



The Role of Technology in Urban Development: A Framework for Sustainable Cities

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Abstract

Sustainable Urban Development (SUD) has become a global priority due to rapid urbanization, environmental challenges, and increasing demand for resilient and livable cities. This study reviewed the effect that the following factors have on SUD: Environmental Management, Safety and Security, Technology in Urban Development, Livability and Well-Being, Green Spaces, Public Transport and Urban Mobility, Waste Management, Sustainable Urban Design and Global Best Practices. The survey was conducted on 50 respondents, and data collected was analyzed descriptively with Pearson correlation, multiple regression, effect size (f^2), mediation analysis and Importance–Performance Map Analysis (IPMA). The model accounted for 70.9% of the variance ($R^2 = 0.709$) in Sustainable Urban Development. Environmental Management ($\beta = 0.311$), Safety and Security ($\beta = 0.301$), and Technology in Urban Development ($\beta = 0.289$) were the strongest predictors. The results highlight the need for holistic environmental, technological and governance approaches for sustainable and resilient urban development.

Keywords: Environmental sustainability, Green urban planning, Public health infrastructure, Smart cities, Sustainable mobility, Sustainable urban development, Urban governance.

1. Introduction

One of the most important 21st century trends in the world is urbanization. Currently, over 55% of the population of the world lives in urban centers and it is expected to rise to almost 68% by 2050 (Kundu and Pandey, 2020). Rapid urbanization has led to a wealth of opportunities for economic growth, innovation and social change, but also significant infrastructure, transport, environmental, resource use, public health, housing and service delivery challenges. In this growing urbanized world, governments and urban planners are looking for innovative solutions to ensure sustainable development without compromising the quality of life of the citizens. In this context technology has become a key enabler for sustainable urban transformation to build smarter, more efficient and environmentally friendly cities (Turok et al., 2023). The application of high-tech solutions in urban systems has revolutionized urban planning, management, and experience. City administrators now have more access to real-time information and analytical capabilities than ever before, thanks to digital technologies like the Internet of Things (IoT), Artificial Intelligence (AI), Big Data analytics, Geographic Information Systems (GIS), cloud computing, blockchain and smart sensor networks. These technologies enable evidence-based decision making, increase operational efficiency, optimize resources and engage citizens (Sabri and Witte, 2023). Technology is a key factor in solving the myriad problems that are caused by the rapid growth of urbanization, as it facilitates data-driven governance and intelligent infrastructure management (Yesufu and Alajlani, 2025).

The idea of a sustainable city highlights the significance of harmony between economic development, environmental wellbeing, and social equity in order to achieve the long-term sustainability and success of a city. The main goals of sustainable cities are to reduce the environmental footprint, lower resource use, increase energy efficiency, foster social equity and enhance the quality of life for their citizens (Oktay, 2024). Innovative solutions

for transportation, energy, waste management, water, health care, public safety, and environmental monitoring are all achieved through the use of technology to help achieve these goals. Urban technology development has therefore emerged as one of the must-do strategies to realize the objectives set in the United Nation's agenda, specifically Goal 11 – Make cities inclusive, safe, resilient and sustainable (Mishra and Singh, 2023). The mobility of cities is one of today's significant challenges for the larger cities as a result of the increased population density, air pollution and traffic congestion, and transportation inefficiencies. ITSs relieve real-time data collection, smart traffic lights, GPS-equipped transportation services, automated fare collection and AI-driven route optimization to increase transportation efficiency and shorten travel times (Papadakis et al., 2024). Electric scooters, self-driving cars, electric buggies, bike-sharing and Mobility-as-a-Service (MaaS) are some of the new mobility solutions that offer eco-friendly alternatives to traditional transport. The innovations help to lower the emissions of greenhouse gases, broaden access to services and boost the mobility experiences of citizens in the city (Miraftabzadeh et al., 2024).

Sustainability in the environment is a major issue in modern urban planning. Sustainable resource management is a key priority in cities as these cities consume a significant amount of energy and produce a considerable amount of greenhouse gas emissions. The use of technology has facilitated the introduction of smart energy grids, renewable energy systems, energy-efficient buildings, and sophisticated environmental monitoring systems in cities. The use of smart meters and sensors connected to the Internet of Things (IoT) enables the tracking of energy consumption patterns in real-time, which helps to manage energy more efficiently and prevents energy waste (Kosoe and Ogwu, 2025). Likewise, smart water management systems support the monitoring of water distribution networks, the identification of leakages and water conservation measures. In these applications, technology plays a major role in protecting the environment and climate resilience. Another significant area of technology that contributes to sustainable urban development is waste management. The conventional waste collection and disposal systems are typically inefficient, leading to higher operational expenses and pollution. Smart waste management technologies are designed to make waste management more efficient by using sensor-equipped waste bins, route optimization software, automated waste collection scheduling and digital waste monitoring systems (Zhu et al., 2025). These not only lower the amount of fuel used and the operating costs, but they also help to implement recycling programs and the principles of the circular economy. Therefore, effective waste management technologies are crucial to keep the city clean and sustainable (Watson et al., 2024).

Technology plays a vital role in urban livability and citizen well-being, in addition to infrastructure and environmental management. The urban experience of living: safety, access, health, recreation, environment, social inclusion. Smart city technologies enable better service provision via digital government applications, telemedicine, intelligent health care systems, and citizen participation applications (Chen, 2023). Digital services is one of the ways of minimizing the administrative burden and enhancing access to key services and a more convenient and stress-free urban lifestyle. Also, tools and technology to enable remote work, flexible commuting, and digital communication solutions can improve work-life balance and wellbeing. Urban green spaces are another important aspect of sustainable urban development which needs to be developed and preserved. Parks, gardens, recreational facilities, and the natural landscape provide a benefit for physical health, mental wellbeing, conservation of biodiversity, and adaptation to climate change. The use of technological tools, like GIS mapping, environmental sensors, drone monitoring and smart irrigation systems, supports better planning and management of green infrastructure (Abdussamad et al., 2024). Children and the elderly are special groups that benefit most from well-designed green spaces due to their capacity to offer them recreational space, socialize, exercise, and rest psychologically. The implementation of green space management by using technology is gaining greater significance as cities try to be more sustainable and livable (Sun et al., 2025).

Technological innovation also is a tremendous asset to public health and safety. The advanced integration of smart surveillance, emergency response systems, environmental monitoring and predictive analytics allows government officials to detect risks, quickly handle emergencies and improve public security. In recent world health emergencies, digital technologies have been instrumental in disease monitoring, tele-health, contact tracing, and communication of information to the public (Zhang et al., 2025). The capabilities highlight the ways technology can bolster urban resilience and enhance preparedness to face future challenges. Further, cybersecurity measures and data governance are gaining significance in the context of cities' growing reliance on digital technologies and the management of vast amounts of sensitive data. While there are numerous advantages of technology-based urban development, there are still some challenges that impede implementation. Several factors such as financial, infrastructure, regulatory, data privacy, cybersecurity and technological gaps, and low digital literacy can hinder the implementation of smart urban solutions (Trivedi and Shah, 2024). Furthermore, without inclusive policies, this unequal access to technology could increase social inequities. Good governance, partnership working, public-private partnerships and citizen engagement are therefore key factors in ensuring that technological innovations support equitable and sustainable urban development (Jamil, 2021).

Around the world, there are a number of cities that have become models of technology-powered sustainability. Advanced technologies have been adopted in the fields of transportation, energy, environment, governance and public services in cities like Singapore, Copenhagen, Amsterdam, Stockholm, and Seoul. These cities provide insights into the ways that smart investments in technology can improve sustainability, economic competitiveness, environmental quality and wellbeing. These experiences offer great lessons to other cities interested in sustainable development through innovation and digitalization. In this context, there is a need for a comprehensive framework to describe the relationships between technological innovation and sustainable urban development in the context of the rising role of technology in the development of future cities. Hence, this study focuses on how technology can help in urban development in relation to various urban functions such as transportation, environmental sustainability, waste management, public health, urban liveability, green infrastructure, governance, and citizen well-being. The research will create a framework for sustainable cities to offer practical guidance to policy makers, urban planners, researchers and technology developers in developing a more resilient, inclusive, efficient and sustainable city.

2. Review of Literature

Urbanization has revolutionized cities as engines of economic, social and innovation development. But the consequences of higher population density, environmental degradation, transportation congestion, waste generation and resource scarcity have posed huge difficulties to urban sustainability (Humbal et al., 2023). To overcome these concerns, governments and urban planners are increasingly turning to technological solutions that will make cities more efficient, sustainable, and livable. Today, the development of new technologies, including the Internet of Things (IoT), Artificial Intelligence (AI), Big Data Analytics, Geographic Information Systems (GIS), cloud computing and smart sensor networks, are at the heart of contemporary urban development strategies. These technologies enable the use of data for decision-making, more efficient use of resources, and better provision of public services, which helps to develop sustainable cities (Jacques et al., 2024). Sustainable cities go beyond improvements in technology, and include social, economic and environmental dimensions. Technology is an enabler, which can help realize goals for sustainability through improvements in transportation systems, waste management, energy efficiency, public health, governance and urban livability (Al-Emran and Griffy-Brown, 2023). This literature review revisits the research that has been undertaken in the context of technology-driven urban development, as well as the contribution of technological innovation to sustainable cities.

2.1. Concept of Sustainable Cities and Urban Development

The idea of sustainable urban development was born out of the wider concept of sustainable development that was introduced by the Brundtland Commission. The concept of sustainable cities is based on the idea of living in a way that does not harm the environment and is not destructive of its resources (Reiser, 2023). Agyeman and Evans (2003) define sustainable cities as spaces that combine environmental concern, economic sustainability and social equity to build resilient and livable cities. In the context of urban sustainability, the efficient use of natural resources, minimization of environmental impacts, fostering renewable energy sources and improving social inclusion are all essential. With a growing global population, urban populations are increasingly pushed to the limit in terms of infrastructure, housing, transportation and public services. Technological innovation is considered as offering practical solutions for these challenges, because of its ability to enable smarter resource management and better urban governance (Dashora et al., 2025). The new smart city ideas have reinforced the link between technology and sustainability. Smart cities are the use of information and communication technologies (ICTs) for enhancing the performance of the infrastructure, the involvement of citizens in the city, and the quality of urban services. The key goals of sustainable cities and smart cities are similar, such as to optimize environmental performance, maximizing the use of resources and improving the quality of life (Shao and Min, 2025).

2.2. Technology as a driver of Urban Development

The data produced by modern city systems, such as transportation, communications, public service and environmental monitoring, is enormous. City administrators can make decisions and enhance urban management through gathering, analyzing and utilizing this information (Dahmane et al., 2025). The idea of a “real-time city” is introduced by Kitchin 2014, which refers to the provision of a constant flow of information through digital technologies about urban activities and the performance of urban infrastructure. Cities can optimize traffic management, energy distribution, as well as public safety and emergency response systems through real-time monitoring. Artificial Intelligence also plays a significant role in urban management with the implementation of automated decision-making and predictive modeling. Machine learning algorithms can detect patterns and trends that enable proactive action to be taken and thereby increase efficiency and overall urban performance (Lartey and Law, 2025). The role of Big Data Analytics in urban planning and urban governance is also crucial. Data from transportation systems, mobile devices, social media, and public services can be used to help inform citizens about their behavior and their city's dynamics (Durga et al., 2025).

2.3. Smart Transportation and Urban Mobility

One of the biggest problems in the growing cities is transportation. The issue of traffic congestion, emissions from automobiles, fuel consumption and poor public transport infrastructure has a negative impact in terms of economic productivity and environmental quality (Mavlutova et al., 2023). Transportation solutions based on technology have thus emerged as a pivotal part of sustainable urban development policies. Intelligent Transportation Systems (ITS) leverage sensors, communication systems, GPS and data analysis to enhance transportation efficiency and mobility (Elassy et al., 2024). Papa and Lauwers (2015) state that smart transportation systems bring benefits to traffic flow, travel times, the safety of the road and the environment. Real-time traffic monitoring can help authorities adapt their traffic signals in real-time and respond to traffic congestion promptly. Technological innovations have also been implemented in public transport systems. These technologies support the use of public transportation, decrease private vehicle use and decrease CO₂ emission. New mobility options like e-bikes, electric scooters, autonomous vehicles and electric buggies provide ways to move without the car. Shared mobility platforms further contribute to reducing traffic congestion and promoting environmentally friendly transportation practices. There is evidence that inclusion of these modes of mobility in urban transport systems has the potential to enhance accessibility and sustainability (Papadakis et al., 2024).

