

Emirati Journal of Civil Engineering and Applications
Vol 2 Issue 2 (2024)
Pages 64 - 70
Available at
www.emiratesscholar.com

Overview of the Smart City initiatives and challenges in Middle East

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ARTICLE INFO

KEYWORDS
Smart cities; Middle East; Initiative; Project; Management

HOW TO CITE
Daouda, E. (2024). Overview of the Smart City initiatives and challenges in Middle East. Emirati Journal of Civil Engineering and Applications, 2(2), 64-70.
https://doi.org/10.54878/opgm4m83

ABSTRACT

Cities already house half of the world's population, a proportion that is expected to rise to 70% by 2050 (Kirimtat et al., 2020). This expansion has caused cities to expand at an alarming rate, affecting the quality and performance of their services as well as their residents' quality of life. Many countries and governments around the world have begun taking action and developing potential strategies to mitigate the negative effects of overpopulation and climate change, as well as to create urban spaces where people can carry out their daily activities with high success rates in a sustainable, creative, and socially responsible environment. Due to the potential for developing innovative solutions for the social and environmental problems that are constantly changing and evolving based on the responses of the public, the concept of smart cities has recently gained popularity in developed nations primarily in Europe and the USA. Problems related to health, traffic, and pollution, scarcity of resources, waste management and poor infrastructure arises and hence development of city falls apart. These problems undermine the growth of city and dismantle it completely. This has led to application and adaptation of technology as a solution of all these issues hence the concept of Smart Cities is developed. Smart Cities bring solutions to sustainable environment. As a result, numerous governments and businesses from the private sector are starting various field test initiatives all around the world (Lai et al., 2020). Moreover, other regions such as Middle East, UAE and Saudi Arabia have also started considering smart city initiative as modern more accessible alternatives for their needs. This paper will use literature reviews to look at the aspects of "smart cities", their applicability and adoption in Middle East, in addition this paper will discuss the challenges that need to be considered when designing a smart city.

Double-blind peer review by independent reviewers.

Received: 24 Jul 2024, Accepted: 25 Nov 2024, Published: 27 Dec 2024
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Introduction

Cities already house half of the world's population, a proportion that is expected to rise to 70% by 2050 (Kirimtat et al., 2020). This expansion has caused cities to expand at an alarming rate, affecting the quality and performance of their services as well as their residents' quality of life. Many countries and governments around the world have begun researching and developing potential strategies to mitigate the negative effects of overpopulation and climate change, as well as to create urban spaces where people can carry out their daily activities with high success rates in a sustainable, creative, and socially responsible environment. One of the strategies that have highly been recommended by countless studies is the Smart City system. The term "Smart City" was first coined in the late 1990s by the European Union to describe the use of technology and data to improve the quality of life in urban areas. The concept was further developed and popularized in the early 2000s by a number of technology companies, urban planners, and researchers.

Recent technical advances have enhanced the growth of smart cities in world. Smart city model signifies the next phase in the context of urbanization (Kirimtat et al., 2020). Notably, effective functioning of a smart city relies heavily on advanced technology and sophisticated networks. For this reason, smart city technology can be defined as a framework that is primarily and continuously monitored by Information and Communication Technology (ICT) in the development and promotion of services that address some of the most pressing issues of urbanization (Lai et al., 2020). Smart city technology is essentially based on networking intelligence, which enables the wireless exchange of data and information amongst variously networked devices.

Smart city concept

It is crucial to ensure quality of life and sustainable development in the intricate social ecologies of cities and metropolitan areas. Cities are actively exploring ways to achieve the objective of becoming "smart" and managing city resources more efficiently while solving development and inclusion concerns as they become more aware of the idea of the "smart city." The conception of smart city is arrived from the combination of knowledge from the society and digital city (Camero & Alba, 2019). It is basically defined as a multi-layer system of innovation where different forces are brought together to better the system. They include digital networks, individual intelligence, and social capital of the city which together bring about a layer of collective intelligence (Yigitcanlar, Kankanamge & Vella, 2022). Notably, a city is considered intelligent when it achieves economic competitiveness and innovation achieved through combination of knowledge and skills. Notably to achieve this, smart city initiative must have pillars. These pillars include, infrastructure, social, Economy, management, Legal, technology, and management as shown in Figure 1 below. Notably, these pillars cut across all aspects hence effective in middle East.

