

**Evaluating the Impact of Smart Cities on Urban Sustainability
and Citizen Perceptions: A Case Study of the Twin Cities**



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DEDICATION

This thesis is lovingly dedicated to my parents, whose unwavering support and quiet strength have guided me through every step of my academic journey. I also dedicate this work to my sister, who encouraged me to take on this challenge and whose resilience continues to inspire me every day.

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Abstract

This study investigates the influence of smart cities on urban sustainability and citizen perceptions in the Twin Cities. As rapid urbanization intensifies pressure on resources, traditional urban systems increasingly struggle with environmental degradation, economic inefficiencies, and weakened social cohesion as a result of lack of synergies. These challenges underscore the growing relevance of smart cities, which integrate digital technologies and data-driven systems to connect the different subsystems and support the achievement of Sustainable Development Goal 11: making cities inclusive, safe, resilient, and sustainable.

Drawing on quantitative data from structured questionnaires and qualitative insights from semi-structured interviews, the findings show that smart-city characteristics are positively associated with the three key dimensions of urban sustainability: economic growth, environmental sustainability and social wellbeing. The results also indicate that as citizens' experiences and perceptions of smart-city initiatives become more favorable, their attitudes toward adopting future smart technologies strengthen accordingly. Overall, the study highlights that smart cities function not merely as technical solutions but as interconnected systems that bring together people, institutions, and innovation to enhance the urban environment and improve everyday life in meaningful ways. It argues for a collaborative environment that leverages the collective expertise and resources of all stakeholders to enhance the positive impact of smart city initiatives.

Keywords: Smart Cities, Urban Sustainability, Citizen Perceptions,

Table of contents

CHAPTER 1	1
Introduction.....	1
1.1 Problem Statement.....	4
1.2 Hypothesis.....	5
1.3 Research Objectives.....	5
1.4 Research Questions.....	5
1.5 Organization of the Study	5
CHAPTER 2	7
Literature Review.....	7
2.1 Smart Government.....	8
2.2 Smart Economy.....	10
2.3 Smart Environment	14
2.4 Smart Living	16
2.4.1 Social Inclusion and Connectivity	16
2.4.2 Education	17
2.4.3 Healthcare	18
2.4.4 Safety and Security	20
2.5 Smart Mobility	22
2.6 Smart People	27
2.6 Synergies Across Smart City Indicators	29
2.7 Citizen Perceptions of Smart Cities	29
2.8 Theoretical Framework.....	30
CHAPTER 3	34
Research Methodology	34
3.1 Study Area	34
3.2 Sampling and Sample Size.....	37
3.3 Data Collection	38
3.3.1 Structured Questionnaire Survey	39
3.3.2 Interview Guide	40
3.3.3 Data Analysis	41

CHAPTER 4	43
Data Analysis	43
4.1 Descriptive Analysis	43
4.1.1 Demographic Characteristics	44
4.1.2 Respondents Awareness of Smart Cities in the Twin Cities.....	45
4.1.3 Respondents Views on Smart People Initiatives	46
4.1.4 Respondents Awareness and Experiences of Smart Living Measures	47
4.1.5 Respondents Perception of Smart Mobility Solutions	49
4.1.6 Citizen Views on Smart Environment Solutions	51
4.1.7 Public Engagement with Smart Governance Initiatives	52
4.1.8 Respondents Experiences of Smart Economy Initiatives	56
4.1.9 Pearson Correlation.....	60
4.2 Inferential Analysis.....	62
4.2.1 Linear Regression between Smart City Indicators and Citizen	
Perceptions.....	63
4.2.2 Linear Regression between Smart City Indicators and Citizen Attitudes	
towards Smart City Development.....	64
4.2.3 Linear Regression between Citizen Perceptions and Attitudes towards	
Smart City Development	65
4.3 Thematic Analysis	66
4.3.1 Technological Integration and Innovation in the Developing World	66
4.3.2 Environmental Sustainability.....	67
4.3.3 Governance, Institutional Coordination and Policy Continuity.....	68
4.3.4 Economic Efficiency and Human Capital Development	70
4.3.5 Citizen Engagement, Social Impact and Safety	71
4.3.6 Integration and Path to Urban Sustainability	72
CHAPTER 5	74
Conclusion & Recommendations	74
5.1 Conclusion	74
5.2 Recommendations.....	76
Annexure A.....	92
Annexure B	99

Annexure C	100
Annexure D	101

CHAPTER 1

Introduction

Embracing smart cities is no longer a choice but a necessity for sustainable urban development. The term was coined in the book “The Technopolis Phenomenon” in 1992 (Gibson et al., 1992) and it was used to describe the increasing use of Information Communication Technology (ICT) in city infrastructure in the 1990s (Albino et al., 2015). Technologies such as Artificial Intelligence (AI), sensors and Internet of Things (IoT) help process real time data, hence tackling “wicked problems” and enhancing urban city management (Afzalan et al., 2017). The idea gained immense popularity after IBM introduced ‘Smarter Planet’ in 2008, which integrated ICT in all areas of life (Wiig, 2015), after which cities such as Amsterdam, Cairo and Vienna started their own smart city projects as it was soon established that smart cities improve governance by improving urban management and reducing managerial burden (Harrison & Donnelly, 2011). Moreover, such smart city initiatives help countries achieve their UN Sustainable Development Goals (SDGs), and in particular achieve SDG 11, “making cities and human settlements inclusive, safe, resilient and sustainable” (Alisjahbana, 2019).

Today, according to IMD’s Smart City Index 2024, the top 3 smart cities in the world include Zurich, Oslo and Canberra (IMD, 2024). However, with the exponential rate of urbanization in Asia, there is an estimation that “ninety-six per cent of urban growth will occur in the less developed regions of East Asia, South Asia and Africa with three countries; India, China and Nigeria, accounting for 35 per cent of the total increase in global urban population from 2018 to 2050” (UNHABITAT, 2020). Resultantly, smart cities are being rapidly incorporated in the Asian urban landscape as well. Hence, there is no doubt that these countries are catching up with their Western counterparts in competing in technology integration, with some even leading the way in ICT indicators; East and North East Asian countries alone making up 75% of fixed broadband subscriptions in Asia (UNESCAP, 2016). Some noteworthy smart city examples from Asia include that of Vietnam in which technology is integrated to govern the ancient capital. Additionally, to mitigate haze pollution resulting from rapid urbanization in China,

a study by (Zhang & Wu, 2023) piloted smart cities to assess their impact on air quality. These pilots were found to successfully combat urban haze pollution, hence empirically establishing that smart applications in the environment can tackle the challenges of environmental degradation, proving to benefit the urban environment. Most research on smart cities is conducted by Western countries, making it less applicable to Asian contexts. Western models emphasize citizen participation, placing individuals at the center of governance, whereas in many Asian countries, national governments play a dominant role in promoting and planning smart cities (Joo & Tan, 2020). As a result, Asian nations have developed their own distinct "smart city strategies" (OECD, 2020). In South Asia, Pakistan exemplifies this approach, with its capital, Islamabad, recognized as a smart city, ranking 116th out of 142 globally (IMD, 2024).

In 2023 Pakistan had a population of 241.49 million, with a national annual growth rate of 2.55% (PBS, 2023). The increasing growth rate across the nation means that most cities are expanding exponentially at an unprecedented rate, with existing towns being “developed” further. This unplanned urbanization poses great threats to the country such as environmental degradation, increased poverty and socioeconomic inequality, safety and security issues, traffic congestion and increased demands on resources, just to name a few. To address these issues Pakistan’s government has integrated smart cities in “Pakistan Vision 2025”, which aims to transform the urban landscape of the country by integrating sustainable, environment friendly measures throughout the city and improve e-connectivity, governance and security (Irfan, 2018).

At present day, both the government and the private sector are taking measures to convert conventional cities into smart cities to better cope with the challenges of urbanization. This is done by integrating the six key indicators of smart cities: smart government, economy, environment, living, mobility and people (Vinod Kumar & Dahiya, 2017). Private sector examples include those of Capital Smart City, Islamabad, and Lahore Smart City (Capital, 2023; Lahore, 2024). Notable government measures to integrate smart city initiatives into the country include the ‘Safe City Project’, in which 2512 cameras have been installed that aid in criminal investigations and traffic management (I. Police, 2016). Moreover, Pakistan Citizen

Portal digitalized certain government facilities, hence enhancing service delivery and increasing public engagement by developing online portals. The government of Punjab has adopted the “Integrated Command, Control, and Communication System” (IC3), which enhances security by improving the efficiency of the police by automating the First Investigation Report (FIR), hence streamlining the complaint lodging system (Gondal, 2021). In 2015, the “e-Khidmat” initiative was launched to deliver citizen-focused services online, including passport and license applications, and property-related matters (PITB, 2015).

Furthermore, the use of telemedicine in Pakistan increased significantly following the COVID 19 pandemic (Handforth et al., 2021). Local print and digital media broadcasted Skype IDs and WhatsApp numbers of doctors of various specialties for online appointments and consultations (Nagra et al., 2021). Online consultations made it possible for more people to get medical advice without having to visit the hospital. Telehealth platforms such as EZShifa and Sehat Kahani also made seamless cyber consultations possible (Mahdi et al., 2022).

Smart cities when linked with sustainable development “are viewed as a vision, manifesto or promise aiming to constitute the twenty first century’s sustainable and ideal city form” (Trindade et al., 2017). Integrating ICT into the city acts as the basis towards achieving goals set forth by cities, such as environmental protection, financial development, poverty eradication, improved security, etc, all of which not only contribute towards urban sustainability and sustainable development, but are also sub categories of the main pillars of a smart city (Giffinger & Gudrun, 2010). Urban sustainability is defined by (Wu, 2014) as “an adaptive process of facilitating and maintaining a virtual cycle between ecosystem services and human wellbeing through concerted ecological, economic, and social actions in response to changes within and beyond the landscape.” Hence, it is composed of three primary dimensions: economic, environmental and social (Zeng et al., 2022). However, as per the researchers best knowledge, the overall impact of smart cities on urban sustainability have not been noted, as existing literature on sustainable cities focuses primarily on smart city characteristics and features, such as the technology used in urban management (Hashem et al., 2016; Zanella et al., 2014), or focus on more micro areas such as the relationship of smart cities with governance, politics, etc.,

(De Guimarães et al., 2020; Pereira et al., 2018). Current smart cities have been criticized for being bias for their technology implementation as they are ignoring and undermining the community and people, exacerbating inequal resource allocation, privacy issues and the digital divide (Hollands, 2020; Kitchin, 2015).

This study aims to ascertain citizen perception and readiness to accept smart city innovations in the Twin cities. It will do this by assessing public perception and attitudes toward various aspects of smart cities, including smart economy, smart government, smart mobility, smart environment, smart living, and smart people. By doing so it will determine the readiness to use and adopt more similar nationwide initiatives. The study will also investigate the impact that Islamabad as a smart city has on urban sustainability; the impact that smart cities and technological interventions have on the environmental sustainability, economic growth and social well-being in urban areas of Islamabad and Rawalpindi.

1.1 Problem Statement

Smart cities are often seen as a roadmap for sustainable urban development, but their empirical impact remains uncertain. Research in this area focuses on either the technical aspects, such as infrastructure and digital advancements, or the social dimensions, such as governance and community well-being. This study focuses on the social aspects of how smart city initiatives contribute to urban sustainability beyond economic and technological efficiency. While much of the existing research highlights their potential for growth, fewer studies assess their real-world effectiveness, particularly in ensuring a higher quality of life. Additionally, while smart city projects demand significant investments, they can sometimes overshadow urgent urban challenges like housing shortages and poverty, raising questions about their true value for urban sustainability.

The idea of smart cities is still a novel idea for Pakistan as there is still limited knowledge and partial awareness as to what it means in the country (Irfan, 2018). Islamabad and Rawalpindi, collectively known as the “Twin Cities”, with the former being the capital of the country is the pioneer of smart city solutions in the nation, making this city ideal for study. However, the extent to which its citizens are aware of, receptive to, and ready to adopt smart city technologies is an aspect

that hasn't been studied yet. Moreover, the actual impact of these technologies on urban sustainability and the overall quality of life is also yet to be fully explored.

This research aims to evaluate the impact of smart city initiatives on urban sustainability and assess citizen perceptions of smart cities, focusing on key areas such as the smart economy, smart mobility, smart environment, and smart living. By bridging the gap between smart city development, urban sustainability, and citizen engagement, this research aims to provide an evidence-based understanding of smart city initiatives in the Twin Cities. Understanding the attitudes and readiness of the citizens of Islamabad and Rawalpindi towards smart city adoption will provide valuable insights into the potential for nationwide replication, more informed policy decisions and the role of public engagement in shaping successful urban sustainability models.

1.2 Hypothesis

There is a positive relation between smart cities and urban sustainability.

1.3 Research Objectives

- To assess public perception and attitudes toward various aspects of smart cities, including smart economy, smart mobility, smart environment, and smart living, among the citizens of Islamabad and Rawalpindi.
- To determine readiness to use and adopt more similar nationwide initiatives.
- To evaluate the impact of smart cities on urban sustainability.

1.4 Research Questions

- What is the perception of a smart city according to citizens?
- What is the level of citizen readiness for adopting smart city initiatives?
- How do smart cities and technological interventions contribute to the environmental sustainability, economic growth and social well-being in urban areas of Islamabad and Rawalpindi?

1.5 Organization of the Study

This smart city research is a comprehensive study that fulfills the guidelines and content of research work. Chapter 1 provides a comprehensive overview of the intent of this research. Chapter 2 focuses on smart city case studies and their impact on urban sustainability, together with academic articles from smart cities globally

and from Islamabad, elaborating on citizen perceptions of smart cities. Methods and data strategies are discussed in Chapter 3, describing the tools and techniques for data collection of this smart city research. Chapter 4 describes the in-depth analysis of the data and findings received through the field research and the thematic analysis from the qualitative data. This smart city research concludes with detailed results analysis prior to the conclusion and recommendation in Chapter 5, demonstrating the impact of smart cities on urban sustainability and the citizen perceptions of smart cities in the Twin Cities of Islamabad and Rawalpindi.

CHAPTER 2

Literature Review

Urban sustainability is defined by (Wu, 2014) as “*an adaptive process of facilitating and maintaining a virtual cycle between ecosystem services and human wellbeing through concerted ecological, economic, and social actions in response to changes within and beyond the landscape.*” Hence, it is composed of three primary dimensions: economic, environmental and social (Zeng et al., 2022). The equilibrium between three vital dimensions of sustainability is defined as sustainable development in cities. For example, the international organisation ICLEI (Local Governments for Sustainability) states that “*sustainable cities work towards an environmentally, socially, and economically healthy and resilient habitat for existing populations, without compromising the ability of future generations to experience the same*” (ICLEI, 2016). However, institutions play an essential role in cities, especially in solving problems, due to which it is of paramount importance to add the institutional element. Therefore, sustainable urban development can be defined as a synergistic relationship between environmental, economic, institutional and social structures in cities (Bell & Morse, 2018).

Due to significant challenges caused by rapid urbanization, cities across the world are implementing smart city initiatives, as these are believed to have the potential to solve urban challenges (Haarstad & Wathne, 2019). Smart cities refer to urban areas that utilize digital technologies to improve connectivity, sustainability and quality of life (Kumar et al., 2020). They aim to achieve Sustainable Development Goal 11, “*Make cities and human settlements inclusive, safe, resilient, and sustainable*” (UN, 2015). Copenhagen, Oslo and Zurich are three such metropolitan areas that have consistently ranked among the top ten smart cities globally (IMD, 2025). Copenhagen has focused on its waste to energy program and its carbon neutral ambition, while Oslo is renowned for its green infrastructure and transition to electric vehicles (Ahvenniemi et al., 2017). Zurich has made considerable strides in reducing fossil fuel dependence to protect the environment and increase economic growth (Angelidou, 2015). Common digital technologies include artificial intelligence (AI) and Internet of Things technology

(IoT). AI simulates human cognition and enables systems to learn from data by identifying trends and patterns. Machine learning (ML) and natural language processing (NLP) are both examples of AI technology (Shah et al., 2022). IoT devices on the other hand are a web of appliances integrated with sensors. They collect and monitor real time data which is sent to the central processing hub, through which decisions are made (Hossain & Muhammad, 2016). This is of particular importance and relevance in smart cities as sensors are embedded on the roads, in the hospitals and even in homes, as data driven decision making is the foundation for smart cities to ensure efficiency and sustainability. The following are the 6 characteristics of smart cities as defined by (Giffinger & Gudrun, 2010).

2.1 Smart Government

This indicator of smart city refers to strengthening the connections and interactions between the government and stakeholders by employing information communication technology (ICT), as advancements in ICT allow for better allocation of resources and communication of rules and policies (O'Reilly, 2011). ICT-based governance, also known as E-governance or smart governance refers to the “*collection of technologies, people, policies, practices, resources, social norms, and information that interact to support city governing activities*” (Chourabi et al., 2012). The governing activities focus on interactions between government and citizens, government and businesses, and between governments, to provide citizens with personalized notifications and services, or provide administrative and legal consultancy, for instance (Anindra et al., 2018). Hence, stakeholder engagement, ICT-based provision of services, and network-based relationships form the basis of this contemporary form of governance (Gil-Garcia et al., 2015).

In other words, smart cities aims to digitalize governments using technology, with the primary aim to simplify processes. ICT can be integrated into the governance infrastructure to connect all the stakeholders, hence accounting for participatory governance, more inclusive policy making and ease of service delivery.

Blockchain is an emerging technology which is used in governance for improved efficiency, productivity, security, trust and transparency between citizens and governments (Khanna et al., 2021). It has the potential to do this as it is

decentralized, secure and auditable (Farouk et al., 2020). It can be used for e-voting to ensure free and fair elections, as it is anonymous, decentralised, and secure, ensuring efficient vote counting, voter confidentiality, and secure vote casting (Daramola & Thebus, 2020). Moreover, rigging or changing results is virtually impossible, making it a model of consideration for countries such as Estonia and South Korea (Bulut et al., 2019; Taş & Tanrıöver, 2020).

Even public service agencies are digitalized to reduce corruption, providing equitable and transparent access to goods and services (Akpan-Obong, 2022). A study by (Rubasundram, 2019) found that automation and digitalization reduced the chances of error. In Nigeria, for instance, following the utilization of ICT in the financial sector, all salaries were accurately and timely transferred to public servants.

Copenhagen, being among the top smart cities of the world actively engages its residents in decision-making processes, encouraging residents to use digital platforms and mobile applications to access real-time data on air quality, energy consumption, etc allowing them to make informed choices about consumption (Ivanov Petrea & Ursache, 2023).

Pakistan's e-governance journey began in 2002 with the launch of its first e-government directorate, which aimed to provide a channel for citizens to share complaints and suggestions with officials. In 2003, National Database and Registration Authority (NADRA) introduced a computerized national identity card system, ensuring more secure and streamlined identity issuance (Alam, 2013). Eventually, the 'Pak Identity' app was developed by NADRA, which allows residents and citizens to apply for, update, and modify national identity documents, including the Computerized National Identity Card (CNIC), National Identity Card for Overseas Pakistanis (NICOP), and Pakistan Origin Card (POC). NADRA, allows users to take and upload photos, undergo biometric verification, and make payments for various services all from the comfort of their home via the Pak Identity app, averting the need to go to any office (*Pak Identity*, 2025).

It is important to recognize the interconnected nature of urban systems, where the digitalization of government services and institutions has a ripple effect, shaping and influencing multiple other sectors of the city. This goes to prove the

General Systems Theory which states that parts of a system work together, representing the exchange of information and resources, improving efficiency and enhancing quality of life (Rousseau, 2015). The option of automated taxation has made taxation efficient and transparent for both the taxpayer and tax collection authority worldwide (Alm et al., 2016; Tambun & Kopong, 2017). In Pakistan, the option of using the Tax Asaan App has done the same; it has allowed income tax return filing and income and sales tax registration, just to name a few (*Tax Asaan by FBR, Pakistan*, 2025). Additionally, the app also has the potential to broaden the tax base as it allows filing complaints about businesses that aren't tax filers by reporting their unverified invoices (Ain, 2025).

A study by (Qureshi et al., 2017) examined Pakistan's digital governance efforts. The research concluded that these digital tools have enhanced transparency, improved accountability in public services, and made government information and services more accessible to citizens. They also found a notable improvement in public satisfaction, as e-governance has helped raise the quality and ease of accessing government services.

2.2 Smart Economy

This indicator of smart cities refers to all actions and programs aimed at transforming and strengthening the economy. Smart economies have the potential to foster economic growth and development by increasing research and development, by improving connectivity with global markets and enhancing rural-urban linkages (Popova & Popovs, 2022). A quasi-natural experiment based on 239 cities in China found that economic growth in smart pilot cities was 3% higher than in non-smart cities. Apart from this empirical growth, economic improvements were also seen in qualitative forms, such as decreased rural to urban migration, increased social inclusion and access to credit markets, with these improvements being particularly prominent in the lesser developed regions of the country as these sectors were able to capitalize on the 'advantage of backwardness' (Liu et al., 2022).

With the advent of the 4th wave of industrialization, the manufacturing industry is being revolutionized, with IoT devices and sensors being embedded in the manufacturing process, relaying real time data and optimizing efficiency. AI and ML analyze this data and deduce meaningful insights, improving decision

making and quality control in production, ultimately benefitting companies by helping them increase productivity, reduce costs and increase profits. By adopting these trends it is possible for individual companies, multinationals and economies to survive in an ever changing, intensely competitive, global marketplace, as a smart industry accounts for a smart economy (Yin et al., 2018).

A study by (Khera et al., 2021) revealed that digital financial inclusion (DFI) can foster 2.2% extra GDP growth per year for a country by simply increasing financial inclusion, thereby increasing the accessibility and efficiency of financial services. Similar findings have been uncovered in Pakistan as well, with the growth of mobile banking providing financial services to the previously underserved and unbanked populations. It has reduced transaction costs, encouraged formal savings, and has paved the way for the formalization of the economy through formal banking channels. Efficient money transfers have led to higher transaction volumes and deposits which have created more liquidity in the system. Over time, this has increased GDP growth, employment, and has even reduced poverty. Mobile banking has laid the foundation for a digital economy, which enables fintech, digital payments, e-commerce, etc, all necessary in smart economies, vital for smart cities (Rizvi et al., 2017).

Copenhagen, a leading smart city, has a flourishing startup ecosystem, with many renowned global platforms having emerged from there. *Trustpilot* is a notable example; an online business review platform that started from a small co-working space from the heart of Copenhagen, that has now spread to London and New York (Hoggett, 2021; Klavsen, 2015). Moreover, Copenhagen embraces the features of a smart economy, and even integrates it with the green economy, by encouraging initiatives such as the Green Tech Challenge that promotes Green startups, thereby not only strengthening the economy, but also enhancing environmental sustainability by building green careers and investing in clean energy (Hub, 2015). The city has heavily invested in smart city solutions, including high speed internet connectivity, which has helped build a knowledge based economy, allowing higher educational institutes and research and development institutes to further innovate and contribute to the economy (Finance, 2022).

Business incubators, a relatively new practice, are a viable tool for economic development as they are designed to support the development of new businesses by providing a range of new services and resources. They can create more jobs than any other business and economic programs. They mentor emerging businesses by offering a range of support services such as managerial and technical advice. Moreover, they assist startups in leveraging the necessary finances by connecting them with investors and vendors, whilst providing networking opportunities to facilitate connections within the entrepreneurial ecosystem (Al-Mubarak & Busler, 2012). Skill development and training workshops are also provided, establishing the link between smart economy and smart people, as such skill development trainings improve the capacities of citizens (C. Li et al., 2020). University Based Incubators for instance help students start new ventures and assist the institutes in achieving their research milestones. These incubators, if working optimally are even considered as a stepping stone towards economic progress of the developed and developing economies of the world as they are at the forefront of research and development. Their plethora of innovations and inventions generate job opportunities, triggering economic growth (Farransahat et al., 2021).