2.4. Sustainable Cities and their Waste Management

Waste management is a critical component of sustainable cities, as rapid urbanization and population growth generate large volumes of waste. Traditional waste management systems often face challenges such as inefficient collection, high operational costs, and low recycling rates (Garg and Arora, 2025). To address these issues, sustainable cities are adopting smart waste management solutions that utilize IoT-enabled sensors, digital monitoring platforms, and route optimization systems to improve collection efficiency, reduce fuel consumption, and lower greenhouse gas emissions (Lakhout, 2025). An effective waste management system begins with waste segregation at source, allowing recyclable materials such as paper, cardboard, plastics, metals, and glass to be recovered and reintroduced into manufacturing processes (Rashad et al., 2025). Organic waste, including food

waste from residential and commercial facilities, can be processed through composting or anaerobic digestion to produce compost and renewable energy. Similarly, used cooking oil can be collected and converted into biodiesel, transforming waste into a valuable resource. These resource recovery initiatives support circular economy principles by minimizing landfill disposal and maximizing the value extracted from waste streams (Sharma, et al., 2024). Digital waste tracking systems further improve transparency and accountability by monitoring waste generation, collection, recycling, and disposal activities. Combined with environmental monitoring technologies such as air and water quality sensors, these systems enable data-driven decision-making and support sustainable urban development. By integrating smart technologies, recycling programs, and resource recovery practices, cities can reduce environmental impacts, conserve natural resources, generate economic value from waste, and create cleaner, more resilient urban environments (Alnanih et al., 2025).

Waste is a significant problem in cities, due to its generation in high volumes. The current waste management system is often inefficient, with waste not being collected properly, fuel being wasted, and not enough waste being recycled. The rise of technology has revolutionized waste management and brought in smart solutions such as smart collection and monitoring systems. Smart waste management is the use of sensor-laden bins that track the amount of trash inside and alert waste management companies to pick up times (Voukkali et al., 2024). An effective sensor-based waste collection system for optimizing waste collection routes, lowering operational costs and enhancing service efficiency. The algorithms used for route optimization aim to reduce fuel usage and greenhouse gas emissions, while also ensuring that waste is collected on time (Hussain et al., 2024). Digital waste tracking systems help ensure transparency and accountability throughout the waste management process. Advanced recycling technologies can generate re-usable products from waste materials, thus supporting the implementation of circular economy and resource recovery. The integration of technology in waste management plays a major role in improving our cities, protecting the environment and utilizing resources sustainably (Dissanayake et al., 2025). Environmental monitoring technologies also are a major part of sustainable city management. Environmental sensors such as air quality sensors, water quality monitoring systems and climate observation networks contribute to understanding environmental conditions. These technologies play a role in implementing pollution control, in the creation of environmental policies and in climate adaptation (Hong et al., 2025).

2.5. Sustainable Cities and Energy Efficiency

Energy use is one of the big problems with urban sustainability, as urban areas make up a large percentage of the energy use and emissions of greenhouse gases worldwide. Technological advances have helped cities increase their energy efficiency and move toward a more renewable energy system (Sharma et al., 2025). Smart grids are the use of digital communication technologies in electricity distribution systems to allow for efficient energy distribution. Smart meters offer consumers and utilities information about energy use in real time that can help them use energy efficiently (Powell et al., 2024). A wide range of energy waste reduction, reliability, and sustainability benefits of smart energy systems. Sustainable urban development is also complemented by renewable energy technologies like solar photovoltaic systems, wind energy systems, and energy storage solutions. Smart energy management systems manage renewable energy generation and consumption, helping to stabilize the grid and decrease reliance on fossil fuels (Pandiyani et al., 2023). There are technologies that can help meet climate mitigation targets and contribute to urban low carbon development that are critical. Energy saving is also a significant aspect of green buildings and sustainable offices. BAS controls the HVAC system according to occupancy and environment. Studies show that smart building technologies have the potential to significantly reduce the amount of energy consumed and enhance the comfort and productivity of the building's users (Bhanye, et al., 2025).

2.6. Technology, Livability, and Citizen Well-Being

Urban livability is the dimension of life lived in the city, which includes safety, accessibility, environmental quality, healthcare, education, recreation and social inclusion. Technology is becoming a key asset to improving urban living and citizens' health and well-being. Digital government services. simplify interactions between citizens and public institutions. Delivering essential government services, paying utility bills, applying for services and reporting urban issues online are more efficient for residents. These systems can streamline administration processes and enhance the effectiveness of services (Sheikh and van Ameijde, 2022). Smart technologies in healthcare have revolutionized urban health systems with their benefits of accessibility and efficiency. The integration of telemedicine platforms, EHRs, remote patient monitoring, and AI diagnostics optimizes healthcare services and patient outcomes. In times of public health crises, digital technologies enable disease monitoring, the sharing of information and health care coordination (Eddabbah et al., 2026).

2.7. Green Spaces, Health, and Urban Sustainability

Urban green spaces are vital elements in sustainable cities due to their social, environmental and health benefits. Parks, recreational facilities, community gardens and urban forests provide benefits such as regulating temperatures, promoting physical activity, enhancing biodiversity, and improving air quality. Access to green spaces is an important factor that positively affects mental health, social interaction and community cohesion (Zhang and Qian, 2024). Outdoor recreation opportunities enhance physical and cognitive development in children and positively affect physical health and decreased social isolation in older adults. GIS mapping, remote sensing, drone surveys, and smart irrigation systems are used to support planning and management of green infrastructure with the aid of technology (Pereira et al., 2024). These tools will help urban planners determine green space needs for urban areas and make decisions on optimizing green space management. Smart watering solutions help save water and promote plant health, supporting environmental sustainability and water resources conservation (Kifayatullah et al., 2025).

2.8. Safety Security and Smart Governance

Safety and security are basic pillars of sustainable urban development. Smart technologies enable a greater level of urban resilience through better emergency preparedness, disaster management, crime prevention, and public health services (Almulhim, 2025). Rapid response to emergencies and security threats are aided by intelligent surveillance systems, emergency communication networks, and predictive analytics. A smart governance system brings together information from various sources, aiming to improve the effectiveness of decision-making processes and the coordination of public agencies (Mohsin et al., 2025). Smart governance also ensures transparency and accountability as well as citizens' participation. Digital platforms enable dialogue between governments and citizens, allowing citizens to cast their opinion, engage in policy development and access public information (Sharmin and Chowdhury, 2025). The interactions enhance the effectiveness of democratic governance and increase citizens' confidence in public institutions. While these advantages, there are still a number of concerns to be addressed, including privacy, cybersecurity, and digital exclusion. Therefore, there is a need to balance technological innovation with ethical issues and citizens' rights in effective governance frameworks (Sadat, 2025).

2.9. Research Gap

The field of smart cities, urban sustainability, digital government, transportation systems, and environmental technologies have been extensively discussed in the existing literature. Most studies are, however, directed towards individual technological solutions, and do not consider the synergy of the different solutions towards sustainable urban development. In addition, there is limited research that integrates public transportation, waste management technologies, sustainable office, urban mobility solutions, green spaces, citizen well-being, health and safety systems and global best practice into a holistic framework. Likewise, there are no empirical studies which investigate public perceptions about the role of technology in making cities sustainable, especially in developing countries. To address these gaps, this study aims to fill the gaps by creating a holistic framework that explores the different technological dimensions and their impact on sustainable urban development, livability, environmental sustainability, and citizen well-being.

3. Research Methodology

The chapter outlines the methodology outlined to explore the role of technology in urban development and contribution to sustainable cities. Research methodology is a systematic approach for gathering, analyzing and interpreting data for effective solution of the research objectives and answering the research question. In this study, the authors want to explore how technological innovation, including smart transportation systems, waste management technologies, digital governance, sustainable offices, green infrastructure, health and safety systems and urban mobility solutions, can play a role in sustainable urban development. The research design, research population, sampling technique, data collection techniques, research instrument, validity and reliability of the research instrument and data analysis techniques used in the study are presented. This chapter discusses the research design, study population, sampling technique, data collection techniques used, research instrument, validity and reliability of the research instrument and data analysis technique used for conducting the study.

3.1. Research Design

The study is an attempt to employ quantitative research approach with descriptive survey research design. In the social sciences, quantitative research is popular because it allows researchers to gather numerical data and statistically study relationships between variables (Creswell and Creswell, 2017). Given the aim of this research is to examine the perception of the respondents about the role of technology in sustainable urban development, a quantifiable approach is used. With the descriptive survey design the researcher can collect information from many respondents at one time and investigate their views, attitudes and perceptions on a range of technological aspects of sustainable cities. Sekaran and Bougie (2016) state that Survey research can be particularly useful in order to identify patterns, trends and relationships among variables in a population. In addition, the design of the survey allows for efficient collection of data and the results to be used to generalize to the larger population given a sufficiently large sample size.

3.2. Research Framework

This study is based on the concept that technological innovation is one of the major factors contributing to sustainable urban development. Advanced technologies like Artificial Intelligence (AI), Internet of Things (IoT), Big Data Analytics, Geographic Information Systems (GIS) and smart sensor networks have been identified as key technologies that can enhance urban efficiency, environmental sustainability, and the quality of life (QoL) of citizens (Zhao, 2025). Technology-related dimensions such as public transportation and urban mobility, waste management technology, livability and well-being, stress-free technology, sustainable cities and environmental management, sustainable offices, green spaces, health and safety systems and global best practices are treated as independent variables in this study. Sustainable urban development is dependent variable. It is assumed that more technological integration in urban systems has a positive impact on the sustainability outcomes, such as better resource management, protection of the environment, public service delivery, and citizens' well-being (Tavanti, 2023).

3.3. Study Population

The research target group for this research is the urban population, university students, academic researchers, engineers, urban planners, government employees, information technology professionals, environmental specialists and others who have knowledge or awareness about urban development and sustainability issues. These groups are chosen due to their direct involvement in urban planning and management processes and/or their effects on their daily lives as a result of urban technologies. Increased acceptance and relevance of data collected will be obtained

by selecting respondents who have knowledge of the study topic (Bryman, 2016). To get a range of views from different types of respondents adds to the richness and validity of the results in sustainable urban development, which requires the engagement of several actors.

3.4. Sampling Technique and Sample Size

The study uses two sampling methods which are purposive sampling and convenience sampling. A purposive sampling was used to select those who have the relevant knowledge on technological innovations and Sustainable Urban Development, and convenience sampling was used to ensure the efficient access of the respondents who have the required knowledge to participate in the survey (Ahmad and Wilkins, 2025). This combination is ideal for research with specific content domains that require knowledgeable answers. The sample size is calculated following the guidelines suggested by Ahmed et al. (2024) which recommends sample size for large population at 95% confidence level is about 50 respondents with 5% margin of error.

3.5. Sources of Data

The research is based on primary and secondary data sources. Primary data are those data which are gathered by the researcher with the help of a structured questionnaire prepared for this study by the respondents. Primary data are firsthand information about public perception of the use of technology in sustainable urban development. Secondary data is gathered from peer reviewed journal articles, books, conference proceedings, government reports, policy documents and publications from international organizations like the United Nations and the World Bank. These sources offer theoretical background and empirical support to informing the research framework and analysis of the results.

3.6. Research Instrument

The main instrument used to collect data is a structured questionnaire. The questionnaire was designed after conducting a literature review on smart cities, urban sustainability, technological innovation and sustainable development (Dalati and Marx Gómez 2018). The instrument consists of two main parts. The first part gathers demographic data, such as gender, age, education level, profession, and knowledge about sustainable cities. The second section includes assertions about respondents' perceptions of technology in urban development, public transport and urban mobility, waste management technologies, livability and well-being, stress-free technology and digital convenience, environmental sustainability, sustainable workplaces, green spaces, health and safety services, and global smart city technologies. The answers are rated on a 5-point Likert scale from Not Important (1) to Very Important (5). The Likert scale is a popular method in perception-based studies because it is both an easy and effective way to measure attitudes and opinions (Likert, 1932).