Social

The concept of smart cities being based on smart communities where citizens can actively participate in the design process is made possible by advancements in communication technology with local organization such as local meetings. Citizens can access information about their communities and explore ways to become involved in the planning process through data, scenarios, and models informed by contemporary technology. However, current forms of participation are still passive, and new media and the web are increasing the fluidity of interaction (Haque, Bhushan, & Dhiman, 2022). Smart cities must also balance the needs of various communities and prioritize the social conditions of their citizens.

Technology

The evolution of technology has allowed modern cities to become smarter by using big data analysis to avoid and anticipate problems. Smart cities must connect various devices and components to enable real-time decision making, increase sustainability, and improve citizens' quality of life (Irvine et al., 2022). Information and communication technology is a significant driver of the smart city initiative, along with other drivers such as sustainability and quality of living, which can transform urban life and improve city management (Suchita & Sujata, 2019). However, technology faces challenges in developing a smart city, such as a limited technologically sound human resource with practical skills, the need for educating and training employees with IT skills, and organizational barriers such as politics, cultural differences, and lack of inter-departmental cooperation.

Legal

The success of the evolution of smart cities relies heavily on adhering to legal requirements. Political bodies, such as councils and governments, have a significant influence on these initiatives. As such, political and legal factors are both crucial for the development of smart cities. To support smart city development, governments and organizing entities should establish policies. Furthermore, government officials must address legal and regulatory concerns to ensure that development is frictionless and sustainable. This involves creating a legal

ISSN: 3006-6948 - https://doi.org/10.54878/opgm4m83

framework that supports the deployment of new technologies and infrastructure, while also protecting the privacy and security of citizens. Officials must also address issues related to data governance, intellectual property, and liability, to ensure that all stakeholders are protected and can benefit from the development of smart cities.

Economy

The push for smart city initiatives is heavily influenced by economic factors. A city's economic competitiveness is a crucial measure of its success as an intelligent city. A smart economy includes various elements related to economic competitiveness such as entrepreneurship, innovation, productivity, and flexibility of the labor market (Vishnivetskaya & Alexandrova, 2019). The ability to innovate and capitalize economically is what distinguishes a city as intelligent. The aim of a smart city is to maximize profits and facilitate the flow of capital, which requires constant economic growth due to the short lifespan of ICTs (Ahad et al., 2020). Government involvement in smart city projects is crucial to ensure that these initiatives benefit the public as a whole rather than just private corporations. Smart city projects are complex and require significant investments, making them attractive to big tech companies that are often motivated by profit rather than the public good. Without government oversight, these companies could monopolize the development of smart city technologies, potentially resulting in unequal access and benefits for different segments of the population.

Sustainability

Sustainability is a development concept that seeks to balance economic, social, and environmental considerations to ensure that present needs are met without compromising the ability of future generations to meet their own needs. It aims to promote economic growth and social progress while also safeguarding the environment, natural resources, and biodiversity. Sustainable development involves using resources efficiently, reducing waste and pollution, promoting renewable energy sources, and preserving ecosystems and biodiversity. This concept recognizes that the planet's resources are finite and that development must be based on responsible and sustainable use. Sustainability is becoming increasingly important in today's world as environmental concerns continue to grow, and people recognize the need to protect our planet for future generations. The Brundtland commission report (The United Nations Report 1987) defines sustainable development in two ways: development that prioritizes the world's present needs, and development that recognizes the limitations of the environment's ability to meet present and future needs, despite unlimited technological advancements. Social, economic, and environmental sustainability are the three main components of sustainable development, which are crucial for cities to maintain a sustainable water, energy, and food supply, as well as to reduce greenhouse gas emissions and manage water resources (Toli, & Murtagh, 2020).

Smart Cities in the Middle East

The Middle East is known for its rich history, culture, and tradition. However, in recent years, it has also become synonymous with rapid urbanization, economic development, and the adoption of advanced technologies. Today, the region is home to some of the fastest-growing cities in the world, with increasing populations, and demand for public services, infrastructure, and resources (Joghee, Alzoubi, & Dubey, 2020). In response to these challenges, policymakers and private sector actors have increasingly turned to smart city development as a means of improving the quality of life for their citizens, promoting sustainable growth, and enhancing the region's global competitiveness.

Smart Dubai initiative

The UAE, in particular, has emerged as a leader in smart city development, with several cities in the country actively pursuing smart city initiatives. For instance, Dubai has launched its Smart Dubai initiative, which seeks to make Dubai the happiest city in the world by leveraging technology to enhance the quality of life of its residents. The initiative includes a range of projects, such as the Smart Transportation project, the Smart Environment project, and the Smart Economy project (Joghee, Alzoubi & Dubey, 2020). The Smart Dubai initiative is a comprehensive plan designed to transform Dubai into a leading smart city by leveraging cutting-edge technologies and innovative strategies. The initiative aims to enhance the quality of life for residents and visitors, boost economic growth, and create a more sustainable and efficient city. This essay will provide an overview of the Smart Dubai initiative, its objectives, and its impact on the city.

