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Case study article

Smart and Sustainable Cities: The Case of Amman, Jordan

Ra'Fat A. Al-Msie'deen

Department of Software Engineering, Faculty of IT, Mutah University, Mutah 61710, Karak, Jordan

Correspondence
*Ra'Fat A. Al-Msie'deen
Department of Software Engineering, Mutah University.
Email: rafatalmsiedeen@mutah.edu.jo

Abstract
In an era shaped by rapid urbanization and digital transformation, smart cities have become a global imperative for sustainable, efficient, and citizen-centric development. This article analyzes Amman's development into a smart city, highlighting its role as a model for emerging urban areas. Leveraging recent technologies such as AI, IoT, blockchain, and big data, Amman is actively transitioning from a traditional city to a smart one enhancing mobility, energy efficiency, education, healthcare, and citizen engagement. This study examines Amman's smart city vision and roadmap, technological infrastructure, key application domains, implemented innovation projects, and global rankings. It also explores the challenges the city faces, future research opportunities across various domains, the role of software in urban development, and the critical factors contributing to Amman's success as a smart city. This article serves as a vital reference for researchers, policymakers, urban planners, and practitioners aiming to shape next-generation smart cities. The case of Amman underscores how strategic governance, public-private collaboration, and the effective use of emerging technologies can accelerate sustainable urban transformation.

Keywords
Smart city, Amman city, Urban sustainability, Artificial intelligence, Internet of Things.

I. INTRODUCTION

As societies advance, Information and Communication Technology (ICT) has experienced considerable growth and transformation. Technologies such as the Internet of Things (IoT) and cloud computing have gained prominence in recent years [1]. These technologies are becoming integral to the evolution of cities. Consequently, urbanization and advancements in ICT have led to the emergence of the Smart City (SC) paradigm [2].

SCs have undergone substantial development in recent years, significantly expanding their capabilities across various domains. Broadly defined, a SC is an urban area that leverages ICT to enhance the quality of life for its residents, while also improving the sustainability, efficiency, and responsiveness of city operations. These modern urban environments rely on advanced ICT infrastructure to address the evolving needs and expectations of their citizens [3].

According to recent studies, by 2030, sixty percent of the country's population will reside in modern cities [4]. This trend presents a significant challenge for governments, as managing large urban populations with traditional methods becomes increasingly difficult particularly as the demand for services rises. SCs, equipped with advanced ICT infrastructure, offer a solution by enabling more efficient management of growing urban populations and their diverse needs.

IoT technology embeds sensors into everyday objects and uses connectivity to enable data exchange across various applications. In cities, where objects outnumber people, IoT offers vast connectivity potential. Unlike the internet's network grid, IoT is a mesh of interconnected devices that manage large volumes of urban data. In SCs, IoT enables platforms like sensors and cameras to collect and share information, supporting data-driven decisions for efficient city management [5]-[7].

Over the past two decades, the concept of SCs has gained popularity, though confusion remains due to overlapping terms and definitions [8]. Today, the SC paradigm is recognized as a promising and practical approach. Each SC has distinct characteristics, requirements, and infrastructure, with citizens expecting flexible, comfortable, and high-quality services.

Many definitions of SCs exist [8]-[12]. In this article, a SC is defined as a city that integrates up-to-date traditional infrastructure (*e.g.,* streets, hospitals, schools) with modern communication technologies (*e.g.,* ICT, AI, IoT) to enhance citizens' quality of life, optimizing urban services such as education, healthcare, energy, agriculture, food, waste, and traffic management.

Since the emergence of SC paradigm, several researchers have attempted to propose the most suitable architecture based on ICT solutions [2]. Due to the diverse requirements and varying conditions in cities implementing SC architectures, these implementations lack standardization and thus exhibit diverse characteristics [13]. Cloud, Fog, and Edge computing architectures complement one another and can operate simultaneously within a single urban setting, each providing unique functionalities.

There is no single ideal architecture for SCs. Cloud computing uses layered services, while fog computing extends cloud by processing data locally to reduce latency. Edge computing processes data directly at the source, such as sensors [2]. These architectures cloud, fog, and edge complement each other and can coexist in the same city, each with unique features [14].

SCs exploit recent technologies such as IoT, smart sensors and cameras, 4G/5G networks, smart traffic lights, and self-driving vehicles to enhance transportation. Moreover, SCs leverage smart meters, smart grids, and renewable energy resources (*e.g.,* wind and solar energy) for effective energy management. Environmental monitoring is improved through the use of air quality sensors and smart waste bins. Furthermore, the public safety sector takes advantage of smart surveillance cameras and emergency response systems [15].

Several domains within SCs benefit from recent technologies. The healthcare domain employs telemedicine platforms and wearable health devices to improve its services. Moreover, citizen engagement is facilitated through web applications and digital participation platforms. Smart buildings also incorporate building management and security systems. In conclusion, data analytics and AI serve as the foundation for these technologies, driving the development of more efficient, sustainable, and livable urban environments.

