

## **The Quadruple Bottom-line approach to Urbanization and Smart Sustainable Cities**

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### **Abstract**

This paper aims to identify the important dimensions of Sustainable Smart City development amongst the citizens of Karachi, Pakistan. This paper is a two-fold study in which the first study was a quantitative study, which used an explanatory approach, conducted on 318 respondents using a survey method. Convenience based sampling technique was used and data was collected through a questionnaire method. These respondents belonged to various organizations in Karachi, Pakistan. Four dimensions were used to evaluate the importance of smart cities development; Economic, Environmental, Social and Smart. The second study was a qualitative study, which used an exploratory approach, conducted on various stakeholders which directly or indirectly impact the smart city development. Purposive based sampling technique was used and the data from 10 respondents was collected through interviews, including government housing authorities, national databases, Small Medium Enterprise owners, and real estate builders etc. They identified the problems and recommended solutions. Six major problems were identified, amongst which budgetary restraint and lack of resources were most critical. There is limited theoretical and empirical support available regarding the challenges that are experienced during successful implementation for smart city development. By highlighting emerging challenges, this study will help practitioners to prepare themselves for sustainable smart city development and provide more efficient and integrated services.

Keywords: Smart sustainable Cities; Urbanization; Pakistan; Challenges

### **1. Introduction**

In the ever-evolving realm of modern living environments, urban areas, and communities, the demand for sustainable urban and regional growth is becoming more critical. Sustainability is an idea which incorporates issues such as urban development, energy and waste management, information systems, and health and safety (Mehmood, et al, 2024; Kima & Feng, 2024). Sustainability has become a very important topic in advance cities but it is a new concept for developing cities. The Internet of things (IoT) and smart city technologies are a solution for sustainability (Jiang, et al, 2023; Khan, et al, 2020). Guided by the United Nations' Sustainable

Development Goals (SDGs), this research emphasizes the necessity for immediate, holistic, and cooperative efforts to achieve the quadruple bottom line of sustainability, which includes social, environmental, economic and smart aspects. This research focuses on the diverse challenges and emerging opportunities within sustainable development by harnessing the vast capabilities of advanced technologies (Mehmood, et al, 2024). People have misconceptualized the term “Smart City”, thinking it refers to super technologies and science fiction with super computers everywhere. However, Smart city refers to as the concept of sustainable living which improves and modernizes lifestyle. Scholars have highlighted the notion of smart cities involving sensors, artificial intelligence, networking, internet of things, cloud computing, urban analytics etc. Policy makers, technologists and urbanites wish to seize the moment to build better and re-imagine the city of the future with the help of smart city technologies. A range of studies have offered insights into application, implementation and usefulness of smart city technologies. Some studies focused on the role of smart cities in gathering and analyzing data for better governance, through city sensors and internet of things (IoT) networks. These technologies have helped in receiving information about hospitals, libraries, traffic, crimes and other services. Other studies focused on using smart city technologies to encourage participation in influencing public service such as smart urban labs, government portals, citizen dashboards and social media applications (Jiang, et al, 2023; Hui, et al, 2023; Sabri, & Witte, 2023; Mehmood, et al, 2024).

Smart cities are recognized as a promising solution for addressing urban challenges. Innovative urban solutions utilizing technology can enhance the efficiency of city operations and the quality of life. From an engineering perspective, the smart city model is increasingly employed to optimize resource management and improve public spaces such as infrastructure, transport, energy, water supply, and security. From a Socioeconomic standpoint, smart cities can transform urban economic and social environments to be more knowledge-based and eco-friendly (Kim & Feng, 2024). The concept of smart city technologies and the process of smart city development is increasing and Pakistan is no exception. Various cities in Pakistan are facing challenges related to climate and demographics. Innovative technologies provide mobility, administration, and energy to help cities become Smart (Vu & Hartley, 2018; Khan et al, 2020).

The quick urbanization is moving towards technological implementation for city management. The integration of urban governance and IoT has enhanced the quality of life. Although studies have highlighted the concept of Smart Cities in the developed countries but there is scarce research for the developing countries such as Pakistan (Khan et al, 2020). Smart city technologies have shown rapid urbanization. This study shows the importance of Smart Cities by the public and its interest in the implementation of the same. Pakistan has a vision of implementing Smart cities initiative by 2025 in its major cities. This vision encompasses policy making with respect to public transportation, infrastructure, community and green public facilities such as parks, malls etc. Smart City technology plays a vital role in creating a sustainable city. Statistics show that urban communities will grow in Pakistan by 2050 and rural population will decrease indicating massive migration from rural to urban areas. Therefore, it will become more vital to build systems and technology that will guide city governments to manage urban communities better (Khan et al, 2020).