In developing countries such as Pakistan, incubators can also utilize entrepreneurship and skills for SMEs, ensuring balanced economic growth, reducing rural-urban disparity (Ahmad et al., 2022). The Pakistani entrepreneurship ecosystem has significantly expanded since 2012, with an increasing number of business incubation centers and funding opportunities in the government and private sectors (UNDP, 2024). This is a significant improvement from the previous years, as in the past these business incubators were not working to their full potential because firstly, a limited number of incubators existed which weren't sufficient to meet the needs of small and medium scale entrepreneurs. Secondly, majority incubators were government controlled, with the exception of a few private incubators and university incubators, making government policies such as lack of sufficient funding and investment a major barrier to the establishment of further incubators and funding for more projects (Mahmood et al., 2015).

In Pakistan's second largest province; Punjab, the 'Qeemat Punjab' App is designed to inform the public about the daily prices of agricultural produce set by

the Deputy Commissioners in Punjab. Complaints of any price discrepancies faced by citizens can be submitted online, which will be resolved by the relevant Price Control Magistrate (*Qeemat Punjab - Apps on Google Play*, 2024). By reporting and resolving price discrepancies, the app reduces information asymmetry between buyers and sellers, and enhances transparency by beating artificial inflation, which weakens the economy. In addition to this, uniform prices of produce throughout the market space prevents monopolistic practices by encouraging fair competition, hence strengthening market efficiency (Hanna et al., 2019). Therefore, this app is an ideal example of a synergy of smart economy and smart governance as it is through the app that the citizens are involved in the process of check and balance of prices, creating an equilibrium where citizens, markets, and governments work together to produce economic fairness and resilience to strengthen the economy. The citizens use the app to encourage transparency of markets (smart economy), and the government utilizes citizen provided data for decision making and enforcement (smart governance).

However, since the app requires location permissions, full name, ID, gender, etc to submit complaints, privacy is compromised and complainants are susceptible to risks in cases of robberies. Furthermore, the app puts users in vulnerable situations as it cannot detect unauthorized logins from unknown devices or locations, making them prone to security breaches considering the significant amount of personal information stored on the app (Habib et al., 2025). The transmission of data to central servers, creates exploitable pathways for both state and non-state actors. When such actors gain access to users' devices or app credentials, they can extract personally identifiable information (PII), including names, phone numbers, and precise coordinates, enabling continuous surveillance and physical tracking of at-risk individuals. The transmission of location data further amplifies this risk, as attackers can reconstruct a user's movement history, and even participation in sensitive activities such as protests, thus enabling targeted monitoring or persecution. Another critical concern lies in weak network security protocols, where geographic data can be intercepted and falsified, leading to the wrongful implication of individuals through manipulated digital evidence. Such vulnerabilities expose users not only to cyber risks but also to political and social

harms, as falsified data may be used for surveillance or criminalization (*Josh and Mak International, 2023*). Collectively, these risks underscore the urgent need for robust encryption and ethical oversight in the deployment of digital public infrastructure in smart cities.

The Capital Development Authority (CDA) has introduced a cashless system to increase transparency and enhance efficiency of public services in Islamabad. QR codes, mobile applications and online portals are to facilitate these cashless payments for parking fees, land transfer, etc, so that the connection between citizens and government is made smooth and there is no possibility for corruption as all transactions are online (CDA, 2025). However, considering the lacking digital infrastructure and the prevalent digital divide in the nation, the quality of the app and the extent of the usage of the app is a matter of concern.

2.3 Smart Environment

Emerging technologies and new methodologies are being developed to tackle major environmental issues like climate change and ecosystem damage. These innovations include smart energy grids, smart agriculture, advanced weather prediction systems, and intelligent waste management solutions (Bolla et al., 2022). For instance, smart grids rely on sensors and IoT devices to track and adjust energy use, which helps cut down on waste and improve overall efficiency. In agriculture, technologies like AI, and real-time sensors help farmers boost crop production while minimizing the use of harmful chemicals. Owing to climate change, efficient agriculture is the need of the hour, and agricultural waste can be minimized by applying IoT technology in fields (Mueller et al., 2012; Tao et al., 2021). This can be done via automation, in which a network of sensors automatically responds to conditions without any human interference (Nikesh & R. S., 2016). This is particularly useful in the agriculture sector, to maximize yield and efficiency of human and physical resources. One example of this is the use of IoT devices to monitor crops and soil in real time to detect moisture levels, and then turn the sprinkler systems on/off to avoid wastage of water (Kour & Arora, 2020). Data analytics also utilizes IoT and can be applied to agriculture in smart cities. IoT devices have the capacity to collect and analyze large amounts of data, which can be used for decision making, forecasting, farm management and precision farming

(Elijah et al., 2018; Sinha & Dhanalakshmi, 2022), hence accounting for more efficient and sustainable farming using data driven practices (Dlodlo & Kalezhi, 2015).

Similarly, smart waste systems use digital tools to streamline garbage collection and disposal, helping to lower the environmental footprint of waste (Ang & Seng, 2021; Dashkevych & Portnov, 2022; Peralta Abadía & Smarsly, 2021). One such example is from Copenhagen, which has implemented a state-of-the-art waste disposal system, comprising of underground vacuum tubes which transports waste directly to recycling centres. This system has completely eliminated the need for any garbage collection trucks, minimizing environmental impact (Gargiulo et al., 2013). The city's forward-looking approach to environmental sustainability was evident through its ambitious goal of becoming the world's first carbon neutral capital by 2025, which although abandoned in 2022, did drive most smart environment solutions, such as its smart waste system (Alaverdyan et al., 2018).

Another city at the forefront of sustainability initiatives is Zurich. The city is increasing its green spaces in densely populated areas through its famous 'District 9' project, and these green spaces have also contributed positively to the city's footprint by enhancing biodiversity, and hence determining the link between urban green spaces and environmental sustainability (Peric et al., 2022). Moreover, breakthroughs in the transportation sector have significantly reduced carbon footprint, with greenhouse gas emissions from transportation alone having decreased by 40% from 1990-2020 (Menendez & Ambühl, 2022). Therefore, the claim that Zurich's commitment to adopting smart environmental initiatives has played a significant role in enhancing the city's overall urban sustainability is valid.

Pakistan, being a developing country, battling climate change, is for the first time in its history adopting a climate friendly, scientific approach to convert a solid waste dump site into an urban forest and solar park, under the Mehmood Booti project in Lahore. Previously, as part of a risk assessment of the Mehmood Booti Open Dumping (MBOD) site, a physio-chemical analysis of groundwater and leachate, and estimation of gas emissions were carried out, which revealed water samples polluted with heavy metals. It was concluded that all water locations could be threatened with leachate contamination due to the continued accumulation of

solid waste at the MBOD site (Alam et al., 2017). The transformation of this dumpsite will not only deter further leachate, but it will also control pollution by capturing methane and converting it into usable energy, restoring land, promoting sustainable energy production, and making the urban landscape more sustainable (Hasnain, 2025).

The Twin Cities of Islamabad and Rawalpindi are introducing a dual-bin waste collection system in residential areas, and a triple-bin system in commercial centers to improve their waste disposal system and reduce pollution. A control room for real-time monitoring will also be set up to ensure strict implementation of segregation and sorting (APP, 2025a). Therefore, there is nothing distinguishing the fact that the program will improve the overall environmental and urban sustainability of the region.

2.4 Smart Living

The primary aim of smart cities is to enhance sustainability, efficiency, and quality of life (Chang & Smith, 2023). Smart living is sometimes described as being equivalent to quality of life (Ozkaya & Erdin, 2020). It comprises of everyday actions, interactions and tasks that improve the quality of life of individuals by increasing social inclusion, improving connectivity, and improving access and quality of healthcare, education, etc.

2.4.1 Social Inclusion and Connectivity

Building social cohesion to combat social exclusion and inequality is of utmost importance, as not only does it prevent polarization in society, which leads to conflicts, but digital and social inclusion also prevents marginalization and keeps everyone connected and informed about global events (Carter et al., 2023; Namer et al., 2024).

Social inclusion and strong social networks promote strong, stable institutions. These structures make society harmonious by securing rights for individuals, accounting for smooth economic transactions, investment, education, etc (Schulz, 2024). These strong institutions facilitate in technological change and innovations, whilst maintaining transparency.

Connectivity in smart cities goes beyond simple broadband connections; it extends to the complete integration of digital and physical infrastructure, allowing

all residents to fully participate in economic and social life. Stable internet access for instance, ensures that everyone has access to online education, telemedicine, and e-governance services (Deursen & Dijk, 2018). Another example of the aforementioned technological change in institutions includes digital identification systems, and online government portals, which breakdown bureaucratic barriers and make essential services more transparent and accessible (Reuter, 2019). Together, such advancements bridge both the digital divide, by ensuring digital literacy and equal access to information and technology, and the social divide, by enabling diverse populations to engage meaningfully in education, healthcare, governance, and economic opportunities, thereby fostering social inclusion and connectivity in smart cities, and improving their quality of life (Anastasiu, 2019).

2.4.2 Education

Technology can revolutionize the education sector. An example of this is the use of AI powered chatbots to answer student queries and offer them personalized learning experiences (Anisha et al., 2022). Another way this can be done is through the use of intelligent tutoring systems (ITS) (Kulik & Fletcher, 2016), which integrate AI-powered algorithms to analyse student data and use these insights to improve teaching strategies by creating tailored learning experiences for each student. Typically, this comprises of content, assessments, and feedback that are specially designed to suit each students learning capacities and needs, rather than using a ‘one size fits all’ model, which is used in conventional teaching. Additionally, ITSs has the capacity to utilize natural language processing (NLP) and machine learning (ML), giving it the ability to communicate with students just like humans, making learning more interactive and personalized. The Carnegie Learning Cognitive Tutor for example, uses AI to provide tailored feedback and instructions to students, resulting in improved performance (Kulik & Fletcher, 2016).

Moreover, AI powered virtual assistants may aid students with special needs, such as those with auditory and visual impairments, improving their quality of education. AI and IoT can also be integrated in educational institutions to ensure the smooth running of administrative tasks and improving the efficiency of lecturers alike. IoT tools for instance, can track students’ attendance, progress and

participation, and give teachers real time feedback (Tan et al., 2018). NLP and ML can automatically grade student work, which increases the accuracy of grading and efficiency of work as well (X. Li et al., 2020).

The COVID 19 pandemic saw a rise in the use of ICT, AI and IoT technologies in educational systems for smart cities due to the increased need for online learning (Raza, 2020).

While a smart education system can allow real-time monitoring of students' learning progress through dashboards and support for remote and online learning, there are significant hazards of a smart education system, such as data privacy and security and cost of implementation (Chakraborty & Abougreen, 2021; Khan et al., 2023). The use IoT devices for instance bring with them an array of data-privacy and security issues as continuous sensor-based monitoring of classrooms and students yields immense amounts of personal and behavioural information, raising concerns about consent and surveillance (El-Haggar et al., 2023; Garzón et al., 2025). In addition to this, the use of AI and NLP negatively impact students' critical thinking and problem-solving skills, as technology is doing the thinking for the students instead (V et al., 2024). In other words, these technologies threaten to dehumanize the entire learning environment of the education sector, as they also considerably alter the teacher-learner relationship. Therefore, while smart city education initiatives do hold some merits, their integration need to be done with considerable reconsideration and strict regulations to ensure that they don't deprive young students of the required necessary mentorship.

In Pakistan, although AI, IoT and augmented and virtual reality haven't been integrated into educational institutes yet, but just like many other parts of the world, there has been a steady rise in the number of online tutoring and e-learning platforms available for students, which improve the overall accessibility of online education (Iqbal et al., 2020). Notable examples include Khan Academy and Virtual University, Pakistan.

2.4.3 Healthcare

A research by (Mohammadzadeh et al., 2023) found that technology when integrated in the healthcare sector has proved to increase accessibility, optimize patient outcomes, reduce costs, and enhance efficiency. Overall, smart cities are at

the forefront of healthcare innovation, driving advancements in access, patient outcomes, cost reduction, and efficiency. A promising trajectory for the future of healthcare is indicated using cutting edge applications and technology such as the IoT devices, Wearable devices, AI, Telemedicine, Electronic Health Records, Mobile Health and Biometric sensors.

However, such technology should be integrated into the healthcare system with great caution as immense ethical and privacy challenges arise with their deployment, making patient data protection and compliance with laws essential (Bartoletti, 2019; Vayena et al., 2018). Using AI for clinical assessments and diagnosis is also on the rise. However, excessive dependency on AI and the lack of willingness of practitioners to question errors or double check results not only challenges professionalism but also threatens human lives in the healthcare industry (Hazarika, 2020). On the contrary, on the other hand, in some cases, it may be difficult to build the trust of health care workers and patients alike in using AI in hospitals and believing in AI assisted procedures and technologies such as robotic surgery and image analysis, and recommendations such as clinical decision support, predictive analysis and identification of potential drug candidates due to the lack of awareness (Sun & Medaglia, 2019).

This technology can be applied to a developing country (such as Pakistan) to make healthcare more accessible and affordable, to digitalize healthcare infrastructure, to increase public health awareness, to establish and increase existing emergency response services, to establish research and development, and to improve community involvement. By focusing on these aspects, health outcomes of residents of the developing nations can be improved.

Nevertheless, technology integration through smart city initiatives in the health care sector offer promising results, especially for developing countries if their use is regulated after deployment to prevent exploitation. Pakistan uses smart technology in healthcare through the widespread use of wearable devices in hospitals and clinics, which monitor vital signs such as blood pressure and oxygen. These devices transmit real time data to doctors for analysis, enabling timely decision-making for best patient care (Weddell & Magno, 2018). In addition to this,

nationwide telehealth services such as EZShifa have made healthcare more accessible and convenient (Mahdi et al., 2022).

The Federal Government of Pakistan established the National Command and Operation Centre (NCOC) soon after the first confirmed case of COVID-19 in 2020, with the mandate of making data-driven decisions to control the pandemic. Its responsibilities ranged from implementing lockdowns to coordinating nationwide health responses. One of its key initiatives was the launch of the Resource Management System (RMS) on May 31, 2020, which provided real-time information on both COVID and non-COVID hospitals across the country, including the availability of essential resources (Nawaz et al., 2022, p. 19). Complementing this system, the Pak Nigehbaan App was introduced to guide citizens in locating nearby hospitals with available beds and ventilators, thereby enabling timely access to treatment and optimizing patient care (Hussain, 2020). Additionally, the National Emergency Operation Centre (NEOC) developed the Integrated Disease Information Management System, a central database for COVID-19 statistics that supported forecasting and facilitated the implementation of smart lockdowns to contain outbreaks effectively (Noreen et al., 2021). Similarly, the Sehat Tahaffuz helpline (1166), which had previously focused on polio and immunization awareness, broadened its services during the pandemic to provide COVID-related guidance and even connect callers directly with doctors when needed (Sharmin, 2020). Unlike blanket lockdowns that posed serious economic risks, smart lockdowns targeted specific hotspots by using epidemiological data to track spikes in infections, enforce local restrictions, and carry out contact tracing. This differentiated strategy, made possible through the daily collection of case numbers, hospitalizations, and mortality data, played a crucial role in limiting the spread of the virus while minimizing disruptions to livelihoods (APP, 2020; Emmanuel et al., 2023). Collectively, these initiatives strengthened urban sustainability, even amid crises such as the pandemic, by harnessing technology and fostering greater resilience across the nation.

2.4.4 Safety and Security

Smart city initiatives enhance urban sustainability and improve the quality of life of citizens. While these initiatives can mitigate carbon emissions, improve

air quality, reduce traffic congestion, they can also strengthen public safety and make cities more resilient and inclusive for all.

ICT applications are used to reduce crime, enhance emergency responsiveness, and safeguard communities. These applications include smart surveillance systems, digital emergency response mechanisms, adaptive lighting systems, and mobile platforms that support public safety (Alsamhi et al., 2019; Bibri & Krogstie, 2017). Smart surveillance systems use AI and ML to analyse activities in public spaces, identify unusual or potentially threatening behaviour, and thereby contribute to crime prevention and safer urban environments. Similarly, emergency response frameworks utilize IoT devices and sensor-based technologies to promptly detect incidents, notify relevant authorities, and accelerate intervention, which ultimately improve outcomes. In addition, mobile safety applications empower citizens to report incidents directly while also receiving timely alerts from government agencies, fostering greater transparency, trust, and accountability between residents and institutions.

However, the extent to which technology integration can improve urban security and aid in criminal prosecution is still debatable as some technologies, such as facial recognition technology (FRTs) for instance, raise ethical and legal concerns. FRTs have been shown to consistently misidentify individuals from marginalized groups, including racial and ethnic minorities, raising concerns about discrimination and rule of law (Chan, 2022). As a result, such technologies may also be prone to exploitation and misuse by incompetent governments as well. In addition to this, technical faults such as false positives, may occur as FRTs have to tackle the problem of accuracy considering that they work on a probabilistic basis. This is especially common when sample suspect images are of poor resolution, or when watchlists contain images of people who closely resemble one another (Grother et al., 2019). In addition to this, continuous use of facial recognition for surveillance is a violation to the right to privacy as well as it violates the right to the protection of personal data (FRA, 2015).

Copenhagen utilizes CCTVs and cameras to ensure public safety and deter crime (Harmon et al., 2015). Emergency response mechanisms increasingly rely on real-time data and analytical tools to deliver services that are both timely and

effective. Adaptive smart lighting has been introduced in the country, which automatically adjusts to surrounding conditions. This not only improves visibility but also strengthens residents' sense of security within public spaces.

'Safe City' has emerged in Pakistan, which is a smart city initiative that specifically focuses on safety and security. While safe and smart cities both involve the integration of ICT into the urban infrastructure, safe cities are particularly geared towards creating secure urban areas (Hong, 2022). Islamabad's Safe City project was inaugurated in 2016. It significantly improved the security of the capital and reduced crime as it was possible to monitor and trace down suspects. Islamabad police had solved at least six cases with the help of the Safe City Project, including a bank robbery and vehicle theft (Asad, 2016). Punjab Safe City Project was also inaugurated in 2018, with the primary focus of establishing technology infrastructure such as surveillance cameras and data centers across Punjab. These were to be utilized via the Integrated Command, Control, and Communication (IC3) System; an integral organ of the Safe City project, as it analyses and consolidates data from surveillance systems and relays it to the emergency response forces and law enforcement agencies, enabling real time communication and response. This is made possible with its five service areas viz, emergency call centre, dispatch centre, strategic operations and monitoring suite, CCTV Control and crisis management centre (PITB, 2018; P. Police, 2018).

2.5 Smart Mobility

Smart Mobility refers to the use of technology to improve the efficiency of transport systems. This includes traffic monitoring to reduce congestion, and smart parking systems to detect vacant parking spots, just to name a few (Wolniak & Grebski, 2023b). In addition to this, ICT when integrated into the transportation system can also increase safety, by alerting pedestrians about potential hazards, and increase convenience by alerting citizens about possible delays caused by roadworks, accidents, etc (Wolniak, 2023).

With the ever-increasing population in urban centers, traffic monitoring is a vital requirement for smart cities to prevent congestion on roads. The application of technology, also extends to mobility and transportation, as smart traffic system (STS) use real-time data and, IoT devices process this data to make decisions to

efficiently manage traffic flow (Misbahuddin et al., 2015). In smart traffic management systems, sensors can be installed directly into the roads to track vehicles (Sharif et al., 2018). Cameras use digital image processing to analyze and predict traffic flow. The data collected is then used to manage traffic more effectively (Javaid et al., 2018).

Significant improvements have been seen in recent years in smart mobility, with a heightened focus on the nexus between transportation and the environment, especially in Asian countries, with cities like Seoul, Singapore and Tokyo adopting Intelligent Transportation Systems (ITS) to increase the efficiency of the transportation network (Su et al., 2022). Cities like Bengaluru and Singapore have introduced shared electric vehicles, (Feardots et al., 2022). Tokyo and Seoul have metro services that span the entire city, making them efficient and environmentally friendly. Moreover, a range of other micro mobility options such as large-scale bike sharing options in cities such as Beijing allow for eco-friendly alternatives to conventional travelling (Alcaide Muñoz & Rodríguez Bolívar, 2021). The overall transport infrastructure of many Asian countries is being developed as they are a massive market for electric vehicles. Large charging stations are being set up, with some countries such as Tokyo even introducing subsidies to purchase electric vehicles and incentivizing their use to encourage citizens (Yabe et al., 2012).

Electric vehicles when compared to conventional fuel powered vehicles are significantly better for the environment as they emit 97% less CO₂-equivalent greenhouse gases compared to petrol vehicles, and 70% less CO₂-equivalent compared to diesel-powered vehicles (Das et al., 2024). Although manufacturing their batteries do have significant detrimental environmental impacts, electric vehicles still deliver lower greenhouse gas emissions and reduced fossil fuel consumption over their entire lifetime as compared to conventional fuel powered cars (X. Xia & Li, 2022), hence making them the most environmentally sustainable, personal vehicle in today's urban landscape.

Tokyo, the capital of Japan once facing various transportation challenges overcame them by adopting smart mobility solutions. Central to this transformation is a multimodal, integrated public transport system that enables seamless travel across the city, thereby reducing reliance on private vehicles. The system is further

strengthened by real-time monitoring, which provides timely updates such as service delays. The introduction of contactless, cashless fare payments enhances both convenience and efficiency for commuters. In response to the growing threats of climate change and air pollution, Tokyo has also promoted the use of electric vehicles, offering incentives to encourage their adoption. These initiatives reflect Japan's broader national commitment to lowering its carbon footprint, with cities like Tokyo striving to build greater urban resilience and sustainability. The table below presents an assessment of how these smart mobility measures contribute to advancing urban sustainability in Tokyo. (Wolniak & Grebski, 2023a)

Table 1 Problems before smart mobility adoption and corresponding improvements in Tokyo.

Source: Wolniak & Grebski, 2023a

Problems Prior to Smart Mobility Adoption	Advantages and Resolution
Balancing the demand for transportation services with the existing infrastructure	Improved transportation efficiency and reduced congestion
Integration of various transportation modes and systems	Enhanced accessibility and connectivity across the city
Managing the increasing demand for public transportation during peak hours	Reduced reliance on private vehicles, promoting sustainable transportation
Ensuring reliable and accurate real-time data for commuters	Real-time information and updates for better trip planning
Overcoming potential resistance to change from commuters accustomed to traditional transportation methods	Integration of multiple modes of transportation for seamless transfers
Addressing safety concerns and establishing regulations for new mobility solutions	Promotion of eco-friendly options such as bike sharing and micro-mobility
Managing and maintaining advanced technologies and systems for efficient operation	Implementation of intelligent transport systems to optimize traffic flow
Balancing the needs of pedestrians, cyclists, and motorists in shared spaces	Emphasize on pedestrian-friendly infrastructure, promoting walking as a viable mode on transportation
Ensuring inclusivity and accessibility for all segments of the population	Collaborative approach between government, operators, technology providers

In Pakistan, in the capital of the province of Punjab, Lahore, the Orange Line Metro, was launched on Oct 26, 2020. It not only provides an ecofriendly alternative to personal vehicles, but also facilitates in improving job prospects, particularly for those who are more dependent on public transport, hence supporting the economy as well. This indicates the importance of a good transport network as it plays a significant role in strengthening the nexus between smart mobility and smart economy (Hasnain, 2023). In addition to this, the Orange Line Metro also gives the metropolitan an opportunity to address infrastructural shortcomings as much of the area along the Orange Line route lacks essential public facilities. Hence, this metro is a promising development toward enhancing overall accessibility to schools, healthcare, and other essential infrastructure and facilities. In other words, the Metro is considered as an integral part of Lahore's urban regeneration strategy, contributing positively to urban planning, economic growth, and environmental sustainability (Rana & Bhatti, 2018).

