AI for Future Cities

ARUP

Urban Planning and Design

AI for Future Cities series

The rapid evolution of artificial intelligence runs on a promise to enhance efficiency, speed and innovation. But what does this mean for cities: for how they are planned, designed, built and managed? What are the opportunities and what are the risks? Amongst the hype and speculation, how do we ensure that these technologies support us in achieving our shared goal of creating cities that are better for people and the planet?

Compiled by Arup's Foresight team, **AI for Future Cities is a series of critical reflections and expert insights on the uses and impacts of artificial intelligence across all aspects of our cities** – from planning through to running them, from infrastructure through to the flows of resources. It will give you a rich understanding of how AI already operates in the urban context today, what trends are shaping its use tomorrow, and informed speculation on the long-term possibilities.
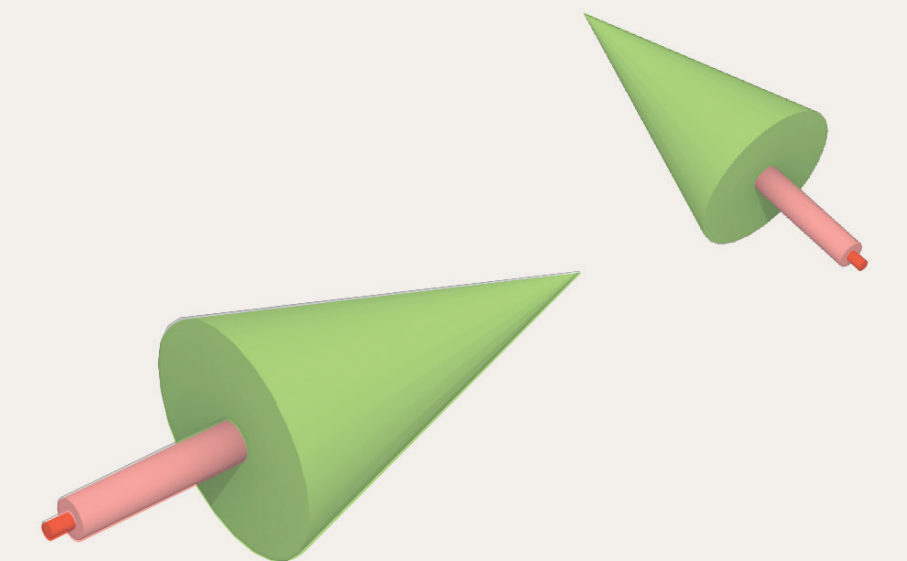
This is issue 01 of a series on AI for Future Cities. Upcoming publications will focus on these themes.

06	Workplace
05	Nature
04	Circularity
03	Water
02	Energy
01	Planning and design

Contents

This first issue in the series focuses on **Urban Planning and Design**. How are generative AI models changing the work and required competencies of practitioners and decision-makers? What does a city look like that has been shaped by AI? And how do we ensure that AI remains a tool we use intelligently?

Foresight Perspective:
What unforeseen consequences will AI have for designers and planners?

To drive sustainable cities, we might use AI for more iterative and participatory approaches, where the city becomes a collaborative and ever-evolving playground; redesigning and adapting to changing needs.

Urban planners have been looking to integrate digital technology into their practice for years. Today, the pressures for efficiencies in planning, design and delivery are greater than ever. Overlapping factors ranging from growing urbanisation, public sector spending challenges and increased competition are pushing design practitioners to do more with less.

Artificial intelligence appears as a boon in this context. The industry is looking towards generative AI models to enable planners and designers to tackle urban challenges and ideate around solutions more quickly and efficiently. Combining these generative AI models with an increasing availability of real-time data allows practitioners to uncover novel insights that are grounded in the local context.

Imagine a city where AI is fully integrated into the design lifecycle. AI-enhanced digital twins enable planners to anticipate and respond to climate events and to demographic shifts. Interconnected infrastructure systems create more responsive and integrated cities. AI breaks down silos between building services and allows structures to adapt in real time to environmental conditions and user preferences. Planning processes are fast and, thanks to generative AI, citizens can see what their place will look like as it is designed, giving them the opportunity to be involved meaningfully.

"We could imagine whole cities becoming more rapidly reconfigurable; mutating, changing and evolving in front of our eyes as AI connects contextual data streams to collective needs and drives nuanced adaptations and redesigns."