Building Smart cities need support in infrastructure, technology, policymaking, finances and human capital. Thus, stakeholders from all levels from private companies and governments must

overcome challenges for successful development of sustainable Smart Cities (Jiang, et al, 2023; Vu & Hartley, 2018).

This study focuses on identifying which aspects of Smart Cities are important and prioritizes the areas on which government and local bodies must start working on. This research has built on and expanded the study conducted by Homer (2022). It has focused on collecting the subjective perceptions of different stakeholders (citizens of Karachi, Pakistan) regarding the conceptualization of Smart Cities. Homer (2022) created a measurement instrument based on the four factors of Smart Cities; namely; Planning, Environment, Social and Smart. This study has incorporated the same factors in identifying the perspectives of the core theory and dynamics of the sustainable Smart Cities. Along with that, interviews were also taken from different stakeholders on the problems of implementing the Smart Cities phenomenon in Pakistan. Pakistan is taken as a sample for investigation in understanding the dynamics of Smart Cities as the major cities will undergo massive changes in near future with respect to transformation (Khan, et al, 2020).

Jiang et al, (2023) pointed out that the appropriate use of smart technologies in the smart cities (IoT, Connected devices, city sensors, AI, Cloud) are more subtle, changeable and influenced by contexts and circumstances. Potential of smart cities depend upon their environment in which they are embedded and understanding the contexts through its stakeholders will be able to shape the roles of smart city developer's and their efforts will be directed in the right way. The development of sustainable smart cities can be obstructed by various challenges. There is limited theoretical support available regarding the challenges faced during the successful implementation of smart sustainable cities development (Jiang et al, 2023; Hui, et al, 2023; Sabri, & Witte, 2023). Therefore, this study investigates the important areas of Smart cities and the challenges that are faced by developers and government agencies in its implementation. This study is a small step in highlighting the importance of Smart City development. It also provides insights into the critical challenges and their solutions to better prepare practitioners for smart city development.

This study is organized into five parts; the first part is the introduction, the second is literature review, the third is methodology which comprises of both the studies; study 1 comprises of quantitative methods, data collection and empirical analysis while study 2 is qualitative, comprises of interviews and themes extracted. After which the fourth part is the discussion section which integrates both the studies and their interpretations, and lastly fifth part is the conclusion of the study.

### **1.1 Research Propositions**

*Proposition 1. This study proposes to identify the factors critical in implementing smart city development*

*Proposition 2. This study proposes to identify the challenges faced by developers and government agencies in smart city infrastructure implementation.*

### **1.2 Research Questions**

Smart sustainable cities are a major concern for the government and urban population therefore this paper highlights the importance of smart sustainable cities and the challenges associated with it.

**Research Question 1.** What are the factors important in the implementation of smart sustainable cities?

**Research Question 2.** What are the challenges faced by developers and government agencies in smart city infrastructure implementation?

## **2. Literature Review**

### **2.1 Smart Sustainable cities**

The term Smart City is an urban space which are efficient, sustainable and more livable which utilize modern technologies. Approximately 55% of the global population live in urban areas and as the world population is increasing rapidly, according to United Nations this is expected to go up to 70% and 2.5 billion people will be living in cities by 2025. Urbanization leads to water pollution and land degradation and Smart sustainable cities have been proposed as a solution to these problems (Du Plessis, A., 2022). These are a new concept theoretically as well as in implementation. As cities will be reaching their limits, innovations are necessary for surviving the negative effects of over population. The management of necessities of citizens of Pakistan is hugely compromised as the demand of electricity, energy and water is increasing immensely. Shortage of water and load shedding, increasing prices of petrol, gas and other utilities have adversely impacted the standard of living of urban population. Intelligent and networked technologies are needed to meet the needs of this escalating urban population (Malik, 2022). The city governments play a vital role in creating efficient use of electricity and public transport. Green, sustainable and environmentally friendly cities can ensure a longer and healthy lifestyle for its citizens. Information and communication technologies enable the integration of energy, administration and mobility. Citizens are connected to the urban infrastructure via gadgets and smart phones where artificial intelligence (AI) plays an important role. Developed cities have self-driven cars which run on AI and electric batteries. Homes have smart water taps and meters and electricity conservation technology to save electricity and water. Networking of devices are used to control heating, cooling, lighting and managing home appliances all with a smart phone. Solar power panels placed on rooftops provide renewable energies to consume. Even traffic, and security is managed by smart technology and digital cards are used for transaction (Malik, et al 2019; Khan et al 2020; Homer, 2022).

