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Prospects and Challenges of Urban Cities in the Era of Digital Transformation and Artificial Intelligence Applications

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Abstract

This research paper aims to explore the future of cities in light of the unprecedented technological advancement and acceleration of digital technologies and artificial intelligence applications. Digital transformation has become a strategic imperative rather than a mere form of organizational luxury, making it incumbent upon states and institutions to integrate digital technology into their policies, plans, and various functions, including management approaches, work organization, and service delivery to citizens. At the urban management level, digital transformation has presented new opportunities and prospects that support urban organization, sustainability, and improved service quality. Simultaneously, this paper seeks to elucidate the major challenges impeding the digital transformation of cities, including social, technical, and legal challenges, through systematic analysis of the most important academic research in this field.

Keywords: Digital transformation, Artificial Intelligence, Smart cities, Digital governance, Urban sustainability, urban governance.

1. Introduction

Technological development and the digital revolution have brought about tangible changes in social and economic structures, which in turn have produced new forms of relationships and interactions within the modern city. Digital transformation has affected all aspects of urban life. What has further reinforced the concept of digital transformation is the orientation of states and governments toward adopting formal policies that encourage and urge both state institutions and citizens alike to embrace the digital transformation pathway (Şahnagil et al., 2022). However, these ideas have encountered diverse and competing opinions, ranging from acceptance and rejection to concerns and numerous questions about the prospects and challenges of digital transformation. Opinions have become divided between supporters and opponents. The first group hopes that artificial intelligence systems and applications will help us achieve a qualitative leap in urban planning and management and in finding solutions to urban problems and raising the standard of urban prosperity. The second group, meanwhile, is plagued by concerns and fears that machines will control our destinies and expose us to technical and security problems, social and ethical crises, and challenges that exceed our human capabilities (Benaouda, 2024).

2. Research Problematic

The world is experiencing accelerated urbanization that exerts enormous pressure on resources and infrastructure within cities, which has prompted decision-makers to adopt the path of digital transformation as a strategic choice for managing this complexity (Şahnagil et al., 2022). In recent years, the matter has gone beyond merely digitizing administrative procedures; it has reached the point of integrating artificial intelligence applications into the very fabric of the urban landscape with the aim of achieving sustainable development within cities and improving citizens' quality of life (Benaouda, 2024). However, this technical transition has brought with it new ethical and technical challenges. To discuss these ideas, we adopted the descriptive-analytical method to study recent literature on this subject. The study's problematic was centered around the following main research question:

Main Research Question:

How can modern cities adopt the path of digital transformation and exploit artificial intelligence technologies in their urban systems in a way that promotes efficiency and sustainability, while ensuring the protection of privacy, reducing technological dependence, and maintaining social justice? From the main question, we derived three sub-questions:

- What are the most important characteristics of digital transformation in contemporary cities?
- What opportunities will digital transformation provide for improving the efficiency of urban services, sustainability, and raising the standard of quality of life for citizens?
- What are the challenges and obstacles that stand in the way of digital transformation?

3. Conceptual Framework

Artificial intelligence is closely linked to various aspects of life and fields of knowledge. Formulating a unified and comprehensive concept is extremely difficult. Moreover, there exists variation in temporal, spatial, epistemological, and technological contexts in the definitions provided for the concept of artificial intelligence due to the rapid advancement of this field of knowledge, which prevents the achievement of comprehensive consensus on a specific definition within scientific communities .

3.1 Digital Transformation

Researcher Mohamed Haitham provided a precise definition of the concept of digital transformation after compiling existing definitions from modern literature, specialized academic literature, and websites of specialized private companies such as IBM, Google, and Oracle, which amounted to 56 definitions (Mohamed Haitham, 2023). After reviewing and refining them, he concluded the following:

Digital transformation is a process that employs digital technologies to change business models and business processes in a government or commercial institution, with the aim of creating value for the consumer (customers or citizens) (Mohamed Haitham, 2023). He also defined it as a process that employs digital technologies (big data and data mining, computers, and Internet of Things) with the aim of changing the manner of management, business models, and services.

West (2001) defined it as the use of information technology, particularly web-based Internet applications, to support and facilitate citizen access to services provided by local government, in addition to providing services to the business sector and various government entities.