In this section, the author introduces the SC paradigm, highlights its importance, proposes a definition for a SC, and presents the most common SC architecture. Furthermore, the article covers key topics related to Amman City (named *Philadelphia* in the past). It introduces the city, discusses its vision and roadmap, and outlines the key technologies and application domains. It also presents executed projects within the city, as well as the challenges Amman faces and potential research opportunities. Finally, the article reviews Amman's global ranking and identifies the key factors behind its success as a SC.

The subsequent sections of this article address the following topics: Section II presents Amman city as a smart and sustainable city, and, finally, section III gives a summary of this work.

II. AMMAN SMART CITY

This section presents Amman as a smart and sustainable city. Amman was ranked 127th in the IMD Smart City Index 2025 (127 out of 146 cities worldwide), moving up from 128th place in the 2024 index (128 out of 142 cities worldwide) [16]. As the capital of Jordan, Amman is situated in the northwestern region of the Kingdom. The city covers an area of approximately 7,579 km², and its population is expected to reach 6 million by the end of 2025.

Amman was initially developed as a conventional city with fundamental infrastructure, including buildings and roads. Today, it integrates advanced technologies such as 4G/5G networks, Artificial Intelligence (AI), blockchain, and others (see Fig. 1).

Fig. 1. Overview of Amman as a smart and sustainable city.

A. Amman's Vision and Roadmap

Amman's long-term vision aims to significantly enhance the quality of life for its residents by leveraging advanced and emerging technologies, while promoting a flexible and sustainable model of urban development. At the core of its Smart City (SC) approach are three foundational pillars: the integration of automation through the latest technological innovations, the re-engineering of business and administrative processes to increase efficiency, and fostering strategic partnerships with the private sector to support implementation.

The city's strategic roadmap involves identifying key resources necessary for realizing the SC vision, understanding and evaluating the diverse needs of stakeholders and end-users, and selecting high-potential projects that align with the broader urban development goals. Fig. 2 highlights essential information and structural features of Amman City.

In 2019, the Greater Amman Municipality (GAM) created a SC roadmap for Amman [17]. This plan leverages advancements in technologies such as AI and big data to address the city's urban planning challenges. Additionally, it aims to expand the use of e-services and automate processes across various ministries to enhance transparency and boost the efficiency of government operations. The roadmap also focuses on improving city services and alleviating traffic congestion within Amman.

To date, there is no dedicated department specifically tasked with developing Amman as a sustainable and SC. However, such a department could be established in the near future to oversee and coordinate all SC initiatives.

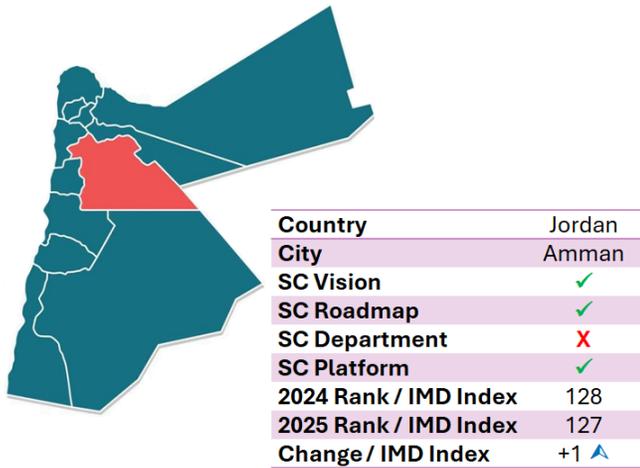| Country	Jordan
City	Amman
SC Vision	✓
SC Roadmap	✓
SC Department	✗
SC Platform	✓
2024 Rank / IMD Index	128
2025 Rank / IMD Index	127
Change / IMD Index	+1 ▲

Fig. 2. View of Amman city highlighting key aspects of the smart city paradigm.

B. Technology Infrastructure in Amman

Amman was originally developed as a traditional city with basic infrastructure, including buildings, roads, hospitals, universities, schools, and green spaces (*i.e.,* parks). Today, it has adopted advanced technological infrastructure, featuring 4G/5G networks, high-speed communication systems, sensors and surveillance cameras, high-performance computing devices, fast internal networks, modern data centers, disaster recovery solutions, robust firewalls, blockchain technology, cybersecurity systems, AI, IoT, and more.

Today, technology forms the backbone of many SCs around the world. The adoption of advanced technologies such as IoT, big data, AI, and cloud computing aims to tackle key urban challenges and improve various public services and functions. As illustrated in Fig. 3, several of these technologies, including AI, IoT, and blockchain, have been integrated into Amman's infrastructure to support its SC initiatives.

C. Amman Smart City Application Domains

Urban areas encompass multiple domains where the integration of ICT leads to significant transformation. In this study, the author adopts *Yin's* taxonomy of application domains [15], categorizing them into four main groups: business, citizen, environment, and government. Fig. 4 illustrates this taxonomy as a basis for classifying various SC approaches.

As a smart and sustainable city, Amman encompasses various domains, including agriculture, education, healthcare, energy, traffic, and others. It is important to classify each smart initiative in Amman and in other cities into its appropriate category. For example, initiatives aimed at addressing traffic congestion are classified under citizen-related domains.

