Journal of Infrastructure, Policy and Development 2024, 8(8), 5744.
https://doi.org/10.24294/jipd.v8i8.5744

Article

Smart cities in Lima: A transformative model for a sustainable future

Alex Pacheco*, Edwin Roque, Amanda Duran, Guido Larico

Professional School of Systems Engineering, Universidad Nacional de Cañete, Cañete 15701, Peru
*** Corresponding author:** Alex Pacheco, apacheco@undc.edu.pe

CITATION

Pacheco A, Roque E, Duran A, Larico G. (2024). Smart cities in Lima: A transformative model for a sustainable future. Journal of Infrastructure, Policy and Development. 8(8): 5744. https://doi.org/10.24294/jipd.v8i8.5744

ARTICLE INFO

Received: 9 April 2024
Accepted: 9 May 2024
Available online: 30 August 2024

Abstract: Smart cities incorporate fundamental aspects such as sustainability and citizens' well-being. Therefore, the objective of this study is to analyze the feasibility and effectiveness of the implementation of an evaluation model of the transformation processes towards smart cities as a strategy to improve the state of the transformation processes in Lima, Peru. The research is descriptive and basic. A questionnaire was administered to 80 municipal officials in Lima, focusing on the variable "smart cities evaluation model", covering three key dimensions: open data, smart public transport and energy efficiency, with a total of 15 questions and the variable "state of the transformation processes", analysed through the dimensions of educational level of the population and municipal budget, with 10 questions. The results revealed that 48% expressed a gap in terms of the availability and quality of accessible information. 53% argued that stronger energy conservation and sustainability strategies need to be implemented. In addition, 53% felt that the education level needs to focus on improving local education systems. In conclusion, transformation processes drive economic, social and environmental development, improving the quality of life and promoting equality among citizens. This study contributes to a broader understanding of how to address these challenges in order to build more sustainable and liveable cities in the future.

Keywords: sustainability; smart cities; transformation processes; open data; public transport

1. Introduction

Cities are facing great uncertainty regarding the growth of innovative and scientific technologies, which generates a need in society to achieve technological growth that allows for the care of the environment (de la Cruz et al., 2021; Quiñones et al., 2016). Currently, smart cities are those that use technology to improve the quality of life of the population, which involves reducing social inequalities and defending the future of new generations (Alvarado López, 2017). The transformation of cities into smart cities has been a primary vision in recent years, which is why the government is creating small, medium and large strategies related to the progress of cities (Bjørner, 2021). According to (Giffinger et al., 2007), a smart city is characterized by: smart economy, smart environment, smart life, smart governance, smart people and smart mobility. However, the limitations that exist in municipal budgets make it difficult to implement smart city projects (Villarejo, 2015). Budgetary difficulties are forcing cities to find new formulas to transform themselves and provide urban services with greater efficiency. An example of this is the Europe 2020 strategy, which includes commitments to promote the development of smart cities by investing in information technologies that are essential for infrastructure and the development of social and human capital. The growth of the world's population is leading to the emergence of smart cities that guarantee people's quality of life (Castilla et al., 2020; Córdova, 2017).

The International Telecommunications Union (ITU, 2016) and Bjørner (2021) point out that a smart and sustainable city is innovative and uses Information and Communication Technologies (ICT), among other aspects, to improve the efficiency of operations, urban services, competitiveness and quality of life, which guarantees the satisfaction of the needs of present and future generations in a social, economic, cultural and environmental way. Consequently, cities need to set measurable objectives, for which indicators are used to measure the state of transformation processes. In addition, city indicators are used to establish a common language, provide transparency in governance, communicate the benefits of investments, manage city operations, evaluate the city's performance in different areas and support decision making. Some indicators for measuring smart city standards are ISO 37128 and 37122 (Huovila et al., 2019). In order to move forward with a process of urban transformation, three main factors are needed: culture, quality architecture and knowledge as a development factor (Ruiz, 2015). Likewise, sustainable urban planning must be carried out, which gives the city a new and unique appearance.

In Peru, low levels of ICT innovation and development are hampering the implementation of smart city plans and pilot projects. This results in unreliable internet connectivity, inadequate public transport and lack of energy efficiency for a large part of the population. However, the government is taking initiatives to strengthen the sector, seeking collaboration with educational institutions and the private sector (Copaja and Esponda, 2019). It is essential that smart and sustainable city initiatives are not perceived as a distant and unattainable future, but as a current necessity to address societal challenges.