Wait, slow down.

Artificial intelligence and the thirst for data are not without their problems. The rocketing demand for computing power places pressures on energy grids and requires data centres to move into the city where space is already at a premium. New infrastructure that is not only embedded in the urban fabric but also delivers positive social value for communities is necessary.

The quality of data and how it is used are also in question. Planners will have to think critically about bias, privacy and accountability, particularly where the processes behind the AI models are hidden. How can we balance technological advancements with human oversight? How can we ensure AI-driven urban planning and design is equitable and inclusive? What safeguards are needed to prevent bias and protect privacy? What new skills and responsibilities do future planners need to prepare for today?
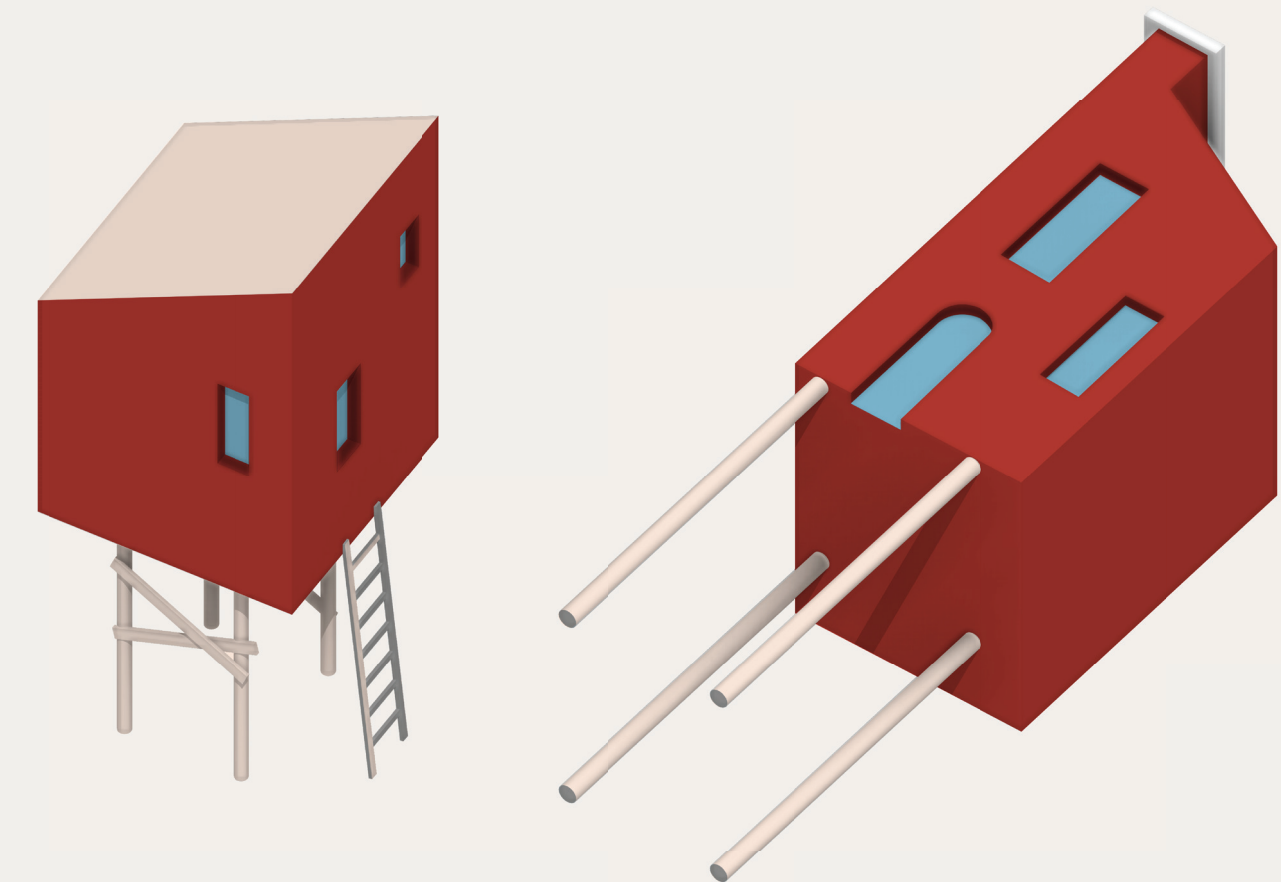
Horizon Scan Evidence:
Trends shaping the future of AI in Planning and Design

This is a small selection of key data we are tracking on how AI operates in the context of cities at present (now→), emerging trends we are observing (near →), and informed speculations we are making about long-term possibilities that stem from signals of change (next →).