While the short-term sustainability of the Orange Line Metro is commendable, the long-term sustainability does raise concerns owing to the political and social uproars attached to the project. Social pressure for instance, may challenge the nature and implementation of urban regeneration projects. Moreover, land acquisition issues do pose a significant challenge for development. A study by (Rafique et al., 2022) found that although the citizens are not completely opposed by land acquisition, they demand more than simple compensation for their loss; they also want gains from regeneration. It was believed by 28% of respondents that alternate land options would be better than cash compensation due to the prospect of upward mobility through regeneration. Therefore, it is safe to say that such initiatives come with their fair share of challenges, especially when implemented in developing countries as they must be considerate of a plethora of other issues, making it impossible for such projects to be successfully implemented with tunnel vision.

In the Twin Cities of Islamabad and Rawalpindi, the Capital Development Authority (CDA) has launched a mobile app to facilitate residents by providing detailed information about metro and electric feeder bus routes and stops integrated with Google Maps. The app allows trip planning with estimated travel times, bus

stop information, and even tourist attraction information to boost tourism. Moreover, further updates on the app will allow for e-payments by integrating digital and mobile wallets to elevate the public transport system to match that of international standards. This app has made urban transportation more convenient and environmentally friendly, accounting for overall improved urban sustainability of the Twin Cities (APP, 2025b). This will lead to a more efficient and environmentally friendly city. However, authorities suspend its functioning in the wake of severe weather conditions and political turmoil, raising concerns about the reliability of this mode of transport.

2.6 Smart People

Smart cities are not simply about the integration of technology in all domains of life, but also about utilizing that technology and developing human and social capital to further develop the urban landscape and trigger a chain reaction of sustainable development. The indicator of smart people refers to all actions and programs that improve the education, skills, innovative capacity, and civic engagement of citizens. This involves human capital, development and social innovation.

Social innovation refers to ideas that enhance or support the functioning of society, often including actions that have the intention of social change, initiated as an act for the common good to resolve a social problem (Caganova et al., 2015). Social innovation can be more important than technological innovation as it can trigger social development, which is an essential component of urban sustainable development as it improves the opportunities and conditions of all people of society (Jurenka et al., 2017).

Human capital also plays a significant role in developing the economy of a country as it helps build urban sustainability. One example is Copenhagen's thriving research, innovation, and startup ecosystem, backed up by a well-developed education system, that promotes advancements and learning in all fields, across all age groups through professional development programs and vocational training programs (Copenhagen's Action Plan For the SDGs, n.d.). The city focuses on education, economic growth, innovation, skill development and the wellbeing of its residents. For this reason, the city promotes flexible working hours and has been

awarded as one of the world's leading cities for maintaining a healthy work–life balance (Pratt, 2025).

A flourishing education sector through which well-rounded students graduate each year also significantly contributes to human capital development, which leads to urban sustainability. Scholarships, for instance allow many students to pursue higher education, and contribute directly to skill development, knowledge and competencies through formal education, which correlates with increased employability and productivity in the labor market (Becker, 1994). Moreover, since many international scholarships have 'bonds', that require students to return to their country of origin, this promotes the development of human capital in the origin country as well, serving to contribute to the local economic development and workforce (McMahon, 2009).

In addition to this, international scholarships also play an essential role in enhancing social capital by promoting cultural exchange and fostering collaborative networks. Interactions between students from different nationalities and sociocultural backgrounds promote cross-cultural understanding and tolerance, which increases social cohesion in both, the host and origin society, vital for urban sustainability, as it ensures that the social fabric is tightly knit together (Perna et al., 2014).

Such scholarships also exist in Pakistan. Funded by the Higher Education Commission (HEC), British Council, and Common Wealth, some of which are needs based, some merit based, and some a combination of both, all of which enable quality education for all by removing financial barriers, and acting as a catalyst for individual development and social cohesion, reinforcing the interconnectedness of education, social inclusion and sustainable development (Khosro et al., 2024). A study by (Ahmed et al., 2022) found that need-based scholarships boost academic performance by approximately 4% in male students, improving outcomes like skills acquisition, and career progression, hence playing a vital role in increasing their chances of upward mobility by enhancing their human capital.

Moreover, civil society organizations have initiated IT courses to aid in the capacity building of the Pakistani youth to train them for the work force. The 'Bano Qabil' Program is one such example, which offers free IT courses in digital marketing, web development, etc, to empower the youth (Dawn, 2025).

2.6 Synergies Across Smart City Indicators

All six indicators of smart cities are interconnected as technology integration in one domain has significant impacts in the rest. For example, the adoption of electric vehicles is an example of smart mobility but also improves air quality by reducing dependence on fossil fuels and improves the overall quality of life. Similarly, by cultivating partnerships with academic institutions and industry leaders, collaborative projects drive innovation, triggering scientific development. High speed internet, improved access to quality education and improved health outcomes, all improve the quality of life of individuals and account for better human and social capital and eventually lead to a strong economy. Such smart solutions represent a remarkable integration of sustainability and technology. Through these initiatives, urban sustainability can be achieved, in which cities are socially cohesive, economically strong and environmentally sustainable.

2.7 Citizen Perceptions of Smart Cities

A study by (Wirtz et al., 2022) investigated citizen perceptions of smart cities based on a survey of 906 citizens in Germany. Results found that citizens had the best perception of digital connectivity, such as city-wide WiFi networks, giving it an average relevance score of 4.05. Other areas that received high ratings included smart mobility and environment, indicating that residents are more satisfied with technologies that directly improve their daily living conditions and quality of life rather than those aspects of smart cities that have more gradual results. As a result, smart economy and governance were ranked lower, even though people do acknowledge their broader importance, they still appear to prioritize other services that deliver more immediate benefits.

In addition to this, there was also an evident discrepancy for the priority areas when it came to smart city development between the citizens and the government, as the latter's primary focus was always smart governance and a smoother, more efficient bureaucracy, but the citizens always favored actions that would make their life instantly more efficient and improve their quality of life. Citizens rated ten different service areas as more relevant than public officials did, while officials rated another ten areas higher than citizens (Wirtz et al., 2022). This difference in ratings points towards an imbalance in how service priorities are set, indicating a

need for better understanding of public expectations and government decisions, which can be done through public engagement to gain a better understanding of citizen expectations, needs and preferences.

Another study by (AlAli et al., 2023) found significantly positive attitudes towards adopting smart city initiatives in Qatar, with 92% stating infrastructure in smart cities should be sustainable as this has the potential to solve climate change and environmental challenges. The major common concern that was raised was over data sharing and privacy as citizens were worried about the usage of their personal information, especially in the domain of smart governance.

2.8 Theoretical Framework

General Systems Theory developed by Ludwig von Bertalanffy will be used to explain this research. It offers a way to look at different areas of knowledge, like technology, economics, sociology, and psychology through a shared lens. Instead of focusing on every minute detail, it emphasizes how the parts of a system interact and work together. This helps build an understanding of complex systems by examining the bigger picture and finding common patterns across different fields (von Bertalanffy, 1950). This theory extends to cities, as proposed by (H. Xia & Wang, 2017), modern cities are complex systems that combine cyber, physical and social systems.

A system as explained by (Rousseau, 2015) is a “set of interacting or interdependent component parts forming a complex whole. Every system is...surrounded and influenced by its environment, described by its structure and purpose and expressed in its functioning”. A system can also be further categorized into subsystems. This theory is used to explain cities, which are defined by (James et al., 2013) as “a large and permanent human settlement and cities generally consist of complex subsystems for example for sanitation, utilities, land usage, housing, or transportation.” Hence, when viewing a city from the lens of the systems theory, a city is seen as the “environment”, while the various systems that exist within the environment, such as powerplants, are subsystems of the energy system, and infrastructure, are a subsystem of the transport system. This is graphically represented in Figure 1 below (Lom & Pribyl, 2021).

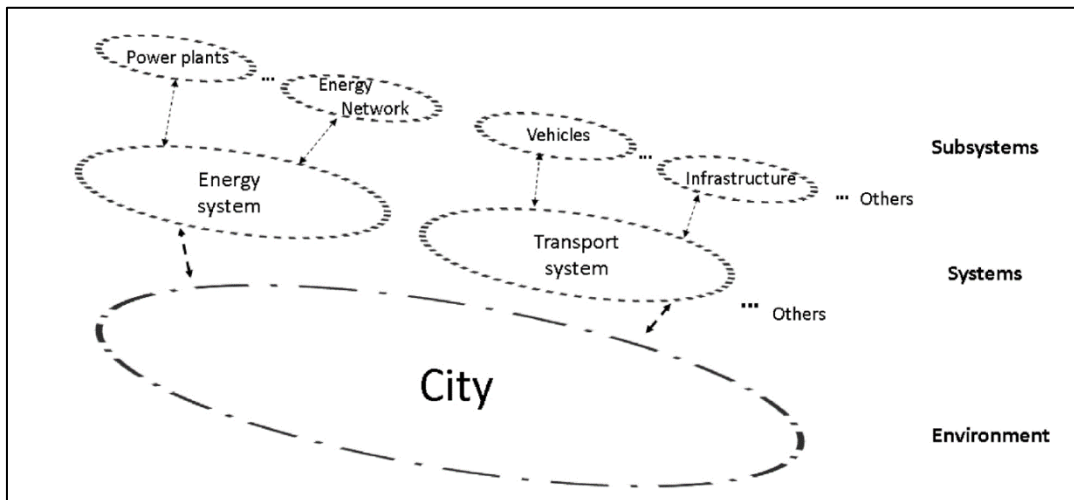


Figure 1- The example of a traditional city fitted to the Systems Theory

As seen in Figure 1, the subsystems in traditional cities do not interact with other subsystems; they only interact within own systems and the overall environment. In smart cities on the contrary, as pictorially represented in Figure 2, everything is integrated, and each subsystem is interconnected with the other, representing exchange of information and/resources, improving efficiency and enhancing quality of life. This interconnectedness is a result of the intricate networks that make up the smart cities, where technology, physical spaces, and human interactions come together (H. Xia & Wang, 2017). The true essence of smart cities lie in how seamlessly these elements integrate—blending digital advancements with urban life, whilst prioritizing sustainability. This perspective moves beyond just technology, emphasizing the dynamic relationships that shape the city’s overall functionality and impact its sustainability (Sheth et al., 2013; Wang, 2010).

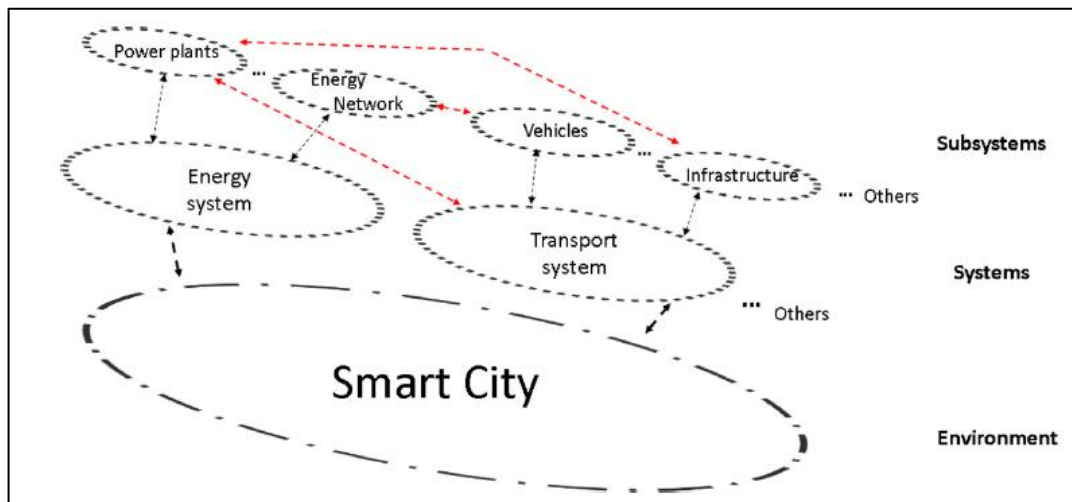


Figure 2- An example of a smart city fitted into the Systems Theory

The systems theory is used to understand smart cities as it views them as dynamic, interconnected systems rather than isolated components. This perspective allows us to see how different urban subsystems, such as transportation, energy, governance, the environment, and society constantly interact to support sustainability. Modern cities function as open and complex systems, continuously adapting to their surroundings (Gang, 2007). For example, a smart city’s transportation system collects real-time traffic data, such as vehicle speeds (input), to identify over-speeding and issue fines (process), ultimately reducing accidents (output).

Hence, cities are considered as an environment according to the Systems Theory. One subset of the Systems Theory is the Cyber Physical System, (CPS), under which cities more accurately fall. CPS means that the physical and virtual (software) worlds are interconnected (Lee et al., 2015). This approach aligns well with the goals of smart cities, which aim to connect various systems, such as energy, transport, and security into a more integrated whole. In a smart city, physical infrastructure is often equipped with sensors and devices such as cameras spread across the urban landscape. These devices communicate wirelessly with tools like smartphones and tablets, all supported by cloud-based technology that form the digital backbone of the system. The data gathered through this setup can include everything from traffic updates and parking availability to air and water quality, and

the real-time status of key city services like public transport, and healthcare (Hashem et al., 2016).

In essence, achieving urban sustainability requires more than just improving individual aspects of a city. A systems approach enables this, as it ensures that smart solutions work together, creating long-term resilience and sustainability.

CHAPTER 3

Research Methodology

This study adopted a mixed method approach for the collection of data to achieve its objectives. This approach was chosen as the research questions, objectives and hypothesis of the study demanded a culmination of qualitative and quantitative data for in-depth information. The analysis of such data helped in getting relevant facts and form a deeper understanding of citizen perception of smart cities and their impact on urban sustainability in the Twin Cities. Data was collected through semi structured interviews and a structured questionnaire.

3.1 Study Area

The Twin Cities, comprising of Islamabad Capital Territory and Rawalpindi, each having a population of 1.11 million and 2.36 million, and area of 906 square kilometers and 5285 square kilometers respectively was the study area of the research (PBS, 2023). Being the capital and the country's first planned city, it is a center point of urbanization. It is also home to the 'Safe City' Project, which integrates technology-led policing, making the security of the capital a model of excellence. Moreover, Capital Smart City, a private housing society currently under construction, is Islamabad's first smart housing society. The study area in this research targeted the ordinary citizens of the Twin Cities, namely those living in sectors E(7-11), F(6-11), G(9-11), H(8-11), I(8-11) and housing colonies of Bahria Town Phases 1-6 and 7-8 and DHAI and II to investigate the public perception on smart cities.

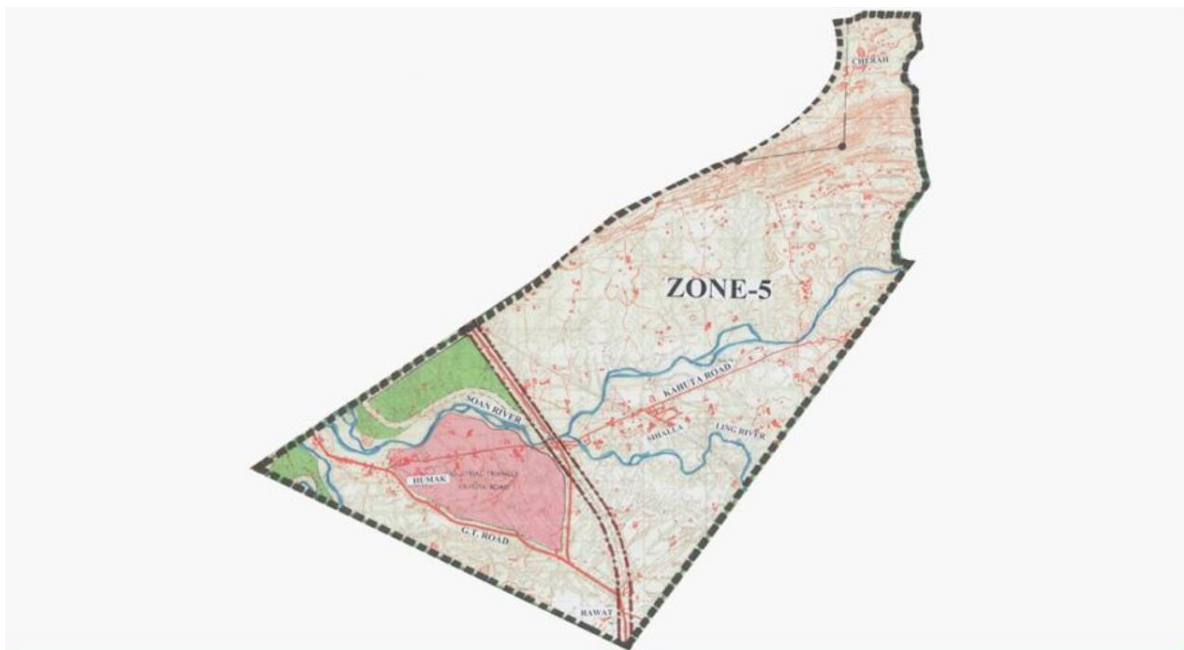
All these areas each comprise of the key six indicators of smart cities (smart governance, economy, environment, living, mobility and people). DHAI and II for instance, have speed radars on roads which detect over speeding cars, 24/7 CCTV monitoring to deter crime, daily recycling, an app exclusively for their residents through which they can launch complaints and maintenance requests, and regular community engagement events which support small business owners in the locality. These smart mobility, smart living, smart environment and smart people initiatives made this society an ideal study area. Similarly, sectors E(7-11), F(6-11), H(8-11) and I(8-11) come under the coverage of the Islamabad Safe City Project and so are

surveilled 24/7 with cameras and monitored under the central data centre, allowing for crime prevention and emergency services dispatching, a prime example of smart governance and smart living. To curb the issue of water scarcity, the housing society of Bahria Town has built its own water sewerage plant. The water from this is then used for horticulture and in fire brigade vehicles. The society as an entity is self-sufficient as it has its own educational institutes providing quality education, hospitals providing modern health care and even cinemas, parks and zoos for recreation and leisure, hence covering major aspects of smart living, which made it a suitable choice for this research.

Additionally, government officials and professionals working on smart city projects and urban development and sustainability were also interviewed to investigate the impact of smart cities, their characteristics and technology on urban sustainability.

Figure 3- Maps of Study Areas (Zones 1 and 5) Islamabad

Source: Sky Marketing



3.2 Sampling and Sample Size

The sampling technique used for this research was purposive sampling. By using this sampling, the responses yielded from interviewees accurately answered and provided an in-depth, valid understanding of the impact of smart cities on urban sustainability as the individuals chosen for the interviews were experts in their fields. Furthermore, by administering the questionnaire in a sample selected through purposive sampling, citizen perception, and use of smart city technologies was studied, as the sample was aware of the concept of smart cities, and they were able to give more informed insights.

The sample size for the questionnaire was 200 people residing in the selected study area. Table 2 showcases the distribution of participants from the study area, with a total of 33 participants from Bahria Town Phases 1–6 and 33 participants from Phases 7–8 (16.5% each). Similarly, 33 respondents (16.5%) were drawn from DHA Phases 1, 3, and 4, and an equal number from DHA Phases 2 and 5 (16.5%). In Islamabad, sectors E(8-11), F(5-11) and G(6-15) together contributed 34 participants, while sectors H(8-11) and I(8-11) also accounted for 34 respondents (17%). This distribution ensured a balanced representation of participants from the study area, and it was adopted to capture a more representative view of citizen perceptions. Moreover, these locations share the same number of smart city characteristics.

Table 2 Segregation of number of respondents who responded to the questionnaire by housing society and sector

Sr. No	Housing Society / Sector from Study Area	No. of Respondents
1	Bahria Town Phase 1-6	33
2	Bahria Town Phase 7-8	33
3	DHA Phase I	33
4	DHA Phase II	33
5	E(7-11), F(6-11), G(9-11)	34
6	H(8-11), I(8-11)	34
	Total	200

The sample size for the interviews was 3 people, each official from the following organizations: Defence Housing Authority Islamabad, Islamabad Safe City, and One Network.

3.3 Data Collection

Quantitative data was gathered using structured questionnaires which were distributed among the citizens of the Twin Cities to evaluate the public perception and attitude towards smart cities, and readiness to adopt similar initiatives. Some questionnaires were administered digitally via Google Forms, while others were administered conventionally on paper to ensure that the digital divide did not become a barrier in this research, and awareness, perception and readiness to adopt smart city initiatives could still be investigated regardless of access and use of Google Forms.

Qualitative data was obtained through semi-structured interviews with government officials and professionals working in urban development, planning and sustainability, and those working in Islamabad Safe City and smart city projects. These semi structured interviews consisted of sets of predefined questions consistent to each professional, together with specific, tailored questions to probe

further into each organization's niche, ensuring in-depth details and comparability across interviewees. The combination of quantitative and qualitative data provided a comprehensive understanding of the public perception of smart cities and their impact on urban sustainability.

3.3.1 Structured Questionnaire Survey

A structured questionnaire collected primary data from 18–60-year-old male and female citizens of the Twin Cities. The questionnaire was divided into 9 sections, including a section on demographics so that a comprehensive understanding could be developed of the characteristics and nature of the sample, and their potential (if any) influence on smart city perceptions. A section was also made on smart city awareness levels to gauge whether the sample had heard of the term before and if they were aware of existing initiatives. A separate section was created for each of the six key indicators for smart cities: smart governance, smart people, smart living, smart economy, smart environment and smart mobility to ask questions about public awareness and perception about existing smart city initiatives in these domains and their opinions and satisfaction levels from them. A specific section was developed to explore perceptions of the Twin Cities as a smart city, focusing on citizens' views regarding the extent to which such initiatives have benefited the area. Further sections on attitudes towards smart city development and citizen perception focused on both their experiences of current initiatives and their openness to adopting future technological innovations.

The questionnaire consisted predominantly of 2 question types; Trichotomous Questions, with “Yes”, “No” and “Maybe” options, and questions with a Likert Scale, ranging from 1-5, indicating “Strongly Disagree” to “Strongly Agree”, respectively. This structured questionnaire with the same set of pre-defined questions and answers helped maintain uniformity, making the data easier to analyze and increased the reliability of the questionnaire. It also allowed for more cost and time efficient data collection. The questionnaire gauged awareness, public perception, willingness to adopt, and perceived benefits of smart city initiatives. The questionnaire catered to both categories of people; those that had variable knowledge of the concept of smart cities and its contributions, and also those that were not familiar with the term at all, hence gaging their perception and readiness

to accept smart cities as well, providing a complete image of public acceptability and awareness.

3.3.2 Interview Guide

Interview guides were created for the interviews. Interviews were conducted with one official from each of the following institutes: Defence Housing Authority Islamabad, Islamabad Safe City and One Network, as illustrated in Table 3.

These organizations were specifically chosen as each of them were specialized in and working on at least two of the six key indicators of smart cities: smart government, economy, environment, living, mobility and people (Giffinger & Gudrun, 2010; Vinod Kumar & Dahiya, 2017). Together, the interviews uncovered the impact of smart cities on urban sustainability. The interview guide consisted of open-ended questions regarding the contributions of smart cities and technological contributions on economic growth, environmental sustainability and social wellbeing. The questions were carefully curated to gain insights of each representative about their views on urban sustainability, their institutions workings towards it, and their future goals.

