NET ZERO CITIES

AI Towards Climate Neutrality

Exploring the Role of Artificial Intelligence in Achieving Sustainable, Carbon-Neutral Urban Futures

Authors: Eden Grace Sicat, Lucía Nogales, Marzia Mortati. Politecnico di Milano. Design Department

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Table of contents

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List of figures

List of tables

No table of figures entries found.

Abbreviations and acronyms

Acronym	Description
WP	Work Package
AI	Artificial Intelligence
ML	Machine Learning
GenAI	Generative Artificial Intelligence
ITS	Intelligent Transportation System
HEMS	Home Energy Management System
NLP	Natural Language Processing
NZC	NetZeroCities
IoT	Internet of Things

Summary

This deep dive **examines the potential and limitations of Artificial Intelligence (AI) in supporting the transition towards climate-neutral cities within the NetZeroCities (NZC) framework**. By analysing opportunities and risks across key emission domains—energy, mobility, agriculture, water, and waste—the study highlights both the transformative possibilities and the systemic challenges of deploying AI for climate action.

The analysis shows that AI can enable more efficient energy management, optimize urban transport, improve agricultural practices, enhance water distribution, and support waste reduction and circular economy initiatives. At the same time, AI development and deployment come with considerable costs, including high energy and water consumption, risks of maladaptation, technological lock-ins, and equity concerns.

Beyond sector-specific applications, the deep dive also explores the role of AI in strengthening **systemic levers of change**, including urban governance, policymaking, and public participation. Emerging experiments demonstrate how AI can foster citizen engagement, support collective intelligence, and generate data-driven policy insights. However, issues of transparency, accountability, bias, and democratic integrity remain central challenges that must be addressed.

Key takeaways emphasize that while AI offers powerful tools to accelerate climate neutrality, it should not be treated as a silver bullet. Instead, cities must pursue **multifaceted strategies** that integrate AI with broader policy, behavioural, and cooperative approaches. This includes investing in greener AI models, ensuring inclusive participation, safeguarding privacy and fairness, and embedding AI within just and equitable climate strategies.

Keywords

Artificial Intelligence; Machine Learning; Generative AI; urban governance; climate neutrality; NetZeroCities; energy management; mobility; circular economy; public participation; systemic levers.

1 Introduction and Objectives

City life is bustling and increasingly becoming a hotbed of social and environmental challenges. As urban populations swell, so do the pressures on our planet, particularly concerning climate change. Cities are massive carbon emitters, making innovative environmental management strategies a must (UN Environment Program, 2024). Among these, the promise of Artificial Intelligence (AI) as a game-changer in achieving climate neutrality stands out (Mastrola, 2023). With the rise of AI and Generative AI, there is a determination to maximize its powerful promise to solve a variety of societal and environmental issues. However, AI is still a fast-evolving technology that has yet to prove its ability to provide effective solutions to the problems cities face, especially in sustainability and carbon neutrality. It is essential for cities to have a comprehensive understanding of both the advantages and the challenges that AI can facilitate in their ambitions to become carbon neutral.

This brief report explores AI's role in urban sustainability, weighing its current applications, future prospects, and the hurdles cities need to overcome. While AI offers tremendous potential, it shouldn't overshadow the necessity for diverse, hands-on approaches to tackling our biggest environmental issues as well as the socio-technical and ethical implications intrinsic to the technology.