3.2 Artificial Intelligence

Artificial Intelligence is the field that seeks to understand the nature of human intelligence by creating computer programs that imitate intelligent actions, deeds, or behaviors (Al-Obeidi, 2015). Artificial intelligence is considered that research in the field of emerging technological sciences through simulating human intelligence and extending it through certain machines that perform the same processes that the human brain performs, such as perception, memory, mental abilities, and the capacity to perform thinking functions (Wang, 2023).

A high-level team of experts in the field of artificial intelligence has proposed an expanded definition of artificial intelligence, defining it as systems or devices programmed and designed by humans that operate in the digital or physical dimension, with the aim of achieving complex goals through perceiving the environment and obtaining and interpreting data, and reasoning about knowledge or processing a set of information derived from collected data, and subsequently determining the optimal action to achieve the defined goal (Amer, 2025).

4. Digital Transformation as a Lever for Efficiency and Sustainability

The modern city relies on its infrastructure and operational functions on integrated systems of information and communications technology. One of its fundamental characteristics is its adoption of a human-centric philosophy, whereby technology is used for dynamic response to economic, cultural, and social variables, with the aim of improving quality of life and urban well-being. We can distinguish between two developmental pathways for the emergence of these cities: either they are designed and created as completely smart entities from the beginning, or they evolve through gradual transformation of traditional urban structures. Digital transformation and the adoption of artificial intelligence applications in urban management open numerous opportunities, of which we mention the following:

4.1 Improving Urban Planning and Data-Driven Decision-Making

The increasingly accelerated pace of urban expansion in recent decades has introduced significant complexities to urban structures and functions, challenging planners to develop effective and responsive management strategies. These increasing complexities require advanced techniques, such as three-dimensional modeling and simulation, to improve the prediction and management of the impacts of urban development. The integration of three-dimensional modeling into urban planning has proven its importance in facilitating more flexible frameworks that can adapt to changes over time and meet current and future urban needs (Shariatpour & Behzadfar, 2024).

In this context, the Decision Support System (DSS) is a set of information systems that support decision-making activities in the city, The DSS serves the levels of planning, design, management, and operation in the city and helps urban stakeholders make decisions about problems that may change rapidly, cannot be easily identified in advance, or are complex in nature (Bibri, 2021).

Consequently, decisions can be made entirely by the machine, rely on the human element, or be a mixture of both. At the technical level, the DSS sifts through and analyzes vast quantities of data, compiling comprehensive information from heterogeneous sources that can be used to solve problems and make decisions. This relates to various urban domains, including transportation, traffic, mobility, energy, air and noise pollution, waste, parking, lighting, public safety, healthcare, and education (Bibri, 2021).

4.2 Resource Management and Environmental Sustainability

Artificial intelligence applications have made it possible to monitor and analyze environmental phenomena with an unprecedented level of detail and precision, providing the foundation for making informed decisions to formulate effective policies for environmental protection and resource sustainability by designing interventions commensurate with specific environmental contexts, whether tracking deforestation patterns in the Amazon, monitoring water quality in a local river, or assessing the impact of urban development on wildlife, among others (Ali & Khattak, 2023). Big data plays a central role in data collection, processing, and interpretation. Furthermore, it helps allocate resources such as water, energy, and land, allowing for efficient and sustainable use. Predictive modeling constitutes another key aspect, as it exploits big data to predict trends and threats, facilitating the adoption of proactive rather than reactive measures in environmental protection and resource management (Ali & Khattak, 2023).

Studies in urban resource management emphasize that advanced digitalization (smart grids, smart meters, smart lighting systems) enables reduction of energy consumption and carbon emissions in cities through precise monitoring and automatic adjustment of consumption. Digital transformation solutions also contribute to improved water and waste management through real-time tracking of leaks and fill levels, which promotes usage efficiency and reduces waste and urban pollution (Kumar et al., 2024).

Artificial intelligence applications have also improved environmental performance metrics such as energy efficiency, carbon sequestration, and weather forecasting. Artificial intelligence can integrate Internet resources to provide accurate and timely predictions about climate change, enabling more effective solutions. These technologies have helped reduce resource consumption, improve energy efficiency, and minimize waste (Kumar et al., 2024). Consequently, digital transformation should not be viewed merely as technical tools but as an indispensable element that opens promising horizons for building a sustainable lifestyle and a more balanced and harmonious relationship with cities and the planet alike.