Table 3- Number of interviewees by institution

Sr. No	Institution	Indicator	Interview Focal Persons
1	Defence Housing Authority, Islamabad	Smart Living, Smart People, Smart Mobility, Smart Environment	1
2	Islamabad Safe City	Smart Governance, Smart Living	1
3	One Network	Smart Mobility, Smart Living, Smart Governance	1
			3

3.3.3 Data Analysis

Statistical Package for Social Sciences (SPSS) was utilized for quantitative data analysis. Descriptive statistics were used to summarize responses, while inferential statistics such as linear regression analysis were applied to identify the relationships in perceptions. The strategic use of SPSS enhanced the robustness of the study, contributing to a comprehensive understanding of the public perception of smart cities.

Thematic analysis was used to study qualitative information in this research, providing a detailed understanding of the impact of smart cities on environmental sustainability, economic growth and social well-being in the Twin Cities. This method allowed for the identification of recurring themes and patterns in stakeholders' perceptions of smart city impacts on urban sustainability. The semi structured interviews yielded in depth information from police and private housing authority officials about the integration of technology in urban development and

planning, security, its implications for the environment and societal wellbeing, together with challenges and barriers in implementation.

CHAPTER 4

Data Analysis

Data analysis section served the significant aspect of this research that focused on the analytical assessment of the collected data, significantly aimed at explaining the correlation between smart cities and urban sustainability. The exploration entailed comprehensive descriptive analysis, drawing from data obtained through rigorous field research. Thematic analysis of qualitative data further enriched the findings, shedding light on nuanced aspects. The descriptive analysis, crucial in discerning patterns, leveraged statistical tests within the Social Sciences package. This facilitated a detailed exploration of independent and dependent variables, contributing to robust understanding of smart cities in the urban, sustainability landscape. Through this analytical lens, this study not only uncovered key findings but also advanced the broader discourse on urban sustainability practices.

4.1 Descriptive Analysis

The quantitative data analysis in this smart city research utilized the Statistical Package for Social Sciences (SPSS) for its primary framework for descriptive statistics. The choice for SPSS was strategic, as it not only facilitated the examination of statistical information but also streamlined the analysis of demographic data. The robustness of SPSS allowed for the application of various tests on the questionnaire data. The research led to the descriptive analysis of the questionnaire survey, analyzing the demographic information initially. Furthermore, Pearson Correlation was conducted as part of this research to describe the strength and direction of the explored linear relationship. This comprehensive analytical approach provided a nuanced understanding of the statistical landscape surrounding smart cities, contributing to a more insightful exploration of their potential impact on urban sustainability in the Twin Cities.

4.1.1 Demographic Characteristics

The demographic characteristics of the participants revealed from the analysis of primary data are shown in Table 4, in which the mean age of the respondents in the study area was 34.25. The fundamental reason for this age was that majority of the respondents were working, male and female individuals. Reflecting to the demographic information, 55% of the respondents were male and 45% of the respondents were female.

The overall literacy rate of the respondents was 100% as the study area had high levels of awareness and education. Regarding the occupation of the respondents, majority were businessmen or self-employed (28%), followed by those employed in the private sector (23%), followed by retired, non-working and unemployed individuals (22%), students (17%) and those working in the public sector (10%).

Table 4 Demographic Characteristics of the respondents

N=200

Demographic Information	
Mean Age	32.25
Gender (Male, %)	55%
Education (Literate, %)	100%
Occupation (Business/Self Employed)	28%

4.1.2 Respondents Awareness of Smart Cities in the Twin Cities

Figure 4 illustrates awareness of smart city initiatives in the Twin Cities. This was a conditional question. Only if individuals were aware of smart city initiatives in Islamabad and Rawalpindi, then they were asked about their perception, awareness and satisfaction levels about the characteristics of the smart cities. Therefore, only the 122 respondents who answered ‘Yes’ were taken to the next six sections of the questionnaire which were on the six key characteristics and indicators of smart cities: smart governance, people, living, economy, mobility and economy, making the number of respondents for questions in those sections 122. The respondents who answered ‘No’ to this awareness question skipped these six sections and were redirected to the ‘Attitudes towards smart city development’ and ‘Citizen Perception’ sections. These sections were filled in by all 200 respondents, as investigating the attitudes of citizens of the Twin Cities towards further development and willingness to directly support such improvements is essential for policy makers.

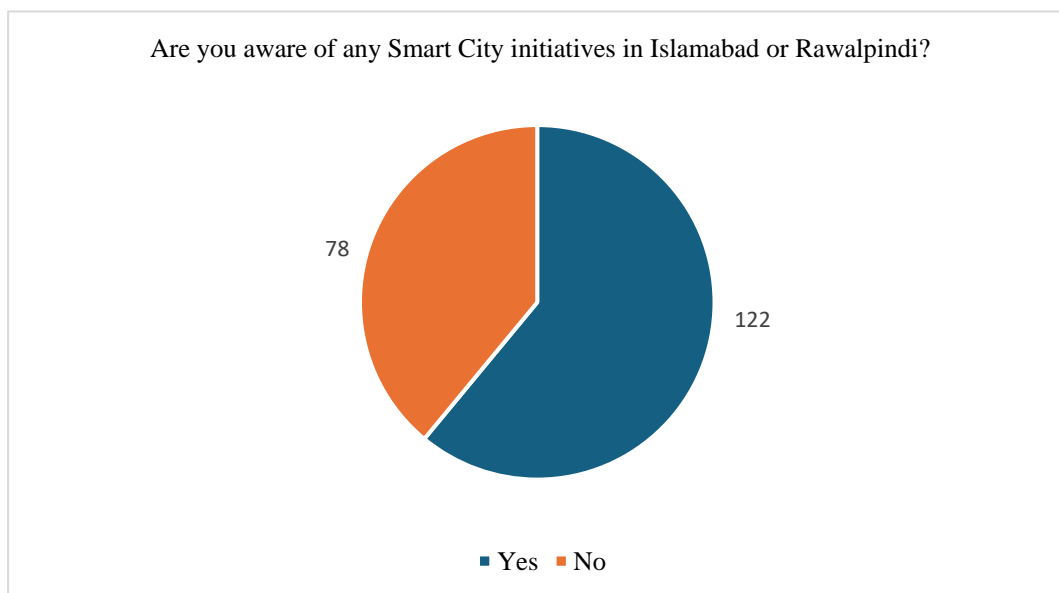


Figure 4 Respondents Awareness
(Source: Field Data)

4.1.3 Respondents Views on Smart People Initiatives

Figure 5 summarizes the Smart People indicator, which was measured through three Likert-scale items. For the first statement, “*The people living in Smart Cities have numerous opportunities to enhance their qualifications*”, responses were largely positive. While no respondent selected “strongly disagree,” a small proportion (6%) disagreed. One-quarter of participants (25%) remained neutral, whereas the majority expressed affirmative views, with 38% agreeing and 31% strongly agreeing.

The second item, “*How willing are you to adopt new technologies for daily life and work?*”, revealed an even clearer inclination toward technological adoption. Only 1% reported being completely unwilling and 2% expressed slight unwillingness. A modest share (13%) indicated moderate willingness, followed by 20% who were generally willing. Notably, nearly two-thirds of respondents (63%) identified themselves as very willing to adopt new technologies. For the purpose of the graph, these categories were aligned with the traditional Likert labels ranging from “strongly disagree” to “strongly agree.”

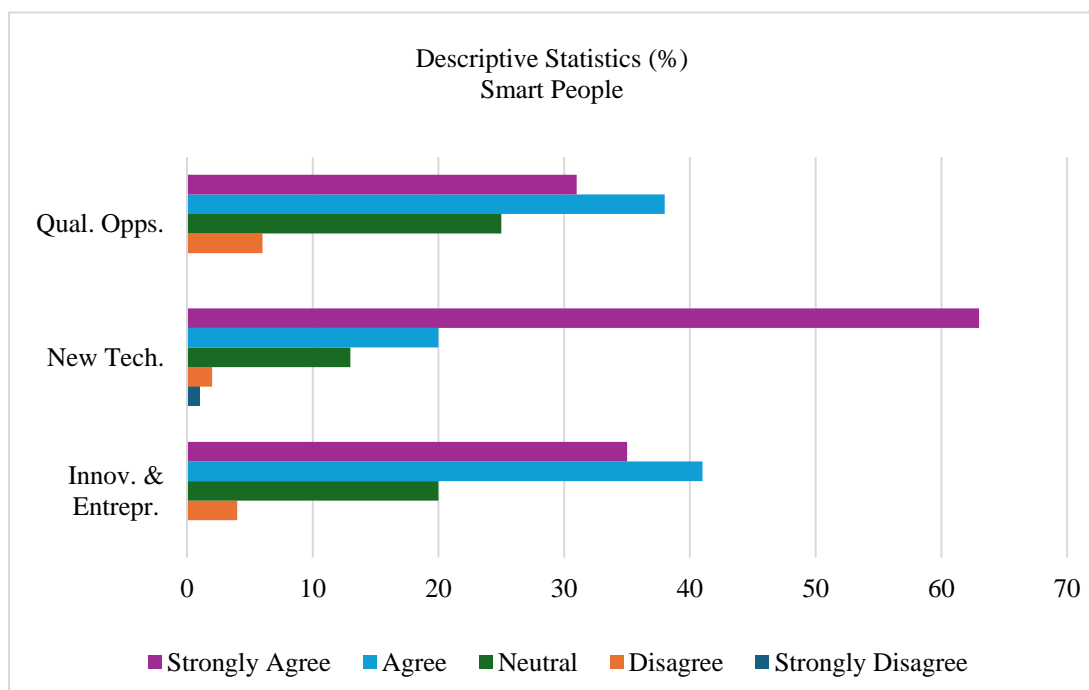


Figure 5 Respondents Awareness and Experiences on Smart People Initiatives (%)
(Source: Field Data)

The third item, “*Do you believe Smart City initiatives will help citizens become more innovative and entrepreneurial?*” showed a similar trend toward optimism. No respondent strongly disagreed, and only 4% disagreed. 20% remained neutral, while the majority expressed confidence in the statement, with 41% agreeing and 35% strongly agreeing.

Overall, these responses suggests that the citizens of the Twin Cities generally view smart-city initiatives that support personal development, technological engagement, and innovation positively, and as a result have an optimistic attitude to adopt such initiatives.

When aligning this indicator with the GST, it reflects the human-capital subsystem, which GST considers essential for the adaptive capacity of any complex environment. High willingness to engage with new technologies suggests that the social subsystem is not only receptive but actively participating in sustaining the overall digital ecosystem of the city. GST emphasizes that information does not move through systems automatically; human agents interpret, act upon, and distribute it. Thus, the readiness of residents to embrace technological change becomes a key factor in the system’s overall ability to exist and evolve. These findings therefore indicate that the Twin Cities have a strong social foundation capable of reinforcing other smart-city subsystems.

4.1.4 Respondents Awareness and Experiences of Smart Living Measures

Figure 6 illustrates responses for the Smart Living indicator, assessed through four Likert-scale items. For the first statement, “*Minorities feel welcome in the Twin Cities*”, opinions were mixed. A combined 18% expressed disagreement (4% strongly disagreeing and 14% disagreeing), while 35% remained neutral. Still, just under half of the respondents reported positive perceptions, with 30% agreeing and 17% strongly agreeing, suggesting a generally welcoming social environment, though not without reservations among some participants.

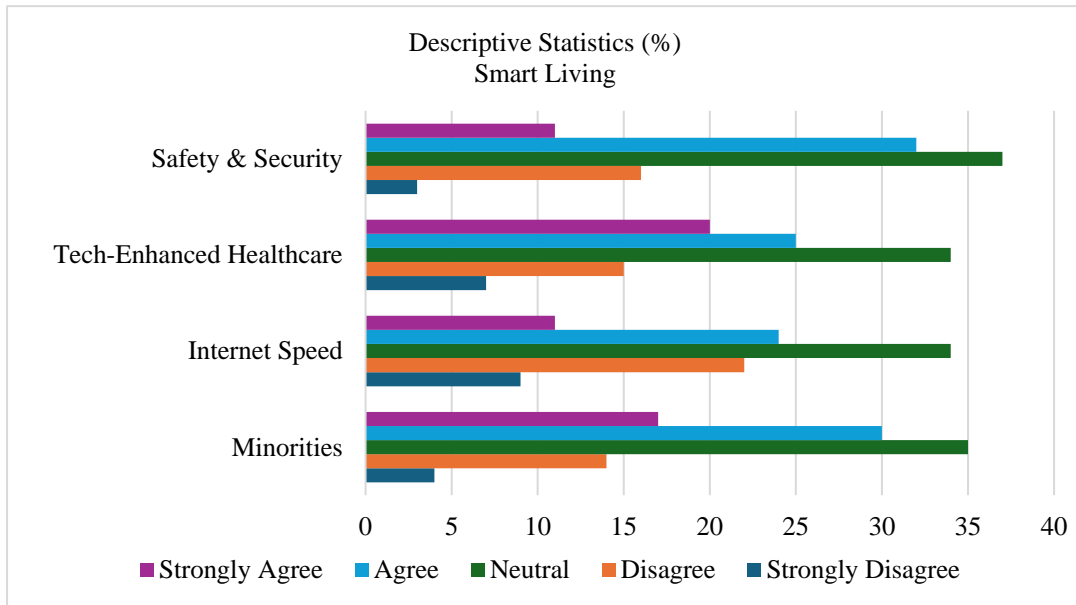


Figure 6 Respondents Awareness and Experiences on Smart Living Initiatives (%)
(Source: Field Data)

Responses to the second statement, *“The current internet speed and reliability in the Twin Cities meet connectivity needs”* reflected greater scepticism. Roughly one-third of participants disagreed to some extent (9% strongly disagreeing and 22% disagreeing), and 34% were neutral. Only a minority expressed feelings of satisfaction with the current digital infrastructure, with 24% agreeing and 11% strongly agreeing, indicating that connectivity remains an area where many citizens see room for improvement.

For the third item, *“How satisfied are you with current healthcare services enhanced by technology?”*, the distribution was more balanced. While 7% strongly disagreed and 15% disagreed, a substantial 34% selected neutral. Positive responses were somewhat stronger, with 25% agreeing and 20% strongly agreeing, reflecting cautious but meaningful confidence in technologically supported healthcare services.

The final statement, *“To what extent do you believe Smart City initiatives, such as the ‘Safe City’ project, have improved the safety and security of public spaces?”* showed a similar pattern. Although 19% disagreed to some degree (3% strongly and 16% moderately), the largest group (37%) remained neutral. At the

same time, nearly half of the respondents expressed confidence in these initiatives, with 32% agreeing and 11% strongly agreeing.

Overall, the Smart Living results indicate a cautious but generally positive orientation toward social inclusion, digital infrastructure, technology-enhanced services, and technology embedded public safety improvements in the Twin Cities.

From the GST viewpoint, the smart living results represent quality-of-life subsystems that effectively bridge social and physical aspects of the city. Residents' views on safety and health services imply that the social subsystem is receiving stronger support as digital tools become more deeply embedded in public services. However, concerns about connectivity and variable satisfaction levels indicate points where these subsystems may not yet be fully integrated. GST reminds us that weaknesses in one subsystem can create strain on others, such as in this case smart governance, smart people and smart economy. The mixed responses suggest that improving digital access and service reliability would strengthen the entire urban environment. The results therefore strengthen the idea that smart living is not an isolated domain but a reflection of broader systemic harmony.

4.1.5 Respondents Perception of Smart Mobility Solutions

Figure 7 illustrates respondents' views on the Smart Mobility indicator, captured through three Likert-scale items. For the first statement, "*Traffic congestion is not a problem in the Twin Cities*", the responses reveal clear dissatisfaction with current mobility conditions. A substantial majority disagreed, with 51% strongly disagreeing and another 29% disagreeing. Only a small share expressed a positive view, as 5% agreed and 7% strongly agreed, while 8% remained neutral. These responses reveal that traffic congestion remains a prominent issue for residents.

The second statement, “*Smart mobility solutions (intelligent traffic signals, ride-sharing apps, smart parking) will reduce traffic congestion*”, drew a more optimistic view. A combined 74% expressed confidence in these technological interventions, with 40% agreeing and 34% strongly agreeing. Meanwhile, 20% remained neutral, and only a small minority disagreed (5% disagreeing and 1% strongly disagreeing). The strong positive response suggests that residents view ride sharing and other technology-driven mobility strategies as a viable strategy to help to reduce congestion.

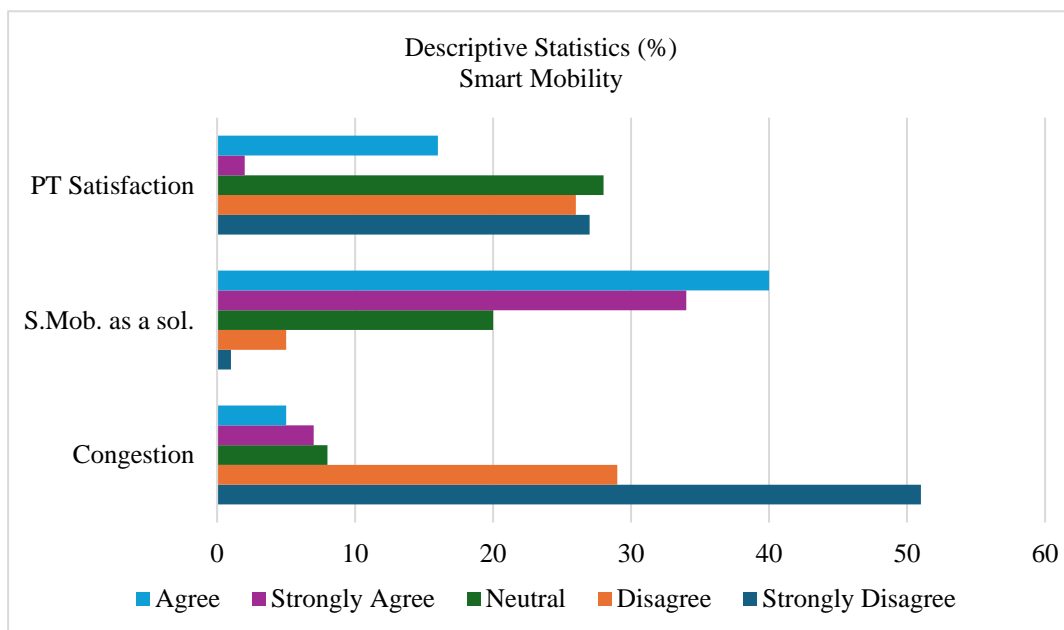


Figure 7 Respondents Awareness and Experiences on Smart Mobility Initiatives (%) (Source: Field Data)

In contrast, evaluations of the current public transport system were more critical. For the statement “*Public transport is satisfactory*”, over half of the respondents expressed dissatisfaction, with 27% strongly disagreeing and 26% disagreeing. About 28% remained neutral, while only 16% agreed and 2% strongly agreed. These responses indicate that public transport services are widely perceived as inadequate and unsatisfactory, reinforcing the need for improvements in accessibility, reliability, and overall service quality.

These findings suggest that while residents are generally frustrated and unsatisfied with present mobility conditions, particularly congestion and public transport, they express hope in the potential of smart mobility solutions to bring

improvements. Mobility, when understood through the lens of the GST influences the economy, environment and living. Therefore, a malfunction in mobility, such as persistent congestion puts strain on the entire system, affecting economic productivity, environmental quality, and social and mental well-being. However, the belief that intelligent traffic systems, ride-sharing tools, and smart parking could improve mobility and alleviate congestion aligns well with the GST view that enhanced integration and information flow can reduce strain between subsystems.

4.1.6 Citizen Views on Smart Environment Solutions

Figure 8 presents the responses for the Smart Environment indicator, measured through three Likert-scale items. The first question, “*How concerned are you about environmental issues (air quality, waste management, water scarcity) in the Twin Cities?*” reveals a notably high level of public concern. A combined 85% of respondents expressed strong worry about environmental conditions, with 57% reporting they were *very concerned* and 28% *concerned*. Another 11% described themselves as moderately concerned, while only a small fraction; 2% each, reported being slightly concerned or not concerned at all. For the representation of this graph, these categories were aligned with the traditional Likert labels ranging from “strongly disagree” to “strongly agree.”

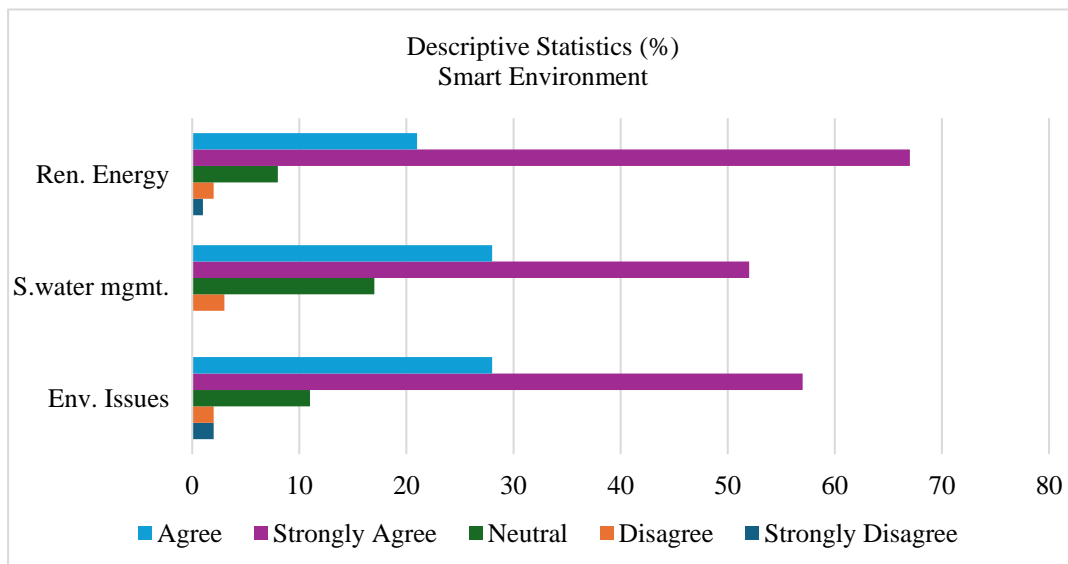


Figure 8 Respondents Awareness and Experiences on Smart Environment Initiatives

(Source: Field Data)

The second item, “*To what extent do you believe smart water management systems (leak detection, water recycling) can help reduce shortages in Islamabad and Rawalpindi?*”, reflects a largely optimistic view towards technology-driven environmental solutions. Over half the respondents (52%) believed these systems could help *to a great extent*, while an additional 28% believed so *to a considerable extent*. A smaller proportion (17%) felt they could help only *to some extent*, and 3% believed they would help only *to a small extent*. These response categories were also aligned with the conventional Likert labels for consistent graphical representation.

The final question, “*How important is the adoption of renewable energy sources (solar energy, hydroelectric) for the future of the Twin Cities?*”, revealed strong support. An overwhelming majority of 88% of respondents viewed renewable energy adoption as highly important, with 67% selecting *very important* and 21% *important*. Only a small minority expressed lower levels of importance: 8% considered it moderately important, 2% slightly important, and just 1% reported it was not important at all. As with the previous items, these categories were adjusted to fit the standard Likert-style scale used in the bar graph.