3.7. Data Collection Procedure

The collection of the data starts after the approval from the appropriate academic institution and finalization of the research instrument. To ensure maximum participation, the questionnaire is sent out both online and in hard copy. There are two types of distribution: online (Google Forms, email communication and social media) and printed (selected educational institutions, government offices and any professional organization where possible). Participants are briefed about the study, consent to the study, and maintain confidentiality. Completed questionnaires are checked for completeness and accuracy, then coded and entered into the Statistical Package for Social Sciences (SPSS) computer software for analysis. This systematic process ensures quality and reduces errors in data processing (Taherdoost, 2021).

3.8. Data Analysis Techniques

The data analysis performed was IBM SPSS Statistics and SmartPLS (according to procedures). To examine the relationships among study variables and to determine the links between Sustainable Urban Development (SUD) and its predictors, descriptive statistics, Pearson correlation analysis, multiple regression analysis, mediation analysis and Importance–Performance Map Analysis (IPMA) were used (Jasrai, 2024; Bryman and Cramer, 2004). The interpretation of the effect sizes was based on the suggestions of Rosenthal et al. (1994).

4. Results

4.1. Socio-Demographic Composition of Respondents

The socio demographic profile of the 50 respondents comprising the study is given in Figure 1. As far as gender is concerned, males were the majority, 68% (n = 34), and females, 28% (n = 14). 2% (n = 4) did not want to answer the question on gender. The age profile showed that the biggest age group was 18-25 years (36%, n = 18), with 26-35 years coming in second (32%, n = 16). The age group between 36 and 45 years was the largest (18%, n = 9) and 10% (n = 5) were aged between 46 and 55. The least frequent age group of respondents were those over 55 years old (4%, n = 2). With regard to educational level, most had a bachelor's degree (36%, n = 18), and 32% (n = 16) had a master's degree. The participants with MPhil/PhD qualifications were 20% (n = 10) and with Intermediate education 8% (n = 4). There were only 4% (n = 2) who had other professional qualifications. Professional Affiliation: Students were the largest (24%, n = 12), followed by the engineers (20%, n = 10). 16% (n = 8) of respondents were urban planners and 14% (n = 7) were IT professionals. The smallest professional group was government officials (10%, n = 5). In general, the demographic profile confirms that the respondents were a diverse and well-educated population, which included representatives from various professional fields providing a sound basis for analyzing the factors that affect sustainable urban development. The substantial numbers of younger and academically qualified participants indicate that the answers are derived from a contemporary view on sustainability issues and urban development techniques, which increases the relevance and credibility of the study's results.

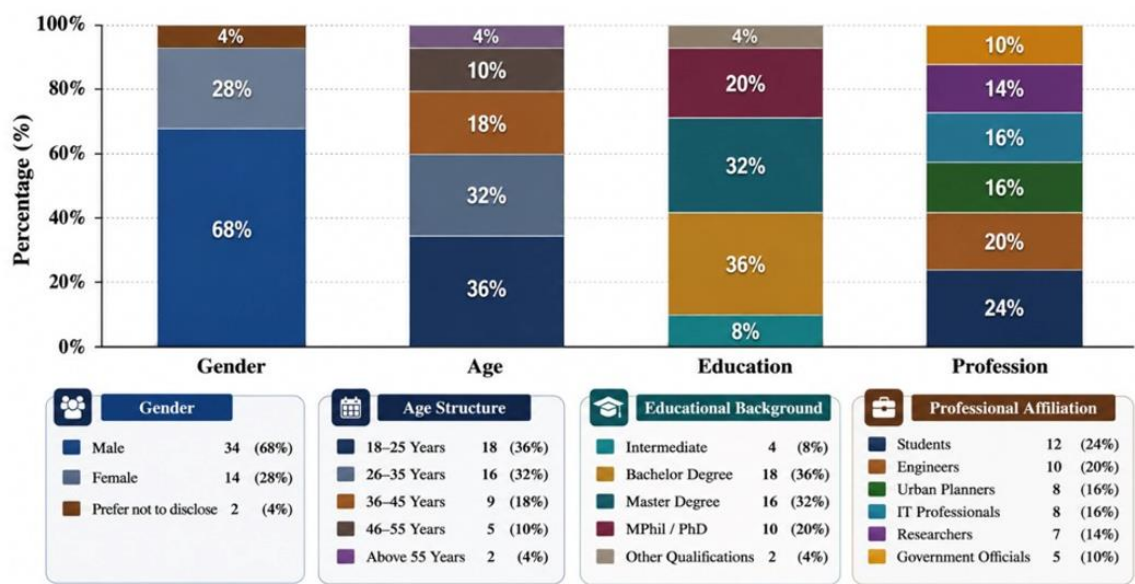


Figure 1. Socio-Demographic Composition of Survey Respondents (n = 50).
Note: Percentages are calculated on total respondents (n = 50).

4.2. Mean Scores and Standardized (β) Coefficients of Study Dimensions

The results of the present study dimensions to Sustainable Urban Development are presented here in Figure 2, which showed a very high level of agreement of the respondents. The mean values varied between 4.47 to 4.74 which means that all dimensions were seen as very important for achieving a sustainable city. Environmental Management has the highest mean score ($M = 4.74$), followed by Health and Safety Services ($M = 4.72$) and Technology in Urban Development ($M = 4.69$), showing that these subjects are playing a leading role in the sustainable development of cities. The scores were high for Livability and Well-Being ($M = 4.68$) and for Green Spaces ($M = 4.65$). Stress-Free Technology ($M = 4.47$) had the lowest mean score but was still significantly higher than the "neutral" score. In general, the results indicated that all dimensions were important aspects of a comprehensive sustainable urban development framework. The standardized regression coefficients (β) for the study dimensions are presented in Figure 3, which indicates the relative effect of those dimensions on Sustainable Urban Development. The findings reveal that the factor of Environmental Management gave the highest positive influence with the value of $\beta = 0.311$ ($p < 0.001$), followed by Health and Safety Services with the value of $\beta = 0.301$ ($p < 0.001$), and Technology in Urban Development with the value of $\beta = 0.289$ ($p < 0.001$). The results indicate that environmental sustainability, public health infrastructure, and technological development are the main factors that make sustainable urban development. Furthermore, the factors of Livability and Well-Being ($\beta = 0.263$, $p < 0.01$) and Green Spaces ($\beta = 0.238$, $p < 0.01$) were statistically significant positive factors, highlighting the importance of quality of life and ecological aspects. Public Transport and Mobility ($\beta = 0.214$, $p < 0.01$) and Global Best Practices ($\beta = 0.204$, $p < 0.01$) also exhibited meaningful effects. There were also comparatively smaller but statistically significant impacts of 0.175 ($p < 0.05$) on Waste Management Technology, 0.132 ($p < 0.05$) on Sustainable Urban Design, and 0.118 ($p < 0.05$) on Stress-Free Technology. In general, all dimensions had positive effects on Sustainable Urban Development, which indicates that urban sustainability is a complex phenomenon and multiple interventions, including environmental, technological, social and governance based, are needed.

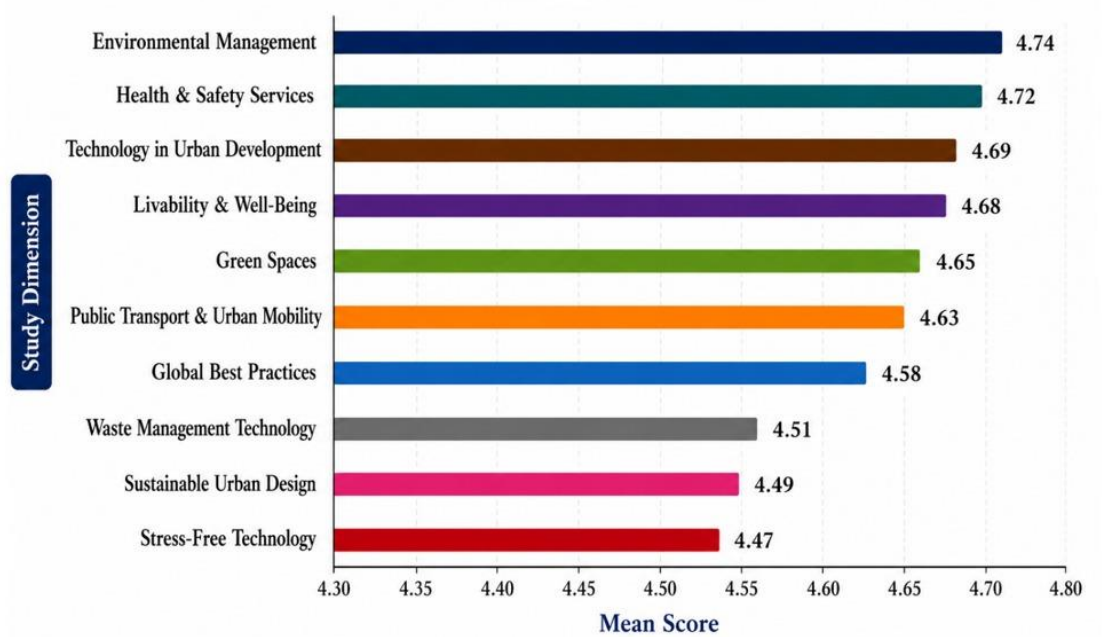


Figure 2. Mean Scores of Study Dimensions.

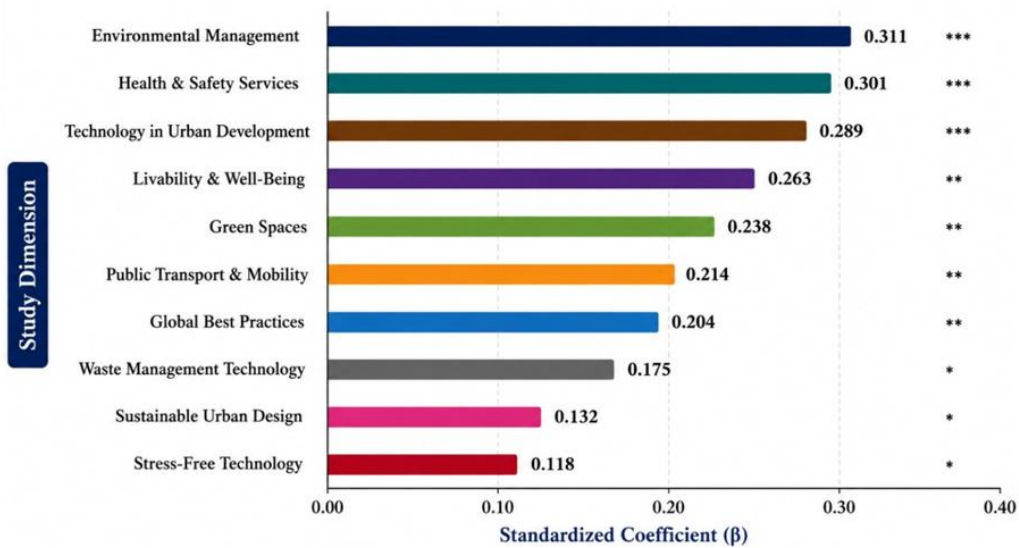


Figure 3. Standardized (β) Coefficient of Study Dimensions.
Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

4.3. Regression Path Diagram for Factors Influencing Sustainable Urban Development

Figure 4 showed the structural regression model of the direct effect of the proposed predictors on Sustainable Urban Development (SUD). The model has a good level of explanatory power, explaining 70.9% of the variance ($R^2 = 0.709$) in sustainable urban development. In the list of the examined predictors, the strongest one is Environmental Management ($\beta = 0.311$, $p < 0.001$), followed closely by Health and Safety Services ($\beta = 0.301$, $p < 0.001$) and Technology in Urban Development ($\beta = 0.289$, $p < 0.001$). The results showed that sustainable environmental actions, public health facilities and technological progress are the most influential factors contributing to sustainable urban outcomes. Additionally, two other indicators, Livability and Well-Being ($\beta = 0.263$, $p < 0.01$) and Green Spaces ($\beta = 0.238$, $p < 0.01$), had significant positive effects as well, highlighting the quality of life and ecological resources in cities. Likewise, Public Transport and Mobility ($\beta = 0.214$, $p < 0.01$) and Global Best Practices ($\beta = 0.204$, $p < 0.01$) had positive influences in the model. However, Waste Management Technology ($\beta = 0.175$, $p < 0.05$), Sustainable Urban Design ($\beta = 0.132$, $p < 0.05$) and Stress-Free Technology ($\beta = 0.118$, $p < 0.05$) were statistically significant predictors, albeit of smaller magnitude. In summary, the results indicate that sustainable urban development is determined by various interconnected dimensions, among which the environmental management and services related to health have the greatest impact.