### **2.2 Smart Urban Landscape**

Consumption of excessive energy leads to emissions of greenhouse gases and results in pollution and climate variability. Dependence on fossil fuels as a source of energy and inefficiency in the utilization of energy leads to climate change such as floods, droughts, extreme weathers like heat waves and cold waves and rise in the sea level. Pakistan uses oil and gas as fossil fuels to fulfill the energy requirements. As a response to rising prices in fossil fuel energies and environment degradation, countries are moving towards renewable energies and smart sustainable environments such as Wind mills, turbines and solar power panels etc. (Alam, 2022). Pakistan must also move towards greater consumption of such renewable energies which can be drawn from wind, and sun. The government has an important role to play in providing the governance and framework for the cities to transit towards energy efficient cities. Households, Planners, Interior Designers, Architects, can contribute to reducing the carbon footprint and moving towards Green buildings and creating Smart Sustainable cities (Malik, 2022). Everyday small things such as switches, lights, stoves, home appliances should be turned off when not in use and can be replaced

with smarter technologies can help build sustainable environments. Green buildings and Smart sustainable cities are a solution and way forward to turnaround the mismanaged urban energies.

### **2.3 Stakeholder Theory**

This research uses stakeholder theory to assess the importance of smart sustainable cities. The stakeholder theory addresses multiple constituencies that are affected by organizations decisions, such as employees, suppliers, students, local communities, banks, competitors, regulators, customers and general public etc. It gauges the morals and values in an organization related to social contract theory, corporate social responsibility etc. It combines the aspects of resource-based view, market economy and socio-political views. As per the theory, the stakeholder's needs should be kept at first. In this research paper, the citizens of Karachi, Pakistan are the stakeholders in question.

Studies have focused on stakeholders as their support direct and indirect is necessary in implementing smart cities infrastructure. Not only that, stakeholders are also the citizens who must know the importance and usage of smart cities. The role of government, private organizations, and policy makers is key in the speedy urbanization of smart cities. Smart city development must also encompass economic, social and environmental dimensions in addressing challenges (Vu & Hartley, 2018; Khan, et al, 2020). Lack of coordination, externalities and information restrictions are few common government failures regarding urbanization (*See Table 1*).

### **2.4 Smart City Infrastructure Framework**

Many cities have globally created different visions for a smart city. Indicator frameworks have been used to evaluate the implementation progress of smart cities. However, these metrics are more tangible rather than intangible which might include; citizens perceptions. Such indices are subjective and complex and thus mostly exclude from the indicator framework. It leads to loss of human centric approach to smart city development. However, as the citizens live in a smart city and are the primary stakeholders of a smart city, their views must be incorporated in the vision and implementation of a smart city framework (Homer, 2022). As each city has a distinctive challenge and need, therefore, engaging citizens in the study is even more critical allowing for better and pluralistic solutions to problems encountered during the smart city development phase. Much of the research has been carried out towards the conceptualization of smart cities while there is a lot of lacking in literature regarding the empirical work (Huovila et al. 2019).

### **2.5 Triple and Quadruple Bottom Line Approach**

This study builds upon the work of Wong, et al (2023), to measure the perceptions of smart sustainable cities and the work of Khan, et al (2020), to measure the challenges of smart sustainable cities. Subjective reality is as important as objective reality as individuals tend to act based on their intentions. It provides deeper understanding of their knowledge about smart cities.

Studies have used the concept of triple-bottom line approach to urban smart city development which involves; environment, economic and social components of smart cities. However, critics identified that most frameworks have ignored the digital and social aspect to it, over emphasizing the economic and environmental aspects. The social aspect thus becomes difficult to assess due to its subjective and intangible nature. The economic aspects involve growth, costs, revenues; the environmental aspects involve resource consumption, waste management, land usage while the social aspects involve people welfare, charitable contributions and fair trade (Slaper, et al, 2011).

Incorporating and evaluating the social element is difficult while politicians and planners often favor the economic dimension of smart cities due to their rational decisions. There has been a lot of debate regarding the smart cities due to their techno-centric nature while ignoring the citizens needs thus disregarding the social element mostly; lower class people. ICT facilitates smart city concept and therefore smart cities are being outsourced to big IT companies who often overlook the social element in favor of profits and economic pursuits. Thus, falling short of the human element. Further, the concept should take up, smart to represent the IT component giving way to a quadruple- bottom line approach which includes all four elements and smart being the enabler complements the other components. Holistically, this study has used the conceptual indicators of

Homer, (2022) and Wong, et al (2023) where the quadruple bottom line approach has been utilized. The four elements of Economic; Environment; Social and Smart. The Economic element involves planning, efficiency, reducing costs; Environment involves water, energy and resource wastage; Social aspect involves safety security and transportation while Smart involves technology in infrastructure.

