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## Exploring Challenges of IoT-enabled Safe City Projects



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**Abstract:** *The Safe City Project is a complex phenomenon based on the Internet of Things (IoT), interconnected devices using Information and Communication Technology (ICT). The purpose of this study is to explore the challenges faced in the development of Safe City Projects. For this purpose, an exploratory case study was conducted in two main cities i.e. Lahore and Islamabad, Pakistan. Some challenges faced by the management while deploying such projects have been discussed. The population is the top management, Middle management, and lower management. Twenty interviews have been taken from Islamabad and Lahore Safe City Projects. Data were analyzed by Creswell's (2009) technique which outlined the six steps to analyzing case study data in order to develop different patterns, themes and descriptions. The finding of this research reflects that Lahore Safe City Project seems to be more successful whereas the results of the Islamabad Safe City Project reflect partial success. Based on the research findings, this research also documents challenges and their remedial strategies to overcome those issues for better implementation of a Safe City Project in future.*

**Key Words:** Safe City Projects, IoT, Challenges, Planning, Implementation

### Introduction

Hernandez et al. (2020) were of the view that the world's population living in cities are more than 55%, which may increase to 67% at the end of 2050. Many people around the world are moving to cities than to rural areas, which has led to improvements in their standard of living, healthy environment, and financial prosperity (Kuddus et al., 2020). This increase in city migration is causing authorities to think about establishing security projects in a realistic way. Each technical project has its own importance, but deploying IoT devices to create a Safe City, is the need of the hour because of growing technologies. So the top

management has to think about developing strategies to develop such systems that could be helpful for the citizens and the government. At the same time, as the population of cities continues to grow in developing countries like Pakistan, some issues will have to be faced by the planner, such as traffic congestion, robbery, kidnapping, and snatching of vehicles.

The government helps to support Safe City Projects by providing support from different departments. But eventually, a combined approach between the government partners, including the law enforcement agencies department and other stakeholders considered

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most effective in delivering Safe City Projects. Kristin, (2021) thought that if we used Safe City technology, like surveillance cameras, wifi, and Internet of Things devices, residents would be safer and law enforcement agencies would be able to get information about crimes quickly (Artigas, 2017).

This research is aimed at providing a deep and comprehensive understanding of the challenges faced by management when developing Safe City projects in Pakistani cities. This research will help top management for the development of successful strategies to overcome challenges that appear during projects. This will help improve safety for citizens in these cities, and help reduce crime.

### Research Question

- Which sort of challenges has to face by the top management while the planning and implementation of the IoT-enabled Safe City Project?
- What remedial measures have been taken to overcome these challenges?

### Literature Review

The idea of a "Safe City" is a way of thinking about urban development that helps us understand how to make cities that are sustainable for everyone (Watson et al., 2020). In the 19th century, there were many empires, but in the 20th century, there were many nations. But in the 21st century, we're thinking about cities and how to make them more sustainable (David, 2019). One way we can do that is by using information and communication technologies (ICT) to help us monitor and track things in the city, and to process and inspect data in a way that is expressive and helpful for the public (Watson et al., 2020). This will help us improve the quality of life in cities and make them safer for everyone (Albino et al., 2015).

According to Castro and Harmon, 2016, the goal of smart cities is to provide speedy and effective services to the public using modern technology. This can be done by redesigning urban infrastructure using technology, which can connect different services and systems together in a way that is more efficient and user-friendly.

Most people will live in cities by the end of the 21st century, but this will lead to problems. The development of urban potential and the

dynamic production of goods and services will slow down, but new technologies will help create Safe Cities. This is often done to ease the problems caused by rapid urbanization (Chourabi et al., 2012). Which creates a lot of challenges in the implementation of such projects.

Some countries that are more developed than others have been interested in initiating smart city research and development projects over the past few years. However, many developing countries don't have the proper systems in place to take care of the smart city concept as they see it. However, based on projects that have been completed and are successful so far, these countries have chosen to initiate these projects. The citizens want to improve their quality of life and take an interest in helping to make the success of projects happen, using information communication technologies (ICTs) (Lee et al, 2012)

Two Safe City Projects have been established in Pakistan, one in Islamabad which is known as the Safe City Project Islamabad and the other at Lahore which is also known as Punjab Safe Cities Authority (PSCA) which is responsible for making the cities in Punjab safe and secure. They use modern technology and surveillance to help police and law enforcement agencies protect the citizens.

### IoT-enabled Safe City Application

The Safe City movement needs scalable IoT deployment strategies to manage a lot of data. This data will be used in different Safe City applications. To support the innovation of Safe Cities, we need to identify the key application requirements and features that the IoT deployments described as under.

