frontiers | Frontiers in Political Science

TYPE Original Research
PUBLISHED 05 March 2025
DOI 10.3389/fpos.2025.1553177

OPEN ACCESS

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North Bangkok University, Thailand

*CORRESPONDENCE
Rudi Hardi
✉ rudi.hardi.psc22@mail.umy.ac.id

RECEIVED 30 December 2024
ACCEPTED 20 February 2025
PUBLISHED 05 March 2025

CITATION
Hardi R, Nurmandi A, Purwaningsih T and Manaf HA (2025) Smart city governance and interoperability: enhancing human security in Yogyakarta and Makassar, Indonesia. *Front. Polit. Sci.* 7:1553177. doi: 10.3389/fpos.2025.1553177

Smart city governance and interoperability: enhancing human security in Yogyakarta and Makassar, Indonesia

Rudi Hardi[1]*, Achmad Nurmandi[2], Titin Purwaningsih[3] and Halimah Abdul Manaf[4]

[1]Department of Government Affairs and Administration, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia, [2]Department of Government Affairs and Administration, Jusuf Kalla School of Government, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia, [3]Department of Government Affairs and Administration, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia, [4]School of Government, Universiti Utara Malaysia, Sintok, Kedah, Malaysia

Introduction: The global expansion of smart cities has reshaped urban governance; however, their heavy reliance on technological innovation often undermines human security, leading to fragmented, unsustainable, and exclusionary systems that fail to meet the needs of vulnerable populations. This study examines the impact of interoperability on smart city governance (SCG) and its role in enhancing human security in Yogyakarta and Makassar, Indonesia.

Methods: The research explores how interoperability is developed through design processes, government alignment, policy fit, user engagement, change management, governance structure, and service consumption. Data were collected from 315 respondents across 47 government agencies and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM).

Results: The findings indicate that interoperability significantly strengthens SCG and enhances human security. Cross-sector collaboration emerged as a key driver of innovation. Despite challenges such as regulatory resistance and data fragmentation, alignment with the national digital strategy, SPBE policy, and Indonesia's One Data initiative facilitates system integration.

Discussion and conclusion: This study shifts the focus of smart city development from technological advancement to addressing urban vulnerabilities. It provides a blueprint for cities like Yogyakarta and Makassar to integrate local policy frameworks with global standards, thereby promoting responsive and equitable urban governance.

KEYWORDS

smart city, smart city governance, interoperability, human security, vulnerability

1 Introduction

For many people, today's world is an insecure place, full of threats on many fronts. Protracted crises, violent conflicts, natural disasters, persistent poverty, epidemics, and economic downturns impose hardships and undercut prospects for peace, stability, and sustainable development. Such crises are complex, involving multiple forms of human insecurity. When they overlap, they can grow exponentially, spilling into all aspects of people's lives, destroying entire communities, and crossing national borders.

In this context of increasing global insecurity, adopting smart city governance has emerged as an important strategy to address these multifaceted challenges. Smart city governance plays

a critical role in improving public service standards (Gao et al., 2020; Tan and Taeihagh, 2020) and enhancing government process efficiency (Gracias et al., 2023; Kuzior et al., 2023). Indonesia provides a compelling case study for examining the interoperability attributes required for effective governance (Amin et al., 2020; Saiya and Arman, 2018), particularly in cities like Yogyakarta and Makassar. These cities illustrate how smart city initiatives can serve as pivotal instruments for augmenting urban resilience, fostering sustainable growth, and reinforcing human security.

Interoperability, defined as the ability of diverse systems and organizations to work together seamlessly through standardized data, processes, and protocols, is a cornerstone of smart city governance (Quek et al., 2023). By enabling the integration of data from various sources, interoperability facilitates real-time decision-making, efficient service delivery, and cross-sector collaboration. It extends beyond technical capacities, encompassing organizational and human dimensions as well (Mehta and Yadav, 2016).

Global analyses of smart city initiatives have highlighted the critical role of governance in driving urban development (Scholl and AlAwadhi, 2016; Karinda et al., 2024). With the growing urban population in Indonesia, the demands on urban governance structures are intensifying (Colclough et al., 2021), necessitating more efficient and responsive service delivery mechanisms (Xiong et al., 2022). Yogyakarta (Hamdala et al., 2022) dan Makassar (Madani and Nasrulhaq, 2017), two key urban centers in Indonesia, are pioneering innovative smart city solutions to meet these challenges. The implementation of interoperable systems in these cities not only streamlines administrative processes but also enhances transparency and accessibility, strengthening trust and fostering greater citizen participation (Mańka-Szulik and Krawczyk, 2022).