Get in touch to explore our expanding database of trends, spanning all issues of the **AI for Future Cities** series.

Increasing urbanisation of data centres
(03)

Digitalisation of life has seen data centres urbanise to provide low-latency and real-time responsiveness to consumers. Their energy, water and space needs, as well as waste heat generation, are issues urban planners need to consider.

CIDOB, 2023 **NOW**

Rapid concept generation
(09)

Generative AI adoption is allowing designers to explore more ideas, including previously unimagined ones, much faster than traditional methods. Here, designers are increasingly using text prompts to generate unique visuals within minutes, supporting rapid ideation and explore design concepts more efficiently.

Forbes, 2024 **NOW**

Biased data influencing decisions
(21)

AI is only as good as the data it is trained on. Poor data in models can perpetuate bias, causing unintended and discriminative consequences in solution designs/plans.

OCHR, 2024 **NEAR**

AI for urban resilience
(25)

Using AI to create higher fidelity and more accessible digital twins. This can help planners better anticipate, prepare and respond to extreme climate events and population shocks, aiding greater levels of urban resilience.

Frontiers Policy Labs, 2024 **NEAR**

Interconnected infrastructure systems
(33)

Using AI to break silos and integrate our systems and infrastructure could allow for vastly improved and responsive urban services and infrastructure.

Wired, 2023 **NEXT**

Growing public spending pressures
(07)

Public spending pressures are universal around the globe and increasing. Delivering more with limited resources creates the need for resource and time efficiency across the design and planning lifecycle.

UNCTAD, 2024 **NOW**

AI in the design lifecycle
(14)

AI has the potential to make projects more efficient, inclusive and creative but carries risks due to bias, privacy issues, and over-reliance on technology. Balancing regulation and human insight will be crucial.

Archdaily, 2024 **NEAR**

Tackling housing shortages
(28)

With interventions across the construction lifecycle, AI can improve location selection for housing, accelerate planning by generating multiple designs consistent with the latest building codes and regulations as well as optimise construction sites and processes.

UN OHCHR, 2023 **NEAR**

Citizen-driven design
(35)