Previous studies have shown that smart cities are a promising solution to address environmental problems and improve the quality of life for citizens (Dai et al., 2024; Yang and Zhen, 2024; Zhu et al., 2024). Some cases have shown that the implementation of information and communication technologies, coupled with sustainable approaches, improves energy efficiency, public transport management and the use of open data for the benefit of the community (Roustaei et al., 2024). However, the technology literature lacks solid, accurate and up-to-date evidence on the status of urban transformation processes towards smart city models. There are gaps in the understanding of how different aspects, such as the level of education of the population and the municipal budget, affect the progress towards a smart city. This paper aims to fill this gap by analysing the proposed smart city assessment model, focusing on the indicators of open data, energy efficiency and smart public transport. Therefore, the objective of this research is to propose a model to evaluate the transformation processes towards smart cities in Lima, Peru. This research contributes to the field of smart cities by providing a comprehensive and applicable assessment that considers both the technological and the social and economic aspects involved in this process. By better understanding these factors, more informed decisions can be made to promote economic, social and environmental development, with the aim of improving the quality of life and equality for all citizens.

2. Literature review

Smart cities represent an innovative response to contemporary urban challenges

by integrating technology, data and citizen participation to improve quality of life, operational efficiency and environmental sustainability (Dávid and Archi, 2024; Guenduez et al., 2024). This concept is underpinned by several fundamental assumptions. First, it is assumed that the integration of information and communication technologies (ICT) into urban infrastructure can improve the efficiency and quality of urban services. Second, it is assumed that involving citizens in city planning and management can generate solutions that are more tailored to local needs, thus promoting transparency and accountability. Finally, there is the premise that smart use of resources, such as energy and transport, can mitigate environmental impacts and promote urban resilience to climate change (Anschütz et al., 2024; Lim and Hwang, 2024).

The main components of smart cities are open data, smart public transport and energy efficiency. Open data is considered essential, as the availability and accessibility of urban data can drive innovation, government transparency and citizen participation (Joyce and Javidroozi, 2024). On the other hand, smart public transport is essential to optimise urban mobility, reduce congestion and reduce greenhouse gas emissions. This includes the implementation of real-time traffic management systems, efficient route planning and multimodal integration (Addas, 2023; Hashim, 2024). In terms of energy efficiency, it is assumed that the adoption of energy efficiency-oriented technologies and policies can reduce energy consumption and carbon emissions, while improving the resilience of the urban energy system (Liu et al., 2024). Together, these components reflect the holistic vision of smart cities as urban environments that harness technology and data to improve citizens' quality of life, promote environmental sustainability and foster economic and social development (Gracias et al., 2023; Castilla et al., 2023).

A study by Chu et al. (2021) in China examined the environmental impact of smart cities. These cities helped reduce industrial emissions by 20.7% and 12.2% respectively, thanks to technological improvements and urban innovation. Slovakia also demonstrated the ability of municipalities to integrate public transport into the smart city concept. By choosing the right mode of transport, individual transport was reduced, improving air quality and the lives of citizens (Bubelíny and Kubina, 2021). The effective use of ICT and interaction with smartphones is needed to improve traditional transport systems (Rojas et al., 2017). Open data is also essential for the development of smart cities. One study evaluated 50 cities and established a framework for open data on air quality to improve governance, transparency, analysis, planning and citizen participation (Leung and Lam, 2021; Neves et al., 2020).

On the other hand, Ortiz and Acero Álvarez (2016) highlights the importance of educating the population, especially young people, in the context of developing cities as innovation ecosystems. To this end, the "smartkids" programme has been implemented, which encourages the creativity and active participation of young people in the construction of smart cities. Through this programme, young people identify urban problems and propose solutions, while learning to design business models and understand the relevance of technology in improving quality of life. In addition, educating the population significantly improves the quality of life of citizens, allowing for an in-depth analysis of aspects such as demographic behaviour, environmental behaviour, family relationships and self-discovery (Zas and Molina, 2018).