The Smart Dubai initiative was launched in 2013 under the guidance of His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai. The initiative is based on three key principles: innovation, integration, and cooperation. The objective of the initiative is to provide a seamless, efficient, and personalized experience for residents, visitors, and businesses in Dubai.

ISSN: 3006-6948 - https://doi.org/10.54878/opgm4m83

One of the primary objectives of the Smart Dubai initiative is to make Dubai a paperless city. This involves digitizing all government transactions, processes, and services. The initiative has led to the development of the Dubai Now platform, which allows residents and visitors to access more than 70 government services online (Sabri, 2021). The platform also includes a feature that enables users to track the progress of their transactions in real-time, reducing the time and effort required to complete government procedures.

The smart transportation projects developed under the Smart Dubai initiative have improved the efficiency and safety of transportation in Dubai. The introduction of driverless vehicles is expected to further reduce the number of accidents on Dubai's roads, and improve traffic flow and travel times (Sabri, 2021).

Abu Dhabi Smart City Initiative

Similarly, Abu Dhabi has launched its Smart City initiative, which aims to improve the city's infrastructure and services by deploying advanced technologies such as artificial intelligence (AI), big data analytics, and the Internet of Things (IoT). The initiative includes projects such as the Smart Lighting project, the Smart Energy project, and the Smart Parking project. The initiative focuses on three main pillars: Smart Infrastructure, Smart Living, and Smart Economy. Each of these pillars is designed to address specific challenges and opportunities facing Abu Dhabi.

Smart Infrastructure is the foundation of the Abu Dhabi Smart City Initiative. It aims to create a reliable and efficient infrastructure that can support the delivery of smart services to citizens and residents. The Smart Infrastructure pillar includes projects such as the deployment of a citywide fiber optic network, the installation of smart streetlights and traffic management systems, and the development of smart grids and renewable energy sources (Noori, Hoppe & de Jong, 2020). These projects are designed to optimize the use of resources, reduce energy consumption, and improve the overall quality of life in Abu Dhabi.

Smart Living is the second pillar of the Abu Dhabi Smart City Initiative. It aims to improve the quality of life for citizens and residents by providing them with access to smart services and amenities. The Smart Living pillar includes projects such as the development of smart homes and buildings, the deployment of smart transportation systems, the creation of smart parks and public spaces, and the provision of smart healthcare and education services (Noori, Hoppe & de Jong, 2020). These projects are designed to enhance convenience, comfort, and safety for citizens and residents, and to promote a healthy and sustainable lifestyle.

Saudi Arabia Smart city initiative: NEOM project

Saudi Arabia has also launched a range of smart city initiatives, including the NEOM project, which is an ambitious urban development project that seeks to create a smart, sustainable, and innovative city from scratch. The NEOM project aims to leverage advanced technologies such as AI, robotics, and renewable energy to create a city that is entirely self-sufficient and sustainable (Alam et al., 2021). NEOM is a planned smart city project in Saudi Arabia, which aims to be a model for the future of sustainable living. The project is being developed as part of the country's Vision 2030 plan, which seeks to diversify the economy away from oil and promote technological innovation.

NEOM is planned to be a fully integrated city, with advanced technologies and sustainable practices built into its infrastructure. The city will be powered by renewable energy sources, such as wind and solar power, and will feature autonomous transportation systems, smart homes, and advanced healthcare and education facilities (Alam et al., 2021). The project is also designed to promote economic growth, with plans to attract investment in a range of sectors, including technology, tourism, and entertainment. NEOM is being developed as a hub for innovation and entrepreneurship, with a focus on developing new industries and creating jobs for Saudi citizens.

Qatar Smart city initiative: Msheireb Downtown Doha project

Qatar has also launched several smart city initiatives, including the Msheireb Downtown Doha project, which aims to create a smart, sustainable, and livable urban environment by leveraging advanced technologies and sustainable design principles. Msheireb Downtown Doha is a pioneering smart city project in Qatar that aims to integrate sustainable technologies and practices into urban planning and development. The project is located in the heart of Doha and covers a total area of 31 hectares (Badran, 2021). It aims to transform the existing urban landscape into a sustainable and livable city that meets the needs of its residents and visitors.

