of buildings, roads, and green spaces for better climate adaptation. In Thailand, the City of Bangkok has explored utilizing spatial analytics and AI to operate smart shading systems and reflective materials within certain neighborhoods, which potentially can scale up to citywide scale (Irvine et al., 2022). Singapore also developed AI-assisted multi-scale microclimate models at the district or neighborhood scale, based on data including weather and climate, urban shape and morphology, and anthropogenic activity. This model enables numerical simulations and AI-based design recommendations to mitigate the urban heat island effect and improve thermal comfort in high-density, urbanized areas. Furthermore, it can also evaluate the proposed AI design recommendations in terms of societal and economic impact, such as carbon savings or cost savings, to further guide urban design and implementations.

Climate-adaptive social resilience

Climate adaptation does not only involve the environmental and physical realm but also covers public health policies to protect residents from health risk exposures. From the societal aspect, cities need to raise public awareness and emergency response capacity through innovative policies and special programs for extreme heat events. Leveraging the rising generative AI and intelligent tools based on large language models (e.g., ChatGPT), cities can support dynamic policy-making and public engagement through AI-aided apps, educating citizens and enabling more flexible policy implementation based on real-time data. Through these capabilities, AI empowers cities to enhance their resilience to extreme heat and adapt to the challenges posed by climate change. In particular, AI-based urban intelligence tools can identify residents' heat risk exposure in real-time, and based on different scenarios, targeted public health policies can be formulated. In the Republic of Korea, Seoul has built an assessment system to track and map urban heat hazards, exposures, and vulnerability on a daily basis using real-time population data and machine learning (Yoo et al., 2023). This system can monitor urban heat hazards and guide site-specific adaptation and response plans for dynamic urban heat events (Figure 8).

Opportunities and challenges

Leveraging urban intelligence for extreme heat mitigation and adaptation in Asian cities presents unique opportunities and challenges shaped by the region's diverse climates, rapid urbanization, and varying levels of technological advancement. In the future, planners and architects may explore novel integration of urban intelligence with traditional knowledge and local building materials. For instance, lime, stone, and bamboo are common traditional South Asian building materials, which can be integrated with smart sensors to enhance cooling strategies. (Ebrahim, 2024). Developing climate-responsive urban infrastructure is another critical strategy for Asian cities regarding the rapid urbanization and demand for new infrastructure. Especially in new urban development, cities can plan and build

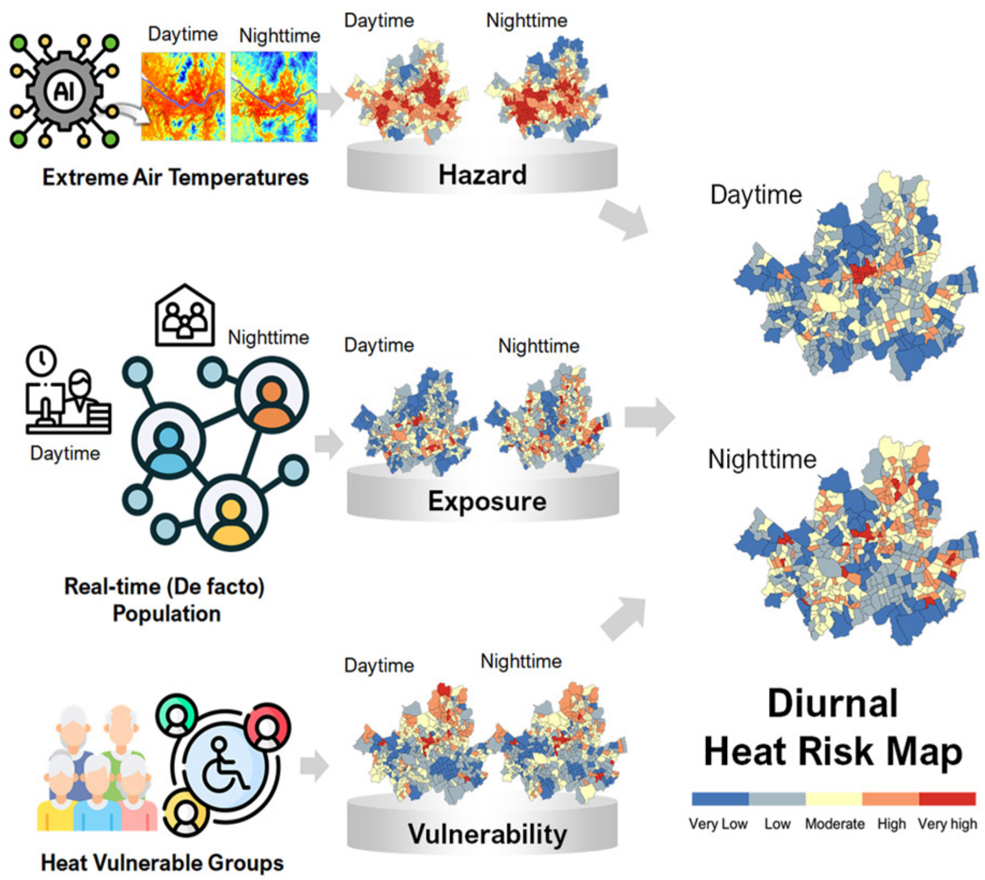

Figure 8: Framework for evaluating and mapping daily heat risk in Seoul, Republic of Korea.
(*Source*: Authors adapt from Yoo et al. 2023).

new areas using data-driven models that predict the impacts of heat islands and optimize the placement of green spaces, water bodies, and wind corridors to mitigate extreme heat. Finally, cities can leverage digital platforms to engage communities in heat mitigation efforts, such as heatwave alerts via mobile apps or participatory energy conservation management through digital tools.

Despite promising opportunities, some risks and challenges require careful assessment and further research. Data availability and quality are a first hurdle for many Asian cities. Limited open data, particularly on microclimates, energy use, and infrastructure resilience, can constrain leveraging urban intelligence to mitigate and adapt to extreme heat. Furthermore, the existing inequality in access to technology creates a digital divide and injustice in many Asian cities, where wealthier neighborhoods may benefit from advanced urban intelligence applications. At the same time, low-income areas often have more vulnerable populations without access to technology. Finally, the rich historic architectural heritage in many Asian cities may cause cultural resistance or regulatory hurdles to implementing urban intelligence solutions for heat mitigation. The preservation of historic architecture limits the extent to which modern, heat-resistant materials and technologies can be used in certain parts of the city, complicating efforts to mitigate heat in densely populated areas.

In summary, while urban intelligence for extreme heat mitigation and adaptation in Asian cities holds significant promise, it requires careful consideration of local contexts. Successful implementation will depend on integrating traditional knowledge with cutting-edge technology, ensuring equitable access to these solutions, and navigating the challenges posed by rapid urbanization and regulatory frameworks.

Conclusion

The rise of smart city development generates vast amounts of data, offering rich resources for advancing urban-related AI technologies but also necessitates automated data processing and analytical power that often exceeds the current capacities of cities. As AI continues to integrate into our urban spaces and environments, cities are blending their physical, social, and digital aspects more than ever, creating new user experiences and daily life scenarios while introducing new problems, risks, and challenges for future living. By combining various data sources with artificial intelligence, urban intelligence aims to improve coordination between different systems and support better, more precise, and forward-thinking planning decisions. Looking ahead, urban intelligence can help understand the complex relationships between ecological, economic, and social factors in the context of climate change, aiding in coordinated digital transformation and refined city management to be more heat-resilient.

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Transforming climate adaptation with artificial intelligence

Case studies in hydroclimatology and agriculture

Rajib Maity

Fellow, Royal Meteorological Society, United Kingdom; AK Singh Chair Faculty of IIT Kharagpur; Alexander von Humboldt Fellow (Experienced Category), Germany; BOYSCAST Fellow (Purdue University, USA).

Professor, Department of Civil Engineering, Indian Institute of Technology Kharagpur, Kharagpur – 721302, West Bengal, India

Emails: rajib@civil.iitkgp.ac.in; rajibmaity@gmail.com

Abstract

The Asia-Pacific region faces urgent challenges due to climate change, including rising temperatures, unpredictable precipitation patterns, and extreme weather events, necessitating the transformation of climate adaptation strategies with Artificial Intelligence (AI). This article investigates the transformative potential of AI, Machine Learning (ML), and Deep Learning (DL) technologies in hydroclimatology to provide innovative solutions for these pressing issues. Through three different case studies in India – a hybrid DL-based approach for multi-step ahead prediction of temperature and heatwave, a DL-based assessment of future streamflow variability, and AI for soil moisture monitoring and intelligent irrigation—our primary exploration reveals significant advancements in predictive accuracy and resource management efficiency. These cases highlight AI's ability to enhance climate models and optimize agricultural practices. Policy recommendations emphasize fostering innovation, regional knowledge-sharing cooperation, and capacity building. Leveraging AI-driven solutions can substantially boost adaptive capacity, mitigate adverse impacts, and ensure sustainable development in the Asia-Pacific region.