D. Smart City Projects in Amman

Amman's digital transformation has led to notable advancements across various sectors of the city. Key accomplishments include the full implementation of electronic services, the availability of 134 online services, the adoption of paperless procedures within the GAM, the launch of the GAM mobile application, the introduction of the Unified Inspection System (UIS), the deployment of QR code applications, and a 98% reduction in visits to municipal or government facilities. As illustrated in Fig. 5, several initiatives have been implemented to support Amman's transition toward becoming a SC. These initiatives involve environment, government, business, and citizen.
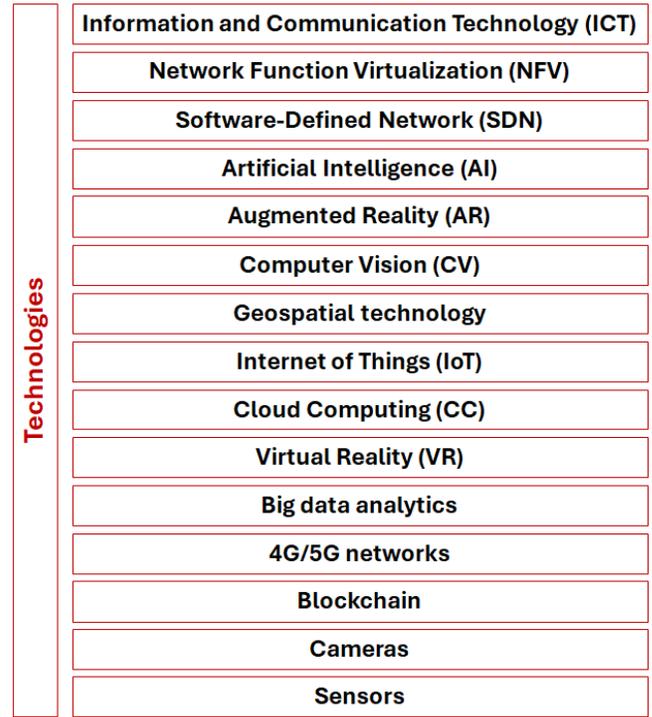
Fig. 3. Smart city technologies: major technologies that define the smartness of a city.
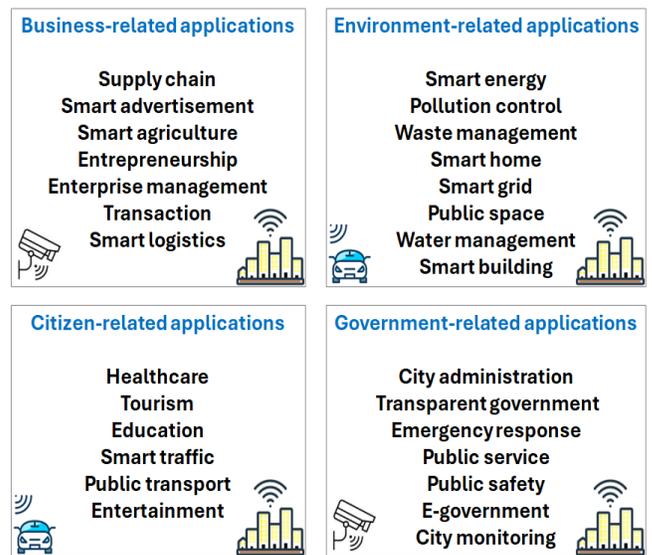
Fig. 4. Application domain taxonomy of various smart city approaches.
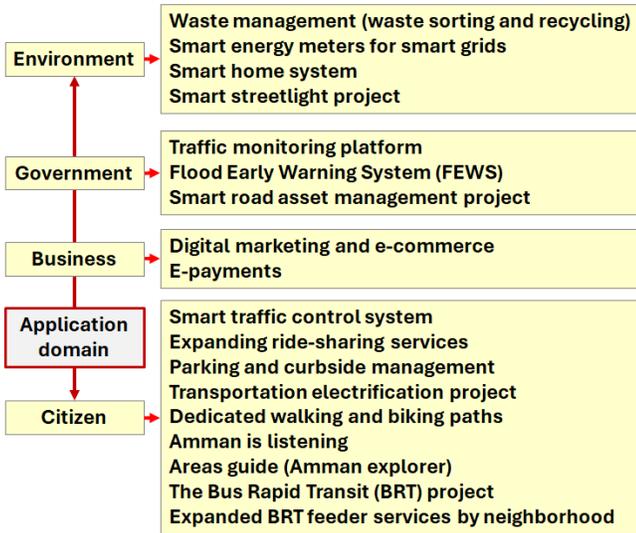
Fig. 5. Summary of smart city projects implemented in Amman city.

The adoption of the SC paradigm in Amman has yielded numerous benefits. These include the implementation of electronic payment systems (*e.g.,* eFAWATEERcom), the delivery of end-to-end digital services, improved efficiency in urban operations and service provision measured by cost, quality, and speed, streamlined procedures through electronic transactions, more effective traffic congestion management, eco-friendly paperless processes, and enhanced employee capabilities through targeted training programs.