### Security and Privacy

The security and privacy of IoT devices are important because if unauthorized people can access sensitive information, they could control the safety and security of Safe Cities (Burhanuddin et al., 2017). To protect users, it is important to have easy-to-use security procedures. However, this is often difficult in the context of IoT devices, which are often resource-constrained. If security procedures are too difficult, people might not trust IoT technology. This would lead to its failure (Matuszak et al., 2015).

## Mobility

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IoT is a system of connected devices that can be moved around. This means that the strategies used to deploy IoT systems need to take this into account (Sanchez et al., [2014](#)). Additionally, the mobility of end-users should be monitored and authorized so that they can safely communicate information. (Sanchez et al., [2014](#)).

## Reliability

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The IoT-enabled Safe City system used to help make the city safe is very important. This means that it must work smoothly and without any problems. The system's purpose is to provide services, so it needs to be dependable in order to provide them reliably (Burke et al, 2006).

## Scalability

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To make sure the Safe City system works properly, we need to test it on a large scale. This involves collecting lots of data from everyday objects and devices that are connected to the Safe City System (Miorandi et al., [2012](#)).

## Real-time Data

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The IoT system should have features to keep track of a lot of different devices in a Safe City. This will let us know what users are doing and how they're doing it so that we can provide accurate information to them (Eugster et al., [2003](#)). It also means transmitting data live, which eliminates the need for synchronous communication between producers and consumers of information. This pattern can improve the speed and reliability of information dissemination, which is especially important in a Safe City (Patti and Acquaviva, [2016](#)).

## Interoperability

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The IoT system will have to be able to communicate with a variety of different devices with different abilities (Talib et al., [2017](#)), in order to take part in city applications that involve different kinds of activities. So, it's important for the system to be interoperable so that data can be shared between different devices. Middleware technologies are used to help make this happen (Miorandi et al., [2012](#)). Finally, it's important to standardize the way devices communicate with each other so that the system can work more

easily (Patti and Acquaviva [2016](#), Talib et al., [2017](#)).

## Awareness of Users

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According to Patti and Acquaviva ([2016](#)), in order for a city to be considered "safe," it needs to have good safety applications. These applications need to be easy to use so that people can use them in different parts of the city, and the city's IoT (Internet of Things) software infrastructure needs to be designed to make this happen. This means that the city's IoT strategies should focus on the needs of the people using the Safe City applications.

## Organization Capabilities

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The IoT-enabled system is complex and requires many different objects to work together. These objects need to be able to recognize different situations and communicate with each other to create temporary advertising systems (Miorandi et al., [2012](#)). These systems help devices and services find each other so that the system can work better.

## Safe City Challenges

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Kravchenko ([2019](#)) believes that fast technological advances have helped cities realize their goals and objectives, but there are still challenges with using IoT technology. One example is the difficult task of implementing secure city projects without having to worry about security issues. Another challenge is that IoT devices are vulnerable to a variety of attacks, which can slow down technological advances. Security concerns remain a major issue when it comes to using IoT technology in a secure city (Park et al., (2018), so steps must be taken to protect data, reduce the risk of hacking, and promote digital security education among users.

## Complexity of the System

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Lacinak and Ristvej (2018) stated that the technology used in Safe Cities is the intelligent integration and combination of various existing systems. This makes the cities more complex, as it brings together different parts of the world with different development and administrative histories. This also complicates the task of making policy, as different areas of the world have different ideas about what is best for them.

Additionally, open data and privacy concerns are also more complicated in Safe Cities due to the increased complexity of the value network.

### Technological Infrastructure

Sadeghi et al. (2015) presented There are a few challenges when it comes to using technology. One big challenge is that there is a lack of knowledge about how different pieces of software work together. Another challenge is that systems can be easily hacked, and personal information can be stolen. Another challenge is that it can be expensive to pay for security solutions and to train IT professionals.

### Governance

To make a city safe, it needs a different government model – one that incorporates sub-institutional policies and programs to improve communication and cooperation between

different organizations. This way, the city can avoid the spread of inefficient cooperation (Belli et al., [2020](#)).

### Security Issues

IoT systems can contain networks that are difficult to access or protect, so cities need to take measures to protect their data and systems (Kravchenko, [2019](#)). Security issues also play a role in the use of IoT systems in cities, since these systems are often found in devices that don't have a power source and are not subject to the same security measures as other devices. (Angelakis et al., [2016](#)):

- There are some differences among different types of technology related to software and hardware connecting IoT devices.
- This can make it difficult for projects to work smoothly and on a large scale. There are ways to overcome these limitations with the help of large-scale deployment.