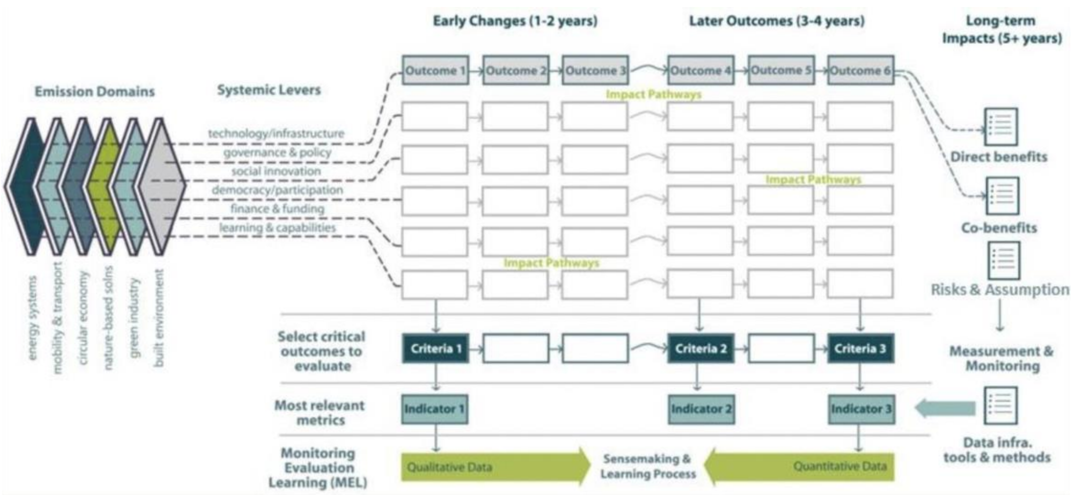

Fig. 1: NZC Theory of Change

2 Context

Cities account for more than 70% of global carbon dioxide emissions, with urban energy consumption projected to increase by nearly 40% by 2030. The growing urban population, estimated to reach 68% of the world's population by 2050, exacerbates these challenges (UN-Habitat, 2022). This rapid urbanization demands radically new strategies to manage environmental impact, making AI a promising tool.

However, AI also has limits and barriers to uptake and implementation often leading to new (and sometimes unforeseen) unsustainable consequences. AI development per se consumes large quantities of energy and water, often making it an answer unfit for purpose. In considering this technology to implement solutions that can help reach climate neutrality, cities need to carefully consider potential gains and losses.

To provide an overview of current applications, we start from the NZC Theory of Change (fig. 1) and cluster some of the most notable projects cities are experimenting with according to the emission domains where AI can have greatest impact, namely: energy, mobility, waste, water, agriculture. For each, we describe the current experimentation and the associated risks and implications. We further describe the opportunities of uptaking AI in some of the systemic levers of change, in particular governance and participation. We conclude with the key takeaways of this brief overview for cities.

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3 Leveraging AI for Climate Neutrality: Navigating Risks and Opportunities in Emission Sectors

The categorization of the risks and opportunities follows aApplications of AI for cClimate nNeutrality with: focus on emission domains. The opportunities are backed with real world examples of AI application.

3.1 AI for Energy Management

3.1.1 Opportunity

Energy management is crucial for achieving climate neutrality, as it directly influences urban carbon emissions. AI technologies provide advanced solutions for predicting, optimizing, and controlling energy consumption patterns, integrating renewable energy sources, and ensuring efficient distribution. In particular, AI is already employed in cities for the optimization of energy use and predictive energy management. However, it is essential to consider the energy consumption of AI itself to fully understand its sustainability.

Copenhagen's Signature AI Project: In Copenhagen, AI plays a critical role in optimizing energy consumption in municipal buildings. The Signature AI Project by the Copenhagen Solutions Lab and Copenhagen Municipality reduces energy use, carbon emissions, and heat and electricity bills. AI uses weather and building usage data, to predict heating and ventilation needs for kindergartens and daycare centers, optimizing energy consumption and indoor climate in around 300 properties under 3,000 m² (Copenhagen Solutions Lab, 2021). This project has significantly contributed to energy savings and reduced carbon emissions.

Smart energy management, exemplified by smart grids, uses AI to optimize energy distribution. These grids (currently used in several cities, like Amsterdam, Lyon, and Florence), analyze real-time data on consumption and generation to balance supply and demand efficiently. According to Wray (2023), smart grids are anticipated to be major contributors to energy savings, driven by AI analytics, demand-responsive networks, and urban microgrids that are modernizing urban grid infrastructure.