Institutional theory emphasizes the significance of the institutional environment in shaping smart governance practices, where different institutional arrangements can lead to varying implementations of smart city initiatives (Tomor et al., 2021). Complementarily, network governance highlights the necessity of collaborative networks that engage multiple stakeholders in co-creating solutions, aiming to address the limitations of traditional governance structures and foster innovation (Bolívar, 2018, 2016). Under this paradigm, the success of smart city governance largely depends on the capacity for technological and institutional innovation, which mediates the interaction between governance practices and stakeholder outcomes, thereby enhancing overall effectiveness (Bokhari and Seunghwan, 2024; Myeong and Bokhari, 2023).

This article interrogates the intersection of smart city governance and human security, explaining ways in which interoperable systems can reduce urban vulnerability and strengthen socio-economic inclusivity. The study is rooted in the concept of Smart City (Belli et al., 2023) Smart city governance (Broccardo et al., 2019) Organizational Interoperability (Coutinho et al., 2019) and human security (Zhang et al., 2022) how this paradigm interacts to support the development of more efficient and inclusive urban governance. It views interoperability as the core of effective city governance (Quek et al., 2023) where a holistically integrated system improves adaptability and responsiveness to emerging urban complexities.

By positioning interoperability, network governance, and institutional environments as strategic enablers, this study not only provides an in-depth analysis of Smart City operations in Yogyakarta and Makassar but also offers practical and theoretical guidance for Smart City development in other regions of Indonesia and globally to establish more robust human security. Through an exploration of policy frameworks and technological adoption, this study examines how enhanced interoperability can drive smarter, faster, and more inclusive governance. This focus on interoperability strengthens the transformative capacity of digital systems to reduce vulnerabilities, promote economic inclusivity, and safeguard urban populations (Nabi et al., 2023) thereby embedding human security as a foundational pillar of smart city development.

2 Literature review

2.1 Smart city governance

Smart cities represent a recent phenomenon in urban development. The distinction between traditional city development and other forms rests in its construction methodology, operational approach, and service impact (Shi and Cao, 2022). Smart cities evoke images of seamless integration of technology into the urban landscape—sensor-equipped infrastructure, autonomous vehicles, and AI-powered services—all designed to enhance the quality of life and efficiency of urban environments (Liu and Yang, 2022). However, the concept of a smart city extends beyond mere technological advancements; it includes smart city governance (Gracias et al., 2023), a multi-dimensional approach that integrates technology, policy, and citizen engagement to drive sustainable urban development. Smart city governance refers to the structures, policies, and processes that leverage innovative technologies to manage urban areas more effectively (Alshwaheen, 2022). Technology, good governance, environmental concerns and citizens are essential components of an adaptable, sustainable smart city framework (Mupfumira et al., 2024).

Smart city governance involves the use of Information and Communication Technologies (ICT) to transform efficiency, share information with the public, and improve government services, which is especially important given the growing urban population and the need for more effective public services (Raghava Rao and Kumar, 2022). To mitigate the environmental impacts of increasing urbanization, it is essential to prioritize the sustainable development of smart cities. These cities leverage information and communication technology (ICT) to promote sustainability by optimizing resource management and minimizing environmental footprints (Mrabet and Sliti, 2024).

The model synthesizes the smart city ecosystem, which comprises eight (8) components (Figure 1) (Anthopoulos, 2017). These models integrate the cyber-physical ecosystem while addressing concerns through the incorporation of standardization perspectives. Furthermore, following research on the classification of domains in Smart Cities (Anthopoulos, 2015) identified two primary classifications based on the types of infrastructure and urban development, as illustrated in Figure 2 (Samarakkody et al., 2022).

Smart city governance represents a paradigm shift in urban administration (Principale et al., 2023), characterized by its complexity as an institutional transformation (Kim and Kim, 2021), and its inherently political nature (Yolles, 2019), which underscores a compelling. This governance model is distinguished by its collaborative nature, involving an array of stakeholders including government agencies, private enterprises, academic institutions, nonprofit organizations, and citizens (Hwang, 2017). Such inclusivity is indispensable for the effective pooling of resources, knowledge, and expertise, thereby addressing urban challenges robustly (Bradley et al., 2022).

FIGURE 1
Components of smart city.

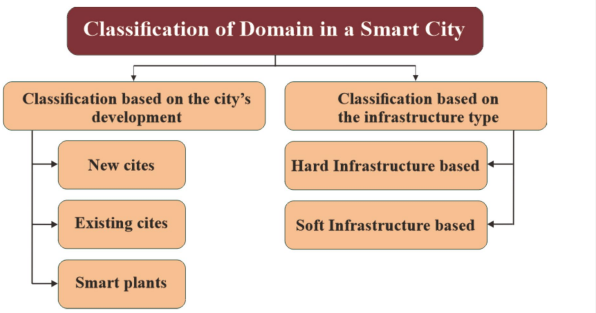

FIGURE 2
Classification of smart cities.