New highly iterative methods of urban planning could emerge by converting text prompts into photorealistic designs for public feedback, involving citizens early in the design process to shape their city.
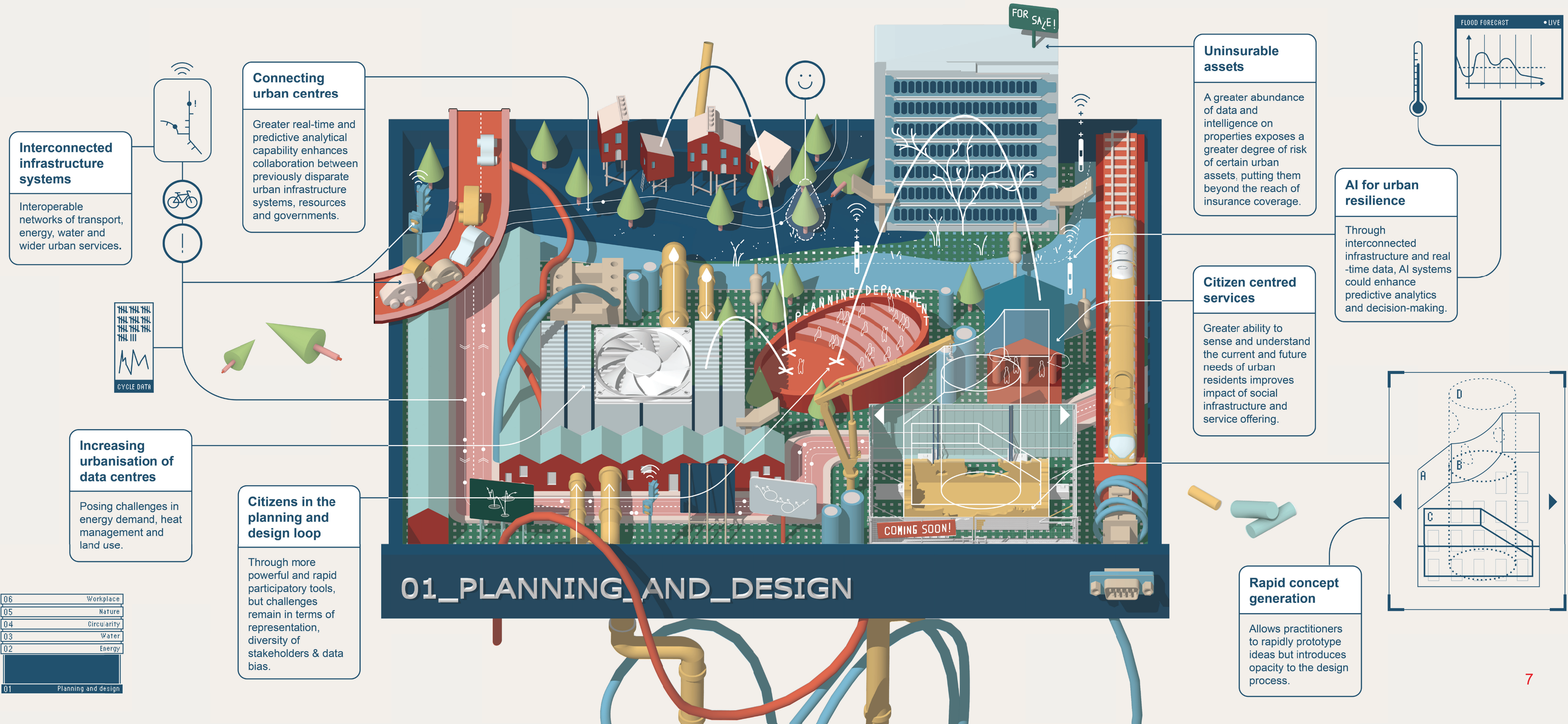
Forbes, 2024 **NEXT**

Immersive and personalised urban experiences
(37)

Immersive and personalised urban experiences such as 3D billboards are increasingly prevalent. AI can help this infrastructure adapt in real time to environmental conditions and user preferences.

Artist: Warm & Fuzzy, 2023 **NEXT**

The City of 2035:
# How might AI shape the city, and what new realities emerge?

Connecting urban centres

Greater real-time and predictive analytical capability enhances collaboration between previously disparate urban infrastructure systems, resources and governments.

Interconnected infrastructure systems

Interoperable networks of transport, energy, water and wider urban services.

Uninsurable assets

A greater abundance of data and intelligence on properties exposes a greater degree of risk of certain urban assets, putting them beyond the reach of insurance coverage.

AI for urban resilience

Through interconnected infrastructure and real-time data, AI systems could enhance predictive analytics and decision-making.

Citizen centred services

Greater ability to sense and understand the current and future needs of urban residents improves impact of social infrastructure and service offering.

Increasing urbanisation of data centres

Posing challenges in energy demand, heat management and land use.

Citizens in the planning and design loop

Through more powerful and rapid participatory tools, but challenges remain in terms of representation, diversity of stakeholders & data bias.

Rapid concept generation

Allows practitioners to rapidly prototype ideas but introduces opacity to the design process.

01_PLANNING_AND_DESIGN

06	Workplace
05	Nature
04	Circularity
03	Water
02	Energy
01	Planning and design

ARUP

Expert Insight:
How can we use AI thoughtfully in Design and Planning?