Intelligent Energy Storage: AI also plays a role in optimizing energy storage. For example, AI can manage battery storage systems, optimizing charging and discharging cycles to extend battery life and efficiency, which is crucial for integrating renewable energy sources into the grid. This could be applied for example in energy storage systems for electric vehicles.

Home Energy Management System (HEMS) in Phoenix, Arizona: Simmons et al. (2019) conducted a study on HEMS, which uses weather and market forecasts to optimize appliance usage, manage battery storage, and maximize solar power. Combining Moving Horizon Estimation (MHE) and Model Predictive Control (MPC), the system balances comfort and cost, reducing energy consumption by 21% and costs by 40%. This optimized energy management, enhances grid stability and reduces load-following cycles for utilities.

3.1.2 Risks

The infrastructure required for smart grids is complex and costly, and integrating AI technologies into existing systems can be disruptive. While the goal is to conserve energy, technologies like Generative AI demand significant power, highlighting the need for greener AI solutions. Large language models like GPT-3 and GPT-4 further increase energy usage. Training these models consumes large amounts of electricity, comparable to the annual consumption of many households. As AI continues to grow, it is crucial to develop transparent and sustainable practices. This includes promoting energy-efficient AI models, encouraging digital sobriety, and implementing policies that focus on renewable energy sources (Calvert, 2024). Governments cannot achieve this alone; the entire AI ecosystem, the private sector, research organisations, and the society overall must be involved in co-imagining and co-developing AI solutions that maximize capacity without excessive energy use.

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3.2 AI in Urban Mobility

3.2.1 Opportunity

AI holds significant promise for reducing greenhouse gas emissions from road transport, with many promising solutions currently in experimental or simulation stages. These examples show that for AI to effectively mitigate emissions, a responsible integration within commercial products and public infrastructure should be foreseen. Machine learning (ML) offers new opportunities across the road transport value chain, particularly in enhancing batteries and biofuels, intelligent transportation systems, and promoting lower-carbon transportation modes. However, to fully harness AI's potential, high-quality big data are essential, as they provide the foundation for predictive analytics and decision-making. Combining new data sources such as real-time sensor data, social media feeds, and satellite imagery, with advanced theoretical insights from areas like deep learning and statistical modeling, can amplify recent ML advancements (Sathiyan et al., 2022). Examples of successful AI applications in this space include intelligent transportation systems and autonomous vehicles, even if risks persist, especially linked to the need of modifying existing infrastructures and privacy.

Intelligent Transportation Systems (ITSs) have the potential to significantly reduce emissions by integrating sensor and communication technologies with data processing. These systems can analyze real-time data to plan, monitor, and control transit. By optimizing public transport systems, ITSs can help reduce wait times and ensure timely and cost-effective travel for users. This improvement in the public transport experience could accelerate and promote a shift from personal vehicles use to higher use of shared vehicles or public transport (Sandalow et al., 2023).

Autonomous vehicles, guided by AI, promise even greater efficiency by eliminating human error and optimizing driving patterns to reduce fuel consumption and emissions. Several applications are under development in the private sector to support this evolution, including the adoption of a Mobility as a service (MaaS) paradigm that is promising to offer a good alternative to personal transport through applications like self-service electric cars, short distance carpooling, and smart parking management all AI-powered for optimization.

In Europe, several cities are experimenting in this direction: Reykjavik is investing in increasing the efficiency of its transport systems, also developing apps (i.e., Strætó) that help manage a smart bus transport network. Copenhagen has developed an integrated system for public transport encompassing an intelligent bus priority system, fully electrified car sharing, and an infrastructure that enhances commuting by foot and by bike. Geneva has implemented an efficient smart parking system, deployed through a network of sensors capable of lowering the number of vehicles searching for a place to park by 30%.

3.2.2 Risks

Although promising, the deployment of AI in urban mobility is not without its hurdles. Modifying existing urban infrastructures to make them AI-ready requires significant investment as well as the development of completely new infrastructures that imply technological, regulatory, and commercial challenges for municipalities. For instance, autonomous vehicles require extensive testing and regulatory approval, which can be a slow and contentious process. Additionally, the infrastructure needed to support autonomous vehicles, such as smart traffic signals and dedicated lanes, requires significant investment. Public acceptance and trust in AI-driven transportation solutions are also critical factors that need to be addressed through transparent communication and robust safety protocols.