It is important that the citizens in question must understand the ground realities and meaning of what is smart and sustainable in order for them to utilize it in future, therefore they need to be part of studies. As the conceptual and implementation of smart sustainable cities moves forward, there is more need for the smart cities' education and dissemination amongst general public.

**Table 1. Challenges**

<b>Challenges</b>	<b>Study</b>	<b>Focus</b>
<b>Information technology support</b>	Hashem et al. (2016); Dobbs, Manyika, and Woetzel (2016); Akçura and Avci (2014)	Big data support; technology in urbanization; ICT paradigm in building Smart cities
<b>Lack of Government knowledge</b>	Nyberg (2018); Arenas, Goh, and Urueña (2019); Vu and Hartley (2018)	Energy infrastructure; IT design for smart tourism ecosystem; emphasizing policy development
<b>Lack of Coordination and Externalities</b>	Vu and Hartley (2018); Warwick (2013); Lin (2014)	Lack of facilitating infrastructure, rulings, judicial interventions; Lack of policy development for Smart Cities
<b>Partnerships</b>	Tavares, Galvane, and Ranck (2016); Lee, Hancock, and Hu (2014)	Establishing innovative partnership; Role of stakeholders as a framework
<b>Implementation Issues</b>	Lytras and Visvizi (2018)	Policy issue and implementation

*Source: Adapted from Khan, et al (2020)*

### 3 Methodology

Two separate studies were conducted using mixed method approaches in this research. Study 1 was a quantitative study while study 2 was a qualitative study. Study 1 used the quantitative data collection in which questions related to the importance of smart sustainable city was asked adapted from Homer, (2022) while Study 2 asked open ended questions through interviews related to the challenges and issues in developing and implementing smart sustainable cities adapted from Kahn, et al (2020).

#### 3.1 Study 1

Study one was quantitative study using survey method with empirical evidences and data gathering through a questionnaire. It consisted of 318 participants from Karachi, Pakistan. 73 respondents were from manufacturing sector while 245 were from service sector. The participants worked in various industries (e.g., education, IT, retail, and financial, FMCG). The survey asked respondents to evaluate if they think Karachi should be a smart sustainable city; then choose their level of importance for each of the statements related to four indicators of a smart sustainable city; including Economic, Environment, Social, and Smart. Population was citizens of Karachi Pakistan. Karachi, one of the largest metropolitan cities and business hub of Pakistan has an estimated population of is 17 million. Sample size was determined using Andrew Fishers formula with 5% Confidence Interval and known population which comes about 320. The data was collected through Google forms from different participants across different organizations. Convenience based sampling was used. SPSS and Smart-Pls 4 was used to assess the data and findings.

**3.1.1 Measures.** Participants were asked to rate 20 items to evaluate the importance of smart sustainable cities in a normative typology adapted from Homer, (2022) on a Likert scale of 1-7. The Likert scale gauged the level of importance from 1 being Not at all important while 7 being extremely important. For the Economic indicator, 6 items were asked related to planning and infrastructure were asked. Cronbach alpha in Homer (2022) was 0.927. The Environment indicator had 7 items and questions were related to clean environment, water and waste management. Cronbach alpha in Homer (2022) was 0.945. The Social indicator had 3 items related to people, information and security. Cronbach alpha in Homer (2022) was 0.853. The Smart indicator had 4 items and questions were related to R&D, Technology and IoT. Cronbach alpha in Homer (2022) was 0.909 (See Appendix). The control variables were age, gender, education, work experience and industry.

**3.1.2 Results.** The demographics data on Gender, Age, Education, Work Experience and Industry was collected from 318 respondents. The results indicated that 198 respondents were male and 120 respondents were female out of total 318 respondents. 73 respondents were aged less than 21; 198 respondents were between the ages of 21-30; 34 respondents were between the ages between 31-40; 7 respondents were between the ages of 41-50 while 6 respondents were above the age of 50. 4 respondents had Matriculation degree; 60 respondents had Intermediate degree; 119 respondents had an Undergraduate degree; 128 respondents had a Graduate degree; while 7 respondents had a Doctorate degree. Out of 318, 249 respondents had less than 5 years of Work Experience; 38 respondents had between 1-5 years of Work Experience; 18 respondents had 5-10 years of Work Experience; 5 respondents had 10-15 years of work experience and 8 respondents had 15-20 years of work experience. Out of 318 respondents, 245 were from service sector while 73 respondents were from manufacturing sector (Table 2).