4.3 Electronic Governance and Improving Quality of Life and Public Services

The foundation of electronic governance is public participation and disclosure of public information, transparency in decisions, and citizen engagement. Citizen participation enables them to discuss public policies for the cities in which they live and to acknowledge the views and perspectives of diverse groups of citizens in order to achieve integration of national policy

In this context, the Organization for Economic Cooperation and Development (OECD) identified in 2015 six cumulative steps for public participation, beginning with communication,

then consultation, then participation, then citizen representation in decision-making bodies, then partnership, and finally shared decision-making and co-production (Araby, 2024). Furthermore, digital governance is a mechanism for transparency and the prevention and combating of corruption, and these efforts are crystallized in fundamental legal reforms in various sectors, ensuring the rule of law and promoting good governance through establishing ethics in public life and supporting participatory democracy, to build a better future for generations to come (Laib & Laib, 2025).

Through activating the digital community to empower citizens to participate effectively in public affairs and contribute collectively to formulating state policies, the citizen is considered not merely a member of a society but also a member of a political community governed by the state, and digitalization grants him the opportunity for effective participation in political life (Gardenier et al., 2023).

Among the advantages of adopting artificial intelligence-supported electronic governance is the simplification and facilitation of public services for citizens within cities. For example, artificial intelligence-powered chatbots can provide citizens with access to information and services twenty-four hours a day, seven days a week, which improves accessibility and reduces bureaucratic delays. This not only improves service delivery (Muñoz, 2024) but also increases citizen satisfaction by facilitating their access to the assistance they need at any time and place, thereby improving the overall user experience. Digitalization also enables the opening of platforms for public services that reduce corruption and nepotism in public administrations, which has a significant effect on citizen satisfaction (Kalisa & Anatole, 2024).

5. Challenges of Digital Transformation

The potential gains of urban digital transformation are accompanied by fundamental challenges that we will attempt to identify in detail by classifying them into three main axes:

5.1 Technical Challenges

- The Challenge of Data Collection in Developing Countries

Data collection represents significant difficulties for researchers. Maintaining data integrity is one of the most important aspects of maintaining research result reliability. However, the social and economic situation of research subjects, their education levels, and their ability to express themselves vary significantly, especially in developing countries, making challenges multiply and limiting data collection to government institutions in these countries (Aiyub et al., 2020). The data becomes influenced by political and ideological orientations, in addition to lack of awareness regarding the importance of data collection. All of this impedes the path of digital transformation due to the fragility of the foundation upon which the entire digital transformation process rests.

- The Challenge of the Digital Divide

The distribution and application of digital technologies in public domains is unequal and contradictory. As a result, a situation arises in which some communities enjoy access to and can widely utilize the fruits of digitization while other communities are deprived of this opportunity. The inequality in accessible access to digital technologies and their possession creates what has been termed the digital divide. The digital divide has multiple dimensions, but

three of its types are considered most important from a referential perspective:

- The divide between urban and rural areas.
- The divide between different types of social and economic groups.
- The global divide between developed and developing countries.

Inequality in educational attainment and income distribution in nearly every community plays a decisive role in forming and deepening the digital divide. According to statistical surveys, individuals with higher education have the ability to use digital technologies at a rate ten times higher than individuals with secondary education. High-income individuals and families are likely to access the Internet and digital technologies twenty times more than low-income individuals.

The digital divide widens further on a global scale, as approximately half of the world's population, estimated at about 4 billion people, cannot access the Internet, and in most developing countries, only 20% have access to digital technologies (Travkina, 2022).

- The Challenge of Maintaining Privacy

Privacy issues have emerged as one of the most prominent contemporary challenges resulting from continuous technological acceleration. Personal data has become a valuable resource that is extracted and employed for multiple commercial and political purposes. This reality has exacerbated concerns related to security breaches, theft of personal information, and government surveillance practices, as well as raising other ethical issues related to data use on social media platforms, a matter that has provoked widespread criticism of those platforms and their practices (Kirkit, 2019).