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3.3 AI for Agriculture

3.3.1 Opportunity

Urban agriculture is becoming increasingly important as cities look for ways to reduce their carbon footprint and improve food security. In India's vast agricultural lands, AI is revolutionizing farming with precision techniques that optimize the use of water, fertilizers, and pesticides, increasing crop yields while reducing the environmental impact of farming practices. In this area, several technological applications are notable, encompassing smart irrigation, drought prediction, and urban farming, even if relevant barriers persist linked to the costs of equipment and lack of technological literacy.

Smart irrigation technology aims to enhance agricultural productivity with minimal manpower by using sensors to detect water levels, soil temperature, nutrient content, and weather forecasts. Microcontrollers manage irrigation by controlling pumps based on sensor data.

Machine to Machine (M2M) technology facilitates communication and data sharing across the agricultural field network (Shekhat et al as cited in Talaviya et al., 2020). Machine Learning for Drought Prediction. In Tanzania, Lalika et al., (2023) demonstrated how this can benefit the community, specifically stating AI's ability to process real-time data and provide early warnings about impending drought conditions. Early detection enables farmers, policymakers, and overall communities to take proactive measures, such as implementing water-saving practices or adjusting agricultural daily tasks. By leveraging AI, we can better prepare for and mitigate the impacts of droughts, ultimately contributing to more resilient and sustainable agricultural systems. Urban farming: AI can also be deployed to support urban farming, for instance by making it energy and water efficient, and minimizing the effort for citizens. One example is the start-up Plenty that developed an AI and robotics run vertical farm for cities, resulting in a 99% reduction in land-use and 95% reduction in water use. In Amsterdam vertical farming company GROWx, together with Wageningen University, Signify and Be-bots have built a robotic and AI driven vertical farm which automates the cultivation of crops.

3.3.2 Risks

Despite these advantages, there are several barriers to the widespread adoption of AI in urban agriculture. The cost of AI-powered farming equipment can be prohibitive for small-scale urban farmers. More so, the access to these types of AI tools are actually not easy to gain. Farmers or farming communities need to undergo capability training in order for them to learn and use AI systems into their farming practices. Numerous universities help bridge this gap through their research work, however, these are only small scale pilots and the widespread use of AI in farming is nowhere near being available to small scale farmers. Additionally, there is a need for training and supporting farmers to effectively use AI technologies. In this case, city governments would need to invest in supporting capacity building for farmers in order to facilitate the use of AI tools for agriculture to ultimately off-set carbon footprint and increase food security. Ensuring that AI-driven urban agriculture initiatives are inclusive and accessible to all communities is essential for promoting equity and sustainability.

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3.4 AI in Water Management

3.4.1 Opportunity

AI can play a big role in helping water infrastructure transition to low-carbon through more effective water usage and distribution. Europe counts a total of 3.5 million kilometers in water pipelines, where often significant parts require drastic renewal. This poses significant challenges to utility companies as well as risks for the sustainable supply of safe drinking water, and waste water management. These interventions will require up to 20 billion euros annually, while challenges such as drought and increased water demand call for the implementation of measures boosting the water grid's efficiency and sustainability. AI-powered systems are promising to help face these challenges by monitoring water quality, detecting leaks, and predicting demand, while ensuring that water resources are used efficiently in the entire locality. For example, AI can analyze data from sensors placed in water distribution networks to identify leaks in real-time, allowing for prompt repairs and reducing water loss. Predictive models can forecast water demand based on factors such as weather conditions and population trends, enabling more efficient water allocation. Other applications of AI are for improved catchment area management, for instance on water quality and the prevention of flooding and contamination, water efficiency on the demand side, drought forecasting and planning, and adequate sanitation. Leading examples of AI applications in smart water management can be found in Finland, where the pilot Silo.AI demonstrated how machine learning algorithms can be used to predict the quality of the water and monitor the water treatment process constantly, and the Netherlands, where the project SW4EU demonstrated its use for water quality control and optimisation.