Introduction

Climate change poses urgent global challenges with rising temperatures, shifting precipitation patterns, and increased extreme weather events (IPCC, 2023; Sarkar et al, 2023; Sarkar & Maity, 2024). Human activities, particularly greenhouse gas emissions, have indisputably driven global warming, pushing temperatures 1.1°C above 1850–1900 levels by 2011–2020. Persistent emissions from unsustainable energy use, land practices, and consumption patterns contribute unequally across regions and within societies, threatening global ecosystems, health, and socio-economic stability. Agriculture and water sectors face heightened vulnerability, endangering food security and water resources (IPCC, 2023; Srivastava et al., 2022b; 2024). The Asia-Pacific region, with diverse climates and extensive coastlines, is no longer an exemption from amplified risks. According to the Asian Development Bank, the region is home to 60% of the world's population. It is highly vulnerable to climate change, with projections indicating a potential increase in temperature by 1.5°C to 3.9 (with an average of 2.7°C by 2050 under the worst climate change conditions (ADB, 2017). Extreme weather events' frequency and intensity have increased, leading to economic losses estimated at $675 billion annually (Hallegatte et al., 2016). Given the dense population and reliance on climate-sensitive sectors, addressing climate change here is paramount in this region.

Climate change generally poses profound challenges in hydroclimatology and agriculture, where the complexity and non-linear relationships in hydroclimatic data present significant hurdles. This vast volume and heterogeneity of the data, encompassing various meteorological, hydrological, and agricultural parameters, further complicate efforts to analyze and interpret the trends and underlying processes. Moreover, there is an increasing demand for precise and real-time predictions and recommendations to manage water resources, forecast extreme weather events, and optimize agricultural practices. Traditional methods often struggle to meet these requirements (Baker et al., 2020), highlighting the need for advanced, data-driven approaches. In this context, Artificial Intelligence (AI), particularly its subsets such as Machine Learning (ML) and Deep Learning (DL) offers promising solutions. These technologies can process large datasets, identify hidden patterns, and provide accurate forecasts, thus enhancing our ability to adapt to and mitigate the impacts of climate change. Therefore, AI may be considered as one of the ways forward to combating climate change issues.

Applying AI, ML, and DL in hydroclimatology and agriculture is not merely theoretical but has shown practical benefits across various case studies and real-world implementations. For instance, AI-driven models have been employed to accurately predict streamflow variations, aiding water resource management and planning (Khan et al., 2023). In agriculture, ML algorithms are being used to optimize irrigation schedules, reducing water wastage while ensuring crop health (Srivastava et al., 2022a). DL techniques, particularly hybrid models, have proven effective in forecasting extreme weather events such as heatwaves, providing critical lead time for preparedness and response (Khan &

Maity, 2022). These applications underscore the potential of AI, ML, and DL in addressing the multifaceted challenges posed by climate change, from ensuring water security to enhancing agricultural productivity and sustainability. By leveraging these advanced technologies, we can develop more resilient systems capable of adapting to the evolving climate dynamics.

This article thus presents the transformative utilization of AI, ML, and DL in addressing climate change impacts in hydroclimatology and agriculture. The focus is to showcase how AI techniques can be applied to complex hydroclimatic data for future streamflow assessments under climate change scenarios, to illustrate the effectiveness of a hybrid deep learning approach for multi-step-ahead predictions of daily maximum temperatures and heatwaves, and to present an AI-based intelligent system for soil moisture monitoring and irrigation management designed for marginal farmers, demonstrating its potential to enhance agricultural productivity and sustainability. By harnessing the power of these advanced technologies, we can better understand and predict complex climate phenomena, optimize resource management, and enhance decision-making processes.

AI-ML-DL techniques in hydroclimatology and agriculture

Overview

The journey of AI began in the mid-20th century with John McCarthy's introduction of 'artificial intelligence' in 1956 (McCarthy et al., 2006). Early AI focused on symbolic methods and problem-solving. ML emerged in the 1980s, shifting to data-driven approaches with advancements in decision trees (Breiman et al., 1984). The rise of the internet in the 1990s led to more data and boosted algorithms, such as Support Vector Machines (SVM) (Cortes & Vapnik, 1995) and Random Forests (RF) (Breiman, 2001). In the 21st century, DL saw a resurgence with deep neural networks advancing tasks such as image and speech recognition (LeCun et al., 1998). Table 1 details essential AI, ML, and DL concepts, defining AI's replication of human cognitive functions, ML's focus on predictive accuracy through data exposure, and DL's use of deep networks for complex data patterns. These technologies are crucial in diverse fields like natural language processing, image analysis, and decision support systems, shaping modern computational paradigms and technological progress.

Table 1: Outlining definitions and classifications of Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL)

Concept	Definition	Types
AI	Any technique enabling computers to mimic human intelligence, performing tasks that typically require human intellect, such as natural language understanding, pattern recognition, and decision-making.	**Narrow AI:** Designed for specific tasks (e.g., virtual assistants).
		General AI: Hypothetical AI capable of performing any intellectual task a human can.
		Superintelligent AI: A theoretical concept surpassing human intelligence across all fields.
ML	A subset of AI focused on developing algorithms that learn from and make predictions or decisions based on data, improving performance over time with more data exposure.	**Supervised Learning:** Algorithms are trained on labeled data for tasks like classification and regression
		Unsupervised Learning: Finds patterns in data without labels, used in clustering and association tasks.
		Reinforcement Learning: Algorithms learn by interacting with an environment and receiving rewards or penalties to maximize cumulative rewards.
DL	A subset of ML utilizing neural networks with many layers to model complex patterns in large datasets, excelling in tasks requiring high-level feature extraction from raw data.	**Feedforward Neural Networks (FNNs):** The simplest form, lacking cycles between nodes.
		Convolutional Neural Networks (CNNs): Excel at processing image data through convolutional layers that learn spatial hierarchies.
		Recurrent Neural Networks (RNNs): Designed for sequential data, used in time series analysis and Natural Language Processing (NLP).
		Long Short-Term Memory (LSTM): Advanced RNN variant effectively managing long-term dependencies.

Specific algorithms used in hydroclimate and agricultural studies

Applying AI, ML, and DL in hydroclimatology and agriculture uses various algorithms (Table 2) designed for specific challenges. AI algorithms often involve expert systems and knowledge-based approaches, aiding drought monitoring and early warning systems (Elbeltagi et al., 2022; Kumar et al., 2023). Knowledge-based systems integrate qualitative reasoning with quantitative data for actionable insights into hydrological processes. ML algorithms are used for pattern recognition and predictive modeling. Techniques such as SVM and RF predict precipitation patterns and drought severity (Maity et al., 2010; Tulla et al., 2024; Vishwakarma et al., 2024). Clustering algorithms help identify hidden patterns in meteorological and hydrological datasets. DL algorithms excel in handling complex data relationships. CNNs effectively analyze satellite data. RNNs and LSTM networks are used in time-series forecasting for streamflow dynamics and temperature variations (Khan & Maity, 2020; 2023; Maity et al., 2021). These models capture temporal dependencies and nonlinear relationships, enhancing predictive accuracy in dynamic environments.

Case studies from India

This section delves into three detailed case studies that showcase the significant impact of AI technologies in tackling major challenges in hydroclimatology and agriculture. By examining these examples, we highlight the practical advantages of integrating AI into these fieles. These case studies also offer insights into how AI can promote sustainable development and enhance climate adaptation efforts in Asia-Pacific and beyond.

Case study 1: Hybrid DL for multi-step-ahead temperature and heatwaves prediction

Accurate prediction of daily maximum temperatures and heatwaves is crucial for mitigating the adverse effects of extreme weather events. Traditional methods often fail to capture the complex relationships between meteorological precursors and temperature variations, especially when dealing with large and heterogeneous datasets. This limitation hampers the

Table 2: Overviewing AI (Artificial Intelligence), ML (Machine Learning), and DL (Deep Learning) algorithms applied in hydroclimatology and agriculture.

Algorithm Type	Algorithm	General Application	Key Features
AI Algorithms	Expert Systems	Drought monitoring and early warning systems	Rule-based inference, domain-specific knowledge integration
	Knowledge-based Systems	Qualitative and quantitative reasoning in hydrological and climate processes	Integration of expert knowledge with data-driven insights
ML Algorithms	Support Vector Machines (SVM)	Precipitation pattern recognition, drought severity prediction	Effective in high-dimensional spaces, kernel methods for non-linear decision boundaries
	Random Forest	Forecasting hydrological variables, land cover classification	Ensemble decision trees handle large datasets and complex relationships
	Clustering Algorithms	Identifying spatial and temporal patterns in meteorological and hydrological data	Unsupervised learning groups similar data points based on defined similarity metrics
DL Algorithms	Convolutional Neural Networks (CNN)	Satellite imagery analysis for land cover classification, cloud pattern recognition	Hierarchical feature extraction, effective in spatial data analysis
	Recurrent Neural Networks (RNN)	Time-series forecasting of streamflow dynamics, climate data analysis	Captures temporal dependencies, sequential data processing
	Long Short-Term Memory (LSTM)	Daily temperature prediction, hydrological forecasting	Memory cells for long-range dependencies, suitable for time-series prediction