E. Challenges Facing Amman as A Smart City

Amman, as a densely urbanized capital, faces a range of ongoing challenges. These include rapid population growth, persistent traffic congestion, a large refugee population in Jordan, limited human resource capacity to implement smart solutions, economic pressures at both regional and global levels, and deeply ingrained citizen behaviors and habits. As shown in Fig. 6, these factors present significant obstacles to Amman's progress toward becoming a SC. The multidisciplinary nature of SCs gives rise to a wide range of research challenges. Some researchers focus on domain-specific challenges [18]–[25], such as those related to agriculture, and healthcare, where each domain presents its own unique set of constraints and requirements. On the other hand, other studies concentrate on open challenges that affect the overall development and sustainability of SCs [26]–[28]. Addressing both types of challenges is essential to ensure the successful implementation and long-term viability of SC initiatives. As the author of this study, I propose a set of open challenges that are critical to the successful development and implementation of SCs. These challenges, derived from both literature insights and personal analysis, include: 1) city infrastructure; 2) data security, safety, and privacy; 3) system interoperability; 4) governance and policy-related issues; 5) coordination and collaboration between the public and private sectors; 6) investment and funding limitations; 7) urban mobility; 8) technological integration; 9) connectivity;

10) public awareness and acceptance; and 11) the transition to sustainable energy sources. These challenges highlight the complex, cross-cutting nature of SC development and underscore the need for holistic, multi-stakeholder approaches in future urban planning.

Jordan's ICT sector particularly in Amman is experiencing rapid growth and plays a vital role in the national economy. As the third-largest contributor to the country's Gross Domestic Product (GDP), it serves as a key driver of sustainable development in the capital. The sector supports the modernization of the public sector and facilitates the implementation of smart infrastructure, including intelligent buildings, advanced transportation systems, digital services, and data-driven solutions. Furthermore, it plays a crucial role in enabling evidence-based policymaking.
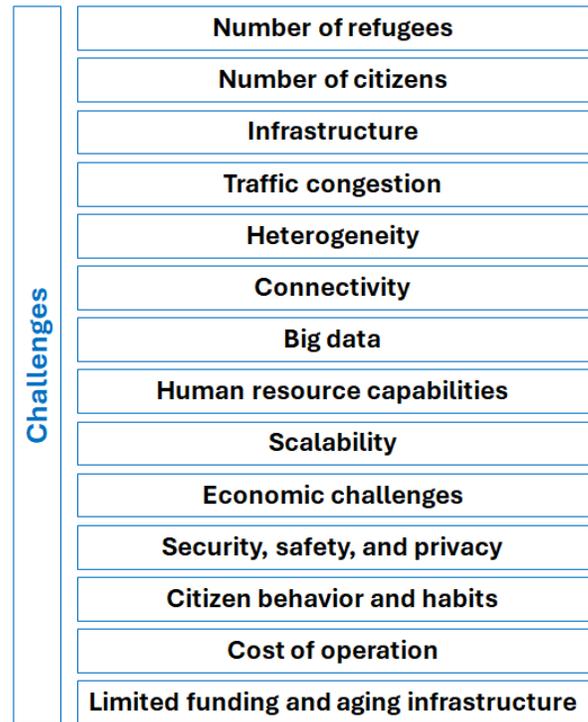

Fig. 6. Smart city challenges in Amman.

F. Research Opportunities within Amman Smart City

Based on the knowledge acquired through literature review, the author proposes several research opportunities grounded in both existing studies and personal insights. Figs. 7 and 8 illustrate these promising opportunities, which are closely aligned with SC paradigm. These research directions are particularly applicable to the development and implementation of smart initiatives in the city of Amman.