3.4.2 Risks

AI models, particularly large ones like GPT-3 and GPT-4, consume significant amounts of water. These models require vast amounts of data and computational power, leading to substantial water usage both onsite for cooling servers and offsite for electricity generation (Ren, 2023). Although there has been an effort by big tech companies to address water usage, transparency regarding AI's water footprint remains insufficient. Better reporting and clarity in AI model documentation and public disclosure, similar to carbon footprint disclosures, would benefit city governments by providing essential data to manage local water resources more effectively.

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3.5 AI in Waste Management

3.5.1 Opportunity

Onto waste management, AI has the potential to revolutionize waste management by improving efficiency and promoting recycling. AI-powered waste sorting systems can automatically identify and separate different types of waste, reducing contamination and improving the quality of recyclable materials. Predictive analytics can optimize waste collection routes, reducing fuel consumption and emissions from waste collection vehicles. Additionally, AI can help identify patterns in waste generation, enabling cities to implement more effective waste reduction strategies.

One exemplar application can be found in Amsterdam where AI plays a crucial role in promoting a circular economy within urban centers by focusing on waste reduction and management, resource recovery, and the optimization of product life cycles in industrial processes. AI can help design products that are easier to recycle and manage waste streams more efficiently, contributing to a more sustainable urban environment. AI-driven waste management systems optimize waste collection routes and improve recycling rates, reducing the environmental impact of waste management. Resource recovery technologies use AI to identify and extract valuable materials from waste streams, enhancing resource efficiency and promoting a circular economy.

3.5.2 Risks

Implementing AI in waste management requires overcoming several obstacles. The initial cost of AI-powered sorting and collection systems can be high, and there may be resistance from waste management workers and unions. Ensuring the accuracy and reliability of AI systems in diverse and changing environments is also challenging. Furthermore, promoting a circular economy through AI requires collaboration between various stakeholders, including manufacturers, consumers, and policymakers.

4 Leveraging AI for Climate Neutrality: Unlocking Systemic Levers for Change Applications of AI for Achieve Climate Neutrality: focus on systemic levers

4.1 AI for public participation

AI can play a big role in getting people involved in sustainability efforts. AI-driven platforms and tools can gather and analyze feedback from citizens, improve communication between city officials and residents, and encourage active participation in urban planning and sustainability efforts. This can help create a more informed and engaged community, which is essential for achieving climate neutrality. AI-driven education tools can help educate and mobilize urban populations toward sustainability goals, increasing awareness and fostering community involvement. AI tools can help mobilize urban populations by providing real-time information and resources on sustainability initiatives. This includes AI-powered platforms that encourage citizens to participate in green activities, track their carbon footprint, and adopt sustainable practices.

AI tools can also be adopted to reinforce direct democracy, helping public organisations offer improved public services that are more responsive to the needs of people (Cabannes, 2015). Building on this, Governments are increasingly using digital platforms to invite citizen participation in policymaking, enhancing democratic legitimacy, inclusiveness, and government effectiveness (Aitamurto & Chen, 2017). AI can support these efforts by providing advanced data analysis, improving the efficiency and reach of these platforms, and ensuring that diverse voices are heard in the policymaking process. These platforms leverage recent technological innovations to facilitate large-scale collective intelligence in public decision-making processes, ranging from participatory budgeting to constitution-making (Aitamurto et al., 2016).