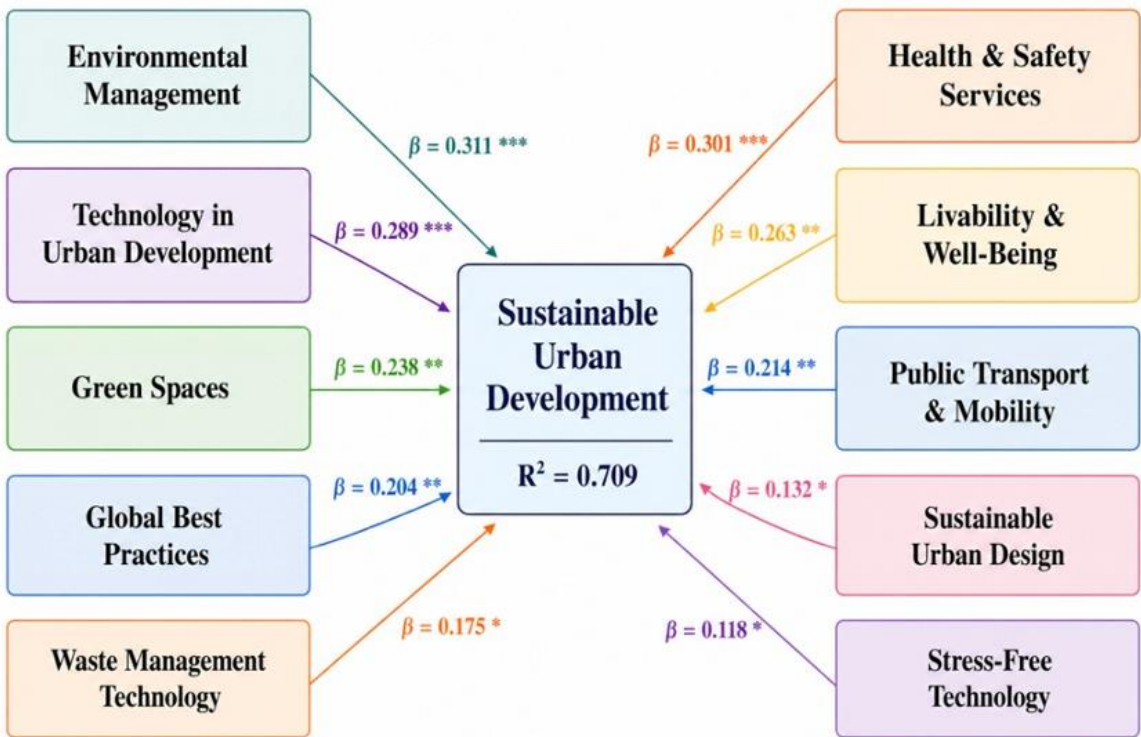


Figure 4. Regression path diagram for factors influencing Sustainable Urban Development.
Note: β = Standardized Coefficient; R^2 = Coefficient of Determination; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

4.4. Comparative Sustainability Scores Across Indicators and Importance–Performance Map Analysis (IPMA)

Boxplot analysis was used to show the distribution of the composite scores across each of the sustainability indicators (Figure 5). Results show moderate variation of the dimensions, with in general between a median score of 3.0 and 3.9, which reflects favorable perceptions of respondents on all sustainability constructs. The median scores for EM and SUD were highest of the two, at 3.8–3.9, indicating that perceived performance in these areas was high. The levels of Livability and Well-Being (LWB) and Global Best Practices (GBP) were also relatively high and indicative of positive impacts for urban sustainability. However, Stress-Free Technology (SFT) had the lowest median score of around 3.0, which suggests that it has lower performance. Some of the indicators showed outliers, especially EM and GBP indicating perceived differences among stakeholders. However, the interquartile ranges remained more or less similar for each indicator, indicating a more or less consistent pattern of responses.

The results reveal that all the dimensions are positively correlated with sustainable urban development and that efforts to improve the dimensions with lower scores may lead to further positive impacts on sustainability.

Figure 6 showed the Importance–Performance Map Analysis, where each predictor is assessed according to its relative importance and performance. The results show that Waste Management Technology (Importance = 0.29; Performance = 4.14), Global Best Practices (0.26; 3.99), Livability and Well-Being (0.28; 3.48) and Public Transport and Mobility (0.24; 3.61) are clustered in the high-importance and high-performance quadrant, which means they are performing well and should be strengthened as strategic areas. On the other hand, Technology in Urban Development (0.22; 2.69) is in the high priority and low performance quadrant and should be prioritized by managers and/or investment. Health and Safety Services (0.12; 2.85) and Environmental Management (0.15; 3.43) and Green Spaces (0.16; 3.28) have relatively low levels of importance but performance. Stress-Free Technology (0.19; 3.91) performs well based on its importance. Overall, the IPMA results indicate that interventions which have a technological component are key domains in which improvements in performance may lead to significant advancement in sustainable urban development.

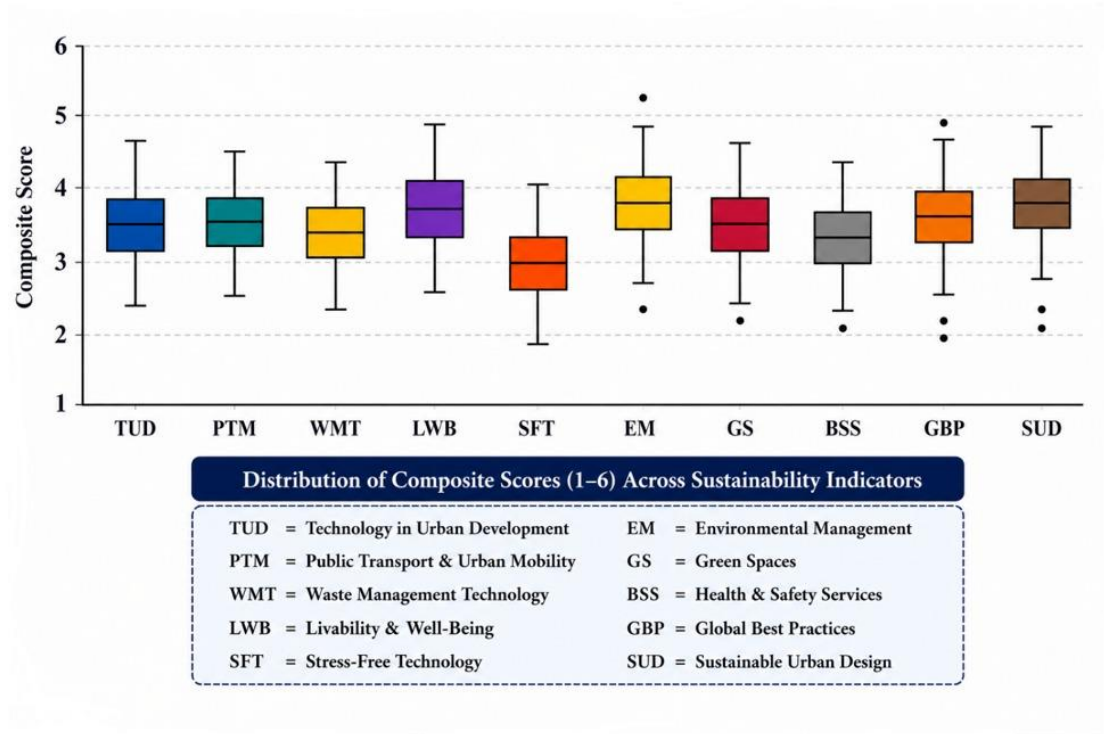


Figure 5. Comparative Sustainability Scores Across Indicators.

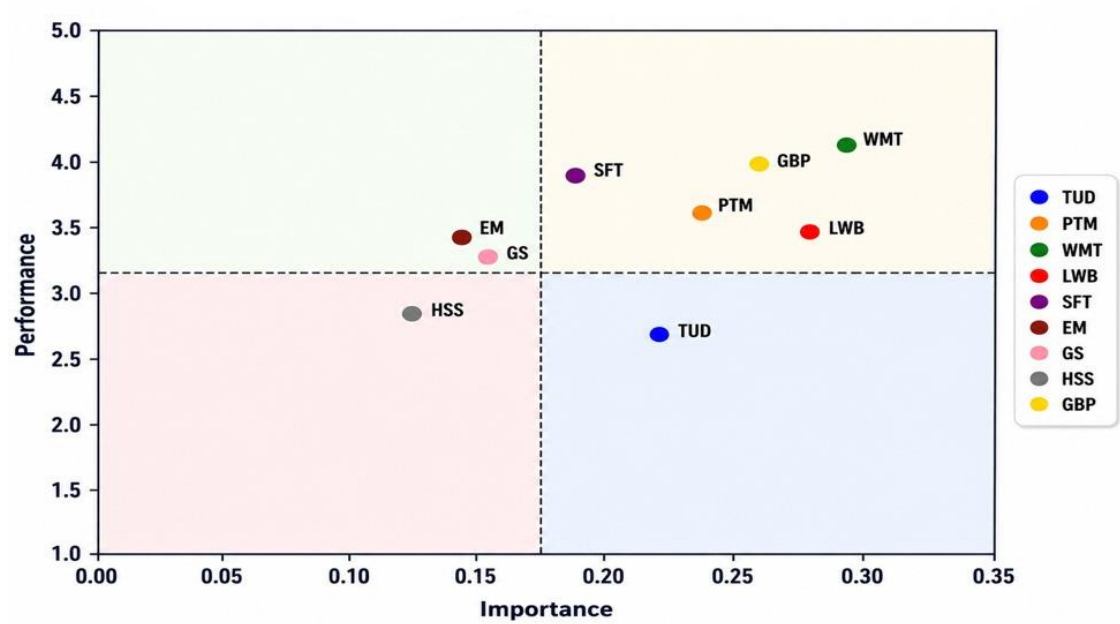


Figure 6. Importance-Performance Map Analysis (IPMA).

4.5. Mediation Model (Indirect Effect) and Pearson Correlation Matrix (Heatmap)

The mediation analysis to understand the role of Smart City Adoption in the relationship between Technology in Urban Development and Sustainable Urban Development is shown in Figure 7. The results show that there is a significant positive relationship between the variables Technology in Urban Development and Smart City Adoption ($a = 0.612, p < 0.001$), which means that technological developments play a significant role in improving the way smart city projects are carried out. Sustainable Urban Development was in turn positively influenced by Smart City Adoption ($b = 0.456, p < 0.001$). The direct effect of Technology in Urban Development on Sustainable Urban Development was still appreciable ($c' = 0.156, p < 0.05$) which indicates partial mediation. Moreover, the indirect effect ($a \times b = 0.279, p < 0.001$) was larger than the direct effect, indicating the importance of the mediating role of smart city adoption between technological capabilities and sustainable urban outcomes. Overall, the effect was reported to be 0.435 ($p < 0.001$), thus the relation was significant overall. The results indicate that

investments in urban technology are best supported by strategies that enable the implementation of a smart city, thus improving the sustainability performance and urban resilience in the long term. The Pearson correlation matrix of the study variables is shown in Figure 8. The results show that the correlation among the dimensions is positive and between moderate to strong ($r = 0.50 - 0.74$). The highest correlation was found between Environmental Management and Health and Safety Services ($r = 0.74$), and between Technology in Urban Development and Environmental Management ($r = 0.74$). In the same way, Livability and Well-Being had high correlations with Health and Safety Services ($r = 0.73$) and Environmental Management ($r = 0.72$). Overall, the results highlight significant interdependencies between dimensions of sustainability, which in turn validate the integrated and multidimensional approach of sustainable urban development.