Overall, the responses highlight a population that is not only deeply concerned about environmental challenges, but also strongly supportive of smart technologies and renewable energy solutions as viable pathways for improving environmental sustainability in the Twin Cities. In GST terms, the environmental subsystem forms the backdrop against which all other subsystems operate. These results suggest that the citizens of the Twin Cities understand the interdependence between smart environment, government, mobility, economy and urban sustainability. Moreover, the smart-city framework, when viewed through GST, relies on feedback loops where environmental data informs policy, technology, and infrastructure decisions. The strong environmental concern observed in the data reflects a population that sees environmental sustainability as an overarching issue.

4.1.7 Public Engagement with Smart Governance Initiatives

The indicator of Smart Governance was measured using a mix of Likert scale and dichotomous (Yes/No) conditional questions.

Figure 9 shows the number of respondents who use government launched applications, such as the Pak Identity (NADRA) app, FBR Tax Asaan app, etc. It was found that 93 respondents (76%) used these applications, while 29 (24%) did not. Out of the 93 citizens who reported to use these apps, 68 (73%) felt that it increased efficiency of processes such as identity verification and tax filing, well as the remaining 25 (27%) saw no changes in efficiency.

Among those who used the applications, perceptions of their effectiveness were generally positive. Nearly three-quarters of users felt that these digital tools enhanced the efficiency of procedures such as identity verification, documentation, and tax filing. This response points toward a growing public confidence in the government's digital transition and reflects the value citizens place on faster, more streamlined processes. However, it is noteworthy that more than a quarter of users did not perceive any improvement in efficiency. Their responses highlight that while digital adoption is progressing, its benefits may not be uniformly experienced. Issues such as inconsistent performance, user-interface challenges, or gaps in digital literacy may limit the perceived usefulness for some individuals. Overall, the findings indicate that government applications are widely used and generally viewed as beneficial but also underscore the need for continued refinement to ensure that digital services deliver equitable and reliable improvements for all users.

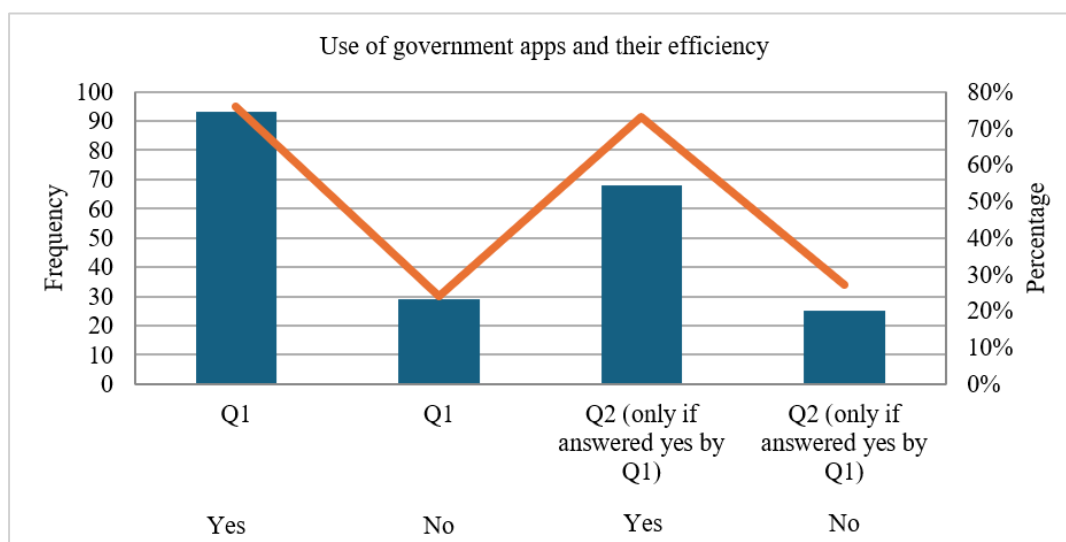


Figure 9 Respondents use of government apps and their satisfaction with efficiency
(Source: Field Data)

Figure 10 illustrates that majority respondents agree (22% strongly agree and 30% agree) that smart city initiatives improve government transparency and reduce corruption in the Twin Cities. A neutral stance was adopted by 25%, while 13% disagreed and 9% strongly disagreed.

A generally positive perception was seen among respondents regarding the role of smart city initiatives in enhancing government transparency and curbing corruption in the Twin Cities, suggesting that many residents view digitalization as viable tools for better governance. However, as a quarter of the citizens adopted a neutral stance, it suggests that a portion of the population remains uncertain about the extent to which smart city efforts translate into tangible improvements. This may be perhaps due to limited exposure to these initiatives, mixed experiences with government services, or a “wait-and-see” approach toward emerging technologies. Lastly, the combined 22% who disagreed or strongly disagreed point to ongoing concerns regarding transparency and corruption that digital systems alone may not fully address. Their responses underscore the reality that technological interventions must be accompanied by institutional reforms and sustained citizen engagement if they are to build trust comprehensively. Overall, the distribution of responses highlights both optimism and caution, reflecting the complex public expectations surrounding smart city governance in the Twin Cities.

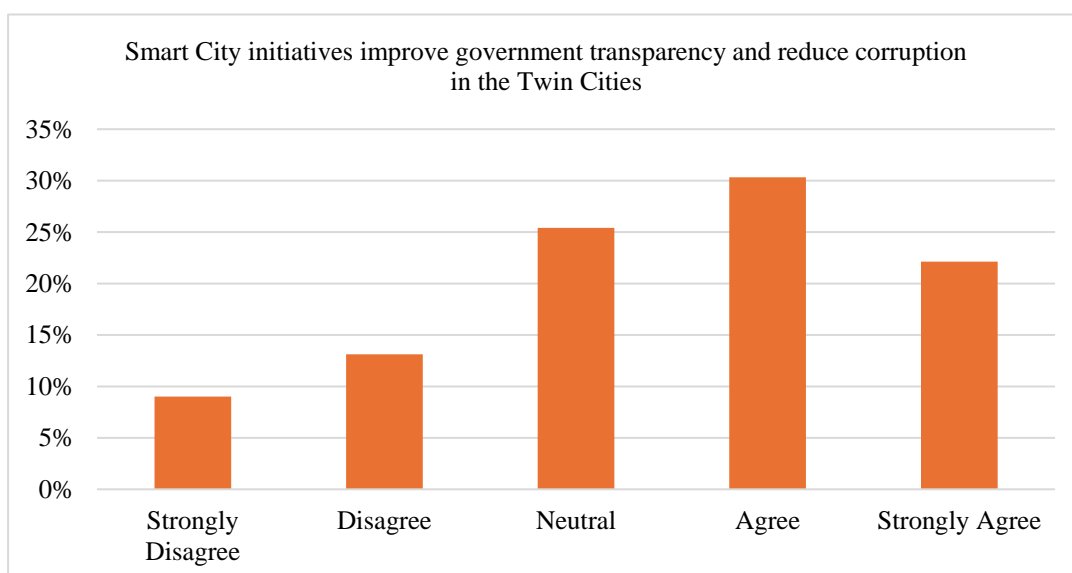


Figure 10 Citizen Perceptions of Smart Governance Initiatives Improving Government Transparency and Reducing Corruption (%)
(Source: Field Data)

Figure 11 illustrates satisfaction levels of the citizens when it comes to participating in decision making processes. The results reveal a clear sense of dissatisfaction among citizens regarding their opportunities to participate in decision-making processes and to voice their concerns. As shown in the figure, just 20% of respondents felt that they were provided with sufficient opportunities to engage with government processes, while more than half (52%) stated that such opportunities were lacking. A further 27% selected “maybe,” suggesting uncertainty or inconsistency in their experiences. These findings point to a noticeable gap between citizens’ expectations for participatory governance and the mechanisms currently available to them in the Twin Cities. The significant proportion of respondents who answered “no” indicates that many individuals do not feel meaningfully included in discussions that affect public services. At the same time, the presence of a substantial “maybe” group highlights potential ambiguity; citizens may occasionally encounter avenues for participation but may not find them reliable, accessible, or influential enough to feel confident in their response. Overall, the data suggest that increasing transparent, and easily accessible channels for citizen engagement could strengthen trust and help ensure that community perspectives are reflected in local governance.

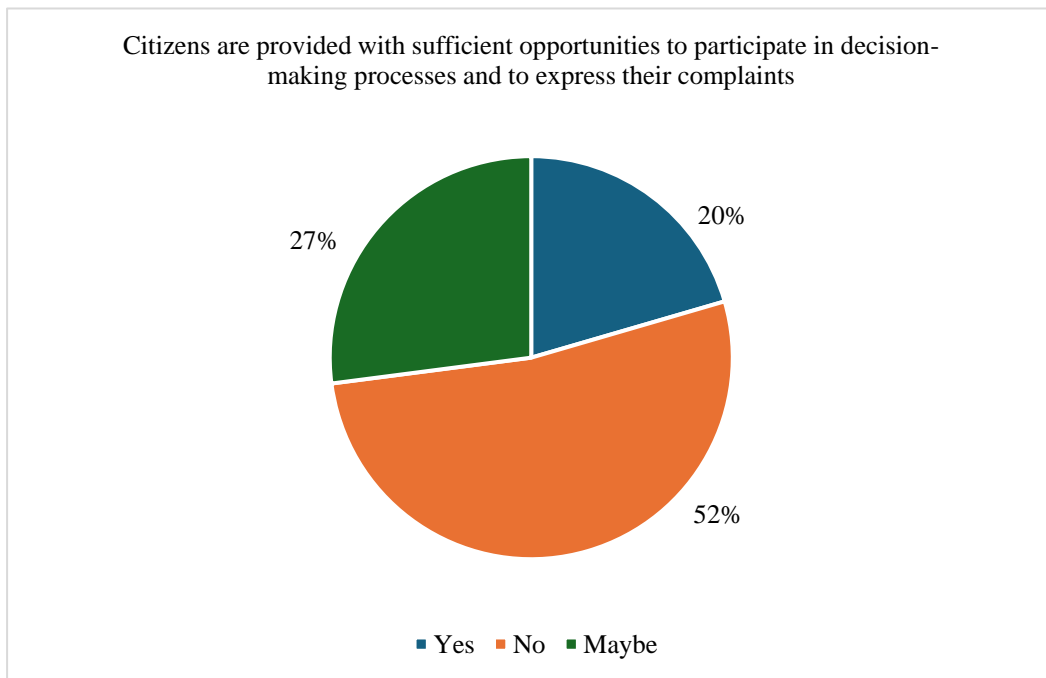


Figure 11 Citizen satisfaction levels in decision making (%)
(Source: Field Data)

The findings for smart governance showed considerable support for the idea that digital governance and smart-city initiatives enhance transparency and reduce corruption. From the perspective of GST, governance functions as a regulatory subsystem that anchors the coordination of other urban systems. The theory suggests that the effective functioning of a system depends heavily on the quality of information flows and feedback loops. The positive attitudes toward smart governance indicate that residents perceive these digital channels as strengthening accountability and communication between the public and administrative bodies. This aligns with the GST notion that when regulatory subsystems are efficient, the overall system becomes more adaptive and resilient. In the case of the Twin Cities, stronger governance feedback loops appear to support a more responsive and interconnected urban environment, as other smart city domains such as smart economy and smart living are highly dependent on this indicator. Nevertheless, the Twin Cities need improvement in setting up robust participatory government mechanisms and complaint launching systems so that citizens feel they have a voice and are part of the decision-making process, as the GST reminds us that improvements in one domain strengthens the entire urban environment, as elaborated earlier.

4.1.8 Respondents Experiences of Smart Economy Initiatives

Figure 12 illustrates the views that citizens have about the impact of digitalization on ease of starting new businesses. The results suggest that respondents hold mixed but generally cautious views about whether online services have made it easier to start new businesses in the Twin Cities. Nearly half of the participants chose a neutral response, indicating that many citizens are either unsure about the impact of these services or have not interacted with them enough to form a strong opinion. At the same time, a significant number of respondents expressed positive views; 27% agreed and 13% strongly agreed that online services have lowered barriers for new business formation, helping in smoother registration processes and easier access to government information. On the other hand, only a small proportion disagreed (9%) or strongly disagreed (2%), suggesting limited outright dissatisfaction. Overall, the pattern implies that while digital services are beginning to support entrepreneurial activity, their effectiveness is not yet

universally experienced. This may reflect uneven awareness, varying levels of digital literacy, or the need for further refinement of existing platforms to make the business start-up process more accessible and reliable for a wider range of users.

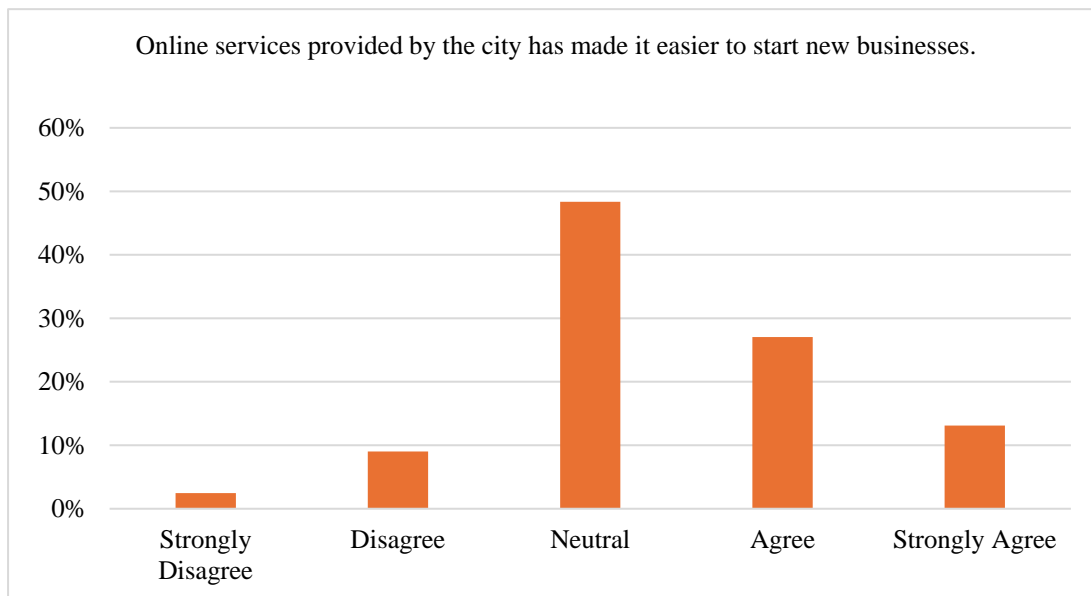


Figure 12 Citizen views on digitalization and its influence on starting a new business (%) (Source: Field Data)

Figure 13 presents citizens' use of digital transactions and their satisfaction with available digital payment systems. Out of the total sample, a clear majority reported having conducted digital transactions (114 individuals, 93%), while a smaller portion indicated they had not (8 individuals, 7%). As the next question was conditional, only those who had answered "Yes" to the previous question proceeded to evaluate their satisfaction with digital payment systems such as e-banking and mobile wallet services. Their responses show significantly positive experiences. Although only a very small percentage expressed dissatisfaction (3% dissatisfied), and 4% remained neutral, a substantial proportion reported favorable experiences; 47% indicated they were satisfied and 46% stated they were very satisfied.

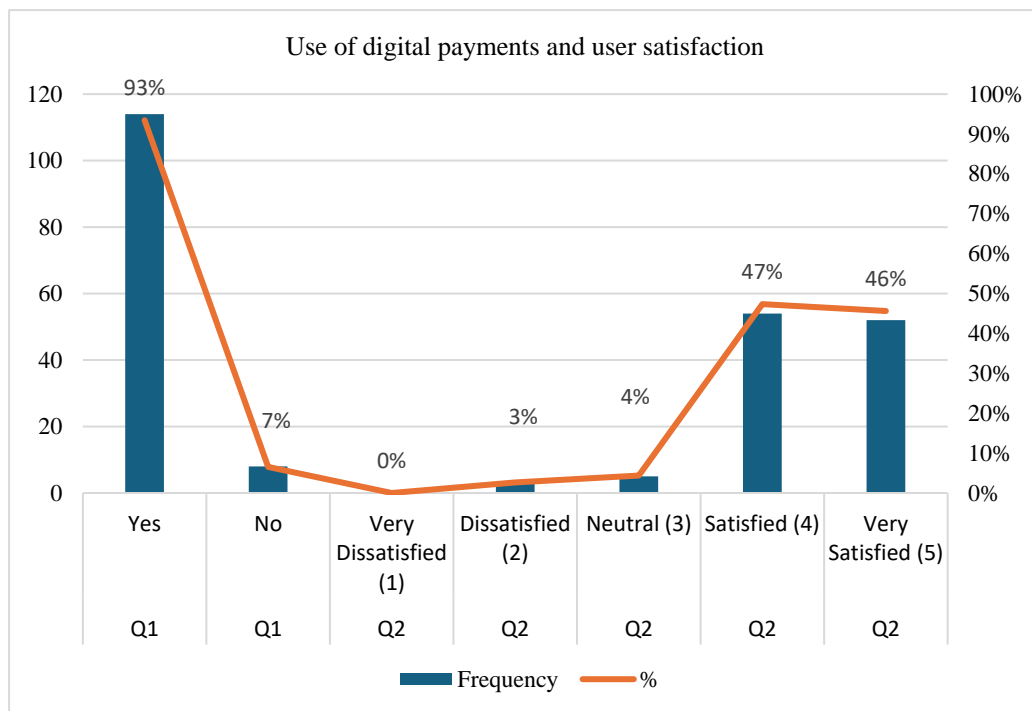


Figure 13- Citizen use of digital transactions and satisfaction levels (%)
(Source: Field Data)

Overall, these results suggest that not only are digital transactions widely used among the citizens of the Twin Cities, but those who use them tend to perceive digital payment platforms and mobile wallets as highly effective and reliable. The very low levels of dissatisfaction imply that major barriers to usage may lie less in user experience and more in initial access, awareness, or trust among those who have not yet adopted these systems. The strong positive responses among users point to a growing acceptance of digital financial tools in the Twin Cities, aligning with broader trends in Pakistan’s digital transformation and highlighting an opportunity for policymakers to further expand digital inclusion initiatives.

According to the GST, the Smart Economy indicator demonstrated that many residents believe online services have simplified business processes and that smart-city initiatives enhance entrepreneurial opportunities. In GST, the economic subsystem functions as both an outcome and a driver of system interactions. This is because the digital economy depends on the support of governance, digital infrastructure, and human resource, each of which emerged as significant in the previous indicators. Positive results in the smart economy indicator therefore act as

evidence that multiple subsystems are functioning in alignment. As per the theoretical framework, when resources flow, whether financial, technical, or infrastructural, the overall system stabilizes and becomes more innovative. Therefore, the responses also indicate the same; residents experience economic benefits as part of a broader integrated system rather than as isolated improvements.

4.1.9 Pearson Correlation

Pearson Correlation was conducted between key smart city aspects to test the relation between them, as illustrated in Table 5, the Pearson Correlation Matrix.

Table 5 Pearson Correlation Matrix

(Source: Field Data)

Smart City Aspects	1	2	3	4	5	6	7	8	9	10	11
1 Smart water management	1										
2 Smart mobility reduces congestion	0.4	1									
3 Renewable energy importance	0.59	0.34	1								
4 Environmental concerns	0.51	0.3	0.53	1							
5 Digital payment satisfaction	0.15	0.11	0.2	0.12	1						
6 Innovation & entrepreneurship	0.15	0.3	0.14	0.13	0.15	1					
7 Online services for business	0.08	0.13	0.08	0.12	0.12	0.29	1				
8 Minorities feel welcome	0.06	0.13	0.09	0.04	0.23	0.09	0.27	1			
9 Opportunities to enhance qualification	0.02	0.07	0.08	0.03	0.1	0.62	0.37	0.05	1		
10 Internet speed & reliability	0.02	0.1	0.14	0.08	0.21	0.1	0.29	0.37	0.22	1	
11 Safety & security	0.08	0.14	0.05	0.04	0.21	0.39	0.37	0.27	0.37	0.23	1

The correlation matrix highlights several notable relationships among the key dimensions of smart-city perceptions in the Twin Cities. A number of significant positive correlations emerged, reflecting coherent patterns in how citizens evaluate governance, mobility, environmental sustainability, digital services, and living. These associations also help clarify which aspects of smart-city are more valued by citizens.

Within the mobility domain, the moderate link between use of renewable resources and smart mobility reduces congestion ($r=0.34$) suggests that residents who view clean energy as important and the city's mobility conditions more favourably also tend to generalize these perceptions across multiple indicators rather than isolating individual components of the system, which goes to support the GST which looks at the different "systems" of a smart city as being interconnected and dependent on each other. This also paves the way for more such smart initiatives in the future for the Twin Cities as it is a good indicator for readiness to adopt, as a good experience and perception in one domain is positively influencing the other.

In the environmental domain, the strongest relationships in the entire matrix appeared between environmental concerns for the Twin Cities and importance for adoption of renewable energy sources ($r=0.53$), indicating that there is a considerable level of awareness in the citizens of Islamabad and Rawalpindi when it comes to the environment. Similarly, a strong correlation was found between environmental concerns and confidence in smart water management systems for the Twin cities with an r value of 0.51. These correlations were both strong and statistically significant, indicating that residents who express concern about environmental pressures are simultaneously more receptive to sustainability-focused smart solutions. This pattern suggests that environmental awareness has the potential to act as the foundation for an array of other smart city initiatives considering the interconnectedness of all domains of the urban environment, as stated in the GST.

Several important associations also emerged within the digitalization, education and innovation cluster. Online services to start new businesses and perceptions that smart city initiatives foster innovation and entrepreneurship were positively related ($r=0.29$). Moreover, opportunities to enhance qualifications and entrepreneurship opportunities in smart cities were strongly correlated ($r=0.62$). Overall, these correlations imply a coherent cognitive framework; respondents who see smart cities as engines of innovation also appear to feel more empowered, more future-oriented, and more aligned with digital transformation more broadly.

Digital infrastructure variables displayed similar results. Satisfaction with internet speed and reliability was positively correlated with satisfaction with digital payment systems and with the perception that online services facilitate business processes, r values of 0.21 and

0.29 respectively. These findings reinforce that citizens who are satisfied with existing digital services are also more likely to trust and use other applications, such as mobile payments and online platforms, indicating positive attitudes towards future smart city initiative adoption in the Twin Cities.

Finally, a meaningful association was found between perceptions of improved safety and security and feelings of social inclusion, particularly among minority groups ($r=0.27$). The relationship is positive, indicating that as perceptions of measures of safety and security increase in the Twin Cities, minority groups feel safer and more welcome as well. Nevertheless, it suggests that residents who observe improvements in public safety may also feel a broader sense of belonging and safety, pointing to the interconnected nature of physical security and perceived social cohesion.

Overall, the correlation matrix illustrates a set of empirically supported relationships. Rather than isolated or contradictory patterns, the correlations reveal clusters of mutually reinforcing perceptions: environmentally minded respondents tend to support green technologies; digitally satisfied users express greater confidence in digital services; and those who view smart initiatives as fostering innovation tend to feel more capable and included. These findings collectively suggest that public perception of smart cities is structured around a small number of underlying orientations; environmental responsibility, digital readiness, trust in governance, and quality of life, each of which shapes attitudes toward multiple smart-city components, setting the foundation for urban sustainability in the Twin Cities.

4.2 Inferential Analysis

Statistical Package for Social Sciences (SPSS) was used for inferential statistics. The choice for SPSS was strategic, as it not only facilitated descriptive analysis, but also streamlined the analysis of inferential data. Moving beyond descriptive statistics, inferential tests were run to explore the deeper relationships between the key variables in the study. Linear regression models were applied to determine the extent to which the six smart city indicators predict overall perception and attitude, and to assess whether perception itself contributes to shaping attitudes toward future smart city development. Together, these analyses offer a clearer understanding of the patterns suggested in the descriptive results and help uncover the factors that meaningfully influence how residents interpret and respond to smart city initiatives in the Twin Cities. Three linear regressions were done to predict the relationships between the smart city indicators and the perceptions and attitudes of the citizens of the Twin Cities.