**Table 1**

*IoT-enabled Safe City Challenge.*

Broad Category	Issues/Challenge	Brief Description
System	Security	Past Research reflects main challenge in protecting data or devices is data security. Hackers' attacks on devices or databases are not usual, but need to take care of the security layer to protect the citizen data(Zhang et al, <a href="#">2017</a> )
	Interoperability	Safe city technologies are based on the integration of different devices and software. This integration is important for the development of a Safe City(Rana et al. <a href="#">2021</a> )
	Integration	Integrating data from different sources can be done using different types of APIs and web services, using any type of encryption key. However, managing the different technical infrastructures involved can be challenging (Gao and Yuan <a href="#">2022</a> ).
	Scalability	Mature smart cities need to have a single level of the interface in order to be enhanced throughout the city. This will create different types of issues and challenges (Kravchenko <a href="#">2019</a> )
	Energy Management	The big challenge in building smart cities is using a lot of power to keep all digital devices working. The systems rely on lots of sensors and wireless equipment (Chen et al., <a href="#">2022</a> )

Broad Category	Issues/Challenge	Brief Description
	Network Security	The "smart city" network needs a good network infrastructure in order to work well. This network can handle large amounts of data quickly and without problems(Pawar et al., <a href="#">2019</a> )
	Reliability	The smart city system needs to be reliable and available on every network at any time. This is important for the law enforcement department, because secrecy is very important during any emergency operation (Talari et al, <a href="#">2017</a> )
	Complexity	Networking devices create a lot of data and transmitting it over the network can create lots of complexity for technical management to keep track of it all (Mohanty et al, <a href="#">2016</a> )
	Heterogeneous	Integrating different types of devices can be a challenge, especially for technical managers on a software or hardware level(Christos, 2016)
Data	Privacy	the privacy of personal data over the network used in any smart city infrastructure and system is a big challenge(Ismagilova et al., <a href="#">2020</a> )
	Data Management	There is a need for a big data management tool that can handle huge amounts of data quickly(Aljahdali et al., <a href="#">2022</a> )
User	Trust	Trust is a big challenge in designing and implementing secure channels at all standards while developing these systems (Zhang et al, <a href="#">2017</a> )
	Integrity	The security of a device or data is a big challenge because the user ensures that no unauthorized person can access the device or data over the network (Alromaihi et al, 2018)
	Confidentiality	Confidentiality is very important to law enforcement agencies because they want to be able to open the user's levels of information without causing too much trouble (Verma et al, <a href="#">2019</a> )
	Technology Adoption	Citizens need to be involved in order for a city to be successful with smart technology. However, many people can't adopt the latest technology because it is expensive or they don't have the right devices (Khatoun and Zeadally, <a href="#">2016</a> )
Services	Availability	The success lies in the availability of a system which must be capable that can be available for the public anytime and anywhere. (Khajenasiri et al, <a href="#">2017</a> )
	IT Infrastructure	IT equipment has the capability to communicate the devices and software with small and large networks. (Macke et al, <a href="#">2018</a> )
Process	Standardization	Different types of hardware and software can work best with different types of smart city systems, which makes it difficult to create a standardized system(Kogan & Lee, <a href="#">2014</a> )
	Authentication	To allow authorized users access to the system, a complex and strong security system is needed (Al-Turjman et al, 2019)



Challenges	Author	Challenges	Author
C13	Harmon, et al., (2015)	C28	Khatoun, and Zeadally, (2016).
C14	Cassandras (2016).	C29	Abdi, and Shahbazitabar, (2020)
C15	Ali, et al., (2017)	C30	Lim, et al., (2018).

### Research Design and Methodology

This exploratory study uses two case studies, as research to answer the research questions. Case studies are a good way to get detailed information about something, and this study will use them to answer specific questions. They're not always the best way to study something, though, because they can be challenging for an organization. (Moll, 2012).

### Unit of Analysis

Individuals can be people, institutes, specific groups, organizations and specific cities. (Kabir et al., 2018). The unit of analysis is the Safe City Project. Two Safe City Projects were selected for this research:

Proj A (Lahore Safe City) and Proj B (Islamabad Safe City)

**Project-A (Safe City Lahore):** Ten Interviews were conducted by the top management, who were involved in the planning and implementing of such Projects.

**Project-B (Safe City Islamabad):** Eight Interviews were conducted by the top management of the Safe City Project team who participated during the implementation process.

**Data Collection:** This study is using a semi-structured interview guide, which was developed by the researcher himself. This type of interview is best suited when the goal is to learn specific information for a specific purpose (Dworkin 2012). Data were analyzed by adopting Creswell's (2009) technique in order to develop different patterns, themes and descriptions.