In Japan, the attractiveness of smart cities lies in sophisticated area management, driven by smart social technology and advanced information communication. While social capital needs to be improved, the government is promoting the construction and improvement of these cities (Nakano and Washizu, 2021). In New Zealand, interest in smart cities has grown due to the expansion of mobile technologies and the use of open data to promote efficiency and environmental sustainability. These technologies are helping to reduce traffic and improve energy efficiency (Barr et al., 2021). In Cuba, scientific research on smart cities is scarce, but essential for development. One study highlights that universities in Havana should focus on research on smart cities to increase the use of ICT and improve the quality of life of the population (Cobas and Hernández, 2018).

3. Method

3.1. Research design

The present research employs a basic research approach and follows a descriptive design to analyze the relationship between the smart city assessment model and the state of transformation processes in the urban context. The study was conducted during the period from March to May 2023.

3.2. Research problems and objectives

This study aims to address a number of key research problems and objectives in the context of the transformation towards smart cities in Lima, Peru. Among the problems identified is the lack of systematic evaluation of urban transformation processes, as well as the need to understand the feasibility and effectiveness of implementing a specific evaluation model. In this sense, the research objectives include analysing the current status of smart city implementation in Lima, focusing on the dimensions of open data, smart public transport and energy efficiency. It also seeks to explore the challenges and opportunities associated with improving the state of urban transformation processes in the city, in order to provide relevant insights for the development of future policies and strategies in this area.

3.3. Sample and selection procedure

The sample of participants consisted of 80 civil servants belonging to the municipality of Lima. Participants were selected through simple random sampling, ensuring representativeness and diversity in terms of experience and job responsibilities in the municipal sphere. To be included in the study, participants had to meet the following inclusion criteria: (a) be between 30 and 55 years of age, (b) give informed consent to participate in the research, (c) be residents of Lima, and (d) be permanent employees with at least 6 months of work experience in a Lima municipality. Incomplete questionnaires and cases where participants expressed unwillingness to continue their participation were excluded.

3.4. Data collection instrument

The data collection technique used was the survey, implemented through a

structured questionnaire designed specifically for this study. To ensure the participation and convenience of respondents, they were provided the opportunity to complete the survey confidentially through a link sent by email. The questionnaire was hosted on the Google Forms platform, allowing participants to respond from any location with Internet access. The questionnaire consisted of two opinion scales based on Likert methodology, which were validated by expert judgement, demonstrating high reliability with a Cronbach's alpha coefficient of 0.804. The first scale assessed the perception of the smart city evaluation model across three key dimensions: open data, smart public transport and energy efficiency, comprising a total of 15 questions. The second scale assessed the status of urban transformation processes, taking into consideration the dimensions of the level of education of the population and the municipal budget, and consisted of 10 questions. This methodological approach allowed for a broad and detailed overview of perceptions and realities related to the implementation of smart cities in Lima, thus providing a solid basis for the analysis and interpretation of the results.

3.5. Validation of the measurement tool

The Likert scale used in the questionnaire was subjected to a process of validation by expert judgement to ensure its suitability and relevance. A panel of experts in the field of municipal management and urban transformation assessed the clarity, relevance and coherence of the statements in the scale. Adjustments were made based on expert comments and suggestions to improve the comprehensibility and applicability of the scale.

3.6. Data analysis

The collected data were subjected to descriptive statistical analyzes, including measures of central tendency and dispersion for each dimension of the independent and dependent variables. In addition, correlation tests were carried out to explore possible relationships between the different dimensions and the opinions of the participants. Statistical software tools such as SPSS were used to perform these analyzes.

3.7. Ethical considerations

The research was conducted in strict compliance with ethical research principles. Participants gave informed consent prior to their inclusion in the study, ensuring their voluntariness and confidentiality. All personal information and responses provided were handled confidentially and used exclusively for research purposes.

4. Results

The questionnaire was applied to 80 employees, on the basis of which the following results were obtained:

4.1. Workers' perceptions of the dimensions of the smart cities variable assessment

The findings obtained from the smart cities assessment provide a critical

understanding of how workers perceive the implementation of smart cities in several crucial dimensions. The notable finding that 48% of participants rate the level of open data as unsatisfactory highlights a significant gap between expectations and reality in terms of accessibility and availability of data. Furthermore, the 43% of respondents who consider the multimodal integration of public transport to be deficient point to challenges in the connectivity and fluidity of the transport system. Furthermore, the fact that 53% of respondents rate the level of Energy Efficiency as "fair" indicates that while progress has been made in this area, there is still room for substantial improvements. These joint results highlight the need to strategically and systematically address issues related to the availability and use of open data, the interconnection of public transport and the optimisation of energy efficiency in smart cities (**Figure 1**).