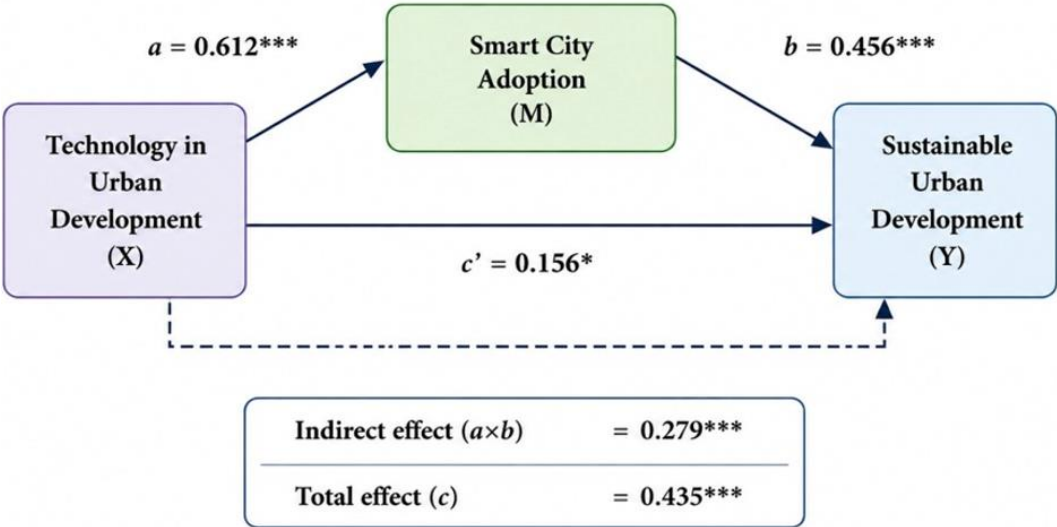


Figure 7. Mediation Model (Indirect Effect).

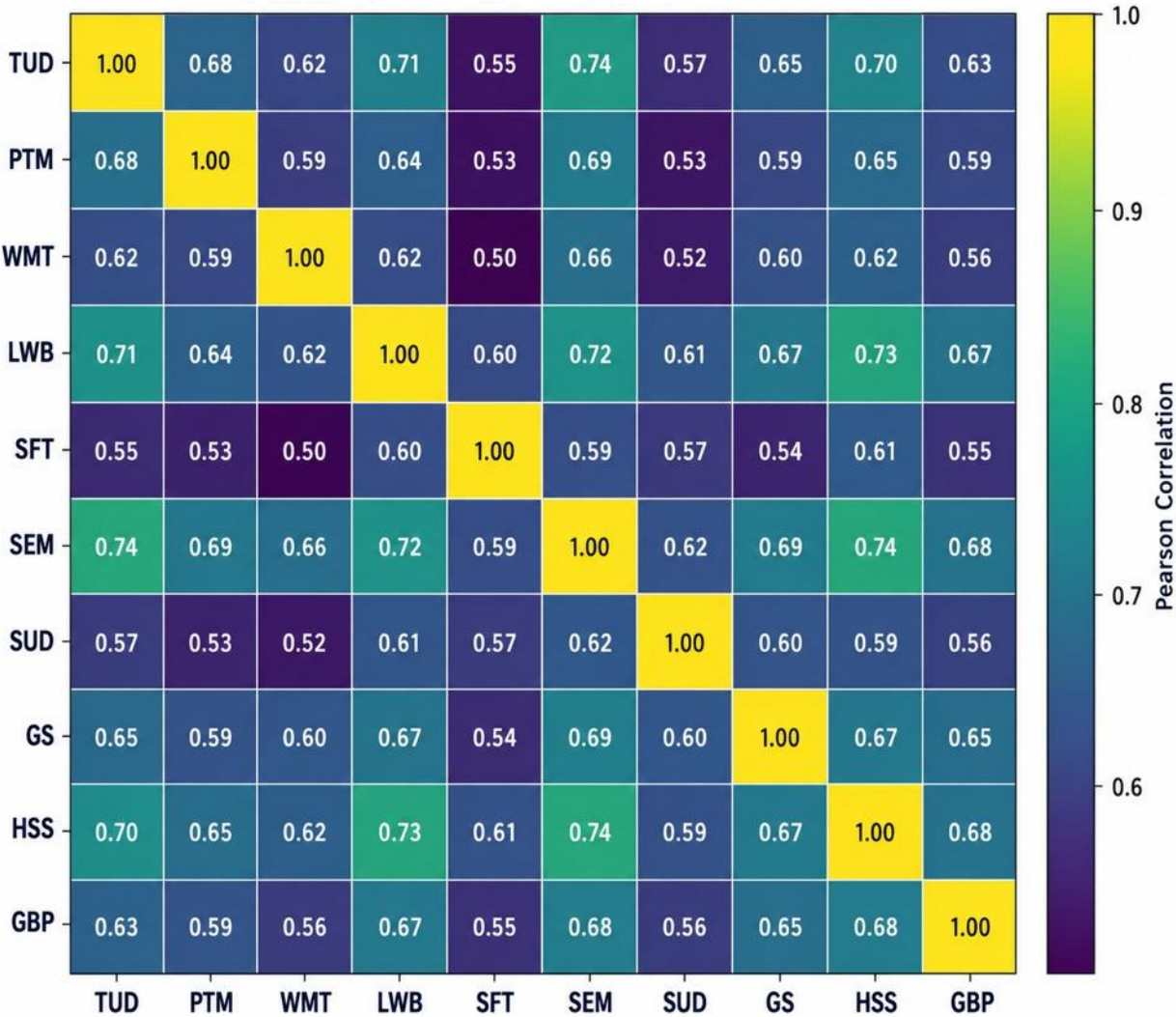


Figure 8. Pearson Correlation Matrix (Heatmap).

4.6. Relative Importance Analysis of Predictors and Cumulative Contribution Curve of Predictors

The relative importance of each predictor to Sustainable Urban Development is shown in Figure 9 by the normalized squared standardized coefficients (β^2). Results indicated that the highest percentages of explained variance (20.97%) was for Environmental Management, closely followed by Health and Safety Services (20.30%) and Technology in Urban Development (19.47%). These three dimensions combined explained over 60% of the model's explanatory power, emphasizing their importance in influencing sustainable urban outcomes. Livability

and Well-Being accounted for 17.71% of the variance and Green Spaces accounted for 15.97%. Moderate contributions were seen for the categories of Public Transport and Mobility (14.34%) and Global Best Practices (13.69%). Waste Management Technology (11.74%), Sustainable Urban Design (8.84%) and Stress-Free Technology (7.91%) had comparatively smaller contributions. Summarized, the outcomes show that environmental governance, health-related infrastructure and technological advancement are the most decisive factors in sustainable urban development while the rest are complementary elements to achieve long-term sustainability goals. Figure 10 showed the cumulative effect of the predictors in order to increase standardized beta weights on Sustainable Urban Development. The cumulative variance explained rose from 20.97% for the best predictor to 41.27% with the inclusion of the second predictor and finally to 60.74% with the inclusion of the third predictor. Notably, the fourth predictor added to the multiple accounted for the additional 78.45% of the model's power, which suggests that the four most powerful dimensions together account for almost 4/5 of the model's strength. The fifth predictor additionally contributed 94.42% of the variance, and the remaining predictors added only a small amount more to cumulative variance of 97.92%, 99.61%, 99.96%, 99.99% and finally 100%. The results indicate a small number of main indicators explain most of the variance in Sustainable Urban Development. Specifically, Environmental Management, Health and Safety Services, Technology in Urban Development, and Livability and Well-Being are the major contributors to sustainability performance, while the other contributors are minor. Investment in these "high-impact dimensions" should be emphasized through policies and urban planning to ensure the highest possible return on investment for sustainable urban development and ensure best use of available resources.

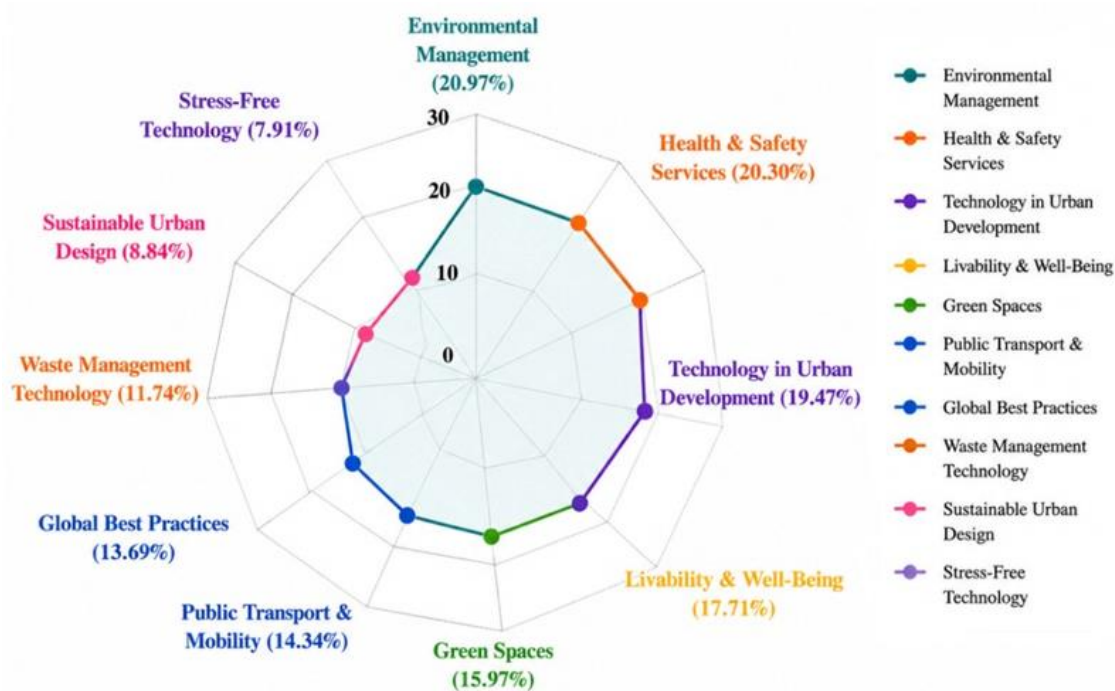


Figure 9. Contribution of each Predictor to Sustainable Urban Development (Relative Importance Analysis %).
Note: Percentages are based on the squared standardized coefficients (β^2), normalized to 100%.

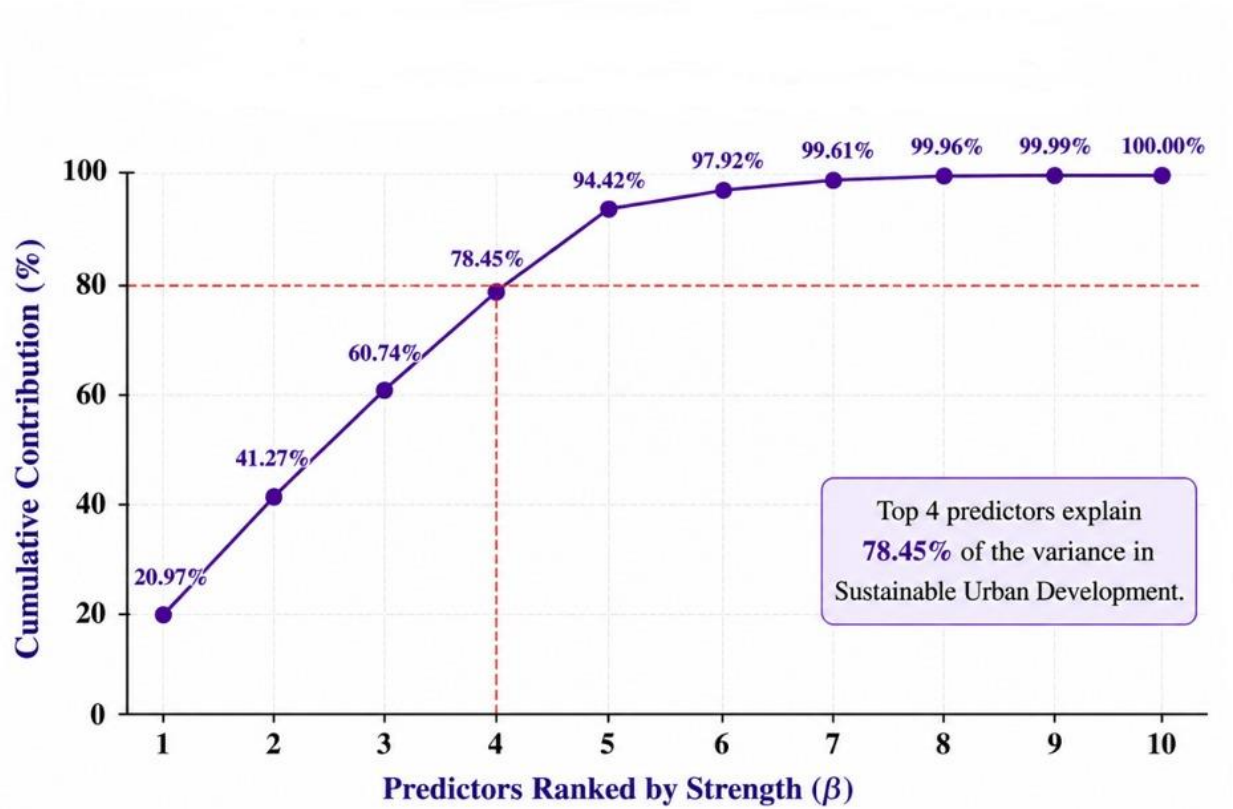


Figure 10. Cumulative Impact of Predictors on Sustainable Urban Development (Cumulative Contribution Curve).