**Table 2. Demographics**

VARIABLES		Frequency	%
GENDER	MALE	198	62.3
	FEMALE	120	37.7
AGE	LESS THAN 21	73	23.0
	21-30	198	62.3
	31-40	34	10.7
	41-50	7	2.2

	ABOVE 50	6	1.9
EDUCATION	MATRICULATION	4	1.3
	INTERMEDIATE	60	18.9
	UNDERGRADUATE	119	37.4
	GRADUATE	128	40.3
	DOCTORATE	7	2.2
WORK_EXPERIENCE	LESS THAN 5 YEARS	249	78.3
	1-5 YEARS	38	11.9
	5-10 YEARS	18	5.7
	10-15 YEARS	5	1.6
	15-20 YEARS	8	2.5
INDUSTRY	SERVICE	245	77.0
	MANUFACTURING	73	23.0

Table 3 shows the descriptive statistics; reliability, mean, standard deviations and correlations of the four factors with all the 20 items. Confirmatory factor analysis (EFA) was performed to identify the significant factors considered by the citizens of Karachi, Pakistan. Table 4 shows the factor loadings of each dimension of sustainable cities. The loading value should be >0.50 to get reliable and valid results. 3 Items from Economic dimensions were removed (ECO1, ECO2, ECO3) as their factor loadings were less than 0.5. While the rest of the dimensions retained all its items with loadings greater than 0.5

**Table 3. Descriptive Statistics**

	Items	Alpha	Mean	SD	1	2	3	4
ECONOMIC	6	0.633	5.7825	.71618	-	-	-	-
ENVIRONMENT	7	0.874	6.5162	.59361	.423**	-	-	-
SOCIAL	3	0.713	6.0063	.82331	.437**	.566**	-	-
SMART	4	0.822	5.7374	.90534	.412**	.447**	.505**	-

N=318; p<0.05\*; p<0.01\*\*

**Table 4. Factor Loadings**

ITEMS	ECONOMIC	ENVIRONMENT	SMART	SOCIAL
ECO4	0.757			
ECO5	0.726			
ECO6	0.790			
ENV11		0.706		
ENV12		0.805		
ENV13		0.717		
ENV14		0.772		
ENV15		0.823		
ENV16		0.828		
SMART1			0.770	
SMART2			0.856	
SMART3			0.849	
SMART4			0.755	
SOCIAL1				0.791
SOCIAL2				0.792
SOCIAL3				0.807



**Table 5. Construct reliability and validity**

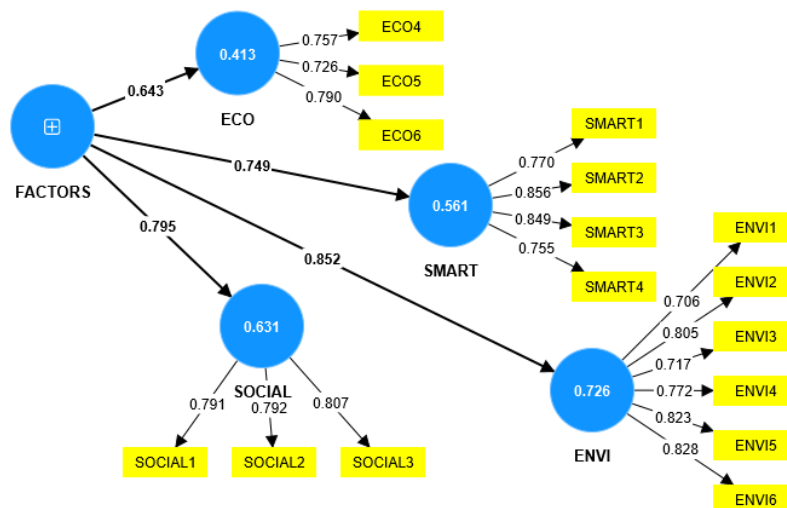
	$\alpha$	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
ECO	0.631	0.636	0.802	0.575
ENVI	0.867	0.870	0.901	0.603
SMART	0.822	0.826	0.883	0.654
SOCIAL	0.713	0.714	0.839	0.635

Table 5 shows the construct reliability and validity of all four constructs. The Measurement Model typically shows the constructs and its convergent and discriminant validity. The Cronbach's alpha and composite reliability should be >0.70, suggested by Nunnally and Bernstein. All AVE values are greater than 0.5 and composite reliabilities are greater than 0.7 therefore they all have convergent validity. Results show that there was no reliability and validity issue.