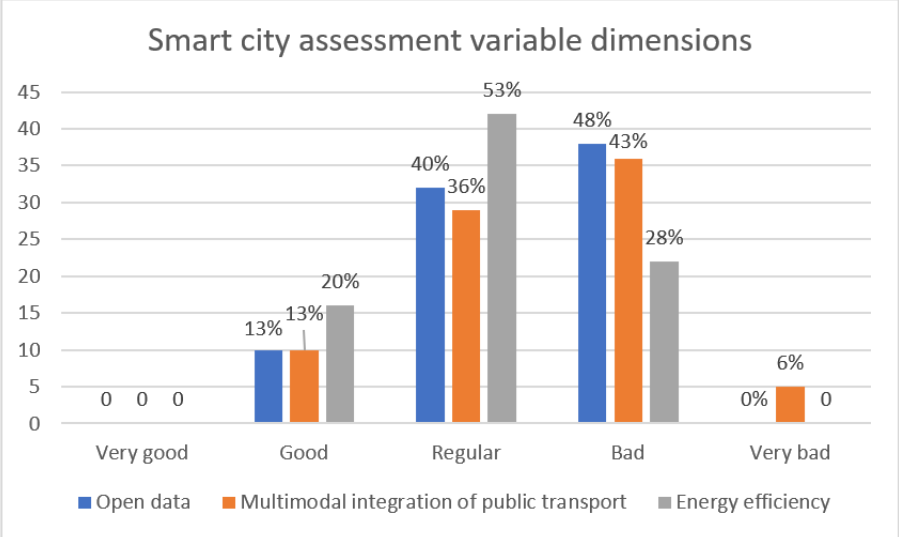

Figure 1. Smart cities assessment.

4.2. Workers' perceptions of the dimensions of the transformation process variable

The results derived from the analysis of the transformation processes provide essential insights into how workers interpret the ongoing transition. The prominent finding that 55% of respondents assess the education of the population as "fair" suggests that there is a widespread perception that the level of education is not reaching its full potential in this context of transformation. In parallel, the strong figure of 50% of respondents rating the municipal budget as "bad" highlights concerns about the allocation of resources to support the changes implemented. These combined results highlight the need to address both the improvement of the education system and the optimisation of financial management in the ongoing transformation processes (**Figure 2**).

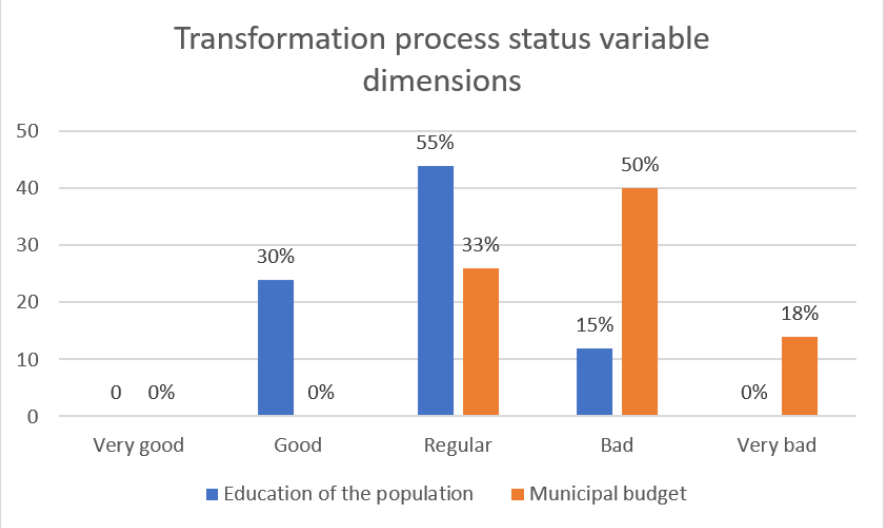

Figure 2. Status of transformation processes.