At the core of smart city governance is the imperative to augment the capability of city governments to address both present needs (Tomor et al., 2019) and anticipate future challenges, while promoting economic, social, and environmental sustainability (Tomor et al., 2019). This shift from traditional top-down administrative tactics to a more dynamic, transparent, and inclusive modality is pivotal. In this new governance paradigm, the integration of information and communication technologies (ICTs) enhances service delivery, elevates citizen satisfaction, and optimizes resource management (Wirtz and Müller, 2023). Despite challenges such as privacy, security, and equity concerns, this framework aspires to render cities not only smarter but also more humane and resilient (Vaira, 2022).

Despite the promising potential of smart city governance, the field remains fragmented and lacks a cohesive framework. Consequently, further empirical research is necessary to explore the various pathways and relationships within smart city studies.

2.2 Network governance and institutional theory

The smart city governance model highlights the critical role of stakeholder collaboration, digitalization, and citizen-centric approaches approaches (Nesti, 2020; Palomo-Navarro and Navío-Marco, 2018). Its implementation, however, varies significantly across cities, influenced by distinct institutional contexts that shape both the configuration and effectiveness of smart governance practices (Tomor et al., 2021). These variations underscore the need for context-sensitive strategies to ensure the successful adoption and sustainability of smart governance initiatives.

Network governance in smart cities refers to the collaborative arrangements between various stakeholders, including government entities, private sector actors, and civil society. This model is characterized by decentralized decision-making and the integration of diverse perspectives to address complex urban challenges (Bolívar, 2018, 2016). Effective network governance relies on the establishment

of robust institutional frameworks and the alignment of political interests to foster coordination and accountability.

Institutional theory provides a lens to understand how institutional contexts influence the development and implementation of smart city initiatives. It highlights the role of regulatory, normative, and cognitive institutions in shaping the behaviors and interactions of actors within the smart city ecosystem (Lupo and Carnevali, 2021). Institutional and technological innovations are critical for moderating the relationships between smart city governance, stakeholder satisfaction, and urban outcomes such as crime rates (Bolívar, 2016; Myeong and Bokhari, 2023).

2.3 Categories and attributes of interoperability

The debate of interoperability is significant primarily in situations where data or services are exchanged between two or more systems. Indeed, for such exchanges to be effective, it is imperative that the systems can interact seamlessly, without any hindrances (Blanc-Serrier et al., 2018). Interoperability is defined as the capability of an organization to engage with multiple other entities across data, systems, and processes to attain shared objectives (Kruger, 2022). This involves facilitating the exchange of data and services in accordance with agreements established between the applicant and the service provider.

Expanding on this notion, interoperability is generally recognized as the capacity of two or more systems or components to exchange information and to utilize the exchanged information effectively (Wasala et al., 2015). The format of data and information exchange plays a critical role in enabling interoperability. Consequently, the standardization of these formats is of paramount importance. Through such standardization, interoperability allows disparate information systems and organizations to collaborate efficiently (Amin et al., 2020).

Further delineating the concept, interoperability encompasses various facets, including semantic interoperability, IT interoperability, and organizational interoperability (Blanc-Serrier et al., 2018). To achieve comprehensive interoperability within an organization, four levels must be realized, starting with technical interoperability, followed by syntactic, semantic, and pragmatic levels (Whitman and Panetto, 2006). There are also four distinct types of interoperability, namely technical, syntactic, semantic, and organizational (Rezaei et al., 2014). Each level is integral to the overarching framework of interoperability, as illustrated in Table 1 (Wasala et al., 2015; Amin et al., 2020).

The need for one group to interact in some way with another group underlies the concept of organizational interoperability (Clark et al., 1999). This type of interoperability necessitates a strong will and commitment from the involved organizations to collaborate. The degree of organizational interoperability dictates both internal and external interoperability. Internal interoperability occurs across various data and information sources within an organization, whereas external interoperability facilitates the exchange of performance data between different organizations (Amin et al., 2020).

2.4 Attributes organizational interoperability

The topics of integration, sharing information, and interoperability in government have garnered substantial attention (Kubicek et al., 2011). Organizational interoperability is an essential factor in achieving efficient, integrated, and transparent intergovernmental services, and it is closely associated with IT governance. Furthermore, the public sector views it as an essential requirement for implementing open data policies and consequently implementing open data services (Margariti et al., 2022; Margariti et al., 2020).