### Case 1: Organization A (Safe City Lahore)

Lahore is a city in Pakistan that is the provincial capital and 2nd most populous. It has a lot of business and civic facilities, as well as being the 5th largest city in South Asia. It's estimated that

by 2030, the city administration has put together a new master plan to make Lahore even better. They're using new technology, infrastructure, and processes to improve security and quality of life. They're also using technology to monitor traffic and manage it better.

The Safe City Project is a project aimed at enhancing the security of citizens and property by using modern technology and surveillance capabilities. This has both security and economic benefits, attracting investment and improving the city's overall condition.

### Case 2: Organization B (Safe City Islamabad)

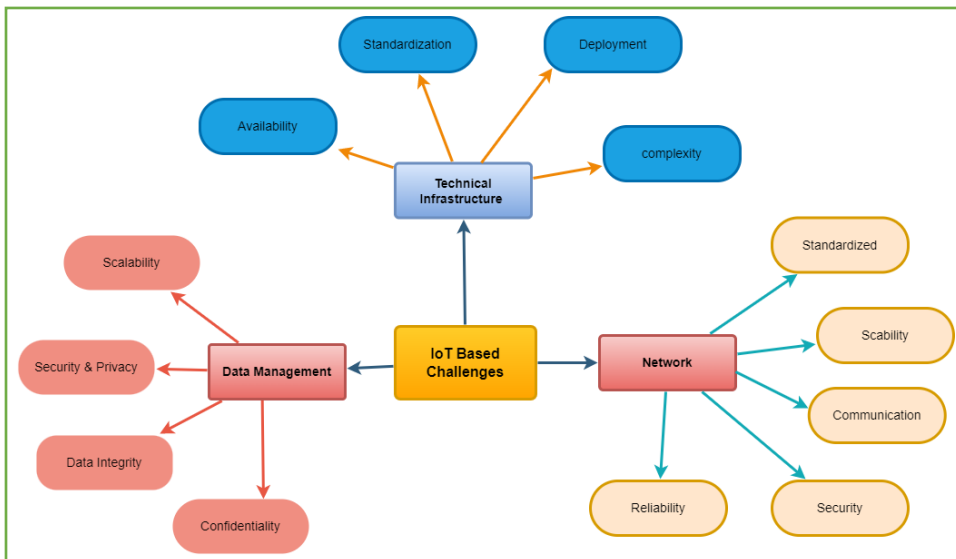
Islamabad, the capital of Pakistan and Safe City Islamabad is a project meant for surveillance to track the movement of vehicles/people to control terrorist/criminal activities in the city. The project is being proposed by top management at an organization like the police or security agency. The Safe City Project is a set of cameras and sensors that help to improve security and governance in Pakistan. The project was started in June 2016 and has already installed 1,950 cameras and 191 ANPR (automatic number plate readers) systems. This is done in an effort to avoid problems like improper handling of equipment that have led to other problems in the past. This project helps to improve the growth of the economy in Pakistan.

### IoT-Based Challenges and their Remedial Strategies

The following challenges were found during the interviews with the management team responsible for implementing the Safe City System in Lahore. These challenges include the proper functioning of the technical infrastructure, data management, and network communication. Each challenge and its potential solutions are explained in more detail below.



**Figure 1**  
*IoT-Based Challenges.*



### Technical Infrastructure

Some of the challenges the Lahore team has faced while implementing software and hardware devices have been identified. These include the difficulty of installing and using technical infrastructure, the need for standardized equipment, and the fact that devices must be available all the time.

**Lack of Weak Infrastructure:** The project will involve installing technology and networking infrastructure in different places, in order to connect the city's surveillance sites with the data centre where the safety data is stored. This will be a challenging task, and the first phase of the project will need to focus on creating the basic infrastructure. After that, the ICT (information and communication technology) infrastructure can be enhanced to improve the level of performance. This will help make the city safer.

**Remedial Strategy:** The high-quality IT infrastructure is important for any city's success. This infrastructure helps to create a safe and reliable system for citizens to use.

**The Complexity of Infrastructure:** The Safe City project is a complex undertaking with a lot of challenges to overcome. It involves connecting a lot of different devices together so that they can

communicate with each other, and this can create a lot of data. The project also has to keep track of all the logs from all of the devices involved in the project so that problems can be fixed and errors avoided.

**Remedial Strategy:** To send data, many different devices and equipment need to be connected to each other on a network. A fibre network can be useful for supporting these kinds of communications, as it allows devices and equipment to be connected using the latest technologies. This system is compatible with networks, so data transmission will not be affected.