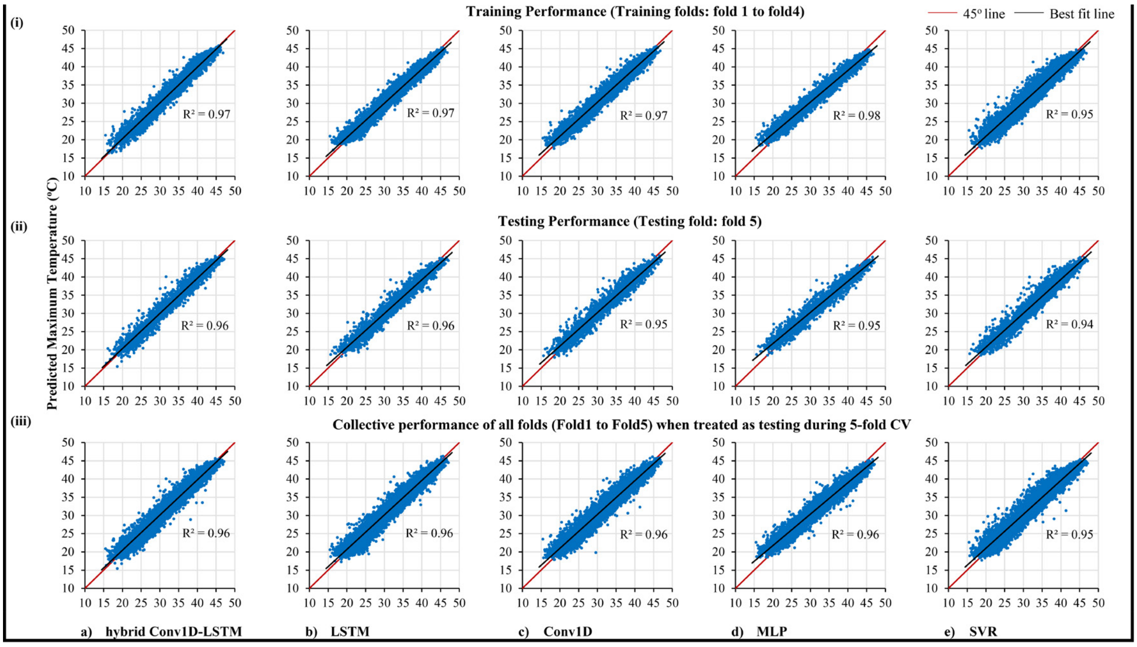

Figure 1: Comparative scatter plots between the observed and 1-day ahead predicted maximum temperature obtained during the (i) training period (i.e. by considering fold1 to fold 4 as training dataset), (ii) testing period (i.e. by considering fold5 as a testing dataset) and (iii) testing period of all 5 folds (i.e., fold1+fold2+fold3+fold4+fold5, when each fold is treated as a testing dataset during 5 fold CV), for a traditionally hot weather city (Jaipur), of a) hybrid Conv1D-LSTM, b) LSTM, c) Conv1D, d) MLP and e) SVR model run respectively (Reproduced from Khan and Maity, 2022).

effectiveness of early warning systems and preparedness measures, particularly in India, which has diverse climatic regions.

To address these challenges, Khan and Maity (2022) propose a hybrid deep learning approach combining a one-dimensional convolutional neural network (Conv1D) and an LSTM neural network, leveraging their strengths to enhance the predictive accuracy of daily maximum temperatures and heatwave events. Historical daily maximum temperature data and relevant meteorological precursors were collected for 28 major cities in India. The Conv1D component extracted local patterns from the data, providing a detailed understanding of spatial hierarchies. In contrast, the LSTM component captured temporal dependencies, enabling the model to learn from sequential data. The hybrid Conv1D-LSTM model was trained on the collected historical data, and its performance was validated using a separate dataset over the observational period to ensure robustness. Finally, the model performance was benchmarked against other conventional ML/DL models and three popular weather applications, namely AccuWeather, real-time weather system, and Weather Underground, to evaluate its predictive capabilities.

The hybrid Conv1D-LSTM model significantly improved over traditional approaches (Fig. 1) and popular weather applications (Khan & Maity, 2022) in predicting daily maximum temperatures and detecting heatwave events. Applied to 28 major cities in India, this model achieved superior accuracy in temperature forecasts and a 20-30% higher success rate in predicting heatwaves. The model's efficacy stems from its ability to capture intricate relationships between meteorological precursors and temperature variations. Conv1D layers excelled in extracting local features, while LSTM layers comprehensively represented temporal dynamics. This combination allowed the model to generalize effectively across diverse climatic conditions, enhancing its reliability for meteorological forecasting. This approach represents a promising pathway for developing sophisticated and reliable early warning systems, ultimately contributing to enhanced disaster preparedness and climate adaptation strategies in Asia-Pacific and beyond.

Case study 2: Deep learning for streamflow assessment Accurate streamflow prediction is vital for effective water resource management, particularly in climate change, which alters precipitation patterns and hydrological cycles. Traditional prediction models often struggle with the non-linear and complex interactions between climatic variables and hydrological responses. Khan et al. (2023) address these challenges by employing DL techniques, specifically LSTM networks, to model monthly-scale streamflow and project it for the future over the Bhadra River Basin (BRB) – a rain-fed river basin in the southern part of India. Historical streamflow data and various meteorological variables were used to train and validate the LSTM model. The K-fold cross-validation technique was also employed to ensure the robustness of the proposed model. Next, its performance was benchmarked against two traditional statistical and ML tools, Multiple Linear Regression (MLR) and Support Vector Regression (SVR), to evaluate its effectiveness in capturing complex patterns and improving modeling accuracy.

The results (Fig. 2) demonstrated that the proposed LSTM model

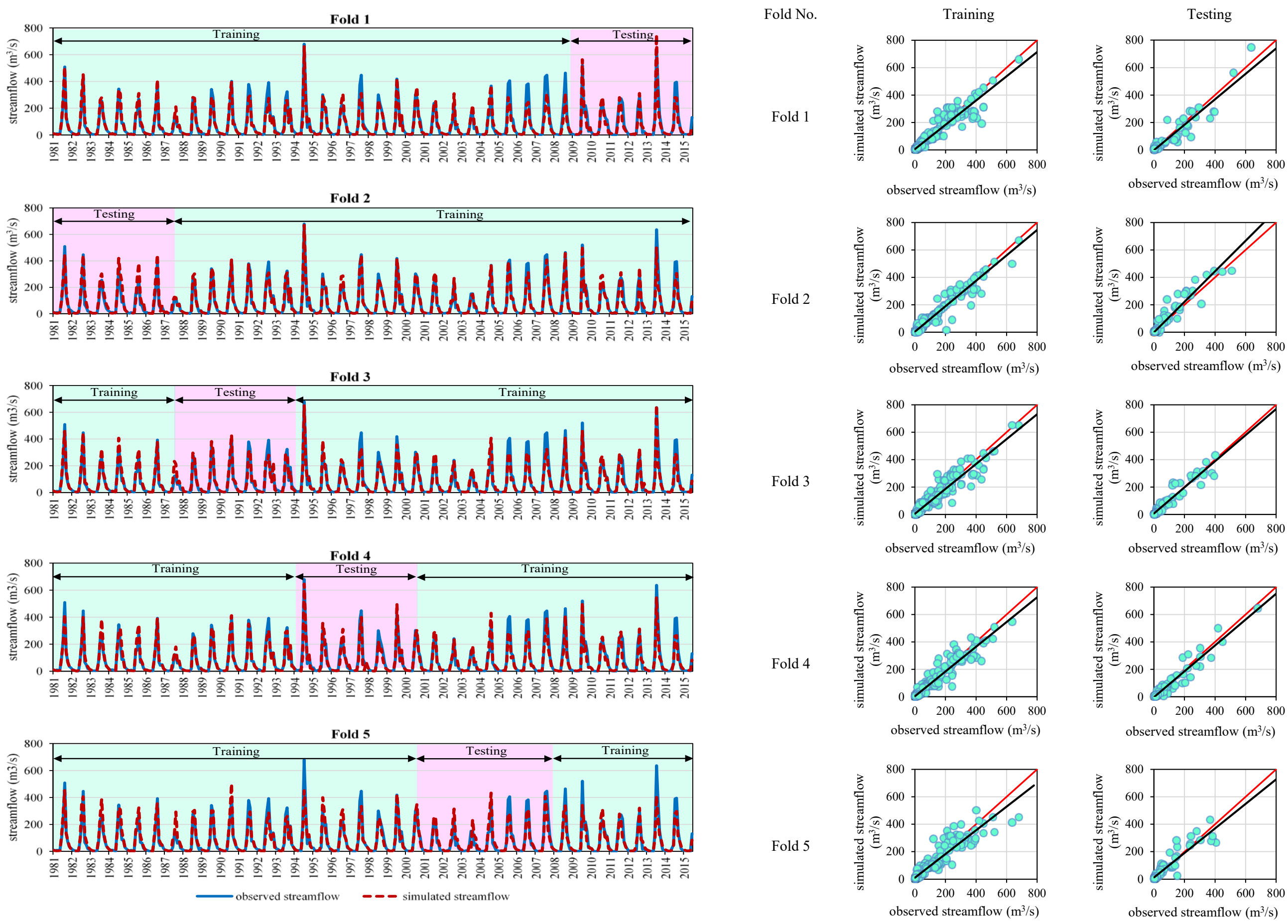

Figure 2: Fold-wise performance of the proposed LSTM model in simulating streamflow over BRB. Observed and simulated streamflow values are shown through time series (left) and scatter plots (right) for all five folds. In the scatter plots, the solid red lines show the 45° line (line of perfect simulation), and the black line shows the best-fit lines for the scatter plots. (Reproduced from Khan et al. (2023)).

successfully simulated the monthly distribution of streamflow over BRB, capturing both high-flow and low-flow regions with reasonable accuracy (with a correlation coefficient of 0.95 and Nash Sutcliff error of 0.89 over the testing period). Moreover, the proposed model significantly outperforms the benchmark models like MLR and SVR models in simulating the streamflow patterns. The superior performance of the proposed model can be attributed to its memory cell structures, which can capture the long-term dependencies and remember the complex non-linear causal relationships over a long period. Additionally, the developed LSTM model was utilized for long-term future projections over BRB after ensuring the model's stability. Simulations from six General Circulation Models (GCMs) under different climate change scenarios were considered for this purpose. The results reveal some critical insights into potential changes in hydrological patterns, highlighting the river basin's experience of increased and decreased streamflow over the high-flow and low-flow months, respectively, enhancing the risk of flood and drought simultaneously.