The process of collecting user data begins at the moment the user browses a website through certain elements contained in the web page, such as the Internet Protocol address or what is known in short as the IP address. Through tracking the protocol address, access is gained to users' personal data and identification of cookies on the device performing the internet browsing. Cookies are small text files sent by network communications belonging to websites we visit and allow the website to identify our data and device data (Kirkit, 2019).

- The Challenge of Cybercrime

Cybercrime encompasses a wide range of illegal acts committed over the Internet or other digital devices, including fraud, identity theft, hacking, malware distribution, and child sexual exploitation. Girls are often the primary targets of these various forms of cybercrime (Suparto et al., 2024). For this reason, there is international consensus on the necessity of unifying laws and intensifying efforts to combat global cybercrime. However, national implementations often vary, which is attributable to differences in legal frameworks, technological capabilities and resources, and available technological infrastructure for monitoring and prosecution, as well as the level of priority each country allocates to cybercrime within its legal and security agenda (Allahrakha, 2024).

5.2 Ethical and Social Challenges

- The Ethical Challenge

Artificial intelligence applications and systems have contributed to improving human quality of life in several domains such as health, education, environment, and security, among others. The machine now assists humans in making decisions based on the massive data it collects, organizes, coordinates, and analyzes. In some

cases, the machine substitutes for humans in decision-making. Here arises a fundamental question: do machines governed by artificial intelligence technology have ethical considerations?

Through examples provided by Mark Coeckelbergh, a Belgian philosopher specializing in the philosophy of technology, the ethical challenges that transcend the algorithms upon which artificial intelligence technology is built become evident (Coeckelbergh, 2020). Coeckelbergh asks: if an autonomous vehicle encounters a situation in which it must choose between colliding with a child or colliding with a wall to save the child's life but with the risk of killing its passenger, what does it choose? Should autonomous lethal weapons be licensed in the first place? How many decisions do we want to delegate to artificial intelligence, and who will be responsible when an error occurs (when the machine makes a mistake)? (Coeckelbergh, 2020)

Moreover, studies have shown that some predictions made by artificial intelligence applications regarding individuals likely to reoffend were erroneous, and that the highest percentage of those recommended by the algorithm were individuals with Black skin, which constitutes racial and unethical classification that reinforces bias and injustice. Certain social, economic, or ethnic groups become targets for police surveillance to a greater degree than others.

- Social Challenges

A person who suffers from limited access to digital resources or a low level of digital literacy is marginalized and isolated from the world. This will lead to the formation of inequality, which will intensify over time until it becomes one of the causes of disconnection from the social community, ultimately leading to the individual's exit from the digitization sphere. Therefore, the impact of digitization on the formation of social capital is complex and multifaceted, depending on the state's developmental strategy in this direction (Polishchuk et al., 2024).

We find that the digital space has created new forms of interaction (conversations, blogs, electronic games, markets, cinemas, cafes, etc.) that emerge from digital social networks and in turn shape individual identity, while cultural and social identity becomes obscured. Individual identity may become a factor that weakens team values and reduces opportunities for its success, as the loss of team spirit in the digital environment can lead to civilizational disasters. The dispersion of people in society will not allow for the preservation of balance between the natural world and technology, nor will it preserve the experience, traditions, and values that have accumulated in the previous generation, which form the social and cultural foundation for the next generation (Sirotkin et al., 2021). Consequently, individuals find themselves between the harshness of reality and the digital mirage.

6. Conclusion

The study concluded that digital transformation in urban cities is no longer a luxury option but rather an urgent strategic imperative to ensure sustainability in the face of demographic and environmental pressures, emphasizing that the integration of artificial intelligence requires prudent governance to mitigate its inherent risks. The findings demonstrated that the transition toward "data-driven planning" constitutes the fundamental pillar for achieving operational efficiency, provided that technology remains an instrument for the "humanization of cities" and the enhancement of quality of life without

erasing cultural identity and social bonds. Conversely, the study cautioned against the structural challenges embodied in the "digital divide," which may exacerbate class disparities and jeopardize social justice, alongside the intricate ethical dilemmas pertaining to data privacy and algorithmic bias. Consequently, the future of cities hinges upon the adoption of a holistic approach that synthesizes technical solutions with stringent legislative and ethical frameworks, thereby establishing "digital citizenship" and ensuring that technology is harnessed in service of humanity whilst safeguarding it against the perils of social alienation.

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