4.3. Correlation coefficient

As can be seen in **Table 1**, Pearson correlation results have been obtained that provide information on the relationships between the different dimensions analyzed in this study. A statistically significant positive correlation of moderate strength was found between the open data and education dimensions of the population ($r = 0.624$, $p < 0.001$). This indicates that as levels of open data increase, workers reported a higher level of education of the population. Similarly, a strong positive correlation was found between the dimensions multimodal transport integration and population education ($r = 0.890$, $p < 0.001$). This suggests that as the levels of multimodal integration of public transport are higher, so is the level of education of the population. Similarly, there is a strong positive correlation between the dimension's multimodal integration of public transport and municipal budget ($r = 0.798$, $p < 0.001$). This indicates that as levels of multimodal public transport integration increase, workers report higher municipal budgets. On the other hand, a weak relationship was found between the dimensions open data and municipal budget ($r = 0.515$, $p < 0.001$). This means that the behaviour of one dimension has no direct influence on the other.

Table 1. Interrelationships between smart city assessment dimensions and transformation process status dimensions.

	M (DE)	1	2	3	4	5
1) Open Data	3.69 (1.16)		0.611**	0.212	0.624**	0.515**
2) Multimodal Integration of Public Transport	3.06 (1.09)	0.611**		−0.087	0.890**	0.798**
3) Energy Efficiency	2.25 (0.934)	0.212	−0.087		0.197	−0.337**
4) Education of the population	3.25 (1.152)	0.624**	0.890**	0.197		0.732**
5) Municipal Budget	2.81 (0.96)	0.515**	0.798**	−0.337**	0.732**	

Note: ** $p < 0.01$.

5. Proposal

Based on the results of the survey, the following model is proposed to evaluate the transformation processes of smart cities, which helps us to evaluate the current

state of cities and then apply the model and obtain ideal results.

Figure 3 presents us the proposal of this research with a city evaluation model based on the Smart City concept. Through the open data, energy efficiency and smart public transport indicators of the Smart City variable, it highlights the importance of maintaining a high level of social, urban and cultural development in order to be considered a Smart City. Likewise, it should be noted that Smart Cities are the result of society's need to build a sustainable future for future generations, enabling a longer quality of life. To achieve this, ICT will be used to help reduce energy consumption and CO_2 emissions. On the other hand, the government must have management plans to advance the transformation process, taking into account three factors: culture, quality architecture and knowledge for development.

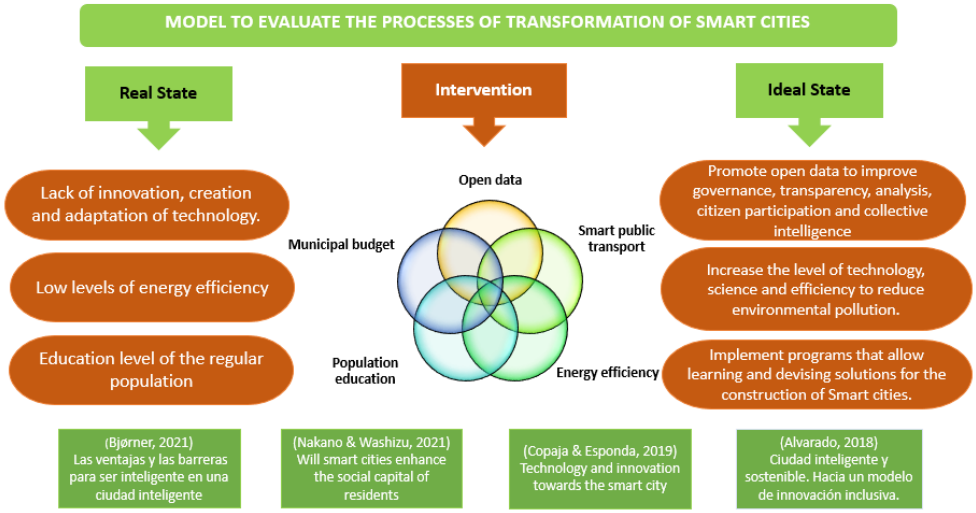

Figure 3. Strategic proposal for assessing smart city transformation in Lima.

6. Discussion

In the graphical representation denoted as **Figure 1**, it can be seen that a significant percentage of 48% of the participants gave a negative evaluation of Lima's open data. This highlights the lack of innovative initiatives and technological adaptation in the region. This lack has an impact on the ability of companies to take advantage of the available information and turn it into substantial sources of revenue. The situation outlined here is in line with the views of Leung and Lam (2021) and Neves et al. (2020), who identify open data as essential to the progress of smart cities. They also highlight its role in improving urban governance, enhancing transparency, analytical capabilities, accurate planning, citizen participation and collective intelligence.