**Non-Standardization of Hardware:** This technical project is implemented if all the different pieces of software and hardware work together in a standardized way. However, this can be difficult to do when the different pieces of hardware and software don't always play well together.

**Remedial Strategy:** One challenge in managing a technology team at a middle level is that all of the team's hardware and software may have different capabilities when it comes to using the interface.

**Availability of System:** The success of any Safe City project is based on the availability of tools and resources that are available to the public at



any time and anywhere in the world. If a desired system is not available, cities may experience delays in implementing it.

**Data Management:** Data management is a big challenge because different types of data must be handled safely and correctly. There is a need for a big data management tool that can handle a huge amount of data quickly.

**The Integrity of Data/ device:** The security of any device or data is a big challenge because the user has to make sure that no one can access it over the network without their permission.

**Remedial Strategy:** The system has to make sure that the right information gets sent on the right path, as planned during the implementation phase.

**Security/ Privacy of Personal Data:**  
The privacy of personal data is important because it protects the personal information of people in government organizations. The security of data is a big challenge, and it is difficult to manage attacks on wireless devices and applications.

**Remedial Strategy:** one has to make sure that the Safe City Project is done securely, and all the standards should be adopted during its implementation. The data can be stored in a secure database protected using encryption/decryption keys.

**Confidentiality of Data:** The privacy of any data is vital for law enforcement agencies. Their focus is on trying to access specific parts of the data using specific checks, in order to protect the data from hackers. However, this is a challenge because every system keeps its own logs and requires some basic authentication to access other areas. The accessibility issue also makes it difficult to keep the privacy of data safe, since technical architects restrict unauthorized access.

**Scalability of Data:** The Safe City project involves installing infrastructure at the city level to improve the efficiency of the systems it uses. This can be a challenge because different systems at different levels of the interface can't always handle the added traffic. To make things work better, the project will need to improve the network and the systems that use it, as well as the data management capabilities of the Safe City System.

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## Network Communication

There are many challenges when working on city projects, one of which is making sure the networks between devices are safe and reliable.

**Standardized Network:** The projects involved the installation of different devices and applications on different technologies. Whenever these different devices and applications are working together, a lot of data is created which can cause problems with controlling the network infrastructure and managing data.

**Network Security:** Network security is an important part of building a Safe City. In order to ensure the city is safe, we need to be sure that all of the systems are connected to the internet and that they are protected from hackers. This is a very difficult task, but it is important in order to keep the city safe.

**Reliability of Network:** Large city-wide safe technologies has to deal with different issues when they are first introduced. One of the biggest challenges is that they will be used in the public sector, where reliability is very important. The safety of the city depends on the technology is reliable, so it has to be able to work on any network at any time. It's also very important for the technology to be accessible in case of emergencies.

**Integration of Network Devices:** The Safe City project is challenging because different devices and software applications need to be connected. This is because different devices collect different kinds of data from different places. The team is having a lot of problems integrating all of this data because it comes from different places and uses different kinds of technology.

**Communication of Devices:** The challenge in developing the Safe City Project was communicating with different hardware and software. Because so many devices communicate over the internet or an intranet, the main Safe City System needed to verify that the request being sent was coming from the original source.

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## Discussion and Findings

The results of this research show that secure and Safe City Projects can be successful using new technological trends, but it depends on the management's considerations such as efficiency, performance, and challenges (Razmjoo et al.,

[2021](#)). The research indicates that the Lahore Safe City as a successful project and Islamabad as a partially successful project. The two examples show how things have improved in terms of performance and efficiency. The first issue lies in the availability of technology and the main guidelines for the use of such projects (Gupta and Hall, 2017). Secondly, consideration of important factors, such as the policy framework for using technology to collect and traffic congestion.

- An effective traffic management system helps reduce traffic congestion by providing real-time traffic information. Communication between the stakeholders is also important so that the system can run smoothly. Change management strategies are also important in order to adopt a bottom-up approach. Teams that are not familiar with how to operationalize Safe City Projects can benefit from the system's help were trained enough, and now they are dedicated and encourages their employees as well as citizens to participate in and provide feedback on any issue.
- There are some police stations that don't have a good working environment because they don't have the resources or the expertise to do things like keep people safe and solve the crime. To fix this, a team of people with different specialities work

together to make sure safe city projects are successful.

## Conclusion

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This research looked at how two different public sector organizations changed their cities for the better. One case study looked at how a city's planning and implementing goals were changed, and the other looked at how top management supported the change. Both studies found that there were challenges along the way however, the ultimate change was successful.