4.2.1 Linear Regression between Smart City Indicators and Citizen Perceptions

A linear regression was done between the six key indicators of smart cities; smart governance, economy, people, mobility and environment were the independent variables, and citizen perceptions were the dependent variable to investigate how people view these characteristics and their performance in Islamabad and Rawalpindi.

Table 6 Statistical Representation of Linear Regression Test

R	R square	Adjusted R square
0.543	0.295	0.255

A moderately strong relationship was found. As shown in Table 6, the model produced an R value of 0.543, indicating a meaningful positive association between the predictors and the dependent variable as $0.30 < r < 0.70$. The positive value signifies that as experience, knowledge and usage of these smart city characteristics improve, perceptions towards smart city initiatives will also improve. The R² value of 0.295 suggests that approximately 29.5% of the variance in the outcome is explained collectively by the six indicators. Although this does not represent a majority of the variance, it is substantial considering that individual perceptions are shaped by multiple contextual factors. The Adjusted R² value of 0.255 further confirms the model's stability after accounting for the number of predictors (independent variables) included. Overall, these results indicate that the six smart-city dimensions contribute meaningfully, though not exclusively, to shaping citizens' perceptions of smart-city development. This implies that while the core smart-city components are important drivers of public perception, other unmeasured social, economic, or experiential factors likely also influence how citizens interpret and respond to the evolving smart-city landscape in the Twin Cities.

4.2.2 Linear Regression between Smart City Indicators and Citizen Attitudes towards Smart City Development

A linear regression model explored how the six smart-city indicators shaped citizens' attitudes toward future smart-city development.

Table 7 Statistical Representation of Linear Regression Test

R	R square	Adjusted R square
0.560	0.314	0.276

A moderately strong overall relationship was produced. As shown in table 7, the model reported an R value of 0.560, indicating that the combined predictors share a meaningful positive association with attitudes toward upcoming smart-city initiatives. The R² value of 0.314 signify that the indicators collectively explain 31.4% of the variance in attitudes, suggesting that nearly one-third of how positively or negatively residents view future smart-city development can be traced back to their evaluations of smart governance, environment, economy, mobility, people, and living conditions. The Adjusted R² (0.276) further support these findings. Although attitudes toward smart-city expansion are influenced by a wide range of personal, social, and contextual factors, these results make it clear that the smart-city performance plays a meaningful role in shaping how residents envision future development. In other words, when citizens view current smart-city components as functioning effectively, they tend to have a more positive outlook toward continued adoption of smart technologies and systems within the Twin Cities.

4.2.3 Linear Regression between Citizen Perceptions and Attitudes towards Smart City Development

A third linear regression was conducted to assess whether citizens' perception of smart-city performance predicted their attitudes toward future smart-city development, as perceptions form the basis for cognitive evaluations that shape attitudes.

Table 8 Statistical Representation of Linear Regression Test

	R	R²	Adjusted R
	0.451	0.204	0.197

As shown in table 8, the results indicate an R^2 value of 0.204. This model explains 20.4% of variance between the two groups is explained by change in one variable i.e., that 20.4% of the variance in the attitude is explained from the perception of individuals of smart city initiatives.

The R value of 0.451 from the linear regression indicates a moderate positive correlation between attitude and perception as $0.30 < r < 0.70$. The positive value signifies that as perceptions towards smart city initiatives improve, attitudes to adopt future initiatives also improve. In other words, citizens who hold more favorable perceptions of existing smart city efforts are also more likely to display supportive attitudes toward adopting upcoming initiatives, making the relationship direct and positive, as positive experiences, awareness, and satisfaction with present smart city services contribute significantly to willingness to embrace future technologies. These findings highlight the importance of enhancing citizen perception through transparent communication, reliable service delivery, and user-centered design to strengthen public acceptance of future smart city initiatives.

4.3 Thematic Analysis

Thematic Analysis was done to analyze the qualitative data from the semi structured interviews to evaluate the impact of smart city initiatives on urban sustainability. This method allowed for the identification of recurring themes and patterns in stakeholders' perceptions of smart city impacts on urban sustainability. The interviews with representatives from One Network, DHA Environment Office, and Islamabad Safe City revealed that the move toward smart cities in Pakistan, with the Twin Cities in particular marks a significant transition from traditional, isolated urban systems to more interconnected and technologically responsive networks. This interconnectedness, achieved through digitalization, automation, and data sharing, enhances efficiency and overall urban sustainability.

4.3.1 Technological Integration and Innovation in the Developing World

The movement towards smart cities and its subsequent impact on urban sustainability can be seen through the integration of technology in every sector of society, from mobility and transportation, to housing, and even security and governance. The representative from DHA for instance, highlighted the installation speed radars and e-tag system for speed monitoring and traffic control. Similarly, the One Network representative spoke about the recent digital tolling systems, automatic number plate recognition (ANPR), and radio frequency identification (RFID) technologies, the latter of which in simple words to the ordinary man is known as the M-tag. All these technologies together help to manage traffic. They were collectively described as

“mechanisms that reduce human error, improve revenue accuracy, and enhance traffic flow.”

Similarly, the Islamabad Safe City interview underscored the role of AI-based surveillance and facial recognition technology (FRTs) in strengthening security and crime prevention, as compared to conventional security measures. Moreover, at a smaller scale, even DHA utilizes a digitalized complaint system and a technology embedded security alert system to provide security to its residents.

Therefore, technology acts as a major link, facilitating communication between different systems and subsystems, as stated by the General Systems Theory (GST). Details from the One Network interviewee further strengthens this claim as technology integration not only made

transportation more efficient but also contributed to environmental sustainability by considerably reducing fuel consumption, as automation and digitalization was backed up by solarization, therefore demonstrating the interconnectedness and multi-dimensional benefits.

Nevertheless, a magnitude of operational challenges exists, which reflect the vulnerability of technology integration in developing countries, such as heavy investment, high installation costs, and data storage issues. For this reason, it is necessary to innovate for successful technology integration especially in the context of developing countries such as Pakistan.

4.3.2 Environmental Sustainability

To achieve urban sustainability, ensuring that all initiatives are environmentally sustainable is of utmost importance. A major challenge for the installation of cameras and for the Intelligent Traffic System (ITS) on the motorways was the continuous provision of electricity. Hence, an interviewee recalled,

“The cost is not only in the form of equipment or infrastructure, but it is more of an operating cost... The only thing is that we have maximized the solarization of the system. The solar system was designed based on that. The highway lights were replaced with solar lights.”

However, the issue for developing nations isn't this simple and doesn't end here, as geographic and socio-economic challenges also have to be considered alongside sustainability factors, and innovations have to be made in accordance with them,

“the batteries of the solar highway lights used to be stolen as they were within the reach of humans as they were kept in a box on a pole. The second thing is that due to climatic conditions, the efficiency of the battery used to drop. In summers, the battery used to get so hot that the efficiency of the battery would decrease. There were many incidents where the battery used to get burnt. So, to solve this problem, we developed and all in one solution of solar batteries: highway lights. These were at such a height and their batteries are embedded inside, they are far from human access, so they don't get stolen. Lights are converted and replaced.”

Therefore, through this, the primary source of electricity during the daytime on the motorways became solar. Secondary became the battery, and fuel powered generator became third tier. As

a result, fuel cost that was initially used for generators decreased by 50% within a year, making technology integration (automation) environmentally sustainable.

Similar efforts to keep the environment at the forefront of urban development were seen across another interview as well. To restore biodiversity, the interview with the DHA environment official revealed work done for ecological land restoration, which made the importance of environmental restoration and sustainability in today's urban landscape evident. The housing society is focusing on tree plantations, particularly on native trees as they grow naturally, provide shade, and require less maintenance, as compared to ornamental trees that offer limited environmental benefit. The interviewee recalled with immense fondness,

“In our newly developing sectors, we are growing fruit orchards and reviving species such as pine trees, which were once common in Rawalpindi. Back in 1914, it even snowed three feet here, something linked to a richer tree cover. But as maintenance declined and deforestation increased, our local temperatures began to rise. So now, we're restoring plantations to reverse that trend so that we can improve the microclimate.”

Other initiatives such as an efficient waste recycling and composting system also indicate an effort to realign the environmental subsystem with sustainability principles. As part of this system, all organic waste is collected and brought to one place where through a proper composting process, an organic fertilizer is made, making DHA self-sufficient in compost-based fertilizers, hence creating a closed loop system, a step towards a circular economy,

“Unlike chemical fertilizers, ours (DHAs) are organic and made from recycled kitchen waste such as eggshells, fruit and vegetable peels and other organic matter. We use this fertilizer across all our green spaces in DHA, and even sell it locally.”

4.3.3 Governance, Institutional Coordination and Policy Continuity

All the interviewees acknowledged the importance of institutional alignment in sustaining smart city initiatives for achieving urban sustainability, as these initiatives require prolonged corporation among multiple public and private stakeholders. For instance, One Network's efficiency and success depends on coordination with the National Highway Authority (NHA) and Frontier Works Organization (FWO), just to name a few. Details about all commuting vehicles on motorways are logged onto a centralized data system, which is accessible by the NHA. In case of any traffic violation, the relevant authorities alert the citizen owing to the hierarchy and communication loop created, as described by the interviewee,

“Because the traffic information of Motorway cannot be shared directly with the district police. So as per law, the communication channel is that FWO would share with NHA, NHA would share with the relevant police, whichever the police of the district maybe...”

Similarly, the Islamabad Safe City project collaborates with police, NADRA, and the Interior Ministry to enhance safety and prompt response. This is done by assisting and coordinating with other departments across the city such as CDA, fire brigade, PIMS, etc. The official stated,

“if there is an accident somewhere, we (Safe City) find out first and PIMS finds out later, similarly, if there is garbage piling up somewhere, often times we are the ones who notify CDA about garbage collection as each of these institutions have desks in our office.”

Therefore, with bureaucratic and government cooperation and institutional coordination, Islamabad Safe City’s six month target is to become a complete **“Fusion Center”**, which is designed to integrate data from multiple sources into a single collaborative framework. Information from diverse sources (CDA, motorway, traffic police, etc,) will be collected, analyzed, and shared to detect and prevent threats or other major crimes and to maximize efficiency of service delivery.

“The goal is to “fuse” maximum data systems and communication channels into one coordinated system.”

At a smaller scale compared to the Islamabad Safe City, to manage security incidents, a Quick Reaction Force exists in DHA which is linked to a central control room. When a theft or emergency call is received, the control room activates the team, which reaches the site immediately. Using CCTV cameras installed across Phases I and II, activities are monitored and tracked. Since formal legal actions require coordination with police, police stations exist within DHA. Together, this system ensures rapid investigation and high recovery rates, as stated with immense pride by the interviewee,

“We’ve achieved nearly 100% recovery in past incidents. Our security system is fully linked with Islamabad Police and other law enforcement agencies.”

This theme when viewed through the lens of the theoretical framework, is a textbook example of administrative and technological urban subsystems interacting through various communication channels. Insights from the DHA interviewee reflect the interconnectedness of technology and institutional coordination. However, the interviews also revealed that political fragmentation and policy discontinuity remain barriers in the Twin Cities. The Safe City representative for instance mentioned how funding gaps delay upgrades to systems, undermining long-term planning. Such lapses disrupt the feedback loops necessary for systemic stability, echoing GST's caution that without consistent coordination, even well-designed systems can relapse into inefficiency. Similarly, when discussing scalability and replicability of the smart tolling system and ITS on all national highways, the only hinderance was political interest and willingness of the government, which was faced during the digitalization of the Swat motorway as well; it was only overcome with the change in governance.

“Different regimes come with different political agendas, and as one party leaves, its projects also come to a standstill and they aren't continued by succeeding governments.”

4.3.4 Economic Efficiency and Human Capital Development

Economic sustainability appeared as a driver and as a byproduct of all smart city initiatives across all interviews. DHA's transition to solar power has significantly reduced fuel cost by generating their own electricity and even selling it back to WAPDA. The interviewee revealed,

“Some parking areas and our headquarters are already powered by solar panels. We even encourage residents to transition to solar.”

The work done by One Network is a prime example of economic efficiency as the reason for the automation of the toll system was recovery of the cost of motorway construction. Therefore, ensuring an efficient and automated toll collection system became crucial. The existing M-tag system faced several challenges, primarily due to high levels of toll pilferage. The loss of toll revenue significantly affected the overall operational income, which in turn impacted the repayment of bank loans obtained for motorway construction. To address this, minimizing revenue leakage became a key priority. Therefore, the automated tolling system is seen as both, a cause and a result of economic sustainability as explained by the interviewee,

“...it has reduced pilferage at toll plazas and improved revenue collection accuracy”

Moreover, automation and digitalization has also created changes in the job market, with an increase in the demand for skilled manpower owing to an increase in demand for green jobs, leading to individuals having transitioned from labour jobs and daily wages to technical jobs, as mentioned by the official from One Network,

“Previously, out of 7,800, there were only 15 who were in technical manpower, and the rest were all in labour manpower. Later it shifted to 1200 employees. And out of those 1200, more than 1000 were the technical employees from the headquarters alone.”

The theoretical framework supports the findings from the interviews as efficiency in one subsystem, in this case energy and mobility has a positive impact on the environment and economic stability by reducing costs and creating jobs through the evolution of the skills landscape.

4.3.5 Citizen Engagement, Social Impact and Safety

The Islamabad Safe City interview ascertained that the overall aim of smart cities is to enhance citizens' quality of life. AI-assisted surveillance, emergency response systems, and community reporting apps improve safety and security of the city and increase public trust in law enforcement agencies. The official said in the interview,

“to make sure that everyone is aware of the latest technologies and to deter any potential deviance, Islamabad Safe City collaborates with Faizabad traffic police volunteers to give opportunities to enthusiastic, young minds, and launches internship opportunities and visits for university students. There is also a complaint app and a helpline to report any issues and to provide feedback to improve services.”

This has further resulted in a positive change in the attitudes of citizens as more responsible citizenship is seen,

“There is now increased reporting of crimes as there is increased public awareness and ease of reporting due to facilities such as police at doorstep as we have the Virtual Women Police Station. The digitalization and environment of the police has also helped improve the general perception of police and law enforcement in our society.

Therefore, despite having a highly reactive public and widespread negativity, digitalization and engaging youth has had a positive social impact, as initiatives such as social media campaigns boosts corporation levels.

Similarly, DHA’s well planned horticulture program has led to the creation of numerous parks and green spaces which offer residents a healthy environment, as stated by an interviewee,

“Currently, there are 88 parks under our management, all being developed with diverse plantations”

Community engagement activities are also part of DHA’s mission. Such activities include family walks, lawn competitions, family festivals etc, with the intention to create spaces where residents can relax, socialize, and enjoy healthy outdoor environments. Therefore, the focus on green spaces and community engagement initiatives promotes social cohesion and well-being, an essential element for urban sustainability.

These human components both, inputs and outputs of urban systems in the GST as citizen participation serves as feedback that maintains the system’s evolution. However, all the interviews also revealed concerns about public cooperation and digital literacy as many residents are reluctant to adopt technology, smart city, or green initiatives due to lack of awareness or simply due to lack of effort. This reinforces the need for awareness to ensure that social subsystems (citizens, communities, and institutions), remain active participants rather than passive recipients in the smart city system to maximize the effects of urban sustainability.

4.3.6 Integration and Path to Urban Sustainability

Insights from the interviews ascertain that the Twin City’s smart city initiatives reflect the principles of the GST as they link various sub-systems together and also link those subsystems to the main urban systems using technology, indicating a significant move towards urban

sustainability by forming linkages and networks between these former isolated systems. Together, the interdependencies create a holistic urban ecosystem that continuously evolves through feedback loops between technology, environment, and human behavior and participation.

However, as made evident through all the interviews, complete urban sustainability cannot be achieved through technology integration alone; it requires government coordination, citizen participation, regulation and monitoring, political willingness, and innovation in accordance to the socio-economic and geographic context to ensure all subsystems contribute to collective resilience. In this sense, the essence of smart cities, as explained through the GST's, lies not in isolated technological interventions, but in the integration of various systems working in collaboration to achieve at broad, environmental sustainability, economic growth and social wellbeing, urban sustainability.

CHAPTER 5

Conclusion & Recommendations

5.1 Conclusion

This mixed method research incorporating both qualitative and quantitative approaches has significantly contributed to the expanding knowledge base and heightened awareness surrounding smart city development in the Twin Cities of Islamabad and Rawalpindi. The synergistic use of diverse research methods allowed for a comprehensive exploration of the multifaceted nature of smart city initiatives, shedding light on citizen perceptions and attitudes and their impact on the urban landscape. By utilizing both qualitative and quantitative dynamics, this research has provided a nuanced understanding of the awareness, perceptions, workings, challenges and outcomes associated with the different smart city initiatives in the Twin Cities.

One of the central findings of this study was as experience, knowledge and usage of smart city initiatives improve, perceptions towards smart city efforts also improve. Additionally, when citizens view current smart-city components as functioning effectively, they tend to have a more positive outlook toward continued adoption of smart technologies and systems.

Another key finding of this study underscores the pivotal role played by existing smart city initiatives in the Twin Cities, as favorable perceptions of these efforts are more likely to display supportive attitudes toward adopting upcoming initiatives in Islamabad and Rawalpindi. The smooth functioning of these projects emerged as a critical catalyst for positive change in the urban environment, promoting urban sustainability and fostering an environment of supportiveness, indicating that the public's everyday experiences with existing digital services play a direct role in shaping future acceptance.

The research indicated how experts understand the role of Smart City initiatives in shaping the future of the urban environment. Themes such as technological innovation in a developing-world context, environmental sustainability, governance and policy continuity, human capital development, citizen engagement, social safety, and the broader integration of these elements all highlight the multifaceted nature of sustainable urban transformation. Respondents consistently emphasized that smart cities are not merely technical constructs, but systems that must bring together people, institutions, and innovations to improve the urban environment and everyday life.

These insights were reinforced and aligned closely with the patterns observed in the quantitative component of the study. To reiterate, participants who viewed existing smart city measures as beneficial, necessary, or effectively implemented were substantially more likely to express positive attitudes toward expanding these technologies and services. The regression model showed a direct and positive relationship between perception and attitude, with favorable perceptions accounting for a meaningful proportion of the variance in adoption-related attitudes. This confirms that residents' trust, satisfaction, and perceived value of current smart city features directly shape their openness to emerging technological developments.

When viewed alongside the thematic findings, the quantitative results reinforce the broader narrative that smart city scalability and progress depends on more than the mere availability of digital tools or infrastructural upgrades. Instead, it relies just as strongly on public sentiment, shared values, and past experiences. The themes of governance, citizen engagement, and social impact that appeared repeatedly in qualitative responses help explain why perceptions hold such predictive power. Where citizens feel heard, trust institutions, and observe tangible improvements in sustainability or service delivery, their attitudes naturally shift in favor of further smart city investments. Conversely, gaps in coordination, policy continuity, or citizen inclusion risk weakening citizen engagement.

Therefore, the mixed method research confirms that citizen perceptions are not passive reflections, but are active drivers of smart city adoption, whilst deepening the understanding by showing why perceptions form the way they do and which aspects of smart city planning matter most to people in a developing urban context.

Therefore, the conclusion extends beyond validating a hypothesis; it offers a holistic view of smart city development as both a technical and social process. The findings underscore that future smart city strategies in the Twin Cities should focus not only on infrastructure but also on cultivating trust, transparency, and participatory governance. When positive perceptions are nurtured through accountability and transparency, stable policies, environmental commitment, and meaningful public engagement, the community becomes not just a beneficiary of smart city transformation, but a willing partner in its realization as well.

5.2 Recommendations

Government and non-government stakeholders, policymakers and NGOs should consider the following findings when initiating future digitalization and smart city projects in the Twin Cities to ensure maximum citizen engagement, satisfaction and smooth functioning to boost urban sustainability.

Fragmented governance and weak institutional coordination often slow the progress of smart city projects. Strengthening collaboration between departments, ensuring policy continuity, and improving communication across institutions can reduce delays and enhance coherence. Greater transparency through open data and consistent updates may also help rebuild trust, which the results show is central to shaping public attitudes.

Citizen engagement emerged as a recurring concern, with many respondents emphasizing the need for meaningful participation. Creating opportunities for residents to share feedback through digital platforms, consultations, and open forums can help align projects with local needs. When citizens feel included, they are more likely to support and adopt new technologies.

A more proactive approach to working with stakeholders, including NGOs, community groups, and public agencies, can strengthen smart city implementation. Early and continuous engagement helps build collaborative relationships and ensures that diverse perspectives and resources contribute to better outcomes.

Additionally, investment in human capital is equally important. Digital literacy programs and technical training, especially for underserved communities, can bridge existing gaps and ensure that technological benefits reach all citizens. Building digital confidence helps create a more inclusive environment where smart city systems function effectively.

Moreover, environmental sustainability and public safety remain areas of high public interest. Strengthening systems for waste management, air quality, water security, and urban safety can increase citizen confidence in smart city initiatives. When these core concerns are addressed, communities become more open to supporting other innovative projects that may initially face reluctance.