Figure 1 shows that 43% of respondents expressed a negative perception of the multimodal integration of public transport in Lima. This figure points to a relevant issue, namely the need for local governments to take responsibility for managing the technological advances necessary to implement a smart public transport system, in line with the notion of a Smart City. This finding is in line with the approaches presented by Bubelíny and Kubina (2021) and Rojas et al. (2017), who underline the demand for technological improvements in conventional transport systems. These improvements,

in turn, would optimise the efficiency of transport services, an objective that could be achieved by incorporating information and communication technologies to provide additional conveniences and facilities to users.

Figure 1 shows that 53% of the participants consider energy efficiency in Lima to be in a fair state. This indicates the importance of expanding efforts to improve energy efficiency levels in the city. Such an improvement is seen as an essential means to boost the well-being of society through smart actions, which in turn prevent the waste of resources. This is in line with Barr et al. (2021) and Chu et al. (2021), who support this perspective, highlighting how smart cities, as drivers of innovative advantages, reinforce both the technological component and energy efficiency. The latter, in turn, relates to the reduction of environmental pollution, contributing to a healthier environment.

Within the analysis of **Figure 2**, it stands out that a significant 55% of the respondents evaluate the level of education of the population as "fair". This percentage reveals a consensus among a substantial part of the participants regarding the educational situation in the community. This perception implies a key recognition that there is clear scope for improving the educational component in the society. The situation outlined here is in line with the views of Ortiz and Acero Álvarez (2016), who considers that educating the population, especially the youth, implies the development of cities in an innovation ecosystem where learning processes and active participation are developed.

In the context presented in **Figure 2**, it stands out that a considerable 50% of the respondents negatively evaluate the municipal budget as "bad". This provides a clear picture of the general perception of municipalities' financial management. This assessment suggests the need for an in-depth review of the way in which resources are allocated and administered, with the aim of achieving a more effective execution of plans, projects and programmes aimed at fostering economic and social development. The assessment presented in this figure is in line with the arguments presented by Giffinger et al. (2007) and Villarejo (2015), who point out that the limitations that exist on the municipal budget make it difficult to undertake smart city projects, forcing cities to find new ways to transform themselves and provide urban services more efficiently.

7. Conclusion

This study reveals significant aspects of the current state and process of transformation towards smart cities. While confirming the promising potential of these cities to address environmental challenges and improve citizens' quality of life, it is crucial to recognise the key areas for improvement identified through the assessment of the smart city model.

The results underline the need to drive innovation and technological adaptation, particularly evidenced by the low appreciation of open data by municipal officials. This highlights the importance of promoting the reuse of information to generate revenue and improve urban governance. It also highlights the importance of improving public transport management, especially in terms of multimodal integration and service facilitation through information and communication technologies.

Energy efficiency emerges as another crucial area for improvement, as it was rated as fair. It is essential to make progress in the implementation of smart actions that avoid waste of resources and contribute to reducing environmental pollution. In addition, the level of education of the population is identified as a determining factor for progress towards smart cities, underlining the need to promote the development of educational processes and active participation, especially among young people, to strengthen the innovation and technology ecosystem.

Finally, the municipal budget is highlighted as a constraint for the development of smart cities. Efficient resource allocation is crucial to fulfil plans and programmes aimed at economic and social development. In summary, this study provides a valuable information base for understanding the current state and challenges for building more sustainable and liveable cities in the future. It is hoped that these results will contribute to the development of policies and strategies aimed at enhancing the transformation towards smart cities in Lima and other urban areas, promoting quality of life and equality for all citizens.

It is important to recognise that, despite efforts to design a robust and reliable survey instrument, there are potential biases and limitations that need to be taken into account when interpreting the results. One potential limitation of the survey instrument could be related to self-selection of participants, as those who chose to respond may have particular opinions or experiences that differ from those who chose not to participate. In addition, the use of Likert methodology could introduce response bias, where respondents tend to select extreme or neutral responses rather than expressing their views in more detail. Furthermore, the external validity of the instrument could be affected by the context specificity of Lima, Peru, which limits the generalisability of the results to other cities or regions. Despite these potential limitations, measures have been taken to minimise bias and ensure the validity and reliability of the data collected, including the validation of the instrument by experts and the use of appropriate statistical techniques in data analysis.