Computer Vision (CV) is an interdisciplinary field that enables computers to interpret digital images and videos [29], with promising applications in SCs. As urban populations grow, integrating CV and AI into healthcare and education becomes increasingly important [30] [31]. While healthcare adoption is progressing, education in SCs remains underexplored, offering opportunities for innovation [32]. Moreover, AI can enhance SC performance in areas like traffic management and city monitoring [33], indicating the need for further research.
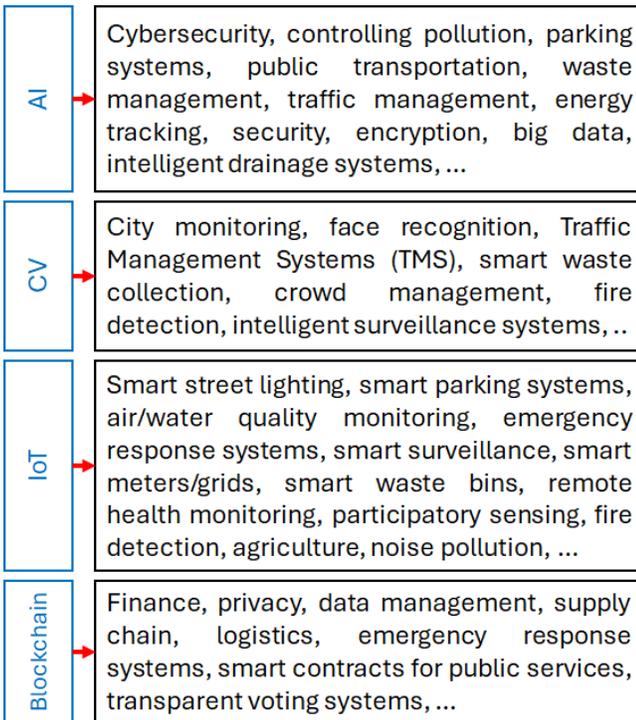
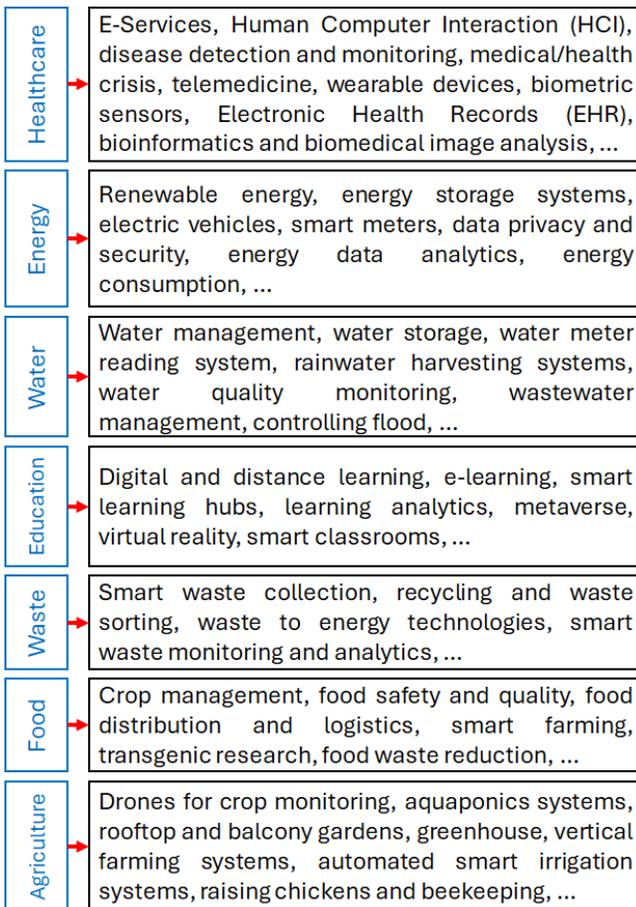Fig. 7. Research opportunities in smart cities for AI, computer vision, IoT, and blockchain.

Fig. 8. Research opportunities in smart cities across sectors including healthcare, energy, water, education, waste management, food, and agriculture.

G. Global Positioning and Ranking of Amman City

Over the past decade, numerous cities around the world have sought to transition from traditional urban models to the SC paradigm. Nevertheless, despite substantial investments from both the public and private sectors, many of these initiatives have fallen short of their intended objectives. Table I presents the top ten SCs for 2025, ranked among 146 global cities.

The data in Table I is drawn from the *IMD Smart City Index 2025* [16], which assesses 146 cities worldwide by combining rigorous academic data analysis with survey responses from 120 residents in each city. This index provides valuable insights into how a city's infrastructure and technological capabilities influence both its overall performance and the quality of life of its residents.

Amman currently ranks 127th out of 146 cities globally in the IMD Smart City Index 2025, indicating room for significant improvement. Despite this, continued efforts and the adoption of innovative strategies can enhance its future standing. One of the city's most pressing challenges is traffic congestion. By upgrading its traditional infrastructure including roads and public facilities and integrating modern technologies, Amman can effectively address these issues. Such advancements are expected to contribute to the city's progression toward a more prominent global position in the near future.

TABLE I.
TOP 10 SMART CITIES IN 2025 BASED ON THE IMD SMART CITY INDEX 2025[16], INCLUDING THEIR 2024 RANKINGS AND CHANGES. AMMAN'S RANKING IS INCLUDED FOR COMPARISON.

City	Country	SC Rank		Rank Change
		2025	2024	
Zurich	Switzerland	1	1	– No change
Oslo	Norway	2	2	– No change
Geneva	Switzerland	3	4	↑ +1
Dubai	UAE	4	12	↑ +8
Abu Dhabi	UAE	5	10	↑ +5
London	UK	6	8	↑ +2
Copenhagen	Denmark	7	6	↓ -1
Canberra	Australia	8	3	↓ -5
Singapore	Singapore	9	5	↓ -4
Lausanne	Switzerland	10	7	↓ -3
Amman	**Jordan**	**127**	**128**	↑ **+1**

H. Key Factors Behind Amman's Success as a Smart City

The success story of Amman as a SC can be attributed to several key factors working together harmoniously. First and foremost, the city's commitment to implementing the right policies and regulations has created a solid foundation for sustainable growth and innovation. These policies not only promote technological advancement but also ensure that development is inclusive and beneficial to all residents. Additionally, the application of sound administrative practices and conditions has been crucial in maintaining efficient governance and seamless coordination among

various city departments and stakeholders. Another significant factor is the strategic allocation and effective management of funds, which has empowered numerous SC initiatives across diverse sectors such as transportation, healthcare, education, energy, and public safety. This financial support has enabled Amman to deploy cutting-edge technologies and infrastructure upgrades that improve the quality of life for its citizens. Furthermore, fostering strong partnerships between the government, private sector, and local communities has encouraged collaboration and innovation, driving the city's digital transformation forward. Together, these elements have positioned Amman as a leading example of smart urban development in the region.