This case study underscores the immense potential of DL techniques, particularly LSTM networks, in hydroclimatology and streamflow prediction. These important findings are crucial for developing adaptive water management strategies to mitigate the adverse effects of climate change on water resources in the Asia-Pacific region and beyond.

AI-driven intelligent system for marginal farmers

Marginal farmers face significant challenges in managing irrigation water effectively, leading to water scarcity, soil degradation, increased salinity, pest outbreaks, and financial strain. Current soil moisture monitoring systems are often costly and complex, making them inaccessible to these farmers (Dutta et al., 2022a; Srivastava et al., 2022a). A promising area for future research is developing an AI-driven intelligent system for real-time soil moisture monitoring to address these issues.

The proposed future case study aims to leverage sensor technology and a user-friendly mobile app to empower marginal farmers in India with precise irrigation management tools, ultimately enhancing crop yields, reducing water waste, and alleviating financial stress. This project would integrate sensor-based soil moisture monitoring with advanced AI algorithms for data analysis. The initial steps include developing a mobile app that spatially displays soil moisture depth and values at various profile depths. Further stages would focus on refining sensor technology to measure soil moisture in electronic pulses, converting these pulses into readable formats, and validating the data through physical measurements. AI algorithms would be applied using observed data for model calibration and validation to ensure accurate predictions, allowing for continuous improvement and optimization of the system.

The future roadmap includes iterative development and field testing of the prototype. Extensive soil moisture data collection, AI-driven predictive analysis, and incorporation of historical data and

Table 3: Integration of AI, ML, and DL in climate change adaptation strategies: Applications, benefits, and challenges

Integration Area	AI/ML/DL Applications	Expected Benefits	Potential Challenges
Hydrological Modeling	▪ Streamflow prediction ▪ Flood forecasting	✓ Improved accuracy in water resource management ✓ Enhanced early warning systems	1. High data requirements 2. Complex model calibration and validation
Agricultural Management	▪ Crop yield prediction ▪ Soil moisture monitoring ▪ Pest and disease detection	✓ Increased agricultural productivity ✓ Efficient irrigation management ✓ Reduced crop losses	3. Integration with existing farming practices 4. Dependence on high-quality, real-time data
Urban Planning and Infrastructure	▪ Heatwave prediction ▪ Urban heat island effect modeling	✓ Enhanced resilience of urban areas ✓ Improved public health outcomes	5. Coordination between multiple stakeholders 6. Scalability of models to different urban settings
Disaster Risk Management	▪ Wildfire risk assessment ▪ Landslide susceptibility mapping	✓ Reduced human and economic losses ✓ Improved resource allocation for disaster response	7. Real-time data integration 8. Uncertainty in predictions due to changing climate patterns
Water Resource Management	▪ Drought forecasting ▪ Groundwater recharge estimation	✓ Sustainable water use ✓ Improved drought preparedness and mitigation strategies	9. Data sparsity in remote areas 10. Incorporation of socio-economic factors
Renewable Energy Planning	▪ Solar and wind power prediction ▪ Optimization of energy grids	✓ Increased efficiency and reliability of renewable energy sources ✓ Better planning and resource allocation	11. Variability in weather patterns 12. Integration with existing energy systems
Biodiversity and Ecosystem Services	▪ Habitat suitability modeling ▪ Species distribution prediction	✓ Conservation of endangered species ✓ Maintenance of ecosystem services	13. Complexity of ecological data 14. High computational requirements
Public Health	▪ Disease outbreak prediction ▪ Climate-related health impact assessment	✓ Proactive healthcare responses ✓ Reduced morbidity and mortality related to climate extremes	15. Integration with public health infrastructure 16. Addressing privacy and ethical concerns

simulation models would be critical components. Expected outcomes include a cost-effective and user-friendly mobile app for real-time soil moisture monitoring, optimized irrigation practices, enhanced crop yields, and improved financial stability for marginal farmers. This case study could demonstrate the potential of AI-driven solutions in addressing critical agricultural challenges, paving the way for broader adoption and innovation in the sector.

Advancing applications and future directions

Integration of AI/ML/DL in climate change adaptation strategies

The integration of AI, ML, and DL into climate change adaptation strategies offers transformative potential across various sectors (Table 3). These advanced technologies enable the development of sophisticated models that can predict the impacts of climate change with unprecedented accuracy and timeliness. By harnessing vast datasets and leveraging complex algorithms, AI-driven solutions can provide insights into water resource management, agricultural productivity, urban resilience, and disaster preparedness (Khan & Maity, 2024; Pande et al., 2022). For instance, ML algorithms can

Table 4: Policy recommendations with expected outcome and challenges for enhancing AI technologies in the Asia-pacific region

Recommendation	Expected outcome	Challenges
Invest in high-speed internet, data centers, and cloud resources.	Enhanced computational capacity for AI research.	High initial costs and need for ongoing upgrades.
Foster innovation through collaboration between governments, the private sector, and academia.	Faster AI technology development and deployment.	Aligning interests and equitable benefit distribution.
Implement programs to build AI skills, focusing on technical and ethical aspects.	Larger talent pool and informed citizens engaging with AI.	Overcoming educational disparities and integrating AI in curriculums.
Promote policies for sharing public sector data in open, standardized formats.	Better data availability for training diverse AI models.	Ensuring data privacy and security with transparency.
Develop regulations addressing AI's ethical implications, like data privacy and transparency.	Responsible AI development and increased public trust.	Balancing innovation with regulation to avoid stifling progress.
Fund AI R&D for climate change, healthcare, agriculture, and critical sectors.	Innovative AI applications for region-specific challenges.	Securing sustained funding and prioritizing research.
Encourage regional collaboration in AI projects to leverage strengths and share practices.	Strengthened regional cooperation on AI issues.	Navigating geopolitical tensions and aligning national policies.
Create a supportive environment for AI start-ups with incentives and mentorship.	Thriving AI start-up ecosystem boosting local innovation.	Mitigating market saturation risks and supporting SMEs.
Educate the public on AI benefits, risks, and opportunities, encouraging community involvement.	Greater public support and informed AI discourse.	Combating misinformation and fostering inclusive dialogue.
Deploy pilot AI projects in disaster management, urban planning, and environmental monitoring.	Real-world validation and strategies for broader AI implementation.	Managing pilot project scalability and transferability.

enhance drought forecasting, optimize irrigation systems, and predict El Niño-Southern Oscillation, while DL models can predict heatwave occurrences and their effects on urban environments (Pal et al., 2020). Additionally, AI applications in renewable energy can forecast solar and wind power availability, thus aiding in the efficient planning and integration of these resources into existing energy grids (Dutta et al., 2022b). These innovations not only improve predictive capabilities but also facilitate proactive measures, thereby enhancing the resilience of communities and ecosystems to climate change. As we advance, the key challenge lies in ensuring the scalability and integration of these AI solutions across different regions and sectors, considering local socio-economic and environmental contexts.

Policy recommendations and practice for enhancing AI technologies in the Asia-Pacific region

A multifaceted approach is essential to enhance the adoption and effectiveness of AI technologies in the Asia-Pacific region (Table 4). Emphasizing the importance of a robust policy framework, governments should focus on fostering innovation ecosystems conducive to AI development and deployment (Jobin et al., 2019). This includes creating incentives for research and development, promoting the exchange of knowledge and resources among countries, and facilitating the integration of AI into various sectors such as agriculture, healthcare, and environmental management (Agarwal et al., 2024). Additionally, it is crucial to address ethical considerations and establish guidelines that ensure responsible AI usage, protecting citizens' privacy and preventing misuse (Jobin et al., 2019). By aligning national strategies with regional goals, leveraging public-private partnerships, and investing in education and skill-building initiatives, the Asia-Pacific region can harness the full potential of AI to drive sustainable development and resilience against climate change (Gasser & Almeida, 2017; Agarwal et al., 2024). These efforts must be supported by continuous dialogue and collaboration among stakeholders to adapt to evolving technological landscapes and ensure inclusive growth (IPCC, 2023).

Concluding remarks

This article explores the transformative potential of AI technologies in addressing climate change challenges, particularly in the Asia-Pacific region. Detailed case studies demonstrate the efficacy of advanced AI techniques in improving climate prediction models, optimizing resource management, and enhancing disaster preparedness. Hybrid deep learning approaches for temperature prediction, heatwave forecasting, and streamflow assessment highlight significant strides in environmental modeling accuracy and reliability. AI technologies integrated into climate change adaptation strategies revolutionize traditional practices, exemplified by AI-driven models in agriculture for soil moisture monitoring and intelligent irrigation, improving water management and crop yields. Policy recommendations emphasize a collaborative approach to AI adoption. The Asia-Pacific region can lead AI-driven climate action by fostering innovation, addressing ethics, and promoting regional cooperation through public-private partnerships, education investment, and supportive policies. In conclusion, the synergistic application of AI holds immense promise for climate change mitigation and adaptation. By leveraging these technologies, we can achieve more precise climate predictions, optimize resource utilization, and enhance our capacity to respond to environmental challenges.