4.7. Magnitude of Each Predictor's Effect on Sustainable Urban Development (Effect Size f^2)

Figure 11 showed the effect size (f^2) of all the predictors in relation to Sustainable Urban Development to understand their practical importance. The variables with the highest effect size are Environmental Management ($f^2 = 0.107$), Health and Safety Services ($f^2 = 0.098$), and Technology in Urban Development ($f^2 = 0.090$), which means that these variables have the most significant impact on the urban sustainability outcomes. The effect size for Livability and Well-Being was 0.075, and 0.057 for Green Spaces, indicating moderate contributions to the model. Public Transport and Mobility (0.046) and Global Best Practices (0.041) showed less but still significant impacts. The stress-free technology (0.014) and the sustainable urban design (0.018) each had a very small effect as determined by the previously established f^2 benchmarks, while waste management technology scored 0.028. In general, all predictors were positive and Environmental Management was the most practically significant predictor in the proposed framework for Sustainable Urban Development.

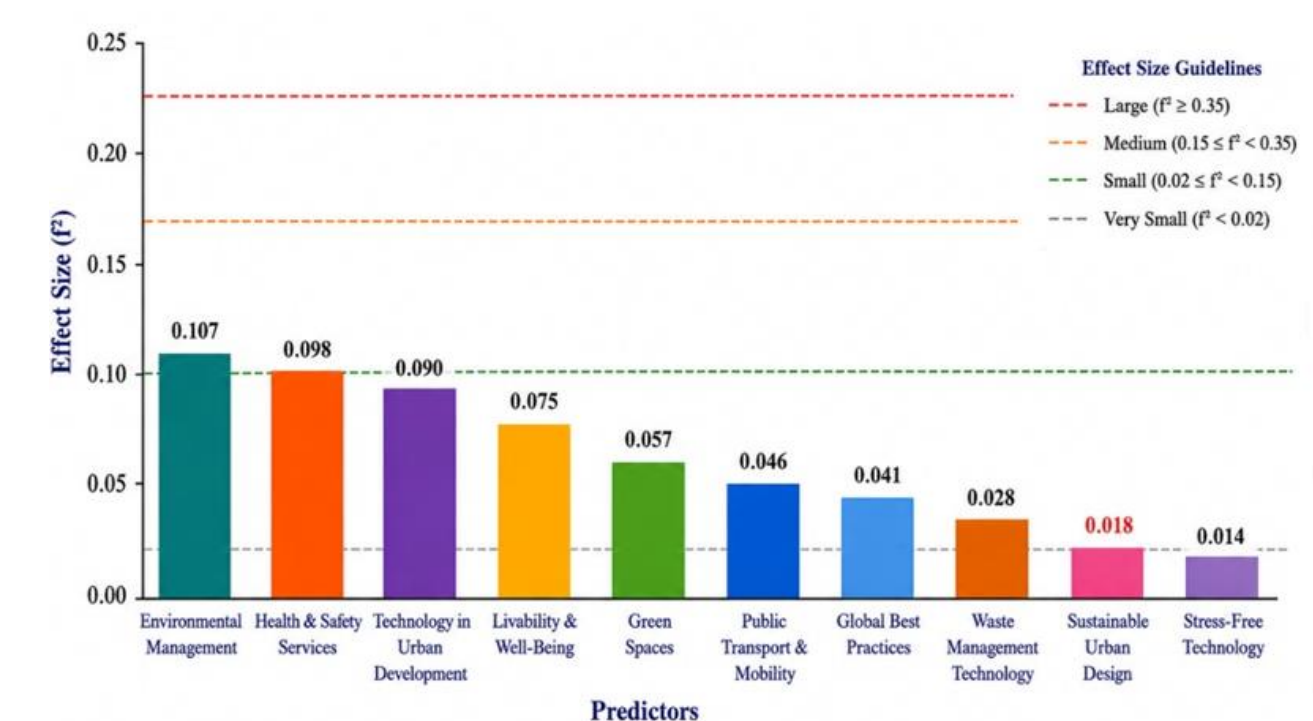


Figure 11. Magnitude of each Predictors effect on Sustainable Urban Development (Effect Size (f^2) of Predictors).

4.8. Proportional Share of Each Predictor in Explaining Variance (β^2 Contributions %)

The relative contribution of each predictor to the variance explained ($R^2 = 0.709$) in Sustainable Urban Development is shown in Figure 12. Environmental Management was the most influential predictor, explaining 20.97% of the variance, followed closely by Health and Safety Services (20.30%) and Technology in Urban Development (19.47%). Livability and Well-Being accounted for 17.71% of the variance, and Green Spaces accounted for 15.97% of the variance. Public Transport and Mobility and Global Best Practices were 14.34% and 13.69%, respectively. Waste Management Technology's contribution was 11.74%, which is moderate, suggesting it has a moderate impact on sustainability. The Sustainable Urban Design and Stress-Free Technology categories had comparatively small contributions (8.84% and 7.91%, respectively). All of these results suggest that sustainable urban development is driven by environmental governance, public health, and technological innovation, and that design and stress-reduction technologies, as secondary but important elements, contribute to improving urban sustainability performance.

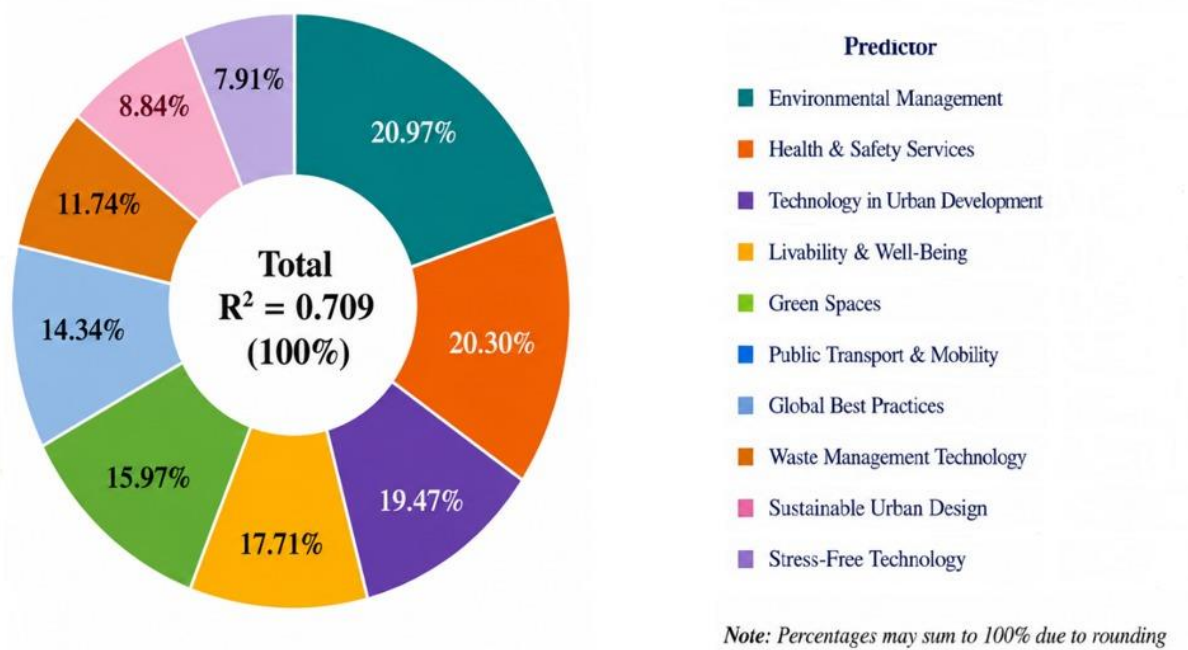


Figure 12. Proportional Share of Each Predictor in Explaining Variance (β^2 Contributions %).
Note: Percentages may sum to 100% due to rounding.

4.9. Discussion

The results of this study add to the body of literature that has been growing highlighting the multi-dimensionality of sustainable urban development in the context of smart cities and environmental change. In recent years, it has become increasingly clear that urban sustainability is a process that cannot be understood in chapters of separate environmental or technological interventions, but rather as a process that involves the integration of governance, technological innovation and environmental stewardship, public health systems and human-centered urban planning (Jacques et al., 2024; Lai et al., 2025). The present results confirm this, as they show that several dimensions of sustainable urban development are interrelated and together have an impact on the results of sustainable urban development. The influence of Environmental Management has been strong, which continues to emphasize the need for ecological governance in urban sustainability agendas. Studies in recent years have documented that cities that have adopted an IEMS approach achieve better resilience against climatic risks, better air quality, and higher ecosystem services (Chan and Chan, 2022; Howard, 2025). The importance of environmental management seen in this research is in accordance with the current sustainability principles that view environmental quality as the basis for sustaining economic growth and social welfare. The Intergovernmental Panel on Climate Change (IPCC) (2023) emphasizes that environmental governance has emerged as one of the most significant factors shaping urban resilience, especially in fast-growing urban areas that are exposed to climate risks and scarcity of resources (Izah et al., 2025).

This significant increase for Health and Safety Services is also representative of a key change in the sustainability conversation since the onset of the COVID-19 pandemic. Public health infrastructure has become a growing part of the wider debate on public health, increasingly being seen as an integral part of urban sustainability, as opposed to a social policy issue (Nunes, 2022). It has been claimed that resilient cities need to have robust health care systems, emergency response capabilities and public services that are readily accessible to ensure social stability in the face of environmental and economic shocks. The present findings confirm these arguments and indicate that the sustainability performance can be improved significantly by health-oriented urban policies (Mathur et al., 2024). Movement of similar conclusions was reported by Mouratidis who noted that citizens' perceptions of urban sustainability are linked strongly to health, safety, and quality-of-life indicators. Technology in Urban Development was another powerful sustainability catalyst, which has been used in the background of recent theoretical advances in the field of smart city studies (Mouratidis et al., 2021). There are contemporary studies that highlight the transformative capacity of digital technologies, artificial intelligence, Internet of Things (IoT) systems and data-driven governance mechanisms on enhancing urban efficiency and sustainability (Ciarli et al., 2021). These innovations are not just technological but are integral to the process of evidence-based decision making, resource management, and improving public service delivery. The importance of technological development in this current study thus validates recent claims that digital transformation is becoming more important than ever in the context of sustainable urban futures (Latupeirissa et al., 2024).

The mediation role of Smart City Adoption is of great theoretical value. The results of recent studies indicate that technology is not enough to achieve sustainability outcomes; it is the institutionalization, the readiness of governance and the involvement of citizens that play an important role (Dai et al., 2024). The results confirm this, showing that the use of smart cities is realized as a tool that converts technological developments into sustainable urban development. This aligns with studies in Europe, China, and the Gulf countries that smart governance systems have resulted in a major improvement in the sustainability effects of investments in digital infrastructure (Shao and Min, 2025). Hence, institutional capacity for successful smart city implementation should be addressed, in addition to technological deployment, as a part of the policy development process. The concept of Livability and Well-Being contributes to new human-centered thinking about sustainability. The evaluation of sustainability is gradually shifting from environmental and economic metrics to the quality of life of residents, as it is reflected in

the available literature about urban development (Almulhim and Yigitcanlar, 2024). Sustainable long-term results are more likely to be achieved in cities that focus on the provision of affordable housing, accessibility, social inclusion, recreation and psychological well-being. The present results support this argument and suggest that livability is a key factor in sustainable urban development. That is to say, there is a need for policies to place greater emphasis on citizens lived experiences than on infrastructure development goals in urban sustainability policies (Wang and Ke, 2024).