I. The Role of Software Systems in the City of Amman

Software systems [34]–[36] are the driving power behind the development of urban areas. They allow the construction of cutting-edge solutions that improve citizens' quality of life, advance sustainability, and stimulate economic growth. By utilizing the force of technology, Amman City [37] can solve the complex issues of urbanization while forming inclusive, diverse, flexible, and livable societies for coming generations.

SC vendors offer software solutions to assist relevant stakeholders such as application developers and city planners in designing, executing, deploying, and administering SC applications for efficient urban evolution and administration. Numerous software systems are designed for various SC domains, each offering distinct benefits and limitations [38]-[40].

Software is critical to the functionality of urban areas, enabling the effective management of numerous urban systems. It supports real-time data gathering, analysis, and decision-making within various domains such as healthcare and agriculture. Thus, software systems improve public services and enhance the quality of life in cities.

In Amman, software systems play a critical role in managing and operating the city. They are utilized to enhance public services, improve the quality of life for citizens, and manage the city's resources. Additionally, they help make Amman more responsive and efficient by automating procedures, analyzing data, and facilitating communication.

III. Summary

This article explores the evolution of Amman, Jordan, into a smart and sustainable city, positioning it as a case study for urban digital transformation in the Middle East. The paper begins by introducing SC paradigm, highlighting the pivotal role of ICT, IoT, AI, and other emerging technologies in shaping modern urban environments. It proposes a working definition of a SC and discusses leading architectures such as cloud, fog, and edge computing.

The study then shifts focus to Amman, offering a detailed overview of the city's infrastructure, vision, digital roadmap, and international ranking. It identifies the key technologies adopted by the city including AI, block chain, and 5G networks and classifies SC applications across four domains:

business, citizen, environment, and government. Specific projects implemented in Amman are examined, such as streetlight project, traffic control system, digital waste management, and the bus rapid transit initiative.

The article also outlines critical challenges facing Amman's SC ambitions, such as rapid urban growth, infrastructure limitations, refugee influx, funding gaps, and data privacy concerns. To address these, the author proposes a set of open research opportunities in sectors like healthcare, energy, education, and urban planning, particularly emphasizing the potential of AI, computer vision, IoT, and blockchain. Furthermore, the author identified key open challenges essential to the effective development and implementation of SCs. The study also emphasized the role of software in urban transformation and outlined the critical factors behind Amman's success as a SC.

In conclusion, the study affirms that while Amman has made commendable progress toward becoming a SC, continuous investment in technology, governance reform, stakeholder collaboration, and education are essential for sustaining this transformation. The article serves as both a practical roadmap and a scholarly reference for researchers, planners, and policymakers interested in SC development in emerging regions.

References

[1] P. Bellini, P. Nesi, and G. Pantaleo, "IoT-enabled smart cities: A review of concepts, frameworks and key technologies," *Applied Sciences*, vol. 12, no. 3, 2022. https://doi.org/10.3390/app12031607

[2] R. Sanchez-Corcuera, A. Nunez-Marcos, J. Sesma-Solance, A. Bilbao-Jayo, R. Mulero, U. Zulaika, G. Azkune, and A. Almeida, "Smart cities survey: Technologies, application domains and challenges for the cities of the future*," Int. J. Distributed Sens. Networks,* vol. 15, no. 6, 2019, https://doi.org/10.1177/1550147719853984

[3] B. Hamid, N. Jhanjhi, M. Humayun, A. Khan, and A. Alsayat, "Cyber security issues and challenges for smart cities: A survey," *in 2019 13th International Conference on Mathematics, Actuarial Science, Computer Science and Statistics*, 2019, pp. 1–7. doi:10.1109/MACS48846.2019.9024768

[4] A. AlDairi and L. Tawalbeh, "Cyber security attacks on smart cities and associated mobile technologies," *Procedia Computer Science*, vol. 109, pp. 1086–1091, *2017 8th International Conference on Ambient Systems, Networks and Technologies, ANT-2017 and the 7th International Conference on Sustainable Energy Information Technology, SEIT 2017*, 16-19 May 2017, https://doi.org/10.1016/j.procs.2017.05.391

[5] J. Tan, X. Sha, T. Lu, and B. Dai, "A short survey on future research of AI and IoT technologies," *in 2022 International Wireless Communications and Mobile Computing (IWCMC),* 2022, pp. 190–195, doi:10.1109/IWCMC55113.2022.9825425