Acknowledgment. Support from my students Subharthi Sarkar, Aman Srivastava, and Mohd Imran Khan in preparing this article is duly acknowledged.

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Artificial intelligence in urban forestry

Strategic tree placement for improved climate adaptation

Abdulrazzaq Shaamala[a], Tan Yigitcanlar[b]

[a]Doctoral Researcher at Urban AI Hub, Queensland University of Technology, Australia.
Email: abdulrazzaq.shaamala@hdr.qut.edu.au

[b]Professor and Director at Urban AI Hub, Queensland University of Technology, Australia.
Email: tan.yigitcanlar@qut.edu.au

Abstract

This study explores the integration of Artificial Intelligence (AI) into urban forestry practice—i.e., AI-driven urban tree-planting practices to optimise tree placement to enhance urban microclimates. Utilising the Ant Colony Optimisation (ACO) algorithm, this research strategically positioned trees within an urban park to improve thermal comfort and overall climatic conditions. Detailed simulations conducted during the hottest week of the year assessed the impact of these optimised tree placements. The results demonstrate significant improvements in urban microclimate conditions, including reduced temperatures and increased shading, thereby highlighting the potential of AI-driven approaches in urban planning. This paper provides invaluable insights for policymakers and urban planners advocating the incorporation of AI technologies to develop sustainable and resilient urban environments and new insights for urban forestry. These findings underscore AI's pivotal role in climate change mitigation and adaptation and offer innovative solutions to enhance urban living conditions.

Introduction

Background

In the age of climate change, Artificial Intelligence (AI) has so much to offer to urban forestry with its innovative approaches to managing and enhancing green spaces within cities (De Lima Araujo et al. 2021). As the impact of climate change has become increasingly apparent, the role of natural solutions in mitigating and adapting to these changes has gained significant attention (Donatti et al. 2022; Debele et al. 2023). Among these solutions, trees stand out as one of the most effective and versatile tools for addressing climate-related challenges (Bäckstrand & Lövbrand 2006; Degirmenci et al. 2021). Trees contribute to climate regulation through a variety of mechanisms, making them indispensable for creating sustainable and resilient urban and rural environments (Figure 1).

One of the primary ways trees combat climate change is through carbon sequestration. Trees take in carbon dioxide (CO_2) from the atmosphere and use photosynthesis to turn it into biomass (Baral & Guha 2004). This process not only reduces the concentration of greenhouse gases in the atmosphere but also stores carbon in the form of trunks, branches, leaves, and roots (Johnson & Gerhold 2003). This carbon can remain sequestered for decades or even centuries, providing a long-term solution to offset anthropogenic emissions. Research has indicated that forests and urban trees are crucial for global carbon storage, highlighting the importance of maintaining and expanding tree cover (Velasco et al. 2016).

Beyond their role in carbon sequestration, trees play a vital role in regulating temperature, especially in urban areas (Teskey et al. 2015). Urbanisation often leads to the creation of urban heat islands, where temperatures are significantly higher than those in the surrounding rural areas due to human activities and infrastructure (Kamruzzaman et al. 2018). Trees help mitigate this effect by providing shade and through transpiration, where they release water vapour and cool the air (Coutts et al. 2016). Studies have shown that the presence of trees can reduce local temperatures by several degrees, thereby creating more comfortable and stable microclimates (Aminipouri et al. 2019; Armson et al. 2012; Bäckstrand & Lövbrand 2006).

In addition to their cooling effects, trees contribute to energy conservation. By strategically planting trees around buildings, energy consumption for heating and cooling can be significantly reduced (Sawka et al. 2013). In summer time, trees provide shade that lowers the demand for air conditioning, whereas in winter, they can act as windbreaks, reducing heating costs. This reduction in energy use not only lowers greenhouse gas emissions from power generation but also translates into economic savings for residents and businesses (Carver et al. 2004; Hwang et al. 2017).

Additionally, by absorbing ozone (O_3), ammonia (NH_3), and nitrogen oxides (NO_x), trees help improve air quality. They trap particulate matter in their leaves and bark, which can lead to a significant reduction in respiratory health issues, particularly in urban areas (Nowak et al. 2018; Nowak et al. 2006). The ability to filter air pollutants underscores the critical role of urban forestry initiatives in promoting public health and environmental quality (Steinparzer et al. 2023).

Water management is another area where trees provide substantial benefits. They intercept rainfall, reduce runoff, and minimise the risk of flooding (Marapara et al. 2021). Their root systems enhance soil infiltration and groundwater recharge while also preventing soil erosion. These functions are essential for maintaining healthy hydrological cycles and protecting

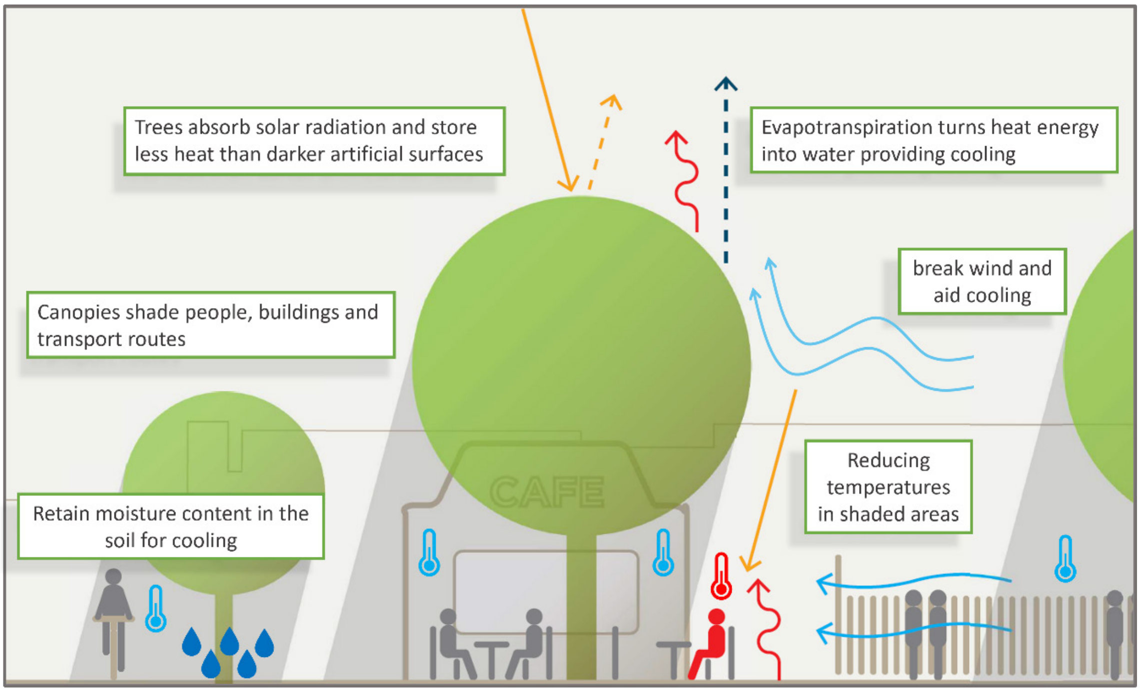

Figure 1: Impact of trees on the surround areas (Shaamala et al. 2024b).

water resources, particularly in urban environments, where impervious surfaces are prevalent (Berland et al. 2017; Russo et al. 2020). Moreover, trees support biodiversity by providing habitat and food sources for a wide range of wildlife species (Barrios et al. 2018). In particular, urban forests, which are vital for plant reproduction and food security, are crucial for pollinators such as bees and birds. Biodiversity underpins ecosystem services crucial for human well-being and resilience, highlighting the interconnectedness between natural and human systems (King et al. 2021).

The social and economic benefits of these trees were equally significant. Green spaces with trees offer recreational opportunities, reduce stress, and enhance mental health (Pasanen et al. 2023). Mature trees often have a higher market value, contributing to economic stability and growth in communities (King et al. 2021). Furthermore, trees enhance the resilience of both natural and human systems to climatic variability (Simonson et al. 2021). They provide shade and reduce heat stress in urban areas, which is particularly important as global temperatures increase. Trees can also serve as natural barriers against extreme weather events such as storms and floods (Van Hespen et al. 2023), thus protecting infrastructure and human lives.

Recent advancements in tree-location optimisation have further highlighted the importance of strategic tree placement in urban planning (Zhao et al. 2018; Shaamala et al. 2024b). Using computational models, urban planners can optimise tree locations to maximise their environmental benefits (Stojakovic et al. 2020). Optimised tree placement can enhance cooling effects, improve air quality, and increase carbon sequestration efficiency. These models consider various factors, such as local climate, existing vegetation, urban infrastructure, and socioeconomic considerations, to identify the most effective locations for planting trees (Shaamala et al. 2024a).

AI has emerged as a powerful tool for enhancing the effectiveness of tree-planting and management strategies. AI algorithms can analyse vast amounts of data to predict optimal planting locations, forecast the growth and health of urban forests, and model the environmental impact of tree-planting initiatives (Bajsanski et al. 2016; Wallenberg et al. 2022). The ability of AI to process and analyse complex datasets enables it to identify the best locations for tree planting, considering various environmental and infrastructural constraints (Chen et al. 2008; Hao et al. 2023). Additionally, AI models can simulate the potential impact of different tree configurations on urban microclimates, helping to optimise tree placement for maximum cooling and air quality improvement (Shaamala et al. 2024b).