The positive contribution of Green Spaces is also in line with the recent evidence of the importance of NbS. There has been significant focus on the potential of urban green infrastructure to tackle climate adaptation, biodiversity, and even public health issues in the period of 2021 to 2026 (Zhang and Qian, 2024). Recent research provides evidence of the positive impacts that green spaces have on the urban heat island, air quality, mental health and community cohesion. This is why the results are in line with the international agendas to promote investment in urban forests, parks, ecological corridors, and green public spaces (Godoi et al., 2025). The International Transport Forum showed that transport is still one of the largest sources of urban carbon emission all over the world. There is evidence that investments in integrated public transport systems help to decrease environmental impacts and increase accessibility and social equity (International Transport Forum, 2021). The results thus emphasize the policy recommendations to promote low-carbon mobility systems and TOD strategies. One significant finding from the study is the high interdependency of the sustainability dimensions. Systems thinking is increasingly becoming a central paradigm in contemporary sustainability theories, which focus on interactions between environmental, technological, social and institutional aspects as the basis for urban sustainability outcomes, rather than on individual interventions (Farnood et al., 2025). The relationships between the study variables are relatively strong, supporting this view and highlighting that increases in one domain of sustainability may lead to positive spillover effects in others. Technological innovation could, for instance, support environmental monitoring, and better-quality green spaces could have a positive impact on public health and livability at the same time (Islam, 2025). The results largely support the current international sustainability agendas, such as the United Nations Sustainable Development Goals (SDGs) and the New Urban Agenda, as well as current smart city frameworks. The findings indicate that sustainable urban development needs an integrated approach that encompasses the dimensions of environment, technology, public health, livability and good governance (Sorooshian, 2024). The 21st century urban policies, therefore, need to shift away from sectoral planning and embrace more comprehensive planning processes, which can respond to the complex challenges of the 21st century urbanization (Creutzig et al., 2024).

5. Conclusion and Recommendations

The focus of this study was the determinants that drive Sustainable Urban Development and how it affects the sustainability of a city, showing that environmental, technological, social and governance factors play vital role. The results confirmed that Livability and Well-Being, Green Spaces and Public Transport also make a significant contribution to urban sustainability, Environmental Management and Safety Security are the most important predictors of sustainable urban outcomes. The mediation analysis revealed that Smart City Adoption plays a pivotal role in driving tech investments towards sustainable gains. In addition, the interdependence between study dimensions suggests all efforts toward sustainability should be conceived and executed in an integrated, holistic fashion, and not as separate projects. The results indicate that policies should focus on environmental government, digital innovation, public health infrastructure and quality of life enhancements to achieve the highest sustainability performance. The findings of this study help to fill the gap in the sustainable cities' literature on the relative significance of the major drivers of sustainability and provide practical guidance on how to make cities resilient, inclusive and environmentally sustainable in the face of the rapidly changing nature of urban challenges. The results showed that the following results have the greatest impact on Sustainable Urban Development: Environmental management, health and safety services, and technology-driven urban solutions, therefore, should be considered as the priority areas in policy and planning. To achieve maximum sustainability outcomes, the investments in smart city infrastructure should be complemented with effective governance mechanisms. Additionally, cities should increase the size of green space and strengthen their public transit networks, as well as implement the best global practices to improve urban resilience and livability. Urban policies should focus on integrated urban planning, which considers the environmental, social and technological aspects. Moreover, involving stakeholders in the process and monitoring the sustainability indicators on a continuous basis is recommended to maintain long-term effectiveness and adaptability of urban development strategies.

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References

- Abdussamad, Z., Judijanto, L., Yusup, A., Husni Tamrin, A. M., Rosyalita, D., & Sari Rahayu, H. W. (2024). Enhancing public service delivery through digital transformation: Challenges and opportunities in the era of e-government. *Pakistan Journal of Life & Social Sciences*, 22(2), 22539–22551. <https://doi.org/10.57239/PJLSS-2024-22.2.001601>
- Agyeman, J., & Evans, T. (2003). Toward just sustainability in urban communities: Building equity rights with sustainable solutions. *The ANNALS of the American Academy of Political and Social Science*, 590(1), 35–53. <https://doi.org/10.1177/0002716203256565>
- Ahmad, M., & Wilkins, S. (2025). Purposive sampling in qualitative research: A framework for the entire journey. *Quality & Quantity*, 59(2), 1461–1479. <https://doi.org/10.1007/s11135-024-02022-5>
- Ahmed, A., Pereira, L., & Jane, K. (2024). *Mixed methods research: Combining both qualitative and quantitative approaches*.
- Al-Emran, M., & Griffy-Brown, C. (2023). The role of technology adoption in sustainable development: Overview, opportunities, challenges, and future research agendas. *Technology in Society*, 73, 102240. <https://doi.org/10.1016/j.techsoc.2023.102240>
- Almulhim, A. I. (2025). Building urban resilience through smart city planning: A systematic literature review. *Smart Cities*, 8(1), Article 22. <https://doi.org/10.3390/smartcities8010022>
- Almulhim, A. I., & Yigitcanlar, T. (2025). Understanding smart governance of sustainable cities: A review and multidimensional framework. *Smart Cities*, 8(4), Article 113. <https://doi.org/10.3390/smartcities8040113>

- Alnanih, R., Elrefaei, L., & Al-Ahwal, A. (2025). Advancing sustainability through an IoT-driven smart waste management system with software engineering integration. *Sustainability*, 17(21), Article 9803. <https://doi.org/10.3390/su17219803>
- Bhanye, J., Shayamunda, R. H., & Matamanda, A. (2025). Smart technologies and approaches in climate change mitigation and adaptation: Implications for policy-making. In *Climate change mitigation and adaptation in practice* (pp. 121–146). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-85217-6_8
- Bryman, A. (2006). Integrating quantitative and qualitative research: How is it done? *Qualitative Research*, 6(1), 97–113. <https://doi.org/10.1177/1468794106058877>
- Bryman, A., & Cramer, D. (2005). *Quantitative data analysis with SPSS 12 and 13: A guide for social scientists*. Routledge.
- Chan, F. K. S., & Chan, H. K. (2022). Recent research and challenges in sustainable urbanisation. *Resources, Conservation and Recycling*, 184, 106346. <https://doi.org/10.1016/j.resconrec.2022.106346>
- Chen, C.-W. (2023). Can smart cities bring happiness to promote sustainable development? Contexts and clues of subjective well-being and urban livability. *Developments in the Built Environment*, 13, 100108. <https://doi.org/10.1016/j.dibe.2022.100108>
- Ciarli, T., Kenney, M., Massini, S., & Piscitello, L. (2021). Digital technologies, innovation, and skills: Emerging trajectories and challenges. *Research Policy*, 50(7), 104289. <https://doi.org/10.1016/j.respol.2021.104289>
- Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.
- Creutzig, F., Becker, S., Berrill, P., Bongs, C., Bussler, A., Cave, B., Constantino, S. M., Grant, M., Heeren, N., Heinen, E., Hintz, M., Ingen-Housz, T., Johnson, E., Kolleck, N., Liotta, C., Lorek, S., Mattioli, G., Niamir, L., McPhearson, T., ... Milojevic-Dupont, N. (2024). Towards a public policy of cities and human settlements in the 21st century. *npj Urban Sustainability*, 4, Article 29. <https://doi.org/10.1038/s42949-024-00168-7>
- Dahmane, W. M., Ouchani, S., & Bouarfa, H. (2025). Smart cities services and solutions: A systematic review. *Data and Information Management*, 9(2), 100087. <https://doi.org/10.1016/j.dim.2024.100087>
- Dai, Y., Hasanefendic, S., & Bossink, B. (2024). A systematic literature review of the smart city transformation process: The role and interaction of stakeholders and technology. *Sustainable Cities and Society*, 101, 105112. <https://doi.org/10.1016/j.scs.2023.105112>
- Dalati, S., & Marx Gómez, J. (2018). Surveys and questionnaires. In *Modernizing the academic teaching and research environment: Methodologies and cases in business research* (pp. 175–186). Springer. https://doi.org/10.1007/978-3-319-74173-4_10
- Dashora, L. K., Firoz C, M., & Shaw, R. (2025). Understanding urbanization, urban sustainability, and environmental transition challenges in Global South. In *Urban sustainability: Navigating environmental transition challenges in Global South* (pp. 1–8). Springer Nature Singapore. https://doi.org/10.1007/978-981-96-4890-0_1
- Dissanayake, H., Manta, O., & Khan, S. (2025). Enhancing supply chain transparency and traceability in waste management practices through blockchain technologies and digital innovations. In *Blockchain technologies for smart circular economy and organisational sustainability* (pp. 177–193). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-89183-0_12
- Durga, K. S., Murty, A., Roy, S., Killedar, M., Swamy, T. N. V. R., & Savaram, M. (2025). Applications of big data analytics in urban planning and development: Current trends and future directions. *Journal of Applied Bioanalysis*, 11(1), 46–54. <https://doi.org/10.53555/jab.v11i1.059>
- Eddabbah, M., Aitzaoui, C., Hachoumi, N., Takhdar, K., & Guezaz, A. (2026). Smart healthcare solutions for urban health development. In *Smart cities for sustainable and urban development: Approaches, innovations and challenges* (pp. 695–743). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-99001-4_33
- Elassy, M., Al-Hattab, M., Takruri, M., & Badawi, S. (2024). Intelligent transportation systems for sustainable smart cities. *Transportation Engineering*, 16, 100252. <https://doi.org/10.1016/j.treng.2024.100252>
- Farnood, A., Eicker, U., Cucuzzella, C., Gopakumar, G., & Khorramisarvestani, S. (2025). Sustainability assessment framework for urban transportation combining system dynamics modeling and GIS: A TOD and parking policy approach. *Smart Cities*, 8(4), Article 107. <https://doi.org/10.3390/smartcities8040107>
- Garg, S., & Arora, P. (2025). Waste management challenges and opportunities: A holistic approach for sustainable development. *International Journal of Environmental Science and Technology*, 22(14), 14753–14770. <https://doi.org/10.1007/s13762-025-06653-5>
- Godoi, N. M. I., Gomes, R. C., & Longo, R. M. (2025). Contributions of urban green spaces to cities: A literature review. *Sustainable Environment*, 11(1), 2464418. <https://doi.org/10.1080/27658511.2025.2464418>
- Hong, A., Choi, D. A., Chung, H., Kumar, P., & Lee, J. (2025). Environmental and health monitoring in smart cities: A systematic review of trends, opportunities, and challenges. *Sustainable Cities and Society*, 130, 106491. <https://doi.org/10.1016/j.scs.2025.106491>
- Howard, C. (2025). Urban planning and sustainable development: A systematic literature review and future directions. *Chinese Studies Monthly*, 1(1). <https://doi.org/10.70731/4gv0e433>
- Humbal, A., Chaudhary, N., & Pathak, B. (2023). Urbanization trends, climate change, and environmental sustainability. In *Climate change and urban environment sustainability* (pp. 151–166). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-7618-6_9
- Hussain, I., Elomri, A., Kerbache, L., & El Omri, A. (2024). Smart city solutions: Comparative analysis of waste management models in IoT-enabled environments using multiagent simulation. *Sustainable Cities and Society*, 103, 105247. <https://doi.org/10.1016/j.scs.2024.105247>
- International Transport Forum. (2021). *ITF transport outlook 2021*. OECD Publishing. <https://doi.org/10.1787/16826a30-en>
- Islam, H. (2025). Nexus of economic, social, and environmental factors on sustainable development goals: The moderating role of technological advancement and green innovation. *Innovation and Green Development*, 4(1), 100183. <https://doi.org/10.1016/j.igd.2024.100183>
- Izah, S. C., Ogwu, M. C., & Salimon, S. S. (2025). Principles of sustainable development and environmental management. In *Evaluating environmental processes and technologies* (pp. 29–63). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-85327-2_2
- Jacques, E., Júnior, A. N., De Paris, S., Francescato, M., & Siluk, J. (2024). Smart cities and innovative urban management: Perspectives of integrated technological solutions in urban environments. *Heliyon*, 10(6), e27850. <https://doi.org/10.1016/j.heliyon.2024.e27850>
- Jamil, S. (2021). From digital divide to digital inclusion: Challenges for wide-ranging digitalization in Pakistan. *Telecommunications Policy*, 45(8), 102206. <https://doi.org/10.1016/j.telpol.2021.102206>
- Jasrai, L. (2025). *An introduction to data analysis using IBM SPSS*. Routledge India. <https://doi.org/10.4324/9781003541578>
- Kifayatullah, S., Saqib, Z., Khan, M. I., Zaman-ul-Haq, M., Kucher, D. E., Ullah, S., & Tariq, A. (2025). Equitable urban green space planning for sustainable cities: A GIS-based analysis of spatial disparities and functional strategies. *Scientific Reports*, 15(1), 22686. <https://doi.org/10.1038/s41598-025-07578-2>
- Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal*, 79(1), 1–14. <https://doi.org/10.1007/s10708-013-9516-8>
- Kosoe, E. A., & Ogwu, M. C. (2025). Sustainable urban planning and environmental management. In *Evaluating environmental processes and technologies* (pp. 463–485). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-85327-2_14
- Kundu, D., & Pandey, A. K. (2020). World urbanisation: Trends and patterns. In *Developing national urban policies: Ways forward to green and smart cities* (pp. 3–49). Springer. https://doi.org/10.1007/978-981-15-3738-7_2
- Lai, Y., Wang, P., & Xia, J. (2025). Systematic review of sustainable urban community development trends, challenges and opportunities. *Discover Sustainability*, 6(1), 616. <https://doi.org/10.1007/s43621-025-01539-5>
- Lakhoui, A. (2025). Revolutionizing urban solid waste management with AI and IoT: A review of smart solutions for waste collection, sorting, and recycling. *Results in Engineering*, 25, 104018. <https://doi.org/10.1016/j.rineng.2025.104018>
- Lartey, D., & Law, K. M. (2025). Artificial intelligence adoption in urban planning governance: A systematic review of advancements in decision-making and policy making. *Landscape and Urban Planning*, 258, 105337. <https://doi.org/10.1016/j.landurbplan.2025.105337>
- Latupeirissa, J. J. P., Dewi, N. L. Y., Prayana, I. K. R., Srikandi, M. B., Ramadiansyah, S. A., & Pramana, I. B. G. A. Y. (2024). Transforming public service delivery: A comprehensive review of digitization initiatives. *Sustainability*, 16(7), 2818. <https://doi.org/10.3390/su16072818>
- Likert, R. (1932). *A technique for the measurement of attitudes* (No. 140). Archives of Psychology, Columbia University.