[6] T. Hoon Kim, C. Ramos, and S. Mohammed, "Smart city and IoT," *Future Generation Computer Systems*, vol. 76, pp. 159–162, 2017,

https://doi.org/10.1016/j.future.2017.03.034

[7] R. Chataut, A. Phoummalayvane, and R. Akl, "Unleashing the power of IOT: A comprehensive review of IOT applications and future prospects in healthcare, agriculture, smart homes, smart cities, and industry 4.0," *Sensors*, vol. 23, no. 16, 2023, https://doi.org/10.3390/s23167194

[8] U. B. Vito Albino and R. M. Dangelico, "Smart cities: Definitions, dimensions, performance, and initiatives," *Journal of Urban Technology*, vol. 22, no. 1, pp. 3–21, 2015,
https://doi.org/10.1080/10630732.2014.942092

[9] G. C. Lazaroiu and M. Roscia, "Definition methodology for the smart cities model," *Energy*, vol. 47, no. 1, pp. 326–332, 2012, asia-Pacifi c Forum on Renewable Energy 2011,
https://doi.org/10.1016/j.energy.2012.09.028

[10] M. Al-Hader, A. Rodzi, A. R. Sharif, and N. Ahmad, "Smart city components architecture," *in 2009 International Conference on Computational Intelligence, Modelling and Simulation*, 2009, pp. 93–97, doi: 10.1109/CSSim.2009.34

[11] S. Yamamoto, S. Matsumoto, and M. Nakamura, "Using cloud technologies for large-scale house data in smart city," *in 4th IEEE International Conference on Cloud Computing Technology and Science Proceedings*, CloudCom 2012, Taipei, Taiwan, December 3-6, 2012. *IEEE Computer Society*, 2012, pp. 141–148,
https://doi.org/10.1109/CloudCom.2012.6427546

[12] A. Monzon, "Smart cities concept and challenges: Bases for the assessment of smart city projects," 2015 International Conference on Smart Cities and Green ICT Systems (SMARTGREENS), Lisbon, Portugal, pp. 1-11, 2015, https://doi.org/10.1007/978-3-319-27753-0_2

[13] F. Longo, A. Puliafi to, and O. Rana, "Guest editors' introduction to the special issue on fog, edge, and cloud integration for smart environments," *ACM Trans. Internet Technol*., vol. 19, no. 2, 2019, https://doi.org/10.1145/3319404

[14] A. Almeida, R. Mulero, P. Rametta, V. Urosevic, M. Andric, and L. Patrono, "A critical analysis of an IoT—aware aal system for elderly monitoring," *Future Generation Computer Systems*, vol. 97, pp. 598–619, 2019, https://doi.org/10.1016/j.future.2019.03.019

[15] C. Yin, Z. Xiong, H. Chen, J. Wang, D. Cooper, and B. David, "A literature survey on smart cities," *Sci. China Inf. Sci*., vol. 58, no. 10, pp. 1–18, 2015, https://doi.org/10.1007/s11432-015-5397-4

[16] IMD. (2025) IMD - smart city index 2025, https://www.imd.org/smart-city observatory/home/

[17] GAM. (July 2022) Voluntary local review - the city of Amman, Jordan,
https://www.ammancity.gov.jo/

[18] D. Balsamo, G. V. Merrett, B. Zaghari, Y. Wei, S. Ramchurn, S. Stein, A. S. Weddell, and S. Beeby, "Wearable and autonomous computing for future smart cities: Open challenges," *in 2017 25th International Conference on Software, Telecommunications and Computer Networks (SoftCOM)*, 2017, pp. 1–5, doi: 10.23919/SOFTCOM.2017.8115596

[19] A. S. Syed, D. Sierra-Sosa, A. Kumar, and A. Elmaghraby, "IoT in smart cities: A survey of technologies, practices and challenges," *Smart Cities*, vol. 4, no. 2, pp. 429–475, 2021, https://doi.org/10.3390/smartcities4020024

[20] R. Jos´e and H. Rodrigues, "A review on key innovation challenges for smart city initiatives," *Smart Cities*, vol. 7, no. 1, pp. 141–162, 2024, https://doi.org/10.3390/smartcities7010006

[21] A. Szorenyi, "The use of artificial intelligence in cities - what opportunities and challenges does AI pose in cities and how can international organizations support AI's ethical use," The Global Cities Hub - Geneva, pp. 1–12, 2024,
https://globalcitieshub.org/en/the-ethical-use-of-artifi cial-intelligence-in-cities/

[22] A. Moghayedi, I. Richter, F. M. Owoade, K. K. Kapanji-Kakoma, E. Kaliyadasa, S. Francis, and C. Ekpo, "Eff ects of urban smart farming on local economy and food production in urban areas in African cities," *Sustainability*, vol. 14, no. 17, 2022, https://doi.org/10.3390/su141710836

[23] H. Yadav, U. Soni, and G. Kumar, "Analyzing challenges to smart waste management for a sustainable circular economy in developing countries: A fuzzy DEMATEL study," *Smart and Sustainable Built Environment*, vol. 12, no. 2, pp. 361–384, February 2023, https://doi.org/10.1108/SASBE-06-2021-0097