**Table 6. Heterotrait-monotrait ratio (HTMT)**

	ECO	ENVI	SMART	SOCIAL
ECO				
ENVI	0.536			
SMART	0.540	0.498		
SOCIAL	0.661	0.710	0.666	

Heterotrait-Monotrait Ratio (HTMT) is used for assessing discriminant validity. According to Henseler et al., if the correlation values are less than 0.80, the HTMT approach best demonstrates discriminant validity between each pair of variables. As demonstrated in Table 6, all the HTMT values were less than 0.80. This study ensures that the constructs in this study are different and not overlapping, contributing to the overall quality and rigor of the research. Figure 1 shows the graphical representation of 4 factors, their respective items retained along with their factor loadings.



## **3.2 Study 2**

This study used as qualitative method in which the key challenges for the development of smart sustainable cities were identified. First the selection criteria were identified, then respondents were selected based on the selection criteria, interviews were conducted. Once the data was collected, then thematic analysis was applied through which key challenges and solutions were identified.

**3.2.1 Process.** In-depth comprehensive interviews were taken and then audios were converted to written transcriptions. Respondents included officials from government housing authorities, private companies, national databases (such as NADRA), SME owners, real estate builders and developers etc. 10 experts were interviewed in total who showed their willingness to participate with ensuring complete anonymity by the researcher. These respondents had more than 5 years of job experience and were either part of managerial or technical expertise in their respective organizations. As Bryman (2016) argued that in-depth interviews are generally conducted with a minimum of 10 and a maximum of 30 respondents therefore this study satisfies the aforementioned criteria.

**3.2.2 Results.** Results indicate a detailed analysis of the identified challenges for smart city development. A total of 6 challenges surfaced after the interviews were converted to transcriptions and thematic analysis was performed. The results showed that the biggest challenge in the development and implementation of sustainable smart cities are “Budgetary Constraints” and “Lack of Resources” in Pakistan. Furthering the study, the respondents were also asked about the recommended solution for each problem mentioned below. Therefore, they also identified possible solutions for the key issues to implement Smart Cities.

**3.2.2.1 Budgetary Constraints.** Budgetary Constraint was the most crucial challenge. Creating an ICT infrastructure requires budget allocation. The respondents emphasized the facilities and technical support are required and sufficient budgets can lead to their installation. This may pertain to future maintenance as well as their upgradation needs. Procuring technology, tools, buildings and infrastructure requires finances. This challenge has also been identified critical in studies of Vu and Hartley, (2018); Hashem et al, (2016) and Khan et al (2020). Respondents highlighted as Pakistan is facing major budget deficits and IMF debt, with the current and ongoing political upheavals, increases in inflation and unemployment, it is a challenge for the Government to make sources of funding for such big scale projects. Only if there is any type of Foreign direct investment or private investments, then such projects can be implemented and unsuccessfully.

The solution recommended was that Smart Cities Governance body have to secure funding from all available source who have prior experience in Smart Cities development especially Foreign Direct Investment.

**3.2.2.2 Lack of Resources.** The results also reveal that Pakistan lacks resources such as human, equipment, sensors, IT as a challenge that impacts development of Smart Cities. This issue has also been identified by other researches namely; Calder (2016) and Arenas et al (2019). Few respondents also identified that the reason for lack of resources is corruption.

To address this problem, it was recommended by the respondents that people must be recruited with considerable experience in smart city development and there must be trainings, workshops and industry engagement. Further, flexible policies must be made for tools, equipment and technology.

**3.2.2.3 Lack of Sustainable Strategies.** As per the respondents of this study, smart cities framework lacks focus and inclusion of economic, social, technological and environmental aspects into the strategies of smart cities. Sustainable strategies are crucial for smart city development (Khan et al, 2020).

The solution recommended by the stakeholders was that monetary and long-term benefits must be created considering environmental protection safeguarding business interests.

**3.2.2.4 Lack of Awareness among citizens.** Respondents highlighted that there is lack of awareness about the sustainable smart cities amongst the citizens of Pakistan. Karachi is the most populous city as well a business hub. It is considered a metropolitan city and yet the citizens are not aware about the concept of smart cities. The situation is worse amongst the villages and small towns and cities as the basic necessities of life are missing. Respondents reported that they had collected this opinion from the general public from different areas of Pakistan. They stated that majority of the residents are unaware of the features and advantages of Smart cities. It is essential to gain maximum utilization once the smart cities are implemented by the citizens and if they are unaware of its utility then they will not be able to access and utilize it properly. This challenge was also highlighted by studies conducted by Rana et al (2019) and Khan et al, (2020).