- Mathur, M., Wani, V. J., Basu, R., Manihar, P., Ansari, M. W. F., Mathur, N., Vyas, S., Nayak, S., Verma, A., & Singh, S. (2024). Urban health resilience: Strategies for strengthening public health systems in response to urbanization challenges. *Indian Journal of Community Medicine*, 49(Suppl. 2), S159–S163. https://doi.org/10.4103/ijcm.ijcm_755_24
- Mavlutova, I., Atstaja, D., Grasis, J., Kuzmina, J., Uvarova, I., & Roga, D. (2023). Urban transportation concept and sustainable urban mobility in smart cities: A review. *Energies*, 16(8), 3585. <https://doi.org/10.3390/en16083585>
- Miraftebadeh, S. M., Longo, M., & Foidelli, F. (2024). Mobility and future trends. In *Emerging battery technologies to boost the clean energy transition: Cost, sustainability, and performance analysis* (pp. 3–11). Springer International Publishing. https://doi.org/10.1007/978-3-031-48359-2_1
- Mishra, P., & Singh, G. (2023). Enabling technologies for sustainable smart city. In *Sustainable smart cities: Enabling technologies, energy trends and potential applications* (pp. 59–73). Springer International Publishing. https://doi.org/10.1007/978-3-031-33354-5_3
- Mohsin, A. S., Choudhury, S. H., & Mueed, M. A. (2025). Automatic priority analysis of emergency response systems using internet of things (IoT) and machine learning (ML). *Transportation Engineering*, 19, 100304. <https://doi.org/10.1016/j.treng.2025.100304>
- Mouratidis, K. (2021). Urban planning and quality of life: A review of pathways linking the built environment to subjective well-being. *Cities*, 115, 103229. <https://doi.org/10.1016/j.cities.2021.103229>
- Nunes, J. P. (2022). Occupational safety and health challenges and solutions in the post-pandemic future of work: ILOs view. *Safety and Health at Work*, 13, S76. <https://doi.org/10.1016/j.shaw.2021.12.975>
- Oktay, D. (2024). Sustainable urbanism and identity: A holistic perspective for future cities. *Perspectives in Architecture and Urbanism*, 1(2), 100016. <https://doi.org/10.1016/j.pau.2024.100016>
- Pandiyani, P., Saravanan, S., Usha, K., Kannadasan, R., Alsharif, M. H., & Kim, M. K. (2023). Technological advancements toward smart energy management in smart cities. *Energy Reports*, 10, 648–677. <https://doi.org/10.1016/j.egyr.2023.07.021>
- Papa, E., & Lauwers, D. (2015). Smart mobility: Opportunity or threat to innovate places and cities? In *REAL CORP 2015: Plan together—Right now—Overall. From vision to reality for vibrant cities and regions* (pp. 543–550). CORP—Competence Center of Urban and Regional Planning.
- Papadakis, D. M., Savvides, A., Michael, A., & Michopoulos, A. (2024). Advancing sustainable urban mobility: Insights from best practices and case studies. *Fuel Communications*, 20, 100125. <https://doi.org/10.1016/j.fueco.2024.100125>
- Pereira, J. V., Vila-Nova, F., Veiga, G., Lopes, F., & Cordovil, R. (2024). Associations between outdoor play features and children's behavior and health: A systematic review. *Health & Place*, 87, 103235. <https://doi.org/10.1016/j.healthplace.2024.103235>
- Powell, J., McCafferty-Leroux, A., Hilal, W., & Gadsden, S. A. (2024). Smart grids: A comprehensive survey of challenges, industry applications, and future trends. *Energy Reports*, 11, 5760–5785. <https://doi.org/10.1016/j.egyr.2024.05.051>
- Rashad, M. A., Hussain, M., Akhter, P., Hamayun, M. H., Ahsan, A., Jamil, F., et al. (2025). Transforming municipal solid waste management: Current status of segregation challenges, waste-to-energy technologies, and circular economy strategies. *Journal of Industrial and Engineering Chemistry*, 1, 12–29. <https://doi.org/10.1016/j.jiec.2025.06.009>
- Reiser, D. (2023). Brundtland report. In *Encyclopedia of sustainable management* (pp. 378–381). Springer International Publishing. https://doi.org/10.1007/978-3-031-25984-5_183
- Rosenthal, R. (1994). Parametric measures of effect size. In H. Cooper & L. V. Hedges (Eds.), *The handbook of research synthesis* (pp. 231–244). Russell Sage Foundation.
- Sabri, S., & Witte, P. (2023). Digital technologies in urban planning and urban management. *Journal of Urban Management*, 12(1), 1–3. <https://doi.org/10.1016/j.jum.2023.02.003>
- Sadat, A. (2025). Digital governance and civic inclusion to enhance public participation in political decision-making processes. *Frontiers in Political Science*, 7, 1671373. <https://doi.org/10.3389/fpos.2025.1671373>
- Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill-building approach* (7th ed.). Wiley.
- Shao, J., & Min, B. (2025). Sustainable development strategies for smart cities: Review and development framework. *Cities*, 158, 105663. <https://doi.org/10.1016/j.cities.2024.105663>
- Sharma, A., Singh, S. N., Serratos, M. M., Sahu, D., & Strezov, V. (2025). Urban energy transition in smart cities: A comprehensive review of sustainability and innovation. *Sustainable Futures*, 13, 100940. <https://doi.org/10.1016/j.sftr.2025.100940>
- Sharma, P., Bano, A., Singh, S. P., Varjani, S., & Tong, Y. W. (2024). Sustainable organic waste management and future directions for environmental protection and techno-economic perspectives. *Current Pollution Reports*, 10(3), 459–477. <https://doi.org/10.1007/s40726-024-00317-7>
- Sharmin, S., & Chowdhury, R. H. (2025). Digital transformation in governance: The impact of e-governance on public administration and transparency. *Journal of Computer Science and Technology Studies*, 7(1), 362–379. <https://doi.org/10.32996/jcsts.2025.7.1.27>
- Sheikh, W. T., & van Ameijde, J. (2022). Promoting livability through urban planning: A comprehensive framework based on the “theory of human needs.” *Cities*, 131, 103972. <https://doi.org/10.1016/j.cities.2022.103972>
- Sorooshian, S. (2024). The sustainable development goals of the United Nations: A comparative midterm research review. *Journal of Cleaner Production*, 453, 142272. <https://doi.org/10.1016/j.jclepro.2024.142272>
- Sun, Y., Chen, S., & Sleipness, O. (2025). Healthy multi-age spaces: Comparing the relationships between green space quality and social interaction among the elderly, children, and the general population. *Land*, 14(11), 2134. <https://doi.org/10.3390/land14112134>
- Taherdoost, H. (2021). Data collection methods and tools for research: A step-by-step guide to choose data collection technique for academic and business research projects. *International Journal of Academic Research in Management*, 10(1), 10–38.
- Tavanti, M. (2023). Technology innovations for the SDGs. In *Developing sustainability in organizations: A values-based approach* (pp. 389–404). Springer International Publishing. https://doi.org/10.1007/978-3-031-36907-0_13
- Trivedi, A., & Shah, H. (2024). Evolving paradigms of smart resilient cities: Strategic integration of smart technologies. In *Smart cities: Innovations, challenges and future perspectives* (pp. 391–405). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-59846-3_17
- Turok, I., Scheba, A., & Visagie, J. (2023). Rethinking urbanization and economic development: A synopsis. *Environment & Urbanization*, 35(2), 297–309. <https://doi.org/10.1177/09562478231193829>
- Voukalli, I., Papamichael, I., Loizia, P., & Zorpas, A. A. (2024). Urbanization and solid waste production: Prospects and challenges. *Environmental Science and Pollution Research*, 31(12), 17678–17689. <https://doi.org/10.1007/s11356-023-27670-2>
- Wang, K., & Ke, Y. (2024). Social sustainability of communities: A systematic literature review. *Sustainable Production and Consumption*, 47, 585–597. <https://doi.org/10.1016/j.spc.2024.04.031>
- Watson, M. J., Machado, P. G., da Silva, A. V., Saltar, Y., Ribeiro, C. O., Nascimento, C. A. O. D., & Dowling, A. W. (2024). Sustainable aviation fuel technologies, costs, emissions, policies, and markets: A critical review. *Journal of Cleaner Production*, 449, 141472. <https://doi.org/10.1016/j.jclepro.2024.141472>
- Yesufu, L. O., & Alajlani, S. (2025). The impact of information technology on societal transformation. In *Technology for societal transformation: Exploring the intersection of information technology and societal development* (pp. 1–14). Springer Nature. https://doi.org/10.1007/978-981-96-1721-0_1
- Zhang, F., & Qian, H. (2024). A comprehensive review of the environmental benefits of urban green spaces. *Environmental Research*, 252, 118837. <https://doi.org/10.1016/j.envres.2024.118837>
- Zhang, H., Zhang, R., & Sun, J. (2025). Developing real-time IoT-based public safety alert and emergency response systems. *Scientific Reports*, 15(1), 29056. <https://doi.org/10.1038/s41598-025-13465-7>
- Zhao, W. (2025). Smart city technologies for sustainable urban planning: Evidence and equity lessons from Shenzhen. *Sustainable Futures*, 10, 101198. <https://doi.org/10.1016/j.sftr.2025.101198>
- Zhu, Z., Zhang, H., Zhang, S., Wang, J., & Ren, H. (2025). Intelligent monitoring and control systems for smart water management. In *Nano-solutions for sustainable water and wastewater management: From monitoring to treatment* (pp. 369–390). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-82794-5_16