References

- Afzalan, N., Sanchez, T. W., & Evans-Cowley, J. (2017). Creating smarter cities: Considerations for selecting online participatory tools. *Cities*, *67*, 21–30. <https://doi.org/10.1016/j.cities.2017.04.002>
- Ahmad, I., Ghani, M. U., Anwar, S., & Butt, F. K. (2022). Chapter 7: SME Sector in Pakistan: Mapping the Policy Framework, Opportunities and Constraints. *PIDE*.
- Ahmed, R., Ahmed, A., Barkat, W., & Ullah, R. (2022). Impact of Scholarships on Student Success: A Case Study of the University of Turbat, Pakistan. *Pakistan Development Review*, *61*, 231–258.
- Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between sustainable and smart cities? *Cities*, *60*, 234–245. <https://doi.org/10.1016/j.cities.2016.09.009>
- Ain, Q. (2025, March 28). *How to Verify Sales Tax Invoices Online in Pakistan – Taxation in Pakistan*. <https://taxationpk.com/insights/verify-sales-tax-invoices-online/>
- AlAli, D., Manivannan, N., & Xu, Y. (2023). A Framework for Effective Design Thinking Based Smart Cities Projects in Qatar. *Smart Cities*, *6*(1), 531–562. <https://doi.org/10.3390/smartcities6010025>
- Alam, A., Tabinda, A. B., Qadir, A., Butt, T. E., Siddique, S., & Mahmood, A. (2017). Ecological risk assessment of an open dumping site at Mehmood Booti Lahore, Pakistan. *Environmental Science and Pollution Research*, *24*(21), 17889–17899. <https://doi.org/10.1007/s11356-017-9215-y>
- Alaverdyan, D., Kučera, F., & Horák, M. (2018). IMPLEMENTATION OF THE SMART CITY CONCEPT IN THE EU: IMPORTANCE OF CLUSTER INITIATIVES AND BEST PRACTICE CASES. *International Journal of Entrepreneurial Knowledge*, *6*(1). <https://doi.org/10.37335/ijek.v6i1.67>
- 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>
- Alcaide Muñoz, L., & Rodríguez Bolívar, M. P. (2021). Different Levels of Smart and Sustainable Cities Construction Using e-Participation Tools in European and Central Asian Countries. *Sustainability*, *13*(6), 3561. <https://doi.org/10.3390/su13063561>
- Alisjahbana, A. (2019). *Smart cities hold the key to sustainable development*. UNESCAP. <https://www.unescap.org/op-ed/smart-cities-hold-key-sustainable-development>

- Alm, J., Clark, J., & Leibel, K. (2016). *Enforcement, Socioeconomic Diversity, and Tax Filing Compliance in the United States*. <https://doi.org/10.1002/soej.12106>
- Al-Mubarak, H. M., & Busler, M. (2012). The incubators economic indicators: Mixed approaches. *Journal of Case Research in Business and Economics*, 4, 1.
- Alsamhi, S. H., Ma, O., Ansari, M. S., & Almalki, F. A. (2019). Survey on Collaborative Smart Drones and Internet of Things for Improving Smartness of Smart Cities. *IEEE Access*, 7, 128125–128152. <https://doi.org/10.1109/ACCESS.2019.2934998>
- Anastasiu, I. (2019). Unpacking the Smart City Through the Lens of the Right to the City: A Taxonomy as a Way Forward in Participatory City-Making. In M. de Lange & M. de Waal (Eds.), *The Hackable City: Digital Media and Collaborative City-Making in the Network Society* (pp. 239–260). Springer. https://doi.org/10.1007/978-981-13-2694-3_13
- Ang, K. L.-M., & Seng, J. K. P. (2021). Embedded intelligence: Platform technologies, device analytics, and smart city applications. *IEEE Internet of Things Journal*, 8(17), 13165–13182.
- Angelidou, M. (2015). Smart cities: A conjuncture of four forces. *Cities*, 47, 95–106. <https://doi.org/10.1016/j.cities.2015.05.004>
- Anindra, F., Supangkat, S. H., & Kosala, R. R. (2018). Smart Governance as Smart City Critical Success Factor (Case in 15 Cities in Indonesia). *2018 International Conference on ICT for Smart Society (ICISS)*, 1–6. <https://doi.org/10.1109/ICTSS.2018.8549923>
- Anisha, P. R., Reddy, C. K. K., & Nguyen, N. G. (2022). Blockchain Technology: A Boon at the Pandemic Times – A Solution for Global Economy Upliftment with AI and IoT. In *Blockchain Security in Cloud Computing* (pp. 227–252). Springer, Cham. https://doi.org/10.1007/978-3-030-70501-5_11
- APP. (2020, July 24). *Prime minister's 'smart lockdown' lauded globally*. The Express Tribune. <https://tribune.com.pk/story/2256498/prime-ministers-smart-lockdown-lauded-globally>
- APP. (2025a, August 22). *Islamabad to get two-bin, three-bin waste collection system*. <https://www.app.com.pk/national/islamabad-to-get-two-bin-three-bin-waste-collection-system/>
- APP. (2025b, August 23). *CDA launches Mobile App to guide citizens on electric, metro bus routes in Islamabad*. <https://www.app.com.pk/national/cda-launches-mobile-app-to-guide-citizens-on-electric-metro-bus-routes-in-islamabad/>

- Asad, M. (2016, March 29). *Safe City Project operational, awaits formal inauguration*. DAWN.COM. <http://www.dawn.com/news/1248566>
- Bartoletti, I. (2019). AI in Healthcare: Ethical and Privacy Challenges. *Artificial Intelligence in Medicine*, 7–10. https://doi.org/10.1007/978-3-030-21642-9_2
- Becker, G. S. (1994). *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education, Third Edition*. The University of Chicago Press. <https://www.nber.org/books-and-chapters/human-capital-theoretical-and-empirical-analysis-special-reference-education-third-edition>
- Bell, S., & Morse, S. (Eds.). (2018). *Routledge Handbook of Sustainability Indicators*. Routledge. <https://doi.org/10.4324/9781315561103>
- Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable Cities and Society*, 31, 183–212. <https://doi.org/10.1016/j.scs.2017.02.016>
- Bolla, S., Anandan, R., & Thanappan, S. (2022). Weather forecasting method from sensor transmitted data for smart cities using IoT. *Scientific Programming*, 2022(1), 1426575.
- Bulut, R., Kantarcı, A., Keskin, S., & Bahtiyar, Ş. (2019). *Blockchain-Based Electronic Voting System for Elections in Turkey*. <https://doi.org/10.48550/arXiv.1911.09903>
- Caganova, D., Bawa, M., Sujanova, J., & Saniuk, A. (2015). *Innovation in industrial enterprises and intercultural management*.
- Capital, S. (2023). *Capital Smart City | The First Smart City in Pakistan*. <https://www.smartcitypk.com/#about>
- Carter, B. M., Sumpter, D. F., & Thruston, W. (2023). Overcoming Marginalization by Creating a Sense of Belonging. *Creative Nursing*. <https://doi.org/10.1177/10784535231216464>
- CDA. (2025, August 6). *CDA Decides to Implement Cashless Economy system*. CDA Gallery. <https://www.cda.gov.pk/public/cdaImagesGallery/cda-decides-to-implement-cashless-economy-system>
- Chakraborty, C., & Abougreen, A. N. (2021). Intelligent Internet of Things and Advanced Machine Learning Techniques for COVID-19. *EAI Endorsed Transactions on Pervasive Health and Technology*, 7(26), e1–e1. <https://doi.org/10.4108/eai.28-1-2021.168505>
- Chan, G. K. Y. (2022). Towards a calibrated trust-based approach to the use of facial recognition technology. *International Journal of Law and Information Technology*, 29(4), 305–331. <https://doi.org/10.1093/ijlit/eaab011>

- Chang, S., & Smith, M. K. (2023). Residents' Quality of Life in Smart Cities: A Systematic Literature Review. *Land*, *12*(4), 876. <https://doi.org/10.3390/land12040876>
- Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J. R., Mellouli, S., Nahon, K., Pardo, T. A., & Scholl, H. J. (2012). Understanding Smart Cities: An Integrative Framework. *2012 45th Hawaii International Conference on System Sciences*, 2289–2297. <https://doi.org/10.1109/HICSS.2012.615>
- Copenhagen's Action Plan For the SDGs*. (n.d.). Retrieved August 27, 2025, from https://international.kk.dk/sites/default/files/2022-01/Verdensma%CC%8AUK_WEB_FIN.pdf
- Daramola, O., & Thebus, D. (2020). Architecture-Centric Evaluation of Blockchain-Based Smart Contract E-Voting for National Elections. *Informatics*, *7*(2), 16. <https://doi.org/10.3390/informatics7020016>
- Das, P. K., Bhat, M. Y., & Sajith, S. (2024). Life cycle assessment of electric vehicles: A systematic review of literature. *Environmental Science and Pollution Research International*, *31*(1), 73–89. <https://doi.org/10.1007/s11356-023-30999-3>
- Dashkevych, O., & Portnov, B. A. (2022). Criteria for smart city identification: A systematic literature review. *Sustainability*, *14*(8), 4448.
- Dawn. (2025, September 20). AKF plans to expand skills training network. *Dawn*. <https://www.dawn.com/news/1943269>
- De Guimarães, J. C. F., Severo, E. A., Felix Júnior, L. A., Da Costa, W. P. L. B., & Salmoria, F. T. (2020). Governance and quality of life in smart cities: Towards sustainable development goals. *Journal of Cleaner Production*, *253*, 119926. <https://doi.org/10.1016/j.jclepro.2019.119926>
- Deursen, A. J. van, & Dijk, J. A. van. (2018). The first-level digital divide shifts from inequalities in physical access to inequalities in material access. *New Media & Society*, *21*(2). <https://doi.org/10.1177/1461444818797082>
- Dlodlo, N., & Kalezhi, J. (2015). *The Internet of Things in Agriculture for Sustainable Rural Development*. <https://doi.org/10.1109/ETNCC.2015.7184801>
- El-Haggar, N., Amouri, L., Alsumayt, A., Alghamedy, F. H., Aljameel, S. S., El-Haggar, N., Amouri, L., Alsumayt, A., Alghamedy, F. H., & Aljameel, S. S. (2023). The Effectiveness and Privacy Preservation of IoT on Ubiquitous Learning: Modern Learning Paradigm to Enhance Higher Education. *Applied Sciences*, *13*(15). <https://doi.org/10.3390/app13159003>

- Elijah, O., Rahman, T. A., Orikumhi, I., Leow, C. Y., & Hindia, M. N. (2018). An Overview of Internet of Things (IoT) and Data Analytics in Agriculture: Benefits and Challenges. *IEEE Internet of Things Journal*, 5(5), 3758–3773. <https://doi.org/10.1109/JIOT.2018.2844296>
- Emmanuel, F., Hassan, A., Ahmad, A., & Reza, T. E. (2023). Pakistan's COVID-19 Prevention and Control Response Using the World Health Organization's Guidelines for Epidemic Response Interventions. *Cureus*, 15(1), e34480. <https://doi.org/10.7759/cureus.34480>
- Farouk, A., Alahmadi, A., Ghose, S., & Mashatan, A. (2020). Blockchain platform for industrial healthcare: Vision and future opportunities. *Computer Communications*, 154, 223–235. <https://doi.org/10.1016/j.comcom.2020.02.058>
- Farransahat, M., Bhinekawati, R., & Hendriana, E. (2021). The Role of University-Based Incubators in Social Entrepreneurship's Development: The Capability Approach as an Evaluative Framework. *Journal of Indonesian Economy and Business*, 36(3), 215–233. <https://doi.org/10.22146/jieb.v36i3.1741>
- Fearnous, J., Anubhove, M. S. T., Hossain, E., Ahmed, S. M. M., & Zeyad, M. (2022). *Evaluation of Modern Smart Cities in South Asian Countries: Advanced Applications of Internet of Things (IoT)*. <https://doi.org/10.1109/SST55530.2022.9954667>
- Finance, D. (2022). *Copenhagen's Action Plan For the SDGs* (p. 26). https://international.kk.dk/sites/default/files/2022-01/Verdensma%CC%8AI_UK_WEB_FIN.pdf
- FRA. (2015, April 25). *Article 8—Protection of personal data | European Union Agency for Fundamental Rights*. <https://fra.europa.eu/en/eu-charter/article/8-protection-personal-data>
- Gang, S. (2007). Modern Urban Management: An Open Complex Giant System. *Urban Studies*. <https://www.semanticscholar.org/paper/Modern-Urban-Management%3A-An-Open-Complex-Giant-Gang/31a61a9552b8851c0e0b6cfdb11ee1c400c8e4f>
- Gargiulo, C., Pinto, V., & Zucaro, F. (2013). EU Smart City Governance. *TEMA Journal of Land Use, Mobility and Environment*, 6, pages 356-370. <https://doi.org/10.6092/1970-9870/1980>
- Garzón, J., Patiño, E., Marulanda, C., Garzón, J., Patiño, E., & Marulanda, C. (2025). Systematic Review of Artificial Intelligence in Education: Trends, Benefits, and Challenges. *Multimodal Technologies and Interaction*, 9(8). <https://doi.org/10.3390/mti9080084>

- Gibson, D. V., Kozmetsky, G., & Smilor, R. W. (1992). *The technopolis phenomenon: Smart cities, fast systems, global networks*. Rowman & Littlefield.
- Giffinger, R., & Gudrun, H. (2010). Smart cities ranking: An effective instrument for the positioning of the cities? *ACE: Architecture, City and Environment*, 4(12), 7–26. <https://doi.org/10.5821/ace.v4i12.2483>
- Gil-Garcia, J. R., Pardo, T. A., & Nam, T. (2015). What makes a city smart? Identifying core components and proposing an integrative and comprehensive conceptualization. *Information Polity*, 20(1). <https://doi.org/10.3233/IP-150354>
- Gondal, M. W. (2021). Exploring the Concept of Smart Cities in Rapidly Urbanizing Pakistan. *Journal of Indian Studies*, 7(02), 385–398.
- Grother, P., Ngan, M., & Hanaoka, K. (2019). *Face recognition vendor test part 3: Demographic effects* (NIST IR 8280; p. NIST IR 8280). National Institute of Standards and Technology. <https://doi.org/10.6028/NIST.IR.8280>
- Haarstad, H., & Wathne, M. W. (2019). Are smart city projects catalyzing urban energy sustainability? *Energy Policy*, 129, 918–925. <https://doi.org/10.1016/j.enpol.2019.03.001>
- Habib, S., Khan, M. T., & Crandall, J. R. (2025). *Examining Leading Pakistani Mobile Apps*.
- Handforth, C., Inam, M., & Karim, M. (2021). *How telemedicine is helping in the fight against COVID-19 (and why it should be here to stay) | United Nations Development Programme*. UNDP. <https://www.undp.org/pakistan/blog/how-telemedicine-helping-fight-against-covid-19-and-why-it-should-be-here-stay>
- Hanna, R. C., Lemon, K. N., & Smith, G. E. (2019). Is transparency a good thing? How online price transparency and variability can benefit firms and influence consumer decision making. *Business Horizons*, 62(2), 227–236. <https://doi.org/10.1016/j.bushor.2018.11.006>
- Harmon, R., Castro-Leon, E., & Bhide, S. (2015). *Smart cities and the Internet of Things* (p. 494). <https://doi.org/10.1109/PICMET.2015.7273174>
- Harrison, C., & Donnelly, I. A. (2011). *A theory of smart cities*. Proceedings of the 55th Annual Meeting of the ISSS-2011, Hull, UK.
- Hashem, I. A. T., Chang, V., Anuar, N. B., Adewole, K., Yaqoob, I., Gani, A., Ahmed, E., & Chiroma, H. (2016). The role of big data in smart city. *International Journal of Information Management*, 36(5), 748–758.
- Hasnain, K. (2023, September 6). *Orange Line touches 100m passengers count*. DAWN.COM. <https://www.dawn.com/news/1768572>

- Hazarika, I. (2020). Artificial intelligence: Opportunities and implications for the health workforce. *International Health*, 12(4), 241–245. <https://doi.org/10.1093/inthealth/ihaa007>
- Hoggett, J. (2021, July 2). *Trustpilot: Denmark's tech unicorn puts its trust in London*. <https://www.londonstockexchange.com/discover/news-and-insights/about:blank>
- Hollands, R. G. (2020). Will the real smart city please stand up?: Intelligent, progressive or entrepreneurial? In *The Routledge companion to smart cities* (pp. 179–199). Routledge.
- Hong, C. (2022). “Safe Cities” in Pakistan: Knowledge Infrastructures, Urban Planning, and the Security State. *Antipode*, 54(5), 1476–1496. <https://doi.org/10.1111/anti.12799>
- Hossain, S., & Muhammad, G. (2016). Cloud-assisted Industrial Internet of Things (IIoT) – Enabled framework for health monitoring. *Computer Networks*, 101, 192–202. <https://doi.org/10.1016/j.comnet.2016.01.009>
- Hub. (2015, June 1). *The Hub | Green Tech Challenge*. <https://thehub.io/startups/green-tech-challenge>
- Hussain, N. (2020, June 5). *NCOC launches app called Pak Nigehbaan to inform about availability of ventilators*. <https://www.thenews.com.pk/latest/668344-pak-nigehbaan-app-launched-regarding-availability-of-ventilators>
- ICLEI. (2016). *ICLEI 2016.pdf* (p. 4). https://e-lib.iclei.org/wp-content/uploads/2016/10/ICLEI-Brochure_Sept-2016_Final.pdf
- IMD, 2025. (2024). *Smart City Index Results—IMD business school for management and leadership courses*. <https://www.imd.org/smart-city-observatory/home/rankings/>
- IMD, 2025. (2025, April 7). *Smart City Index 2025—IMD business school for management and leadership courses*. <https://www.imd.org/smart-city-observatory/home/>
- Iqbal, H. M. N., Parra-Saldivar, R., Zavala-Yoe, R., & Ramirez-Mendoza, R. A. (2020). Smart educational tools and learning management systems: Supportive framework. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, 14(4), 1179–1193. <https://doi.org/10.1007/s12008-020-00695-4>
- Irfan, S. (2018, February 17). *Building Smart Cities in Pakistan*. Pakistan Defence. <https://defence.pk/threads/building-smart-cities-in-pakistan.544793/>
- Ivanov Petrea, M., & Ursache, I.-M. (2023). *INSIDE THE WORLD'S MOST SUSTAINABLE SMART CITY: LESSONS FROM COPENHAGEN*.
- James, P., Holden, M., Lewin, M., Neilson, L., Oakley, C., Truter, A., & Wilmoth, D. (2013). Managing metropolises by negotiating urban growth. In *Institutional and social innovation for sustainable urban development* (pp. 217–232). Routledge.

- Javaid, S., Sufian, A., Pervaiz, S., & Tanveer, M. (2018). *Smart traffic management system using Internet of Things* (p. 1). <https://doi.org/10.23919/ICACT.2018.8323769>
- Joo, Y.-M., & Tan, T.-B. (2020). Smart cities in Asia: An introduction. In *Smart cities in Asia* (pp. 1–17). Edward Elgar Publishing.
- Josh and Mak International*. (2023, May 17). <https://joshandmakinternational.com/>
- Jurenka, R., Caganova, D., Horňáková, N., & Stareček, A. (2017). *Smart City in Terms of Social Innovations and Human Capital*. <https://doi.org/10.4108/eai.14-2-2017.152190>
- Khan, A. A., Bourouis, S., Kamruzzaman, M. M., Hadjouni, M., Shaikh, Z. A., Laghari, A. A., Elmannai, H., & Dhahbi, S. (2023). Data Security in Healthcare Industrial Internet of Things With Blockchain. *IEEE Sensors Journal*, 23(20), 25144–25151. <https://doi.org/10.1109/JSEN.2023.3273851>
- Khanna, A., Sah, A., Bolshev, V., Jasinski, M., Vinogradov, A., Leonowicz, Z., & Jasiński, M. (2021). Blockchain: Future of e-Governance in Smart Cities. *Sustainability*, 13(21), 11840. <https://doi.org/10.3390/su132111840>
- Khera, P., Ng, S., Ogawa, S., & Sahay, R. (2021, June 11). *Is Digital Financial Inclusion Unlocking Growth?* IMF. <https://www.imf.org/en/Publications/WP/Issues/2021/06/11/Is-Digital-Financial-Inclusion-Unlocking-Growth-460738>
- Khoso, P. D. A. A., Awais, E., & Umair, M. (2024). The Role of Scholarships and Financial Aids in Enhancing Access to International Education: Opportunities and Challenges. *International Research Journal of Management and Social Sciences*, 5(4), 1–17.
- Kitchin, R. (2015). Making sense of smart cities: Addressing present shortcomings. *Cambridge Journal of Regions, Economy and Society*, 8(1), 131–136.
- Klavsén, C. (2015, March 16). *From 100 to 300—How Trustpilot creates cohesiveness in a growing company—Nordic Startup News*. <https://nordicstartupnews.com/from-100-to-300-how-trustpilot-creates-cohesiveness-in-a-growing-company/>
- Kour, V. P., & Arora, S. (2020). Recent Developments of the Internet of Things in Agriculture: A Survey. *IEEE Access*, 8, 129924–129957. <https://doi.org/10.1109/ACCESS.2020.3009298>
- Kulik, J. A., & Fletcher, J. D. (2016). Effectiveness of Intelligent Tutoring Systems. *Review of Educational Research*, 86(1). <https://doi.org/10.3102/0034654315581420>
- Kumar, H., Singh, M. K., Gupta, M. P., & Madaan, J. (2020). Moving towards smart cities: Solutions that lead to the Smart City Transformation Framework. *Technological*

- Forecasting and Social Change*, 153, 119281.
<https://doi.org/10.1016/j.techfore.2018.04.024>
- Lahore, C. (2024). *Lahore Smart City | The First Smart City in Lahore*.
<https://www.lahoresmartcitypk.com/#about>
- Lee, J., Bagheri, B., & Kao, H.-A. (2015). A cyber-physical systems architecture for industry 4.0-based manufacturing systems. *Manufacturing Letters*, 3, 18–23.
- Li, C., Ahmed, N., Qalati, S. A., Khan, A., & Naz, S. (2020). Role of Business Incubators as a Tool for Entrepreneurship Development: The Mediating and Moderating Role of Business Start-Up and Government Regulations. *Sustainability*, 12(5), 1822.
<https://doi.org/10.3390/su12051822>
- Li, X., Chen, M., & Nie, J. (2020). SEDNN: Shared and enhanced deep neural network model for cross-prompt automated essay scoring. *Knowledge-Based Systems*, 210, 106491.
<https://doi.org/10.1016/j.knosys.2020.106491>
- Liu, S., Jiang, G., Chang, L., & Wang, L. (2022). Can the Smart City Pilot Policy Promote High-Quality Economic Development? A Quasi-Natural Experiment Based on 239 Cities in China. *Sustainability*, 14(23), 16005. <https://doi.org/10.3390/su142316005>
- Lom, M., & Pribyl, O. (2021). Smart city model based on systems theory. *International Journal of Information Management*, 56, 102092.
- Mahdi, S. S., Allana, R., Battineni, G., Khalid, T., Agha, D., Khawaja, M., & Amenta, F. (2022). The promise of telemedicine in Pakistan: A systematic review. *Health Science Reports*, 5(1), e438.
- Mahmood, N., Jianfeng, C., Jamil, F., Karamat, J., Khan, M., & Cai, Y. (2015). Business Incubators: Boon or Boondoggle for SMEs and Economic Development of Pakistan. *International Journal of U- and e- Service, Science and Technology*, 8, 147–158.
<https://doi.org/10.14257/ijunesst.2015.8.4.15>
- McMahon, W. (2009). Higher Learning, Greater Good: The Private & Social Benefits of Higher Education. [Http://Lst-Iiep.Iiep-Unesco.Org/Cgi-Bin/Wwwi32.Exe/\[In=epidoc1.in\]/?T2000=027209/\(100\)](Http://Lst-Iiep.Iiep-Unesco.Org/Cgi-Bin/Wwwi32.Exe/[In=epidoc1.in]/?T2000=027209/(100)).
- Menendez, M., & Ambühl, L. (2022). Implementing Design and Operational Measures for Sustainable Mobility: Lessons from Zurich. *Sustainability*, 14(2), 625.
<https://doi.org/10.3390/su14020625>
- Misbahuddin, S., Zubairi, J., Saggaf, A., Basuni, J., A-Wadany, S., & Al-Sofi, A. (2015). *IoT based dynamic road traffic management for smart cities* (p. 5).
<https://doi.org/10.1109/HONET.2015.7395434>