TABLE 1 Categories/level and aspect of interoperability.

Categories/level	Aspect
Organizational interoperability	Business process integration beyond the boundaries of a single organization
Semantic interoperability	Ensuring the same meaning of exchanged data through predefined and shared meaning of terms and expressions
Syntactical interoperability	Exchange of information through predefined data format and structure
Technical interoperability	Technical end-to-end exchange of data among systems

Adapted from Wasala et al. (2015) and Amin et al. (2020).

All attributes related to organizational interoperability used in this study are depicted in the following Table 2.

Organizational interoperability represents a significant challenge for organizations as they strive to align their resources—including locations, personnel, products, and software—to function harmoniously by adopting consistent procedures and strategies. To determine the compatibility of different organizations, a comprehensive strategy is essential. This approach should consider several factors, such as procurement criteria, adherence to regulatory frameworks, governance structures, staff restructuring, and patterns of service consumption (Margariti et al., 2022).

2.5 Human security within the framework of governance

Human security has become a pivotal governance framework, emphasizing individual protection over state-centric approaches. Originating from the UNDP's 1994 Human Development Report, this paradigm shift broadens security to encompass economic, social, environmental, and health dimensions (Emetole, 2024; Rao Bonagani, 2024). Ensuring freedom from fear and want remains central to fostering human dignity (Lahiry, 2020, 2024). Human security refers to a condition where individuals, groups, and communities have access to a range of essential options, along with the capacity and freedom to prevent, mitigate, or adapt to threats affecting their human, social, economic, and environmental rights (Eyita-Okon, 2022).

The significance of democratic governance in safeguarding human security is evident, as failures to address socio-economic instability and political violence undermine public trust and exacerbate vulnerabilities (Zua, 2022; Emetole, 2024). These challenges are not confined to specific regions but resonate globally, reflecting the interconnected nature of human security threats (Sprincean et al., 2021). Addressing fundamental needs such as education, health, and food security is vital for enhancing human well-being (Shahnawaz, 2022).

Good governance is essential for human security, as it underpins economic stability and sustainable development (Seifi et al., 2021). Political and social insecurities often impede economic growth,

TABLE 2 Organizational interoperability attributes.

Variable	Indicators
1. Design process	1. Procurement criteria 2. Design methodology 3. Specification process 4. Collaboration 5. Best practices 6. Compatibility with accessibility guidelines and relevant standards
2. Government process alignment	1. Compatibility with intergovernmental legislation issues 2. Certification 3. Compatibility with the National Digital Strategy
3. Compatibility with policies and regulations	1. Compatibility with UU IT 2. Compatibility with SPBE 3. Compliance with 'Satu Data' (One Data)
4. Interaction with users	1. Procedural transparency 2. User Feedback 3. Service level agreement 4. Help Desk
5. Change management	1. Staff restructuring 2. Training 3. Interoperability Learning Profile
6. Service consumption	1. Service agreement (include agreements on service level agreements, data protection, security, and compliance). 2. Organizational culture and governance: establish governance structures that can oversee and coordinate the consumption of services. 3. Resources availability: such as personnel, budget, and technology
7. Governance	1. Coordination 2. Interaction with the Interoperability Guidelines of Information Systems of Indonesian Government Agencies 3. Accessibility to the Indonesian Interoperability Knowledge Base 4. Service Evaluation and Metrics 5. Spread Exploitation of financial resources dedicated to interoperability

Adopted from the article (Margariti et al., 2022; Margariti et al., 2020).

highlighting the need for integrated policies (Farhan, 2023). A constructivist lens offers further insights, emphasizing the role of identity, norms, and cultural factors in shaping security strategies (Pathak, 2021).

Environmental challenges, including climate change and natural disasters, increasingly threaten human security, necessitating robust governance and disaster management frameworks (Chin Sa et al., 2021). Similarly, technological advancements introduce new security dimensions, requiring updated regulatory mechanisms to safeguard rights in the digital age (Sinozic-Martinez and Jahnel, 2024). Human security governance demands a holistic approach integrating economic, social, environmental, and human rights dimensions. Democratic governance plays a crucial role in fostering resilient societies, reinforcing the need for policies that prioritize individual and community well-being.

3 Hypothesis of the influence of interoperability attributes in smart city governance

The passage delves into the critical role of interoperability attributes in advancing smart city governance in Yogyakarta and Makassar, emphasizing their implications for enhancing human security. It critically evaluates how these attributes facilitate the resolution of complex challenges in governmental service delivery, framing the core inquiry around the extent to which the dimensions of interoperability shape the effectiveness and resilience of smart city governance frame. The section proposes a series of theoretical hypotheses regarding how each dimension of the interoperability attribute impacts smart city governance.