These efforts have recently led to the exploration of the potential of AI for mass digital participation which is portrayed to improve public decision-making by harnessing the collective intelligence of citizens. This approach, based on the idea that "many heads are better than one," posits that aggregating individual knowledge and opinions leads to better decisions than those made by a single member or experts alone (Landemore, 2017). This participation generates epistemic, democratic, and economic value by diversifying and enriching knowledge and engagement in law and policy-making processes (Aitamurto & Chen, 2017). In this space, GenAI and Natural Language Processing (NLP) are instrumental in managing and synthesizing the vast amounts of data generated by citizens. For instance, in Madrid the "Decide Madrid" platform employs NLP techniques to categorize proposals, suggest relevant proposals to users, group citizens with similar interests, and summarize comments, thereby facilitating more effective and meaningful citizen participation (Arana-Catania et al., 2021). Like this, many examples in other cities are leading the way, including Better Reykjavik, Taiwan, and Hamburg. This last city uses DIPAS (a system based on NLP) to structure citizen contributions, helping administrators navigate and interpret feedback more accurately and efficiently. GenAI is showing particular promise for deliberative democracy, as it can also help address barriers to participation that arise when specific skills are needed. These barriers often manifest as disparities in participants' ability to use digital tools, produce relevant texts, or create appropriate visual representations of ideas, prototypes, and visions (Tappert et al. 2024). In the domain of GenAI, models like GPT can produce outputs that closely resemble human responses to prompts typically presented in natural language interfaces. This capability not only enriches participant perspectives by offering diverse viewpoints but also aids in envisioning future scenarios and interpreting data. This potential is being explored through diverse experimentations, such as the work by von Brackel-Schmidt and colleagues (2024). The researchers present a case involving participants in envisioning the future of The Hamburg metropolitan city in 2040. The case demonstrated that participants, irrespective of their backgrounds, could rapidly visualise their concepts for the city's future without requiring specific artistic or technical skills. While these types of integration of GenAI herald significant potential, they also present challenges. These concern the capacity to balance the possible

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unintended consequences (Belanche et al. 2024; Sætra 2023). For instance, GenAI's ability to fabricate persuasive yet factually inaccurate content represents a relevant risk, particularly in the manipulation of deliberative discourse and possible dissemination of misleading information or fake news.

Such risks are profoundly pertinent to the deliberative context, where the truthfulness, accuracy, and quality of information are of prime importance.

Co-design with AI is another emerging area where AI can significantly impact public participation. This involves citizens working collaboratively with AI systems to design solutions for urban challenges. By leveraging GenAI, participants can rapidly generate visualizations, prototypes, and other creative outputs without needing specialized artistic or technical skills. This approach democratizes the design process, allowing a broader range of citizens to contribute their ideas and perspectives. For example, in the "Helsinki Summer Streets" project, the City of Helsinki used the UrbanistAI platform to engage a diverse group of citizens and local business owners in co-designing pedestrian-friendly streets. Participants worked in small groups to create and visualize various design scenarios, which were then voted on and refined in collaboration with city planners. This inclusive process not only enhanced the design outcomes but also ensured that the final plans reflected the community's vision and needs.

- AI in Digital Citizen's Participation
- Democratising AI: Principles for Meaningful Public Participation

Beyond democratic participation, AI can also strengthen other types of bottom up activities in cities. One example is Citizen Energy Communities, currently seen as a promising approach to creating sustainable and reliable energy systems despite limits linked to scaling and long-term maintenance. The role of AI in such processes could be multiple: from aiding citizens' initiatives with asset management and community platform building, to the development of alternative pricing and business models for local energy exchange. However, this is hard to implement if investments and support do not also come from commercial parties.

4.2 AI for city governance and policy making

AI can transform urban governance by enhancing public service delivery, increasing transparency, and engaging citizens in sustainability initiatives. It can streamline administrative processes, improve decision-making, and foster a more participatory approach to urban planning. It can enhance public services and optimize service delivery, making it more efficient and responsive to citizens' needs. It can also support more transparent governance analyzing and displaying data transparently, increasing accountability and fostering trust between citizens and government officials. For instance, by processing historical climate data, machine learning algorithms can forecast future trends with surprising accuracy, guiding policy decisions (Onyema et al., 2022) and mitigation strategies. With this, cities can be better equipped to harness large environmental datasets that can be used to plan for the climate transition (PECB, 2024).