This research paper describes different challenges faced during the implementation of the Safe City Project and discusses how the management has addressed them accordingly. The most frequent challenge identified was security and privacy concerns with regard to data. Another issue was the need for an infrastructure for a Safe City and the challenge of transitioning to new technology (Appio et al., [2019](#)). The city's safe city project lacks the technical resources it needs to keep up with the changing environment. The study concludes that the most common challenges are related to data and management and that every researcher writes about these issues in different ways. The proactive strategy was devised for issues and challenges raised during the implementation of safe city projects.

## References

- Abdi, H., & Shahbazitabar, M. (2020). Smart city: A review of concepts, definitions, standards, experiments, and challenges. *Journal of Energy Management and Technology*, 4(3), 1-6. <https://doi.org/10.22109/JEMT.2020.206444.1205>
- Ahmed, E., Yaqoob, I., Gani, A., Imran, M., & Guizani, M. (2016). Internet-of-things-based smart environments: state of the art, taxonomy, and open research challenges. *IEEE Wireless Communications*, 23(5), 10-16. <https://doi.org/10.1109/MWC.2016.7721736>
- Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of urban technology*, 22(1), 3-21. <https://doi.org/10.1080/10630732.2014.942092>
- Aljahdali, A. O., Alluhaib, G., Alqarni, R., Alsharef, M., & Alsaqqaf, A. (2022). Big data analysis and forensics. *International Journal of Electronic Security and Digital Forensics*, 14(6), 579-593.
- Angelakis, V., Tragos, E., Pöhls, H. C., Kapovits, A., & Bassi, A. (Eds.). (2016). *Designing, developing, and facilitating smart cities: urban design to IoT solutions*. Springer.
- Anuar, A. N. A., Bookhari, S. N., & Aziz, N. A. (2012). The effectiveness of Safe City Programme as safety basic in the tourism industry: Case Study in Putrajaya. *Procedia-Social and Behavioral Sciences*, 42, 477-485. <https://doi.org/10.1016/j.sbspro.2012.04.213>
- Appio, F. P., Lima, M., & Paroutis, S. (2019). Understanding Smart Cities: Innovation Ecosystems, technological advancements, and societal challenges. *Technological Forecasting and Social Change*, 142, 1-14. <https://doi.org/10.1016/j.techfore.2018.12.018>
- Bawany, N. Z., & Shamsi, J. A. (2015). Smart city architecture: Vision and challenges. *International Journal of Advanced Computer Science and Applications*, 6(11). <https://doi.org/10.14569/IJACSA.2015.061132>
- Belli, L., Cilfone, A., Davoli, L., Ferrari, G., Adorni, P., Di Nocera, F., & Bertolotti, E. (2020). IoT-enabled smart sustainable cities: challenges and approaches. *Smart Cities*, 3(3), 1039-1071. <https://doi.org/10.3390/smartcities3030052>
- Burhanuddin, M. A., Mohammed, A. A. J., Ismail, R., & Basiron, H. (2017). Internet of Things architecture: Current challenges and future direction of research. *International Journal of Applied Engineering Research*, 12(21), 11055-11061. <http://www.ripublication.com>
- Cassandras, C. G. (2016). Smart cities as cyber-physical social systems. *Engineering*, 2(2), 156-158.
- Chen, N., & Chen, Y. (2018). Smart city surveillance at the network edge in the era of iot: opportunities and challenges. *Smart Cities*, 153-176. <https://doi.org/10.1016/J.ENG.2016.02.012>
- Chen, Z., Sivaparthipan, C. B., & Muthu, B. (2022). IoT-based smart and intelligent smart city energy optimization. *Sustainable Energy Technologies and Assessments*, 49, 101724. <https://doi.org/10.1016/j.seta.2021.101724>
- Creswell, J. W. (2009). Research designs: Qualitative, quantitative, and mixed methods approaches. *Callifornia: Sage*.
- Dworkin, S. L. (2012). Sample size policy for qualitative studies using in-depth interviews. *Archives of Sexual Behavior*, 41, 1319-1320. <https://doi.org/10.1007/s10508-012-0016-6>
- Elmaghraby, A. S., & Losavio, M. M. (2014). Cyber security challenges in smart cities: Safety, security and privacy. *Journal of Advanced Research*, 5(4), 491-497. <https://doi.org/10.1016/j.jare.2014.02.006>
- Eugster, P. T., Felber, P. A., Guerraoui, R., & Kermarrec, A. M. (2003). The many faces of publish/subscribe. *ACM computing surveys (CSUR)*, 35(2), 114-131. <https://doi.org/10.1145/857076.857078>
- Gao, K., & Yuan, Y. (2022). Is the sky of a smart city bluer? Evidence from satellite monitoring data. *Journal of Environmental Management*, 317, 115483. <https://doi.org/10.1016/j.jenvman.2022.115483>