In summary, the integration of AI into urban forestry practices enhances the precision and effectiveness of tree-planting strategies. By leveraging AI capabilities, urban planners can create greener, healthier, and more resilient cities, ultimately contributing to improved environmental quality and human well-being.

Tree optimisation objectives

The tree optimisation objectives were categorised into six critical climate change mitigation goals (Shaamala et al. 2024a) (Figure 2): (a) enhancing air quality by absorbing pollutants and filtering particulate matter; (b) supporting biodiversity and ecosystem security by providing habitats and connecting ecological corridors; (c) increasing energy efficiency through

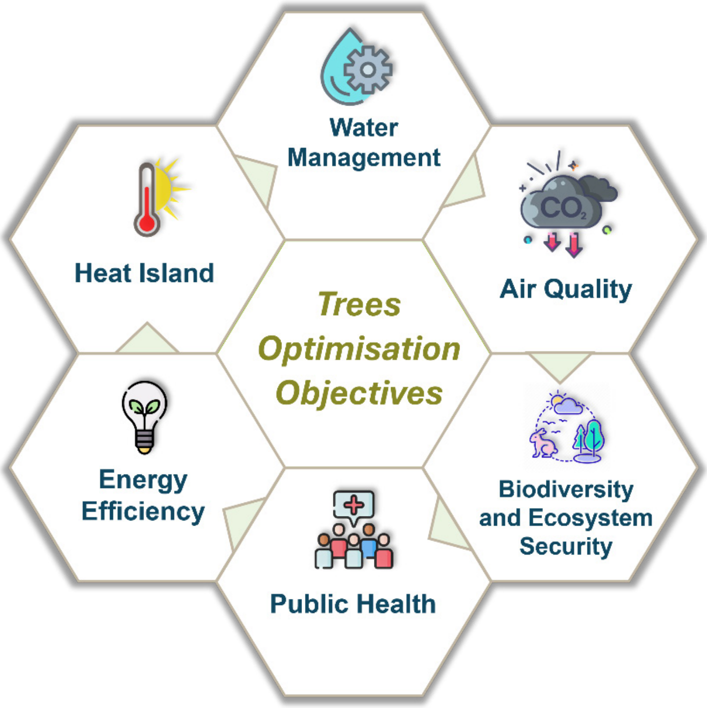

Figure 2. Tree optimisation objectives (Shaamala et al. 2024a).

natural cooling and shading to reduce reliance on air conditioning; (d) promoting public health by creating green spaces that encourage physical activity and improve mental well-being; (e) mitigating urban heat islands by reducing surface and air temperatures; and (f) optimising water management by improving stormwater infiltration and reducing runoff. Collectively, these objectives contribute toward creating a more resilient and sustainable urban environment.

Case study: optimising tree locations for enhancing urban thermal heat

In this study, we employed a multistep optimisation approach to enhance urban heat mitigation through strategic tree placement. The methodology involves the integration of an optimisation algorithm to identify optimal tree locations within an urban park setting, considering multiple constraints and environmental factors (Figure 3). The primary objective is to minimise the Universal Thermal Climate Index (UTCI), thereby improving thermal comfort in urban areas.

Study area

The methodology selected a hypothetical study area and established the initial conditions. A 50×50m plot was chosen, which is an appropriate size for an urban park suitable for conducting tree-optimization experiments. The terrain was assumed to be generally flat with limited existing vegetation cover, making it ideal for analysing the impact of newly planted trees. The soil type in the area was assumed to be loamy, providing favourable conditions for tree growth owing to its good drainage and nutrient-holding capacity. This soil type supports deep root growth without requiring significant soil modification (Figure 4).

Simulation period selection

The simulations to evaluate the cooling effect of tree placement during extreme heat were conducted in Brisbane, Queensland's capital, during the hottest week of February 2023—i.e., 17th-23rd. During this period, temperatures ranged from 23°C to 37°C, which is typical of Brisbane's summer and its pronounced urban heat island effect. The subtropical climate of Brisbane, characterised by high relative humidity, intensifies the perceived heat beyond the actual air temperature. This combination of high temperature and humidity significantly affects human comfort, energy consumption, and urban liveability. By focusing on this particular week, this study aimed to examine tree allocation optimisation under challenging and increasingly common climatic conditions, providing insights into effective strategies for enhancing urban thermal comfort.

Optimisation trajectory and UTCI reduction

The Ant Colony Optimisation (ACO) algorithm is a nature-inspired optimisation technique based on the foraging behaviour of ants (Dorigo & Di Caro 1999). In this algorithm, artificial ants build solutions to optimisation problems by simulating the way real ants find the shortest paths to food sources. The algorithm iteratively improves solutions by reinforcing paths that lead to better outcomes, making it a powerful tool for solving complex problems. The results demonstrated that the ACO algorithm effectively optimised tree locations to enhance the

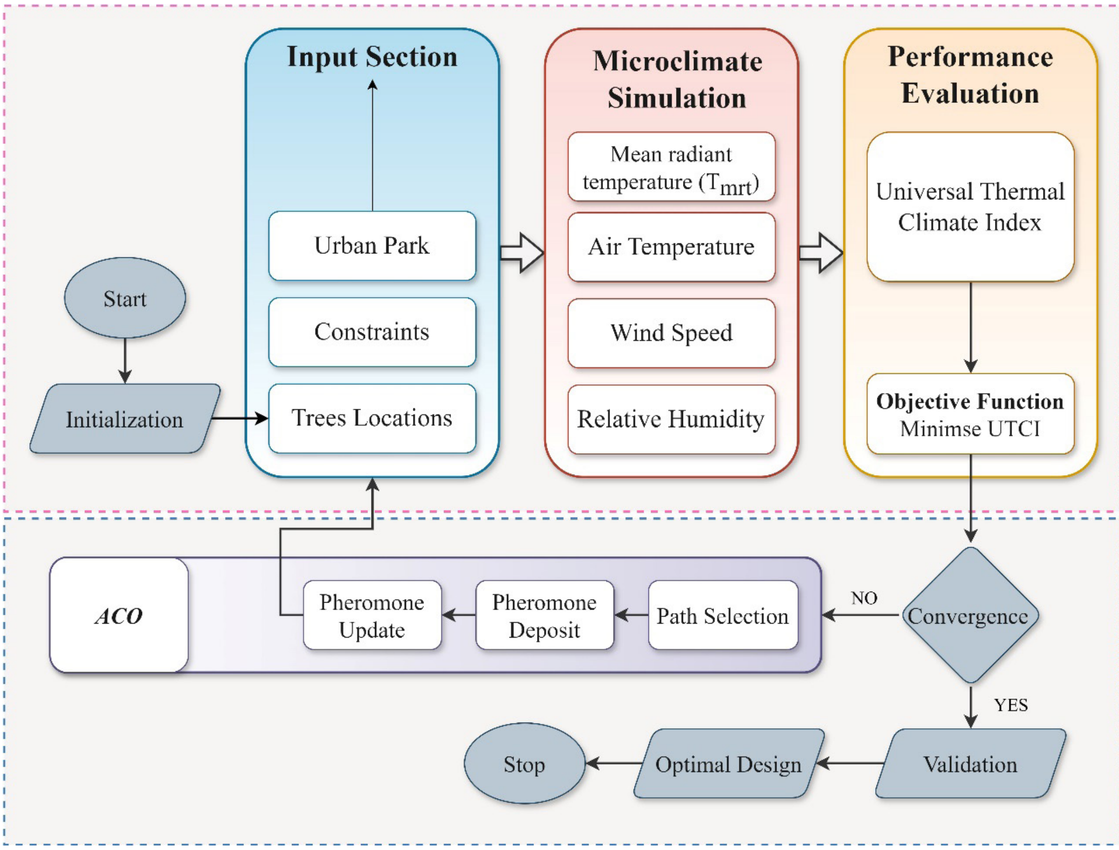

Figure 3. Research methodology (Shaamala et al. 2024b).

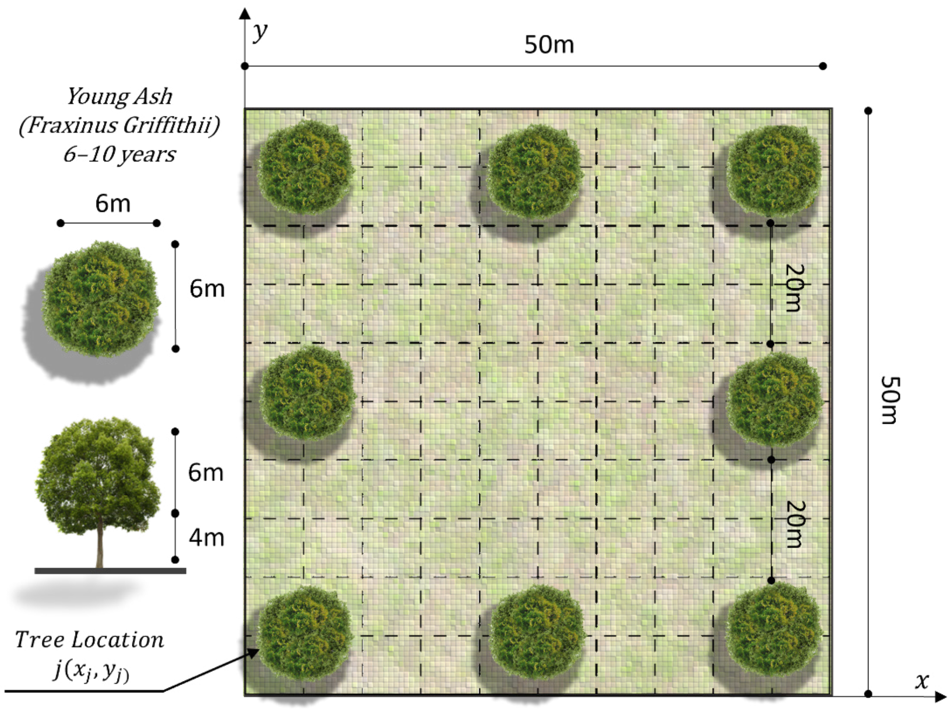

Figure 4. Study area.

urban microclimate (Figure 5). The performance of ACO was typified by a systematic and careful decrease in UTCI values. Although this methodical optimisation process takes longer to converge than some other algorithms, it demonstrates how meticulous and comprehensive the ACO's methodology is in determining the best locations for trees. The ACO strategy involved a step-by-step reduction in UTCI, reflecting its methodological search and placement adjustments. This careful optimisation ensures a comprehensive exploration of the search space, leading to well-considered tree configurations that maximise urban thermal comfort. The consistent decrease in UTCI values using ACO indicated a steady improvement in the urban microclimate, demonstrating the capability of the algorithm to enhance thermal comfort through strategic tree placement.