The solution recommended was to promote the benefits of smart city development in different communities and carrying out awareness programs through print and social media. Awareness programs must also be carried out in schools, colleges, small towns and villages.

**3.2.2.5 Social Acceptability.** Social acceptability amongst the citizens is also a major challenge in the implementation of smart cities. Social acceptability reshapes their lifestyle around the smart cities network. If residents are not educated and literate, they will not accept the new lifestyle created by smart cities. They might feel of the opinion that it is unnecessary and not useful. There is high correlation between awareness of smart cities and acceptance. If they are fully aware about the features of smart cities, chances are that they start accepting it. Therefore, the concept of smart cities must be aligned with the social needs of its citizens. It includes smart healthcare, smart parking, smart education and smart media services. Study conducted by Arenas et al (2019) and Khan et al (2020) support this argument.

Respondents provided solution that more educational events be organized and invite more people and communities to participate in the work related to smart cities. Bring together different communities on a common platform to work on the smart cities' development.

**3.2.2.6 Lack of Governance structure for smart city development.** It was identified by the respondents that one major challenge is the inclusion of important stakeholders for smart city implementation. Government bodies, real estate developers, telecommunication authorities, traffic

police department and other major stake holders need to be onboard and proper governance structure is required for such a massive project to be implemented. Studies conducted by Arenas et al (2019) and Khan et al (2020) confirm this argument in their studies.

As per the respondents, its more of a process than a solution. They recommended to set the goals, then gather resources, initiate the process, select experts who understand and have prior experience in smart city development, create a governance including members from different stakeholder communities, create a team and educate the members and volunteers about the process, governance models and its outcomes.

#### **4 Discussion**

This study was carried out in two-folds. There were two propositions made in this study. The first proposition was about the identification of factors critically affecting the development of smart cities through the lens of the citizens. For this purpose, the first study was conducted using quantitative approach and mostly focused in creating awareness as well as highlighting the importance of smart city development. 318 respondents highlighted that Environmental aspect is the most important dimension of smart cities which included clean water management, waste management, minimizing waste management through smart city development. The citizens of Karachi were mostly concerned with how the smart city will reduce waste and create clean environment for its people. Evaluation of the importance of smart cities is a problem. Different methods and indicators have been used to measure which features smart cities should have. This study has used the dimensions identified by Homer (2022).

The second proposition was about identifying the challenges faced by developers and government with respect to resources and infrastructure and capital etc. in the implementation of smart cities. For this proposition, the second study was conducted using a qualitative approach in which interviews were carried out with stakeholders and six challenges were identified by them which pertains to smart cities development. “Budgetary Constraints” and “Lack of Resources” were the top two amongst them. This study has combined both the qualitative as well as quantitative aspects of data collection from different stakeholders therefore reducing the bias of interviewer rating and including quantifying measures of smart city development.

##### **4.1 Theoretical and Practical Implications**

This study focused on the validation of the instrument created by Homer (2022) but uses the quadruple bottom line of economic, environmental, social and smart elements. This adoption is in line with other sustainability studies (Michael & Elser, 2019) to attain a comprehensive tool to measure smart cities development. While Homer (2022) used the term planning, this study has used the term economic as this element focused on the design and architecture of smart buildings which is related to efficiency and costs. The environmental element focused on the waste, water and energy resources corresponding to how the smart cities can be utilized to reduce waste, water and energy resources. The social aspect revolved around the safety and security and smart element focused on the technology and integration with infrastructure of smart cities. The notion is that sustainability cannot be isolated and must incorporate different aspects.

Presently, there is no clear distinction between compact city or smart city as there are various urban forms and the general population is not aware of the difference. The different urban forms lose

their distinctions and converge during transformation processes combining the concepts of hybrid, compact, sustainable and smart altogether. The theoretical problem addressed here was the awareness and understanding of the citizens about the sustainable smart cities. As the development and implementation of smart cities emerges, the need for education and dissemination is also imminent.

On the practical side, the builders, developers and government authorities need to look at the challenges associated with smart cities development and identify relevant solutions to overcome these challenges. This study therefore provides a corner stone for the challenges identified in smart cities development and provides insights into various aspects of smart cities to the practitioners and stakeholders alike.