- Harmon, R. R., Castro-Leon, E. G., & Bhide, S. (2015, August). Smart cities and the Internet of Things. In 2015 Portland International Conference on Management of Engineering and Technology (PICMET) (485-494). IEEE. <https://doi.org/10.1109/PICMET.2015.7273174>
- Hasija, S., Shen, Z. J. M., & Teo, C. P. (2020). Smart city operations: Modeling challenges and opportunities. *Manufacturing & Service Operations Management*, 22(1), 203-213. <https://doi.org/10.1287/msom.2019.0823>
- Heo, T., Kim, K., Kim, H., Lee, C., Ryu, J. H., Leem, Y. T. & Ko, J. (2014). Escaping from ancient Rome! Applications and challenges for designing smart cities. *Transactions on Emerging Telecommunications Technologies*, 25(1), 109-119. <https://doi.org/10.1002/ett.2787>
- Hernandez, J. L., Garcia, R., Schonowski, J., Atlan, D., Chanson, G., & Ruohomaki, T. (2020). Interoperable open specifications framework for the implementation of standardized urban platforms. *Sensors*, 20(8), 2402. <https://doi.org/10.3390/s20082402>
- Ismagilova, E., Hughes, L., Rana, N. P., & Dwivedi, Y. K. (2020). Security, privacy and risks within smart cities: Literature review and development of a smart city interaction framework. *Information Systems Frontiers*, 1-22. <https://doi.org/10.1007/s10796-020-10044-1>
- Kabir, A., Maitrot, M. R. L., Ali, A., Farhana, N., & Criel, B. (2018). A qualitative exploration of sociocultural determinants of health inequities of the Dalit population in Dhaka City, Bangladesh. *BMJ Open*, 8(12). <https://doi.org/10.1136/bmjopen-2018-022906>
- Khajenasiri, I., Estebasari, A., Verhelst, M., & Gielen, G. (2017). Applications. *Energy Procedia*, 111, 770-779.
- Khan, R., Khan, S. U., Zaheer, R., & Khan, S. (2012, December). Future internet: the internet of Things architecture, possible applications and key challenges. In 2012 10th international conference on frontiers of information technology (257-260). IEEE. <https://doi.org/10.1109/FIT.2012.53>
- Khatoun, R., & Zeadally, S. (2016). Smart cities: Concepts, architectures, research opportunities. *Commun. Acn*, 59(8), 46-57. <https://doi.org/10.1145/2858789>
- Kogan, N., & Lee, K. J. (2014). Exploratory research on the success factors and challenges of Smart City projects. *Asia Pacific Journal of Information Systems*, 24(2), 141-189. <https://doi.org/10.14329/apjis.2014.24.2.141>
- Kravchenko, A. (2019). The Practical Side of IoT Implementation in Smart Cities. *Editorial Board*, 52. [https://doi.org/10.33965/csc2019\\_201908R060](https://doi.org/10.33965/csc2019_201908R060)
- Kuddus, M. A., Tynan, E., & McBryde, E. (2020). Urbanization: a problem for the rich and the poor?. *Public health reviews*, 41(1), 1-4. <https://doi.org/10.1186/s40985-019-0116-0>
- Lacinák, M., & Rístvej, J. (2017). Smart city, safety and security. *Procedia Engineering*, 192, 522-527. <https://doi.org/10.1016/j.proeng.2017.06.090>
- Lim, S. B., Yong, C. K., Malek, J. A., Jali, M. F. M., Awang, A. H., & Tahir, Z. (2020). Effectiveness of fear and crime prevention strategy for sustainability of safe city. *Sustainability*, 12(24), 10593. <https://doi.org/10.3390/su122410593>
- Macke, J., Casagrande, R. M., Sarate, J. A. R., & Silva, K. A. (2018). Smart city and quality of life: Citizens' perception in a Brazilian case study. *Journal of cleaner production*, 182, 717-726. <https://doi.org/10.1016/j.jclepro.2018.02.078>
- Mehmood, Y., Ahmad, F., Yaqoob, I., Adnane, A., Imran, M., & Guizani, S. (2017). *Magazine*, 55(9), 16-24.
- Miorandi, D., Sicari, S., De Pellegrini, F., & Chlamtac, I. (2012). Internet of things: Vision, applications and research challenges. *Ad hoc networks*, 10(7), 1497-1516. <https://doi.org/10.1016/j.adhoc.2012.02.016>
- Mohanty, S. P., Choppali, U., & Kougiianos, E. (2016). Everything you wanted to know about smart cities: The internet of Things is the backbone. *IEEE Consumer Electronics Magazine*, 5(3), 60-70. <https://doi.org/10.1109/MCE.2016.2556879>
- Moll, S. (2012). Navigating political minefields: Partnerships in organizational case study