See: Progress report on bridging data gaps

Concerning this, organisations are increasingly focusing on the intersections of climate and data, exploring the potential applications of AI and ML. In 2020 Refinitiv and the World Economic Forum launched the Future of Sustainable Data Alliance at Davos, and the Network of Central Banks and Supervisors for Greening the Financial System (NGFS) launched a workstream on bridging data gaps a few months later. Another notable example is the European Commission's "Destination Earth" (DestinE) initiative. DestinE aims to develop a highly accurate digital model of the Earth to monitor and predict environmental changes, support sustainable development, and enhance urban planning. The key features of the initiative include: the integration of Large Environmental Datasets from various sources, including satellite observations, ground-based measurements, and socio-economic data, to create a comprehensive digital twin of the Earth; the creation of high-Resolution Simulations of natural phenomena and human activities, providing insights into the impacts of climate change and helping to predict future environmental conditions; the support for Policy and Decision Making through the provision of accurate and up-to-date information.

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DestinE is expected to significantly improve the ability of cities to manage and utilize environmental data. It will provide tools for better predicting climate-related events, optimizing resource use, and implementing effective climate action plans. This initiative exemplifies how collaboration and advanced AI technologies can address complex environmental challenges and drive the transition towards climate neutrality (European Commission, 2022).

AI is also portrayed to dramatically change democracy (Inerarity, 2024). Here, there is however no certainty about the positive or negative consequences of the technology on democracy as the transformation is still underway. Technologies are redefining key aspects of our political systems, not least by challenging economic financing and the notion of an informed citizenry. This demands public reflection and open debate to counteract the tendency of seeing technology as inevitable and neutral. It must be remembered that algorithms are also a source of inequality, as it attempts to decipher society's true essence and preferences based on user behavior and activities online. Although this is intended to liberate people from the influence of authoritative figures and organisations, it also perpetuates existing hierarchies and inequalities while also disproportionately valuing those already well-positioned. Democracy thrives on dialogue and sharing of diverse perspectives, however by favoring misinformation and the creation of echo-chambers AI can corrode democracy.

See: UNESCO: Artificial Intelligence and democracy

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5 Key takeaways for cities

As explored, AI bares substantial potential in optimizing efficiency in several emission domains:

- it can **optimize energy consumption** of buildings, energy distribution and energy storage thus contributing to energy savings while also demanding significant energy to function itself, highlighting the need for greener AI solutions;
- it can radically improve the **efficiency of urban mobility** by reducing congestions and lowering emissions, however this also requires overcoming financial barriers as well as regulatory, technological and commercial ones;
- it can help to radically improve the relevance of **urban farming for future food production**, however this comes with costs associated to the difficulties in accessing the technology and the level of digital literacy of final users;
- it can help improve **water usage and management**, although not without costs associated with transparency regarding AI's water footprint;
- it can **revolutionize waste management** by improving efficiency and promoting recycling, but attention needs to be given to implementing new paradigms linked to the circular economy.

Beyond this, AI also presents overarching challenges, including technological, social and regulatory ones. Data collection and management is a significant one among those: using AI to achieve climate neutrality needs **effective data collection and management.** AI systems are only as good as the data they're fed. One practice that has been helpful for cities is when they join a coalition with other cities and share data amongst the members to build more robust data sets (Taylor et al., 2018). Ensuring cities can do this requires prioritizing human resources, procurement, and legislative support to legitimize use. Further, developing AI infrastructure and competencies within cities is a long-term process that demands commitment from city governments and external stakeholders. The City of Amsterdam wrote this intention in their City AI strategy stating the following key investments and actions: (1) Technical Infrastructure: Invest early in technical infrastructure, including data acquisition, preparation, machine learning techniques, hardware, computational power, a safe working environment, and knowledge representation; (2) Departmental Knowledge: Invest in AI knowledge specifically within legal, purchasing, and audit departments to ensure informed decision-making and compliance; (3) AI Education for Civil Servants: Ensure that every civil servant completes the National AI Course to gain basic AI knowledge.