One of the key features of the Msheireb Downtown Doha project is its focus on sustainable energy and water management. The city uses a centralized district cooling system to reduce energy consumption and carbon emissions (Al-Fadala & Fadli, 2020). It also features a sophisticated water management system that includes a rainwater harvesting system and a wastewater treatment

plant. These initiatives are designed to reduce the city's environmental impact and promote a more sustainable way of living.

Challenges of Smart Cities in Middle East

The challenges of smart cities can be summarized as below:

Infrastructure Development: Building the necessary infrastructure to support smart technologies can be challenging. Retrofitting existing infrastructure and implementing new systems require significant investment and planning.

Regulatory Hurdles: Adapting regulations to accommodate new technologies and data governance can be complex. Privacy concerns, data security, and regulatory frameworks need to be established or updated to ensure smooth integration of smart solutions.

Sustainability and Energy Management: Middle Eastern cities often grapple with energy consumption and sustainability. Balancing smart solutions with sustainable practices, such as efficient energy usage and waste management, is crucial.

Citizen Engagement: Encouraging citizen participation and ensuring inclusivity in smart city initiatives can be challenging. Bridging the digital divide and ensuring that all residents can benefit from these technologies is a significant task.

Cybersecurity Risks: With the integration of numerous digital systems and devices, cybersecurity becomes a major concern. Protecting critical infrastructure and citizens' data from cyber threats is a constant challenge.

Interoperability: Ensuring different smart systems can communicate and work together seamlessly is crucial for the success of smart cities. Creating standards and protocols for interoperability between various technologies is a challenge.

Financial Investment: The cost of implementing and maintaining smart city technologies is substantial. Finding sustainable funding sources and justifying the return on investment (ROI) for these projects can be a hurdle.

Cultural Acceptance and Adoption: Convincing citizens and businesses to adopt new technologies and change traditional habits can be a slow process. Cultural attitudes toward technology and innovation might vary and impact the speed of adoption.

Finally, the Middle East has a complex political and economic environment that can make it challenging to implement smart city technologies. Political instability, economic sanctions, and regional conflicts can all impact the implementation of smart city technologies, making it challenging to ensure that they are sustainable and effective in the long term.

Future Trends and Opportunities

AI technologies can be applied in several departments, such as transportation, healthcare, and public safety, to make service delivery more efficient and to fulfill the citizen demands without increasing the physical footprints of smart city infrastructure. However, as with any other technologies, there are challenges associated with AI, widely known as uncertainties and risks. Some major challenges of AI are biased algorithms, adversarial attacks, and the decisions made by AI systems that can't be explained. These uncertainties can lead to a lack of trust in AI, ultimately hindering the potential benefits of AI technologies. SAI is being developed to address these challenges with AI technologies. The technologies of SAI will help to mitigate concerns of AI vulnerabilities and will secure smart city infrastructures from adversarial attacks on IoT devices or operational threats from the AI technologies. AI technologies can outgrow preparedness and knowledge of cities to mitigate potentially negative outcomes of their use. Smart cities can harness the right policies and governance mechanisms to overcome such risks while allowing them to benefit from the AI technologies.

The increasing use of artificial intelligence (AI) applications and IoT (Internet of Things) devices in smart cities offers several opportunities for both city administrators and citizens. Most of the AI technologies, such as machine learning and deep learning, require huge amounts of data to build the AI models. This big data requirement is one of the significant challenges of AI technologies. IoT devices, on the other hand, provide such big data. Therefore, smart cities with IoT devices hosted on their infrastructures have great potential in utilizing and benefiting from AI use cases. Developing secure and trustworthy AI (SAI) and robust IoT devices will help smart cities use and benefit from AI technologies positively.

Conclusion

Overall, it is evident that the concept of smart cities is gaining momentum across the Middle East region. The implementation of smart city technologies promises to revolutionize the way people live, work, and interact with their environment. Smart cities have the potential to enhance the quality of life of citizens by improving public services, increasing access to information, and creating a more sustainable urban environment. Moreover, smart

ISSN: 3006-6948 - https://doi.org/10.54878/opgm4m83

cities can attract new investments, create job opportunities, and stimulate economic growth in the region. However, despite the benefits, there are several challenges that need to be addressed to ensure the successful implementation of smart city initiatives. These challenges include the need for strong leadership, effective governance, and adequate infrastructure. Additionally, there is a need for public awareness and participation in the planning and implementation of smart city projects. By doing this, smart cities can become a reality in the Middle East, improving the lives of citizens and contributing to the development of the region.

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