- research. *Work*, 43(1), 5-12. <https://doi.org/10.3233/WOR-2012-1442>
- Naphade, M., Banavar, G., Harrison, C., Paraszczak, J., & Morris, R. (2011). Smarter cities and their innovation challenges. *Computer*, 44(6), 32–39. <https://doi.org/10.1109/MC.2011.187>
- Patti, E., & Acquaviva, A. (2016, September). IoT platform for Smart Cities: Requirements and implementation case studies. In *2016 IEEE 2nd International Forum on Research and Technologies for Society and Industry Leveraging a better tomorrow (RTSI)* (1-6). IEEE.
- Pawar, L., Bajaj, R., Singh, J., & Yadav, V. (2019, May). Smart city IoT: Smart architectural solution for networking, congestion and heterogeneity. In *2019 International Conference on Intelligent Computing and Control Systems (ICCS)* (124-129). IEEE.
- Rana, B., Singh, Y., & Singh, P. K. (2021). A systematic survey on Internet of things: Energy efficiency and interoperability perspective. *Transactions on Emerging Telecommunications Technologies*, 32(8), e4166. <https://doi.org/10.1002/ett.4166>
- Razmjoo, A., Ostergaard, P. A., Denai, M., Nezhad, M. M., & Mirjalili, S. (2021). Effective policies to overcome barriers in the development of smart cities. *Energy Research & Social Science*, 79, 102175. <https://doi.org/10.1016/j.erss.2021.102175>
- Sanchez, L., Munoz, L., Galache, J. A., Sotres, P., Santana, J. R., Gutierrez, V., & Pfisterer, D. (2014). Smart Santander: IoT experimentation over a smart city testbed. *Computer Networks*, 61, 217-238. <https://doi.org/10.1016/j.bjp.2013.12.020>
- Santana, E. F. Z., Chaves, A. P., Gerosa, M. A., Kon, F., & Milošević, D. S. (2018). Software platforms for smart cities: Concepts, requirements, challenges, and a unified reference architecture. *ACM Computing Surveys (CSUR)*, 50(6), 78. <https://doi.org/10.1145/3124391>
- Sarkheyli, A., & Sarkheyli, E. (2019). Smart megaprojects in smart cities, dimensions, and challenges. In *Smart Cities Cybersecurity and Privacy* (269-277). Elsevier. <https://doi.org/10.1016/B978-0-12-815032-0.00019-6>
- Shafik, W., Matinkhah, S. M., & Ghasemzadeh, M. (2020). Theoretical understanding of deep learning in uav biomedical engineering technologies analysis. *SN Computer Science*, 1(6), 1-13. <https://doi.org/10.1007/s42979-020-00323-8>
- Sharifi, A., Kawakubo, S., & Milovidova, A. (2020). Urban sustainability assessment tools: Toward integrating smart city indicators. In *Urban Systems Design* (345-372). Elsevier. <https://doi.org/10.1016/B978-0-12-816055-8.00011-7>
- Talari, S., Shafie-Khah, M., Siano, P., Loia, V., Tommasetti, A., & Catalao, J. (2017). A review of smart cities based on the internet of Things concept. *Energies*, 10(4), 421. <https://doi.org/10.3390/en10040421>
- Talib, M. S., Hussin, B., & Hassan, A. (2017). Converging VANET with vehicular cloud networks to reduce the traffic congestions: A review. *International Journal of Applied Engineering Research*, 12(21), 10646-10654. <http://www.ripublication.com>
- Verma, A., Khanna, A., Agrawal, A., Darwish, A., & Hassanien, A. E. (2019). In *Cybersecurity and Secure Information Systems* (1-15). Springer, Cham.
- Watson, A., Musova, Z., Machova, V., & Rowland, Z. (2020). Internet of things-enabled smart cities: big data-driven decision-making processes in the knowledge-based urban economy. *Geopolitics, History and International Relations*, 12(1), 94-100. <https://doi.org/10.22381/GHIR12120209>
- Zhang, K., Ni, J., Yang, K., Liang, X., Ren, J., & Shen, X. S. (2017). Security and privacy in smart city applications: Challenges and solutions. *IEEE Communications Magazine*, 55(1), 122-129. <https://doi.org/10.1109/MCOM.2017.1600267CM>