Overall, the ACO's systematic approach and gradual optimisation process make it a reliable method for urban planners to achieve significant and sustained improvements in urban microclimate conditions.

Spatial configurations from the optimisation algorithm

This study evaluated the tree spatial arrangements suggested by ACO. Figure 6 provides a visual representation of this configuration. The tree configuration pattern generated by ACO follows a clustering approach. Trees were placed in clusters to create concentrated areas of shade, effectively forming microclimatic havens within the urban park. This targeted placement helps significantly reduce the temperatures in the identified hotspots.

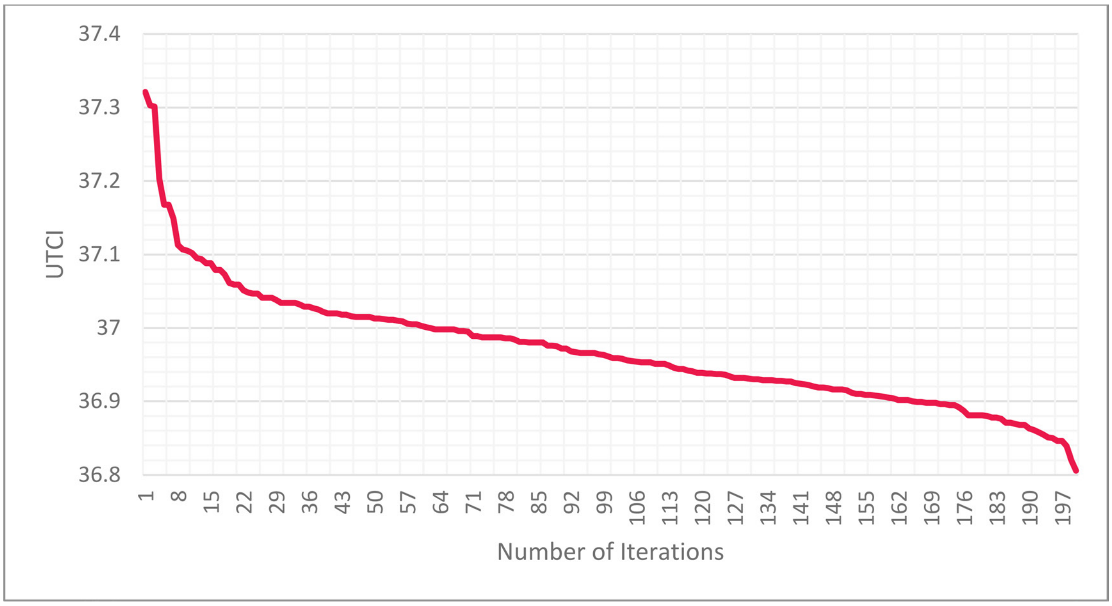

Figure 5. Performance of the optimisation algorithm.

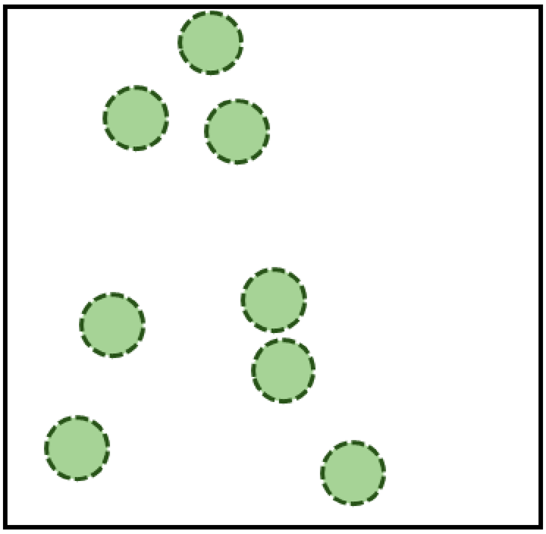

Figure 6. Optimal configurations created by ACO algorithm.

Microclimate simulation for optimal scenarios

To assess the efficacy of the proposed approach, we performed several in-depth microclimate simulations to evaluate the effectiveness of the proposed method for tree placement optimisation. These simulations were created to assess how important urban microclimate variables that impact UTCI are affected by the ideal tree configuration created by ACO. As illustrated in Figure 7, the ideal arrangement produced the best results for a variety of microclimatic parameters.

Figure 8 illustrates the simulation results, showing how tree distribution affects urban microclimates using thermal maps. These maps show significant differences in air temperature according to tree location. Each thermal map generated by the optimisation algorithm highlights the significant impact of the spatial configuration of trees on potential air temperatures in urban areas. Temperatures ranged from below 27°C to above 34°C, with cooler temperatures found under tree canopies.

The most significant cooling effect occurred in scenarios in which trees were strategically placed in the identified hotspots. In the ACO-optimised scenario, the central areas showed significantly lower temperatures, demonstrating that optimal tree placement enhanced shading and reduced heat. This emphasises the importance of intentional tree positioning in reducing urban heat and improving thermal comfort. The ability of the ACO method

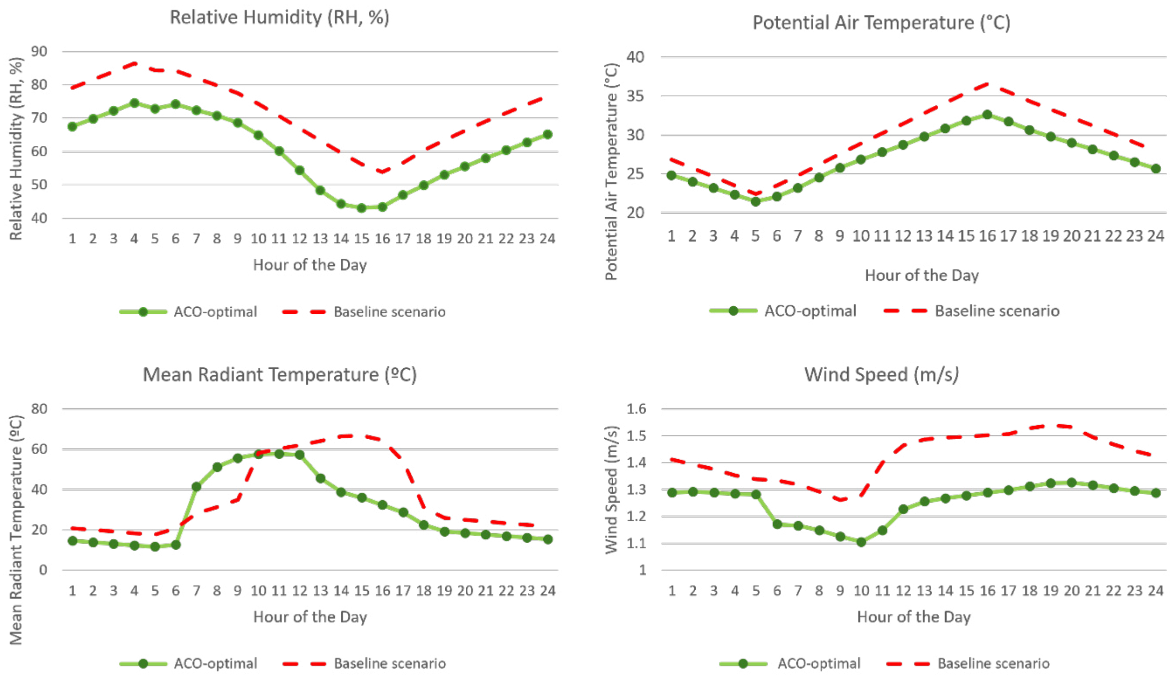

Figure 7. Tree location impacts on relative humidity, air temperature, mean radiant temperature, and wind speed: optimal versus baseline configurations.