From generative AI tools to digital twins, implications of AI in design and planning are transformative. Yet, its development and use carry significant risks. We must critically reflect on how we can shape and use it intelligently.
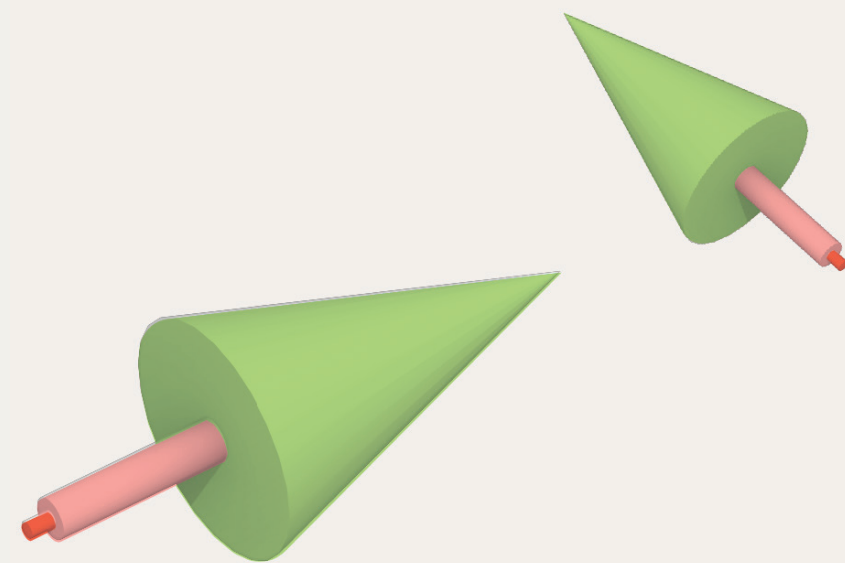
A leading thinker on AI in architecture, Neil Leach claims that "AI is both incredible and terrifying".[1] Indeed, AI technologies are transforming the design of the built environment, marking a paradigm shift with their ability to learn and operate autonomously. They are already supporting designers and planners in data analyses, image generation, design optimisation and performance simulation. Although currently limited to specific tasks, AI tools are developing rapidly, holding extraordinary potential to enhance design processes and address complex urban issues. They will enhance productivity and evidence-driven design. They will boost creativity and broaden access to non-experts, potentially widening public engagement in urban decision-making processes.

AI is not a panacea

Artificial intelligence has limitations, and they must be scrutinised and understood if we are to use it intelligently.

AI tools are not conscious entities and cannot understand their actions. For instance, ChatGPT does not comprehend the meaning of its outputs, which can be inaccurate or contradictory. AI outputs cannot be blindly relied upon.

Garbage in, garbage out: AI systems process massive amounts of data, but their outputs depend on the data they were trained on and have access to. This can exacerbate biases, stereotypes and inequalities.

The black box nature of AI: The complexity of AI models makes it impossible to understand how and why they arrived at specific solutions. This has significant implications for rational and transparent debates over design/planning solutions, accountability in decision-making and responsibilities over performance of what gets built.

Sites are places: AI systems can process visual and spatial data about an area but have limitations in understanding specific sites and the spatial, social, and cultural qualities of places and communities. Site analyses are also value-laden and cannot be entirely outsourced to AI.

Dr Juliana Martins
The Bartlett School of Planning
University College London

1. Leach, N, "AI is both incredible and terrifying: a conversation with Neil Leach", (2021). archinect.com

Further issues regarding ethics, impacts on the environment and human rights are also crucial. For example, increased data gathering raises privacy and intellectual property concerns.

Design and planning are political

Limits to optimisation: AI will augment design capabilities with powerful performance-based design tools. While optimisation may promise the best solutions, choices need to be made. Solutions to multiple criteria may be contradictory. For instance, optimising performance for passive environmental design may undermine street-based urbanism. Ultimately, optimal solutions depend on different priorities and emerge from a balance that designers must strike.

Wicked problems: Many built environment problems are "wicked", a term coined by Horst Rittel and Melvin Webber to describe problems – such as traffic – that are "ill formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly

confusing".[2] The formulation of problems addressed by designers is itself open and contested, and solutions assessed differently depending on who makes the judgment. Design involves a position in the face of these different, and often contradictory, interests and diverse stakeholders.

Implementation also faces political complexities, as illustrated by conspiracy theories. In pluralistic societies, possible solutions may not perform best in the objective world of algorithms.

AI can be a force for good

AI is here to stay. Technological development will continue, tools will have greater capabilities and reliability, and will become increasingly ubiquitous in personal and professional activities. But AI's capacity to help us design better cities will depend on how we shape its development and use it.