The findings and insights in this study have substantial implications for practice and policy in the realm of sustainable urban development. The integration of urban computing and AI can improve urban planning while the block chain can improve governance transparency. The emphasis on citizen engagement and inclusive governance highlights the importance of participatory urban development. Smart sustainable systems emphasizes the balance between technological advancements and environmental sustainability. This study serves as a crucial guide for stakeholders in promoting innovative smart sustainable urban development.

#### **4.2 Limitations**

In both the studies; the Sample size and geographic area were very specific; i.e. Karachi, Pakistan whilst studies may be conducted in different cities and countries to confirm the conceptualizations from studies of Homer 2022. Karachi has a 15 million population therefore collecting a representative sample is a challenge for researchers. This study had limited means and scope. Various governmental bodies can carry out studies on a mass level like population census statistics bureau. This study only covered one city, while the comparison between different cities can be done for better generalizations in future. As only few studies have been conducted using this instrument developed by Homer (2022), there is a need for further validation for the same tool with representative samples from different contexts and countries. There is a need for global consensus and conceptualization for measuring smart sustainable city and therefore more studies need to be conducted using this instrument to validate its applicability. However, there may be differences amongst the citizens priorities due to their climate, culture, economics, landscape and natural infrastructure.

Particularly in the second study, the biggest limitation is the interviewer's ability to gather the data, accurately review the data and extract relevant information from that data. However, the researcher has tried to overcome this imitation by following the interview protocols. Further, only 10 interviews were conducted focusing on the quality rather than the quantity of interviews. In future, studies can be conducted on more participants using mixed approaches for data collection.

#### **4.3 Future direction**

The future studies can opt to dive deeper into the mechanism of smart city implementation. Also, the future studies can focus more into the design aspects of smart cities in which proper planning and framework is created to accommodate the Smart technologies and focus on how the infrastructure will accommodate those smart technologies such as IoT, cloud, smart apps,

surveillance, Cloud and the like. The studies can also create more empirical researches or use different conceptual frameworks in different contexts, and different countries.

Future research can also investigate advanced AI and IoT integrations for various urban functions, broaden the use of blockchain technology in urban governance, and prioritize user-centric design in technological innovations. Additionally, it should strive to create comprehensive solutions that balance technological progress with ethical, social, and environmental considerations.

## 5. Conclusion

The journey towards the development of smart sustainable urban cities is multifaceted and constantly changing. The evaluation and awareness of smart cities require both objective and subjective measures. This study not only contributes to a profound understanding of smart technologies in urban cities but also highlights the importance of integrating these technologies with social, economic, smart and environmental dimensions. This paper aimed to attempt a small effort into combining the two measures of smart cities and get deep insights into the workings of smart cities development. Hence, providing a holistic view of smart sustainable cities. This study was carried out to understand the challenges faced by governments, citizens and private companies for the development of smart cities. This research contributes by infusing the concept of sustainability into smart cities, validating a new instrument which combines the quadruple notion of smart sustainable cities, and identifying challenges and recommending solutions to smart city development. These can act as a guideline for practitioners and government bodies to prepare them for smart city development.

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## Data Availability Statement

As the data collected in this study is primary data and therefore the data is not available publicly. Also, to keep the anonymity of the respondents the data was kept confidential for the qualitative research conducted in this study i.e., the interviews. However, the quantitative data collected from 318 respondents is available in the following Google Drive Repository folder [https://drive.google.com/drive/folders/1GDFx7ysNwICinNMlqpmzbH2Dyld649To?usp=drive\\_1ink](https://drive.google.com/drive/folders/1GDFx7ysNwICinNMlqpmzbH2Dyld649To?usp=drive_1ink)

## Appendix: Questionnaire

### ECONOMIC

Smart sustainable city should have disaster resilient design

Smart sustainable city should have green buildings

Smart sustainable city should have climate resilient infrastructures

Smart sustainable city should have well distributed housing plan

Smart sustainable city should be an integrated township  
Smart sustainable city should have purposed build and well-designed buildings

### **ENVIRONMENT**

Smart sustainable city should have a clean environment  
Smart sustainable city should have water management  
Smart sustainable city should have integrated energy management  
Smart sustainable city should have clean water  
Smart sustainable city should have efficient waste management  
Smart sustainable city should have efficient waste water management  
Smart sustainable city should minimize waste generation

### **SOCIAL**

Smart sustainable city should have real-time transportation information  
Smart sustainable city should have instantaneous reach to authorities  
Smart sustainable city should have a complete range of security system from preventive to reactive

### **SMART**

Smart sustainable city should have a thriving R and D community  
Smart sustainable city should have IoT-enabled infrastructure  
Smart sustainable city should have ICT infrastructure  
Smart sustainable city should have advance technological integration