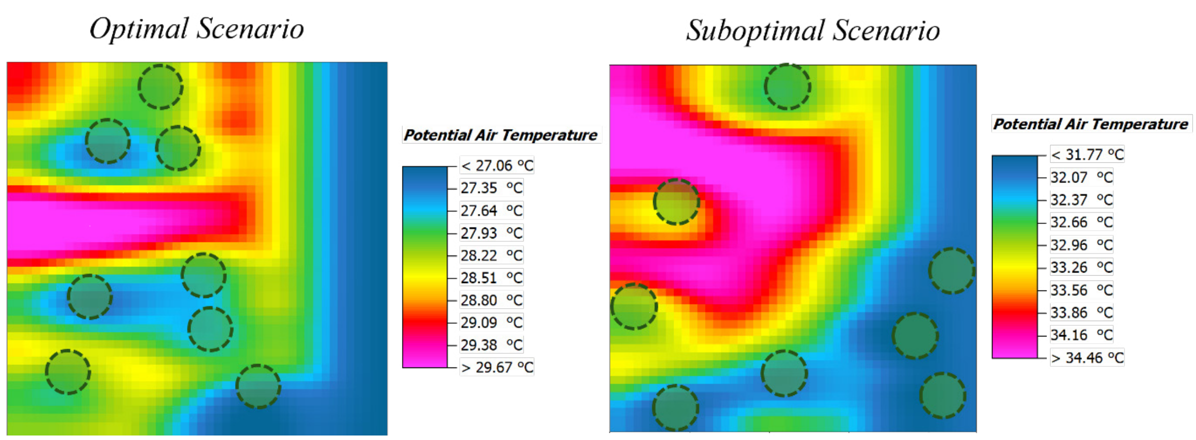

Figure 8. Variation in air temperature for different configuration scenarios.

to systematically lower temperatures in specific areas validates its effectiveness in enhancing urban microclimates through optimised tree placement.

Findings and discussion

This study presents an innovative approach to urban forestry and planning utilising AI, specifically ACO, to optimise trees' location and enhance urban microclimates. This study highlights the significant potential of integrating AI into urban forestry practices for climate adaptation and mitigation. By strategically positioning trees, this study demonstrated notable improvements in thermal comfort and reduced temperatures. The simulations revealed that the ACO algorithm effectively identified optimal tree locations, leading to significant reductions in the UTCI. This index, which combines air temperature, humidity, wind speed, and mean radiant temperature, serves as a crucial measure of thermal comfort.

The strategic clustering of trees, as determined by ACO, created concentrated areas of shade, forming microclimatic havens that significantly lowered local temperatures. The systematic placement of trees underscores the robustness and precision of the ACO approach for enhancing urban thermal comfort. Integrating AI technologies into urban planning represents a forward-thinking approach that prioritises both environmental sustainability and human wellbeing. AI's ability to process and analyse complex datasets enables urban planners to identify the most effective locations for tree planting, considering various environmental and infrastructural constraints.

Moreover, the findings underscore the importance of not only increasing tree cover but also optimising tree locations to maximise environmental and climatic benefits. By leveraging AI, cities can develop more effective climate adaptation strategies to address the challenges caused by rising global temperatures and urban heat islands. This research provides evidence that the AI-driven optimisation of tree placement can lead to more efficient cooling of urban areas, thereby enhancing the quality of life for urban residents.

From a policy perspective, this study highlights the importance of optimising tree locations and groupings instead of simply increasing the overall number of trees. These findings suggest that strategically placed trees offer significantly greater cooling effects than random distributions. This insight could shape policy guidelines that prioritise specific tree placement strategies to maximise urban cooling benefits. Policies incorporating AI-driven tree placement optimisation could lead to more resilient and sustainable urban environments, providing long-term benefits in climate adaptation and urban liveability.

The findings advocate a holistic approach to urban forestry, where AI algorithms can continuously adapt to changing environmental conditions and urban growth patterns, ensuring that tree placement strategies remain effective over time. This dynamic approach to urban forestry can help cities become more adaptable to future climate scenarios, providing a proactive solution to the ongoing challenges of urban heat islands and climate change.

In conclusion, this study demonstrates the transformative potential of integrating AI technologies such as the ACO algorithm into urban forestry and planning. By optimising tree placement, AI can significantly improve thermal comfort, reduce temperature, and contribute to the overall sustainability of urban environments. These insights are crucial for policymakers and urban planners who aim to create more resilient and liveable cities in the face of climate change. The continued development and implementation of AI-driven strategies in urban forestry will be essential for fostering healthier, greener, and more sustainable urban spaces for future generations.

Concluding remarks

AI offers significant potential for climate change mitigation and adaptation for cities (D'Amico et al. 2020; Repette et al. 2021; Son et al. 2023). As presented in this paper by leveraging advanced data analytics and machine learning algorithms, AI can optimise urban forestry by identifying the best tree locations that help adapting to the changing climate. This study illustrated the substantial benefits of integrating AI algorithms, specifically ACO, into urban forestry practices to enhance urban microclimates. By optimising tree locations, the ACO algorithm effectively reduces UTCI, thereby improving thermal comfort in urban areas. These findings highlight the importance of not only increasing tree cover but also optimising tree locations to maximise environmental benefits. This study also highlighted the broader implications of AI in urban planning. By incorporating AI technologies, cities can develop more effective climate adaptation strategies to address the challenges posed by rising global temperatures and urban heat islands. The use of AI to optimise tree placement exemplifies a forward-thinking approach to urban design that prioritises both environmental sustainability and human well-being. Future research should focus on refining optimisation algorithms and expanding their scope to incorporate more complex urban environments and diverse climatic conditions.

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Tech Events

2024

December 10 -13, 2024
4th International Conference on Smart City and Green Energy (ICSCGE 2024)
Sydney, Australia
Contact:
Yuer Peng
Conference Secretary
Tel: (86) 191 8224 0053
Email: icscge@youngac.cn
https://icscge.org/

December 12-14, 2024
III International Conference on Environmental Technologies and Engineering for Sustainable Development (ETESD-III 2024)
Tashkent, Uzbekistan
Contact:
Komil Dullievich, Head of the department “Agricultural Machines”
National Research University-Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (NRU-TIIAME)
100000, Tashkent, st. Kary Niyoziy 39, Uzbekistan
Email: komiljon.astanaqulov@gmail.com
https://etesd.online/

December 14-15, 2024
1st International Conference on Green Technology and Sustainable Development (EAI ICGTSD 2024)
Hyderabad, India
Contact:
Martin Hochel
EAI ICGTSD 2024 Conference Manager
Email: martin.hochel@eai.eu
https://icgtsd.eai-conferences.org/2024/

December 15-18, 2024
International Conference on Sustainable Energy and Green Technology 2024 (SEGT 2024)
Bangkok, Thailand
Contact:
SEGT 2024 secretariat
Email: segtconference@isegt.org; segtconference@gmail.com
https://www.isegt.org/

2025

January 17-19, 2025
2025 2nd International Conference on Smart Grid and Energy
Hong Kong, China
Contact:
Sara Young
Tel: (00) 1 6193091099 (EN)
Email: icsge_contact@academic.net
https://www.icsge.org/

January 21-22, 2025
International Conference on Disaster Management
Singapore
Contact:
Conference Secretariat
Tel: +91 8870915303
Email: info@scienceleagues.com
https://scienceleagues.com/events/index.php?id=2625438

February 26-27, 2025
Sustainability Expo Asia 2025
Singapore
Contact:
Joe Panettieri
Editorial Director, Sustainable Tech Partner
Email: Joe@MentoreVentures.com
https://sustainabletechpartner.com/event/sustainability-expo-asia-2025/

February 15-17, 2025
2025 15th International Conference on Renewable and Clean Energy (ICRCE 2025) is going to
Fukuoka, Japan
Contact:
Ms. Penny P. L. Gan
Conference Secretary
Tel: 86-132-9000-0003
Email: icrceconf@126.com
https://www.icrce.org/

March 7-9, 2025
2025 15th International Conference on Future Environment and Energy (ICFEE 2025)
Sapporo, Japan
Contact:
Ms. Echo Xiong
Conference Secretary
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E-mail: icfee@academic.net
https://www.icfee.org/

March 7-9, 2025
2025 The 9th International Conference on Green Energy and Applications
Singapore
Contact:
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Email: icgea_secretary@163.com
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March 13-15, 2025
2025 the 9th International Conference on Innovation in Artificial Intelligence (ICIAI 2025)
Singapore
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Ms. Ashley Liu
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Email: iciai2018@vip.163.com
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May 7-9, 2025
Future Energy Asia Strategic Summit
Bangkok, Thailand
Contact:
dmg events Asia Pacific Pte Ltd
63 Robinson Road, Afro Asia, #08-01
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Tel: +65 68565206
Email: info@futureenergyasia.com
https://www.futureenergyasia.com/conference/strategic-summit/

May 7-9, 2025
Future Mobility Asia
Bangkok, Thailand
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Jun 2-3, 2025
6th International Conference on Green Energy and Environmental Technology (ICGEET)
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Jan-Mar 2023

Technologies for ecarbonizing transport systems

Apr-Jun 2023

Innovative technologies for disaster risk reduction

Jul-Sep 2023

Partnerships and regional collaborations:

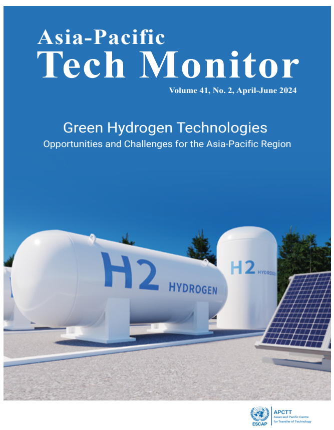
Integrating climate finance with the technology mechanism for climate change

Oct-Dec 2023

Innovative Technologies for Air Pollution Control

Jan-Mar 2024

Digital Innovations for Sustainable Development in Asia and the Pacific



April-June 2024

Green Hydrogen Technologies

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www.apctt.org apctt.techmonitor@un.org 91 11 30973750

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