Looking to the future, we need to further the public's and professionals' understanding of how AI works, increase transparency of training data and algorithms, and build more inclusive datasets. Customised AI

will be critical to making more reliable use of AI. Built environment professionals should engage in collecting datasets and training of models. Urban AI, such as autonomous vehicles, robots, and urban software agents, is itself creating new challenges for cities that designers need to address. More broadly, AI must be regulated regarding private/public ownership, accessibility, data equity and privacy, intellectual property, and wider environmental and labour issues.

AI is, and should continue to be, an assistant in design processes. Designers should retain their crucial roles as experts in understanding the complexities of places and design problems, balancing a variety of interests (including clients) and as decision-makers. Their role may become more relevant with responsibilities in navigating the obscure workings of AI and filtering its outputs for urban processes.

Finally, AI is simply another – even if incredibly powerful – tool. But it is not a solution. To make cities more resilient, equitable and inclusive, we must seek that collectively as a society. These goals are not shared by all and are subject to contested political debates.

2. Buchanan, R. (1992). Wicked problems in design thinking. Design issues, 8(2), 5-21.

Expert Insight:
How do we prepare the future designer for the needs of tomorrow?

The influential architect Cedric Price issued this provocation more than 50 years ago: "if technology is the answer, but what was the question?"[3] This is still as important today. Asking the right questions now will help us to understand the significant risks and opportunities in the use of AI.

Kathryn Firth
Director - Cities, Planning & Design
Arup

Hao-Wen Lin
Senior Designer - Cities, Planning & Design
Arup

Pei Chin Lin
Designer - Cities, Planning & Design
Arup

Efficiency with humanity

AI can optimise systems, workflows, and methodologies to make the design process more efficient. As applications move beyond speeding technical production, checks and reviews, designers will be able to direct AI to solving complex challenges autonomously: like any other intelligent team member, AI could handle technical tasks independently and enable new scales of experimentation, iteration and collaboration.

Yet, only drawing on existing data, AI tools lack the intuition, emotional intelligence and ability to reliably grasp the complex, ambiguous contexts that designers need to deliver excellent work. On the technical level, this gives designers a proactive role: their curation of initial inputs, conditions and context baselines will guide the AI. More significantly, this requires a rebalancing of designers skills. Their subjective experience and understanding of place, context and diversity will be even more important. It will be their responsibility to ensure that the efficiency created by AI advances their practice rather than hinders the progression of their own technical skills.

Rapid prototyping

AI tools that rapidly produce images and text allow us to test multiple design options, and they often provoke us with unexpected outcomes. What's more, they enable clients and the public to participate in 'live' optioneering: quick iterations of ideas and concepts in workshop settings. Clients now expect this use as it helps them experience and understand their options better.

However, we must be cautious of relying on these rapidly produced visuals over a considered and critical design practice. There is a danger that AI capabilities push designers to produce schemes that prioritise bold aesthetics over realisable propositions at concept stage. Designers of the future will still need to hone these skills to visualise and apply their intuitions and the contextual narratives.

3. Price C. "Technology is the answer, but what was the question?" (1979), pidgeondigital.com

Broadening our understanding

In the future, AI could allow for the integration of different large-scale datasets into real-time simulations to test the impact of design decisions on sustainability, energy use, or social equity. This could radically transform how cities are governed by using more robust evidence and developed by giving more emphasis to resilience and adaptability..

One day, AI could even enable us to better integrate other types of data, such as wellbeing metrics, into the urban design process. We can imagine AI-powered urban systems that actively adapt to the physical and psychological wellbeing of residents - managing noise, air quality, green spaces, and social interactions. Such "wellbeing cities" where AI not only enhances energy and material efficiency but could also boost ecological wellbeing and help create more sustainable, biodiverse urban environments by monitoring ecosystem data.

The ability of AI to process, reference and synthesise insight from huge datasets is a powerful asset in solving complex problems. For Arup, with its wealth of multidisciplinary project experience, AI might use our historic data and knowledge base to strengthen our interdisciplinary creative and critical practice, generating unique and radical innovations. Over time, our AI could build a disciplinary memory that connects past experiences with current project challenges, offering predictive insights and building a real-time, self-improving knowledge system that enhances creativity. An important first step is to ensure high-quality and consistent data hygiene that removes the biases present in historical data.

"Design relies on the reflectivity, critical and creative thinking of excellent design to make the vision robust, sustainable and sensitive to lived experience of cities and their communities."