Author contributions: Conceptualization and methodology, ER and AP; investigation and data curation AD; formal analysis and writing—original draft preparation, GL; writing—review and editing, AP. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

References

Addas, A. (2023). The concept of smart cities: a sustainability aspect for future urban development based on different cities. Frontiers in Environmental Science, 11, 1241593.

Alvarado López, R. A. (2017). Smart and Sustainable City: Towards an inclusive innovation model. PAAKAT: Revista de Tecnología y Sociedad, 7(13), 1–17. https://doi.org/10.32870/pk.a7n13.299

Anschütz, C., Ebner, K., & Smolnik, S. (2024). Size does matter: A maturity model for the special needs of small and medium-sized smart cities. Cities, 150, 104998. https://doi.org/10.1016/j.cities.2024.104998

Barr, S., Lampkin, S., Dawkins, L., et al. (2021). Smart cities and behavioural change: (Un)sustainable mobilities in the neo-liberal city. Geoforum, 125, 140–149. https://doi.org/10.1016/j.geoforum.2021.06.010

Bjørner, T. (2021). The advantages of and barriers to being smart in a smart city: The perceptions of project managers within a smart city cluster project in Greater Copenhagen. Cities, 114, 103187. https://doi.org/10.1016/j.cities.2021.103187

Bubelíny, O., & Kubina, M. (2021). Impact of the concept Smart City on public transport. Transportation Research Procedia, 55, 1361–1367. https://doi.org/10.1016/j.trpro.2021.07.120

Castilla, R., Pacheco, A., & Franco, J. (2023). Digital government: Mobile applications and their impact on access to public information. SoftwareX, 22, 101382. https://doi.org/10.1016/j.softx.2023.101382

Castilla, R., Pacheco, A., Robles, I., et al. (2020). Digital channel for interaction with citizens in public sector entities. World Journal of Engineering, 18(4), 547–552.

Chu, Z., Cheng, M., & Yu, N. N. (2021). A smart city is a less polluted city. Technological Forecasting and Social Change, 172, 121037. https://doi.org/10.1016/j.techfore.2021.121037

Cobas, N., Hernández, A. (2018). Smart cities in the collimator of Havana universities: A review from the spirit of Digital Humanities. Interciencia, 489(20), 313–335.

Copaja-Alegre, M., & Esponda-Alva, C. (2019). Technology and innovation towards the smart city (Indonesian). Avances, perspectivas y desafíos. Bitácora Urbano Territorial, 29(2), 59–70. https://doi.org/10.15446/bitacora.v29n2.68333

Córdova, A. (2017). From traditional city to Smart City (Spanish). Revista Geográfica, 158, 171–187.

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

Dávid, L. D., Archi, Y. E. (2024). Beyond boundaries: Navigating smart economy through the lens of tourism. Oeconomia Copernicana, 15(1), 15–25.

de la Cruz, C., Pacheco, A., Robles, I., et al. (2021). Smart transportation system for public universities. International Journal of Information Technology (Singapore), 13(4), 1643–1647.

Giffinger, R., Fertner, C., Kramar, H., et al. (2007). City-ranking of European Medium-Sized Cities. Available online: https://www.researchgate.net/publication/313716484_City-ranking_of_European_medium-sized_cities (accessed on 2 March 2024).

Gracias, J. S., Parnell, G. S., Specking, E., et al. (2023). Smart Cities—A Structured Literature Review. Smart Cities, 6(4), 1719–1743. https://doi.org/10.3390/smartcities6040080

Guenduez, A. A., Mergel, I., Schedler, K., et al. (2024). Institutional work in smart cities: Interviews with smart city managers. Urban Governance, 4(1), 80–90. https://doi.org/10.1016/j.ugj.2024.01.003

Hashim, H. (2024). E-government impact on developing smart cities initiative in Saudi Arabia: Opportunities & challenges. Alexandria Engineering Journal, 96, 124–131. https://doi.org/10.1016/j.aej.2024.04.008

Huovila, A., Bosch, P., & Airaksinen, M. (2019). Comparative analysis of standardized indicators for Smart sustainable cities: What indicators and standards to use and when? Cities, 89, 141–153. https://doi.org/10.1016/j.cities.2019.01.029

ITU. (2016). Key Performance Indicators: A key element for cities wishing to achieve the Sustainable Development Goals (Spanish). Available online: https://www.itu.int/en/ITU-T/ssc/united/Documents/U4SSC%20Publications/KPIs-for-SSC-concept-note-General-June2020.pdf (accessed on 16 March 2024).