Finally, as the use of AI involves collecting and processing vast amounts of data, concerns about **privacy and security** are central**.** Ensuring AI systems are transparent and accountable is essential for maintaining public trust and preventing misuse. Additionally, the potential for **bias in AI algorithms** is significant. If AI systems are trained on biased or incomplete data, they can perpetuate and even exacerbate existing inequalities. Thus, ensuring AI technologies are developed and deployed fairly and equitably is crucial for promoting social justice and sustainability. This is a big deal in climate action, where vulnerable populations are often the most affected. Relying too heavily on AI and tech solutions thus can also distract from other crucial aspects of climate action, like changing behaviors, policy measures, and international cooperation. AI is a powerful tool, but it's not a silver bullet. It needs to be part of a broader, multifaceted strategy towards climate neutrality.

5.1 The Need for a Multifaceted Strategy

While AI has significant potential to contribute to urban sustainability, it is essential to recognize that it should not be the sole focus in addressing climate and sustainability challenges. The over-reliance on AI and technological fixes can overshadow the fundamental need for direct and multifaceted (multi-scale and multi-modal) approaches to climate action. Addressing the core issues of climate change requires comprehensive strategies that include policy measures, behavioral changes, and international cooperation.

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Policymakers and urban planners should invest in energy-efficient AI technologies to support the development and deployment of AI systems that minimize energy consumption and reduce their environmental footprint. Implementing robust data privacy and security measures is essential to protect citizens' data and maintain public trust. Addressing bias in AI models by using diverse and representative datasets ensures fairness and equity in their applications. Inclusive AI strategies that involve communities in developing and implementing AI-driven sustainability initiatives can better address local needs and preferences. Integrating AI into a comprehensive climate strategy that includes policy measures, international cooperation, and behavioral changes is necessary to harness the full potential of AI for climate action. By adopting these strategies, cities can leverage AI to drive sustainability and achieve climate neutrality, contributing to a more sustainable and equitable future for all.

While AI is great at cutting down carbon emissions, the tech itself isn't entirely green. Training large AI models gobbles up a lot of computational power, which means hefty energy use. The carbon emissions from data centers and other infrastructure can sometimes cancel out the benefits. While AI offers transformative possibilities for driving the transition towards climate-neutral cities, it is crucial to recognize that it should not be the primary solution to climate and sustainability challenges. The over-reliance on AI and technological fixes can overshadow the fundamental need for direct and multifaceted approaches to climate action. Addressing the core issues of climate change requires comprehensive strategies that include policy measures, behavioral changes, and international cooperation.

Implementing robust data privacy and security measures is essential to protect citizens' data and maintain public trust. Addressing bias in AI models by using diverse and representative datasets ensures fairness and equity in their applications. Inclusive AI strategies that involve communities in developing and implementing AI-driven sustainability initiatives can better address local needs and preferences. Integrating AI into a comprehensive climate strategy that includes policy measures, international cooperation, and behavioral changes is necessary to harness the full potential of AI for climate action. By adopting these strategies, cities can leverage AI to drive sustainability and achieve climate neutrality, contributing to a more sustainable and equitable future for all.

Gauging from these, while AI holds substantial promise for enhancing urban sustainability and aiding in the fight against climate change, it must be viewed as a supplementary tool rather than a primary solution. The complex and multifaceted nature of climate challenges requires an equally complex and multifaceted response that views the inclusion of public participation at every stage of the AI development, from the decision to adopt an AI tool to initial concept design to real-world deployment and beyond, to identify and reduce harms. AI can provide valuable data insights, optimize resource use, and enhance predictive capabilities, but the foundational work of policy development, behavioral change, and stakeholder collaboration remains paramount. By balancing the innovative potentials of AI with comprehensive, ground-level climate actions, cities can more effectively move towards achieving climate neutrality and ensuring a sustainable future for generations to come. By integrating AI into broader sustainability efforts, cities can harness the power of technology to drive meaningful change, while also promoting social equity, economic resilience, and environmental stewardship. Through collaborative efforts and thoughtful planning, the goal of climate-neutral urban environments can become a reality, paving the way for a healthier, more sustainable future for all.

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