The future designer: creativity x critical thought

While problem-solving will remain at the heart of designers' work, design students of today must develop their own critical thought and creativity to work effectively with AI. Design isn't just about prompting AI to produce an image or layout, nor is an AI-generated product ever a finished one. It relies on the reflectivity, critical thinking and creative practice of excellent design to make the vision robust, sustainable and sensitive to lived experience of cities and their communities. These exciting developments will yield the greatest benefit if they are accompanied by a shift in mindset whereby AI is used to strengthen the human elements of design. Then, an AI-enhanced design practice will unlock new opportunities for society.

Case Studies:
What are we doing today to make cities better through AI?

Arup has worked with partners and clients to develop world-leading AI applications to deliver better outcomes for cities.

These cutting-edge applications raise fascinating questions about how AI may shape the future expectations of planners and designers and how these may be transferable to other domains across the city.

Battersea Power Station Masterplan
London, United Kingdom, 2024

Arup was responsible for 'Future Phases', the next stage in the Battersea Power Station masterplan, delivering future living and working environments that matched the quality and sustainability aspirations of the original plan, alongside the Northern Line extension and the extensive regeneration of the Nine Elms corridor.

Arup developed a series of digital master planning tools that optimised scheme design using generative design, assessment and optimisation algorithms. The tools allowed Arup to quickly iterate through multiple design options that explored the impact of below-ground constraints and maximum permitted height on possible built form, as well as quality of daylight and views, in

order to meet the priorities of both the client and the end user. This allowed for the creation of innovative solutions despite the huge constraints of the site and planning process.

What if the growth in generative AI shifted the role of urban planners and designers beyond tackling technical constraints to focusing more on ethical considerations?

Read more

Adelaide City Plan
Adelaide, Australia, 2024

The City of Adelaide tasked Arup with developing a framework for future growth and enhanced liveability realised through improvements to physical, social and green infrastructure.

Collaborating with City Collective, Mulloway Studios, and Aboriginal Urban Design, Arup employed digital twin technology to create a dynamic model of Adelaide. This model integrated over 400 datasets, providing insights into accessibility of open spaces, public transport, and community amenities to provide an overall liveability score for each of the city's precincts. Understanding this score and integrating growth forecasts allows the City of Adelaide to make informed decisions about its future investment pipeline, infrastructure

requirements and strategic planning controls to best support the city's changing needs. Presenting this data in a visual manner highlights the various urban systems that support the city and make the information accessible to a wide range of stakeholders throughout Adelaide.

What if AI enabled every city to build a connected, live, digital twin?

Read more

Recommendations:
Practical steps for today's practitioners

AI will impact design and planning for cities in profound and unforeseen ways. Although we can't predict these impacts exactly, we can take anticipatory steps today to be better prepared for the future city.

1 Enhance data quality, consistency and integration

Good AI needs unbiased and robust data to be effective. Planning and design authorities at all scales (global, national, regional, local) should look to improve consistency of data across a diversity of data sources.

2 Power creative efficiency

Ultimately, AI should be seen as a planning and design tool, not an end in itself. AI should be used to help designers focus on what they do best and allow for more rapid experimentation and prototyping. This should be done whilst ensuring a human is in the design and decision-making loop to bring context and empathy.

3 Build safeguards against biases

AI has the potential to make planning much more inclusive and equitable, but organisations need to prepare safeguards in their AI adoption to prevent biased decisions, such as bias audits of AI systems and underpinning data.

4 Be prepared for ethical challenges

Designers and planners should be prepared for emerging ethical problems in using AI and be equipped to engage with these emerging questions. Planning and design authorities should put in place ethical frameworks and guidelines to ensure adoption is focused on a shared set of values.

5 Long-term and systemic planning

AI can deliver diverse insights on planetary and social change. Designers should build and practice systems and futures thinking skills to make use of this capability

6 Explore opportunities for enhancing community engagement

The power of generative AI tools today brings exciting opportunities to empower communities to engage with the planning and design process. Practitioners should start to introduce this in their practice to allow citizens to have an active say in how AI could transform their city.