Joyce, A., & Javidroozi, V. (2024). Smart city development: Data sharing vs. data protection legislations. Cities, 148, 104859. https://doi.org/10.1016/j.cities.2024.104859

Lim, J., & Hwang, J. (2024). Exploring diverse interests of collaborators in smart cities: A topic analysis using LDA and BERT. Heliyon, 10(9), e30367. https://doi.org/10.1016/j.heliyon.2024.e30367

Liu, Z., Zheng, H., Gu, J., et al. (2024). Exploring the nexus between green finance and energy efficiency: Unravelling the impact through green technology innovation and energy structure. Heliyon, 10(9), e30141. https://doi.org/10.1016/j.heliyon.2024.e30141

Mak, H. W. L., & Lam, Y. F. (2021). Comparative assessments and insights of data openness of 50 smart cities in air quality aspects. Sustainable Cities and Society, 69, 102868. https://doi.org/10.1016/j.scs.2021.102868

Nakano, S., & Washizu, A. (2021). Will smart cities enhance the social capital of residents? The importance of smart neighborhood management. Cities, 115, 103244. https://doi.org/10.1016/j.cities.2021.103244

Neves, F. T., de Castro Neto, M., & Aparicio, M. (2020). The impacts of open data initiatives on smart cities: A framework for evaluation and monitoring. Cities, 106, 102860. https://doi.org/10.1016/j.cities.2020.102860

Ortiz L. P., Acero Álvarez, M. Á. (2016). Smartkids: building the future of cities through the development of young people's skills (Spanish). Available online: https://www.esmartcity.es/comunicaciones/smartkids-construyendo-futuro-ciudades-traves-desarrollo-competencias-jovenes (accessed on 9 March 2024).

Quiñones, E., Ureña, Y., & Carruyo, N. (2016). Smart city: futuristic vision of the knowledge society in the sucre department-colombia (Spanish). Available online: https://www.redalyc.org/pdf/782/78248283002.pdf (accessed on 7 March 2024).

Rojas, J. P., Bustos, J. C., & Ordóñez Camacho, D. (2017). Smart public transportation at your fingertips (Spanish). Enfoque UTE, 8(1), 122–134. https://doi.org/10.29019/enfoqueute.v8n1.143

Roustaei, M., Niknam, T., Aghaei, J., et al. (2024). Enhancing smart city operation management: Integrating energy systems with a subway synergism hub. Sustainable Cities and Society, 107, 105446. https://doi.org/10.1016/j.scs.2024.105446

Ruiz, J. F. (2015). Urban transformation as a strategy for social change: The case of Bilbao (Spanish). Confines, 21, 155-159.

ur Rehman, U., Faria, P., Gomes, L., et al. (2023). Future of energy management systems in smart cities: A systematic literature review. Sustainable Cities and Society, 96, 104720. https://doi.org/10.1016/j.scs.2023.104720

Villarejo, H. (2015). Smart cities: A European Union commitment to improve urban public services (Spanish). Revista de Estudios Europeos, 66, 25–51.

Yang, R., & Zhen, F. (2024). Smart city development Models: A cross-cultural regional analysis from theory to practice. Research in Globalization, 8, 100221. https://doi.org/10.1016/j.resglo.2024.100221

Zas, B., & Molina, M. (2018). Population education, Proposal of a methodology for the supervision of its processes (Spanish). Revista Novedades En Población, 14(28), 224–230.

Zhu, H., Shen, L., & Ren, Y. (2022). How can smart city shape a happier life? The mechanism for developing a Happiness Driven Smart City. Sustainable Cities and Society, 80, 103791. https://doi.org/10.1016/j.scs.2022.103791

Zhu, J., Gianoli, A., Noori, N., et al. (2024). How different can smart cities be? A typology of smart cities in China. Cities, 149, 104992. https://doi.org/10.1016/j.cities.2024.104992