[24] A. A. Musa, S. I. Malami, F. Alanazi, W. Ounaies, M. Alshammari, and S. I. Haruna, "Sustainable traffic management for smart cities using internet-of-things-oriented intelligent transportation systems (ITS): Challenges and recommendations," *Sustainability*, vol. 15, no. 13, 2023, https://doi.org/10.3390/su15139859

[25] S. Renukappa, P. Mudiyi, S. Suresh, W. Abdalla, and C. Subbarao, "Evaluation of challenges for adoption of smart healthcare strategies," *Smart Health*, vol. 26, p. 100330, 2022,
https://doi.org/10.1016/j.smhl.2022.100330

[26] J. V. den Bergh and S. Viaene, "Key challenges for the smart city: Turning ambition into reality," *in 48th Hawaii International Conference on System Sciences*, HICSS 2015, Kauai, Hawaii, USA, January 5-8, 2015, T. X. Bui and R. H. S. Jr., Eds. IEEE Computer Society, 2015, pp. 2385–2394,
https://doi.org/10.1109/HICSS.2015.642

[27] S. A. Ali, S. A. Elsaid, A. A. Ateya, M. ElAff endi, and A. A. A. El-Latif, "Enabling technologies for next-generation smart cities: A comprehensive review and research directions," *Future Internet*, vol. 15, no. 12, pp. 1–43, 2023, https://doi.org/10.3390/fi15120398

[28] T. Singh, A. Solanki, S. K. Sharma, A. Nayyar, and A. Paul, "A decade review on smart cities: Paradigms, challenges and opportunities," *IEEE Access*, vol. 10, pp. 68 319–68 364, 2022,
https://doi.org/10.1109/ACCESS.2022.3184710

[29] L. Zou, "Chapter 5 - meta-learning for computer vision," in Meta-Learning, L. Zou, Ed. Academic Press, 2023,

pp. 91–208, https://doi.org/10.1016/B978-0-323-89931-4.00012-2

[30] Z. Mohammadzadeh, H. R. Saeidnia, A. Lotfata, M. Hassanzadeh, and N. Ghiasi, "Smart city healthcare delivery innovations: a systematic review of essential technologies and indicators for developing nations," *BMC Health Services Research*, no. 1180, pp. 1–14, 2023,
https://doi.org/10.1186/s12913-023-10200-8

[31] S. Dubey and A. K. Tiwary, "Smart education based on blockchain technology," *in 2023 International Conference on Sustainable Computing and Smart Systems (ICSCSS)*, 2023, pp. 1485–1490, doi:10.1109/ICSCSS57650.2023.10169579

[32] J. Kang and W. Yang, "Research on teaching strategies to promote classroom interaction in smart classroom environment," *in 2023 International Symposium on Educational Technology (ISET)*, 2023, pp. 121–123, doi: 10.1109/ISET58841.2023.00032

[33] H. Herath and M. Mittal, "Adoption of artificial intelligence in smart cities: A comprehensive review," *International Journal of Information Management Data Insights*, vol. 2, no. 1, p. 100076, 2022, https://doi.org/10.1016/j.jjimei.2022.100076

[34] R. Al-Msie'deen, "*ScaMaha*: A tool for parsing, analyzing, and visualizing object-oriented software systems," *International Journal of Computing and Digital Systems*, vol. 17, no. 1, pp. 1–20, 2025, http://dx.doi.org/10.12785/ijcds/1571046420

[35] R. Al-Msie'deen, "Requirements Traceability: Recovering and Visualizing Traceability Links Between Requirements and Source Code of Object-oriented Software Systems," *International Journal of Computing and Digital Systems*, vol. 14, no. 1, pp. 279–295, 2023,
http://dx.doi.org/10.12785/ijcds/140123

[36] R. Al-Msie'deen and A. H. Blasi, "Software evolution understanding: automatic extraction of software identifiers map for object-oriented software systems," *Journal of communications software and systems*, vol. 17, no. 1, pp. 20–28, 2021,
http://dx.doi.org/10.24138/jcomss.v17i1.1093

[37] R. Al-Msie'deen, "Amman City, Jordan: Toward a Sustainable City from the Ground Up," *Preprint*, arXiv, 2024,
https://arxiv.org/abs/2408.01454

[38] R. Saborido and E. Alba, "Software systems from smart city vendors", *Cities*, vol. 101, p. 102690, 2020, https://doi.org/10.1016/j.cities.2020.102690

[39] D. E. Okonta and V. Vukovic, "Smart cities software applications for sustainability and resilience," *Heliyon*, vol. 10, no. 12, p. e32654, 2024,
https://doi.org/10.1016/j.heliyon.2024.e32654

[40] D. Chen, L. Wang, and S. Zhou, "Software systems for data-centric smart city applications," *Software: Practice and Experience journal*, vol. 47, no. 8, pp.10431044,2017, https://doi.org/10.1002/spe.2508