ARUP
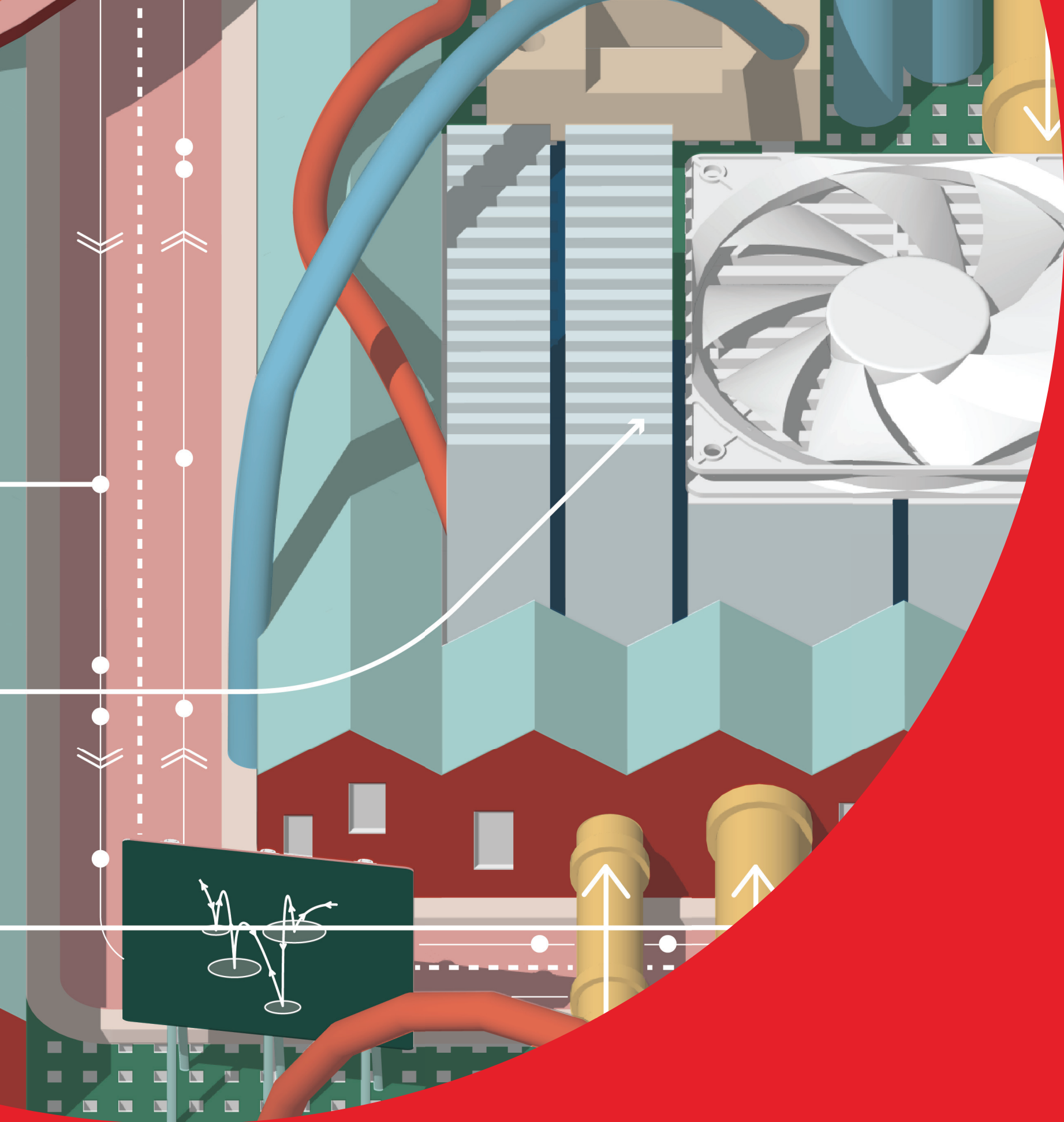
Arup is a global collective of designers, engineers and technical experts. We use imagination, technology and rigour to shape a more sustainable world.

ARUP

Get in touch with our experts to discuss further.

Contacts
Arup University Foresight
foresight@arup.com

Arup Cities, Planning and Design
cities@arup.com

AI for Future Cities Team
Arlind Neziri
Charlotte Cutter
George Harrington
Julien Clin
Ness Lafoy
Sarah Bushnell
Tobias Revell

Urban Planning and Design contributors
Hao-Wen Lin
Kathryn Firth
Nissa Shahid
Pei Chin Lin