- Mohammadzadeh, Z., Saeidnia, H. R., Lotfata, A., Hassanzadeh, M., & Ghiasi, N. (2023). Smart city healthcare delivery innovations: A systematic review of essential technologies and indicators for developing nations. *BMC Health Services Research*, 23(1), 1180. <https://doi.org/10.1186/s12913-023-10200-8>
- Mueller, N. D., Gerber, J. S., Johnston, M., Ray, D. K., Ramankutty, N., & Foley, J. A. (2012). Closing yield gaps through nutrient and water management. *Nature*, 490(7419), 254–257. <https://doi.org/10.1038/nature11420>
- Nagra, M. H., Ehsan, S., Ahmad, U., Ali, M., Hussain, H. A., & Bakar, A. (2021). Retracted: Implementation of a telemedicine service during COVID-19 pandemic in Pakistan. *International Journal of Clinical Practice*, 75(8), e14310.
- Namer, Y., Stöcker, A., Ashour, A., Dieckmann, J., Schmidt, P., & Zurbriggen, C. (2024). *Intersectional Challenges to Cohesion?: On Marginalization in an Inclusive Society*. Campus Verlag.
- Nawaz, A., Khan, M., Wajid, M., Zaman, M., Mahmood, M., Shafi, M., & Waheed, A. (2022). COVID-19 and early responses of Pakistan to mitigate the pandemic: A quick review. *SINDH UNIVERSITY RESEARCH JOURNAL -SCIENCE SERIES*, 54, 65–71. <https://doi.org/10.26692/surj.v54i2.5802>
- Nikesh, G., & R. S., K. (2016). IoT based Smart Agriculture. *SSRN Electronic Journal*, 5(6). <https://doi.org/10.2139/ssrn.4847308>
- Noreen, N., Rehman, S. A. U., Naveed, I., Niazi, S. U. K., & Furqan, I. B. (2021). Pakistan's COVID-19 Outbreak Preparedness and Response: A Situational Analysis. *Health Security*, 19(6), 605–615. <https://doi.org/10.1089/hs.2021.0006>
- OECD. (2020). *2020 Policy Note on Asia-Smart Cities as Engines for Growth*. https://www.oecd-ilibrary.org/content/dam/oecd/en/publications/reports/2020/05/smart-cities-as-engines-for-growth-in-asia_85a3191d/1fbcf870-en.pdf
- O'Reilly, T. (2011). Government as a Platform. *MIT Press*, 6(1), 13–40. https://doi.org/10.1162/INOV_a_00056
- Ozkaya, G., & Erdin, C. (2020). Evaluation of smart and sustainable cities through a hybrid MCDM approach based on ANP and TOPSIS technique. *Heliyon*, 6(10). <https://doi.org/10.1016/j.heliyon.2020.e05052>
- Pak Identity*. (2025, August 22). *Pak Identity*. <https://play.google.com/store/apps/details?id=pk.gov.nadra.pakid&hl=en>

- PBS. (2023). *PBS 7th Population and Housing Key Findings Report.pdf*.
https://www.pbs.gov.pk/sites/default/files/population/2023/Key_Findings_Report.pdf
- Peralta Abadía, J. J., & Smarsly, K. (2021). Internet of Things frameworks for smart city applications—A systematic review. *Computing in Civil Engineering 2021*, 83–89.
- Pereira, G. V., Parycek, P., Falco, E., & Kleinhans, R. (2018). Smart governance in the context of smart cities: A literature review. *Information Polity*, 23(2), 143–162.
- Peric, A., De Blust, D. B., Jiang, Y., Guariento, N., & Wälty, S. (2022). Urban Strategies for Dense and Green Zurich: From Healthy Neighbourhoods towards Healthy Communities? *Proceedings of the 58th ISOCARP World Planning Congress*. 58th ISOCARP World Planning Congress. <https://doi.org/10.47472/rGH9GX8P>
- Perna, L. W., Orosz, K., Gopaul, B., Jumakulov, Z., Ashirbekov, A., & Kishkentayeva, M. (2014). Promoting Human Capital Development: A Typology of International Scholarship Programs in Higher Education. *Educational Researcher*, 43(2), 63–73. <https://doi.org/10.3102/0013189X14521863>
- PITB. (2015). *E-KHIDMAT MARKAZ*.
<https://www.pitb.gov.pk/system/files/Apr%2014%2C%202017%20Chief%20Minister%20Punjab%20Inaugurates%20E-Khidmat%20Markaz%20Faisalabad%20%28Tomorrow%29.pdf>
- PITB. (2018, January 5). *Integrated Command, Control and Communication Center | PITB*.
<https://pitb.gov.pk/ic3>
- Police, I. (2016). *Islamabad Police*. <https://islamabadpolice.gov.pk/safecity.php>
- Police, P. (2018, January 5). *Shehbaz inaugurates Safe City | Punjab Police*.
https://www.punjabpolice.gov.pk/node/5758?utm_source=chatgpt.com
- Popova, Y., & Popovs, S. (2022). Impact of Smart Economy on Smart Areas and Mediation Effect of National Economy. *Sustainability*, 14(5), 2789. <https://doi.org/10.3390/su14052789>
- Pratt, K. (2025, March 24). *Worldwide Work-Life Balance Index 2023*. Forbes Advisor UK. <https://www.forbes.com/uk/advisor/business/work-life-balance-index/>
- Qeemat Punjab—Apps on Google Play*. (2024, April 29).
<https://play.google.com/store/apps/details?id=com.pitb.qeematpunjab&hl=en>
- Qureshi, H. A., Salman, Y., Irfan, S., & Jabeen, N. (2017). A systematic review of e-government evaluation. *Pakistan Economic and Social Review*, 55(2), 355–390.
- Rafique, S., Nadeem, O., Asim, M., & Jalil, A. (2022). Assessing the Potential of Sustainable Urban Regeneration in Lahore: A Case Study of Orange Line Metro Train Route.

- Journal of Art, Architecture and Built Environment*, 5, 67–91.
<https://doi.org/10.32350/jaabe.51.04>
- Rana, I. A., & Bhatti, S. S. (2018). Lahore, Pakistan – Urbanization challenges and opportunities. *Cities*, 72, 348–355. <https://doi.org/10.1016/j.cities.2017.09.014>
- Raza, K. (2020). Artificial Intelligence Against COVID-19: A Meta-analysis of Current Research. In A.-E. Hassani, N. Dey, & S. Elghamrawy (Eds.), *Big Data Analytics and Artificial Intelligence Against COVID-19: Innovation Vision and Approach* (Vol. 78, pp. 165–176). Springer International Publishing. https://doi.org/10.1007/978-3-030-55258-9_10
- Reuter, T. K. (2019). Human rights and the city: Including marginalized communities in urban development and smart cities. *Journal of Human Rights*, 18(4), 382–402. <https://doi.org/10.1080/14754835.2019.1629887>
- Rizvi, S. K. A., Naqvi, B., & Tanveer, F. (2017). Mobile Banking: A Potential Catalyst for Financial Inclusion and Growth in Pakistan. *The Lahore Journal of Economics*, 22(3), 251–281.
- Rousseau, D. (2015). General systems theory: Its present and potential. *Systems Research and Behavioral Science*, 32(5), 522–533.
- Schulz, W. (2024). *Young people’s trust in institutions, civic knowledge and their dispositions toward civic engagement | Large-scale Assessments in Education | Full Text*. <https://largescaleassessmentsineducation.springeropen.com/articles/10.1186/s40536-024-00210-1?>
- Shah, H., Shah, S., Tanwar, S., Gupta, R., & Kumar, N. (2022). Fusion of AI techniques to tackle COVID-19 pandemic: Models, incidence rates, and future trends. *Multimedia Systems*, 28(4), 1189–1222. <https://doi.org/10.1007/s00530-021-00818-1>
- Sharif, A., Li, J., Khalil, M., Kumar, R., Sharif, M., Sharif, A., & Kumar, R. (2018). *Internet of things—Smart traffic management system for smart cities using big data analytics*. <https://doi.org/10.1109/ICCWAMTIP.2017.8301496>
- Sharmin, A. (2020, May 8). ‘Call 1166’: The COVID-19 helpline centre in Pakistan | UNICEF. UNICEF. <https://www.unicef.org/stories/call-1166-covid-19-helpline-centre-pakistan>
- Sheth, A., Anantharam, P., & Henson, C. (2013). Physical-cyber-social computing: An early 21st century approach. *IEEE Intelligent Systems*, 28(1), 78–82.
- Sinha, B. B., & Dhanalakshmi, R. (2022). Recent advancements and challenges of Internet of Things in smart agriculture: A survey. *Future Generation Computer Systems*, 126, 169–184. <https://doi.org/10.1016/j.future.2021.08.006>

- Su, Y., Miao, Z., & Wang, C. (2022). The Experience and Enlightenment of Asian Smart City Development—A Comparative Study of China and Japan. *Sustainability*, *14*(6), 3543. <https://doi.org/10.3390/su14063543>
- Sun, T., & Medaglia, R. (2019). Mapping the challenges of Artificial Intelligence in the public sector: Evidence from public healthcare. *Government Information Quarterly*, *36*(2), 368–383. <https://doi.org/10.1016/j.giq.2018.09.008>
- Tambun, S., & Kopong, Y. (2017). *THE EFFECT OF E-FILING ON THE OF COMPLIANCE INDIVIDUAL TAXPAYER, MODERATED BY TAXATION SOCIALIZATION*. *13*(1).
- Tan, P., Wu, H., Li, P., & Xu, H. (2018). Teaching Management System with Applications of RFID and IoT Technology. *Education Sciences*, *8*(1), 26. <https://doi.org/10.3390/educsci8010026>
- Tao, W., Zhao, L., Wang, G., & Liang, R. (2021). Review of the internet of things communication technologies in smart agriculture and challenges. *Computers and Electronics in Agriculture*, *189*, 106352. <https://doi.org/10.1016/j.compag.2021.106352>
- Taş, R., & Tanrıöver, Ö. Ö. (2020). A Systematic Review of Challenges and Opportunities of Blockchain for E-Voting. *Symmetry*, *12*(8), 1328. <https://doi.org/10.3390/sym12081328>
- Tax Asaan by FBR, Pakistan.* (2025, July 24). https://play.google.com/store/apps/details?id=com.pral.fbr_varification_system&hl=en
- Trindade, E. P., Hinnig, M. P. F., da Costa, E. M., Marques, J. S., Bastos, R. C., & Yigitcanlar, T. (2017). Sustainable development of smart cities: A systematic review of the literature. *Journal of Open Innovation: Technology, Market, and Complexity*, *3*(3), 1–14.
- UN. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development / Department of Economic and Social Affairs*. <https://sdgs.un.org/2030agenda>
- UNDP. (2024, April 24). *State of Youth Entrepreneurship Ecosystem in Pakistan*. UNDP. <https://www.undp.org/pakistan/publications/state-youth-entrepreneurship-ecosystem-pakistan>
- UNESCAP. (2016). *State of ICT in Asia and the Pacific 2016: Uncovering the widening broadband divide*. <https://repository.unescap.org/items/10981cf3-fd96-4460-9ecd-cc7eb3a7d2b7>

- UNHABITAT. (2020). *World Countries Report 2020 report.pdf*.
https://unhabitat.org/sites/default/files/2020/10/wcr_2020_report.pdf
- V, S., Soundarraaj, P. Iatha, Morwani, H., Jani, J., Pathak, P., & Pal, S. (2024). Digital Transformation of Classroom; Impact of AI and IOT in Educational Sector. *Journal of Informatics Education and Research*, 4(2). <https://doi.org/10.52783/jier.v4i2.895>
- Vayena, E., Blasimme, A., & Cohen, I. G. (2018). Machine learning in medicine: Addressing ethical challenges. *PLOS Medicine*, 15(11), e1002689. <https://doi.org/10.1371/journal.pmed.1002689>
- Vinod Kumar, T., & Dahiya, B. (2017). *Smart economy in smart cities*. Springer.
- von Bertalanffy, L. (1950). An Outline of General System Theory. *The British Journal for the Philosophy of Science*, 1(2), 134–165.
- Wang, F.-Y. (2010). The Emergence of Intelligent Enterprises: From CPS to CPSS. *IEEE Intelligent Systems*, 25(4), 85–88. <https://doi.org/10.1109/mis.2010.104>
- Weddell, A., & Magno, M. (2018). *Energy Harvesting for Smart City Applications*. 111–117. <http://dx.doi.org/10.1109/SPEEDAM.2018.8445323>
- Wiig, A. (2015). IBM's smart city as techno-utopian policy mobility. *City*, 19(2–3), 258–273. <https://doi.org/10.1080/13604813.2015.1016275>
- Wirtz, B. W., Becker, M., & Schmidt, F. W. (2022). Smart city services: An empirical analysis of citizen preferences. *Public Organization Review*, 22(4), 1063–1080. <https://doi.org/10.1007/s11115-021-00562-0>
- Wolniak, R. (2023). Smart mobility in smart city – Copenhagen and Barcelona comparison. *Scientific Papers of Silesian University of Technology Organization and Management Series*, 2023. <https://doi.org/10.29119/1641-3466.2023.172.41>
- Wolniak, R., & Grebski, W. (2023a). SMART MOBILITY IN SMART CITY – SINGAPORE AND TOKYO COMPARISON. *Scientific Papers of Silesian University of Technology Organization and Management Series*, 2023. <https://doi.org/10.29119/1641-3466.2023.176.44>
- Wolniak, R., & Grebski, W. (2023b). The usage of smartphone applications in smart city development – urban mobility and traffic management. *Scientific Papers of Silesian University of Technology Organization and Management Series*, 2023(179). <https://doi.org/10.29119/1641-3466.2023.179.39>
- Wu, J. (2014). Urban ecology and sustainability: The state-of-the-science and future directions. *Landscape and Urban Planning*, 125, 209–221.

- Xia, H., & Wang, Z. (2017). (PDF) *systemic thinking on smart cities*. ResearchGate. https://www.researchgate.net/publication/319696315_systemic_thinking_on_smart_cities
- Xia, X., & Li, P. (2022). A review of the life cycle assessment of electric vehicles: Considering the influence of batteries. *The Science of the Total Environment*, 814, 152870. <https://doi.org/10.1016/j.scitotenv.2021.152870>
- Yabe, K., Shinoda, Y., Seki, T., Tanaka, H., & Akisawa, A. (2012). Market penetration speed and effects on CO2 reduction of electric vehicles and plug-in hybrid electric vehicles in Japan. *Energy Policy*, 45, 529–540. <https://doi.org/10.1016/j.enpol.2012.02.068>
- Yin, Y., Stecke, K. E., & Li, D. (2018). The evolution of production systems from Industry 2.0 through Industry 4.0. *International Journal of Production Research*, 56(1–2), 848–861. <https://doi.org/10.1080/00207543.2017.1403664>
- Zanella, A., Bui, N., Castellani, A., Vangelista, L., & Zorzi, M. (2014). Internet of Things for Smart Cities. *IEEE Internet of Things Journal*, 1(1), 22–32. <https://doi.org/10.1109/jiot.2014.2306328>
- Zeng, X., Yu, Y., Yang, S., Lv, Y., & Sarker, M. N. I. (2022). Urban Resilience for Urban Sustainability: Concepts, Dimensions, and Perspectives. *Sustainability*, 14(5), 2481. <https://doi.org/10.3390/su14052481>
- Zhang, L., & Wu, C. (2023). The Impact of Smart City Pilots on Haze Pollution in China—An Empirical Test Based on Panel Data of 283 Prefecture-Level Cities. *Sustainability*, 15(12), 9653. <https://doi.org/10.3390/su15129653>

Annexure A

Survey Questionnaire

Demographic Information

1. Age

- 18-24
- 25-34
- 35-44
- 45-54
- 55-60

2. Gender

- Male
- Female

3. Qualification

- No formal education
- Primary school
- High school
- Bachelors
- Masters/ M.phil
- PhD

4. Occupation

- Student
- Employed (public sector)
- Employed (private sector)
- Self-employed/Business
- Home maker
- Other

5. Please select area of residence

- F/5-F/11
- G/6- G/15
- H/8-H/11
- I/8-I/11
- E/8-E/11

- Bahria Town Phase 1-6
- Bahria Town Phase 7-8
- DHA Phase 2, 5
- DHA Phase 1, 3, 4

Section 1: Awareness of Smart City Initiatives in the Twin Cities

1. Are you aware of any Smart City initiatives in Islamabad or Rawalpindi (eg: Safe City, e governance, online services)?
 - Yes
 - No (Go to attitudes towards Smart City Development)

Section 2: Smart Governance

1. **You have used government launched apps, such as the Pak Identity (NADRA) app, FBR Tax Asaan app, etc.**
 - Yes (Go to next question)
 - No (Go to Q3)
2. **These apps have made the process more efficient (Continue to next question)**
 - Yes
 - No
 - Maybe
3. **Do you believe Smart City initiatives will improve government transparency and reduce corruption?**
 - Strongly Agree
 - Agree
 - Neutral
 - Disagree
 - Strongly Disagree
4. **Do you feel citizens have enough opportunities to participate in decision-making processes (e-governance, public forums)/to voice out their grievances?**
 - Yes
 - No
 - Maybe

Section 3: Smart People

1. How willing are you to adopt new technologies (mobiles apps, digital platforms for daily life and work)?

- Very Willing
- Willing
- Moderately Willing
- Slightly Willing
- Not willing

2. Do you believe Smart City initiatives will help citizens become more innovative and entrepreneurial?

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

3. The people living in Smart Cities have numerous opportunities to enhance their qualification

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Section 4: Smart Living

1. The current internet speed and reliability meet connectivity needs

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

2. Minorities feel welcome in the city

- Strongly Agree
- Agree
- Neutral

- Disagree
 - Strongly Disagree
- 3. How satisfied are you with current healthcare services enhanced by technology (telemedicine, online health records)?**
- Very Satisfied
 - Satisfied
 - Neutral
 - Dissatisfied
 - Very Dissatisfied
- 4. To what extent do you believe Smart City initiatives, such as the ‘Safe City’ project has improved safety and security of public spaces?**
- To a greater extent
 - To a considerable extent
 - To some extent
 - To a small extent
 - Not at all

Section 5: Smart Economy

- 1. Online services provided by the city has made it easier to start new businesses**
- Strongly Agree
 - Agree
 - Neutral
 - Disagree
 - Strongly Disagree
- 2. Have you done digital transactions?**
- Yes (Go to Q3)
 - No (Go to next section)
- 3. How satisfied are you with the availability of digital payment systems (e-banking and mobile wallets such as JazzCash, Alfa, etc)? * Go to next section after completing**
- Very Satisfied
 - Satisfied
 - Neutral

- Dissatisfied
- Very Dissatisfied

Section 6: Smart Environment

1. How concerned are you about environmental issues (air quality, waste management, water scarcity) in the Twin Cities?

- Very Concerned
- Concerned
- Moderately Concerned
- Slightly Concerned
- No concerned at all

2. How important is the adoption of renewable energy sources (solar energy, hydroelectric) for the future of the Twin Cities?

- Very Important
- Important
- Moderately Important
- Slightly Important
- Not important at all

3. To what extent do you believe smart water management systems (leak detection, water recycling) can help reduce shortages in Islamabad and Rawalpindi?

- To a great extent
- To a considerable extent
- To some extent
- To a small extent
- Not at all

Section 7: Smart Mobility

1. Traffic congestion is not a problem

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

2. Smart mobility solutions (intelligent traffic signals, ride-sharing apps, smart parking) will reduce traffic congestion.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

3. Public transport is satisfactory.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Section 8: Citizen Perceptions of Smart City Initiatives

1. How important do you think Smart City initiatives are for improving quality of life?

- Very Important
- Important
- Moderately Important
- Slightly Important
- Not important at all

2. To what extent do you believe Smart City initiatives will benefit the Twin Cities?

- To a great extent
- To a considerable extent
- To some extent
- To a small extent
- Not at all

3. How satisfied are you with the current digital infrastructure (internet access, e-services) in the Twin Cities?

- Very Satisfied
- Satisfied

- Neutral
- Dissatisfied
- Very Dissatisfied

Section 9: Citizen Attitudes Toward Smart City Development

1. You are comfortable with face recognition technologies to lower crime.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

2. You are willing to concede personal data in order to improve traffic congestion.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

3. Would you be willing to adopt Smart City technologies (e.g., using mobile apps for government services, online payments)?

- Yes
- No
- Maybe

4. Do you trust the government to implement Smart City projects effectively?

- Strongly Trust
- Trust
- Neutral
- Distrust
- Strongly Distrust

Annexure B

Interview Guide – DHA Islamabad

Smart Environment

1. How does DHA address key environmental concerns such as water scarcity, pollution, and waste management?
2. What steps is DHA taking toward sustainable energy solutions?
3. What are the biggest challenges DHA faces in achieving environmental sustainability, and how can residents be encouraged to adopt eco-friendly practices?

Smart Living

4. DHA has an app for residents—how has it improved service delivery and efficiency for both residents and service providers?
5. What opportunities does DHA provide for recreation and community building, and how do these events contribute to a sense of community?
6. What steps are being taken to improve healthcare and emergency response in DHA, particularly in phases without major hospitals?

Smart Governance & Safety

7. What measures are in place to ensure safety and security of residents, and how effective have systems like E-tags and CCTV been?
8. What is the procedure for reporting a crime in DHA and how is it followed up? (coordination with local police?)

Smart People

9. In your opinion, how feasible is it to completely transition to digital service delivery through the app, and what kind of support (trainings/workshops) is planned for residents?

Smart Mobility

10. What in your opinion is a loophole in the current speeding system?

Conclusion

11. From your perspective, what is DHA's overall impact on urban sustainability?
12. Do you think DHA's smart initiatives can serve as a model for other housing societies or cities in Pakistan?

Annexure C

Interview Guide – Islamabad Safe City

Safety & Security

1. What was the vision behind the establishment of the Islamabad Safe City Project, and how does it function in terms of surveillance technology (CCTV, ANPR, drones, integration with NADRA, etc.)?
2. How effective has the project been in reducing crime rates and improving law enforcement response times? Could you share examples of resolved cases?
3. How does the Safe City Project coordinate between different security agencies (police, traffic police, FIA, etc.) and ensure citizen participation (e.g., apps or reporting tools)?

Smart Governance & Smart People

4. How does the Safe City Project promote transparency and accountability; are there mechanisms for citizens to access information or report concerns?
5. In your view, how has the project influenced public awareness, trust in law enforcement, and responsible citizenship? Have you seen changes in reporting or cooperation levels?
6. Are there training or educational campaigns for citizens on how to engage with the Safe City systems, and what has been the general public feedback since its launch?

Smart Living

7. How has the project improved the overall quality of life in Islamabad (e.g., reduced fear of crime, safer mobility, better emergency response)?
8. How are emergency services such as medical assistance, disaster response integrated into the system?

Smart Mobility

9. How is the Safe City Project integrated with traffic management systems (e.g., intelligent transport, motorway M-tag, reducing violations/accidents), and what are the penalties for non-compliance?

Conclusion

10. What are the biggest challenges the Islamabad Safe City Project currently faces, and what lessons can other Pakistani cities learn from its experience?
11. Looking ahead, how do you envision the role of Safe City in Islamabad's journey toward becoming a sustainable smart city, and what potential does it hold for replication nationwide?

Annexure D

Interview Guide – ONE Network

1. What were the main objectives behind implementing the Smart Traffic Monitoring and Electronic Toll Collection (M-tag) System?

Design & Implementation

2. What technologies (e.g., AI, sensors, CCTV, data analytics) were used, and how were these systems integrated with existing traffic infrastructure?
3. How do the payment and enforcement mechanisms work in practice, for example, at M-tag toll plazas and within the intelligent transport system?
4. What were the main challenges your team faced during development and implementation, and how were they addressed?

Impact & Effectiveness

5. To what extent have these systems improved traffic flow, reduced congestion, and enhanced safety? Do you have any supporting data?
6. How does the system handle violations and ensure accountability, including its integration with the Punjab Safe City Authority?

Citizen Engagement & Awareness

7. How have citizens perceived these systems; were there awareness campaigns, and how are complaints or feedback handled?

Sustainability & Future Plans

8. How sustainable are these systems in terms of cost, maintenance, and upgrades, and are there plans to expand or integrate with mobility apps or real-time alerts?
9. In your opinion, can these systems be replicated nationwide on major highways? What challenges or opportunities do you foresee?

Environmental Sustainability

10. How do these systems contribute to Pakistan's environmental goals, for example, reducing fuel use, improving air quality, or lowering emissions?

Parking Management System

11. Could you share your insights on the Parking Management System in Islamabad, such as its technology, impact, sustainability, citizen response, and why it was not scaled up further?

12. From your perspective, what role can smart traffic and parking systems play in the broader development of Smart Cities in Pakistan, and how do they impact urban sustainability (environment, economy, and social wellbeing)?