3.1 Design process (DP)

The design process for achieving interoperability in smart city governance adopts a holistic approach that integrates technical solutions, policies, procedures, and stakeholder engagement (Quek et al., 2023). This interoperable design process ensures that systems and services operate in harmony and efficiency. It involves more than just compatible technology; it also requires effective integration and coordination across various aspects of city development (Weichhart and Stary, 2018). According to Margariti et al. (2022), the design process in organization interoperability encompasses several components: procurement criteria, design methodology, specification process, collaboration, best practices, and compatibility with accessibility guidelines and relevant standards (Margariti et al., 2022; Margariti et al., 2020). Thus, the hypothesis can be formulated as follows:

> *Hypothesis 1 (H_1)*: Design process influences smart city governance.
>
> *Hypothesis 2 (H_2)*: Design Process increases the use of smart city services.

3.2 Government process alignment (GPA)

The notion of GPA is essential for achieving efficient urban management in smart city governance by ensuring interoperability. The government provides an essential position in the establishment of smart cities, and the efficient integration of government and public data can create a powerful collaboration for city governance (Shi and Cao, 2022). Aligning government processes ensures that legislative frameworks across different levels of government are compatible, promoting seamless cooperation (Egeberg and Trondal, 2016; Finger et al., 2015). Compatibility with the National Digital Strategy guarantees that local initiatives contribute to broader national goals, ensuring coherence and sustainability (Linkov et al., 2018). Therefore, the relevant hypotheses for this aspect are:

> *Hypothesis 3 (H_3)*: The alignment of government processes has an advantageous impact on the governance of smart cities.
>
> *Hypothesis 4 (H_4)*: The alignment of government processes has positive effects on service consumption.

3.3 Compatibility with policies and regulations (CPR)

Interoperability in smart city governance significantly hinges on compatibility with policies and regulations, which serve as the backbone for seamless integration and functionality across various urban systems (Tian, 2021). Alignment with IT law ensures that all digital interactions and data exchanges adhere to established legal frameworks, safeguarding citizen privacy and enhancing trust in the system (Aljeraisy et al., 2022; Neubaum et al., 2023). Furthermore, compatibility with the Electronic-Based Government System (SPBE) streamlines processes, enabling efficient service delivery and resource management (La Adu, 2023; Noman and Emanuel, 2024). Compliance with the 'One Data' policy is equally vital in ensuring data integrity and accuracy across various city sectors (Maail and Cañares, 2018). Therefore, the hypothesis that is significant to this include is:

> *Hypothesis 5 (H_5)*: Compatibility Policies and Regulations exert an impact on the governance of Smart Cities.
>
> *Hypothesis 6 (H_6)*: Compatibility Policies and Regulations exert an influence on the Design Process.
>
> *Hypothesis 7 (H_7)*: Compatibility Policies and Regulations strengthen the affordability of smart city services.

3.4 Interaction with users (IwU)

Interaction with users is significantly influenced by interoperability (Meijer and Bolívar, 2016). This interaction is shaped by four critical indicators: procedural transparency (Skraaning and Jamieson, 2021), user feedback (Jawaheer et al., 2014), Service level agreements (SLAs) (Alsoghayer and Djemame, 2014), and help desk support (Muhtadibillah et al., 2021). Thus, the hypotheses that can be formulated include:

> *Hypothesis 8 (H_8)*: Interaction with Users has a positive influence on Smart City Governance.
>
> *Hypothesis 9 (H_9)*: Interaction with Users has a positive effect on Service Consumption.

3.5 Change management (CM)

The concept of change management within the domain of interoperability arises as a critical factor for the successful evolution and sustainability of urban centers in the discourse of smart city governance (Alanazi and Alenezi, 2024; Asmorowati et al., 2019). In order to facilitate this integration, it is essential to employ change management effectively, particularly through the development of an Interoperability Learning Profile (Ghorbel et al., 2016; Nehiri and Aknin, 2021), comprehensive training, and staff restructuring (McAleavy, 2021). Therefore, the relevant hypothesis is:

> *Hypothesis 10 (H_{10})*: Change Management has an influence on Government Process Alignment.
>
> *Hypothesis 11 (H_{11})*: Change Management has a positive influence on Smart City Governance.

3.6 Service Consumption (SC)

Service consumption in the smart city governance interoperability framework includes three indicators: service agreements (Ivars-Baidal et al., 2024), Organizational Culture and Governance (Scholl et al., 2014), and resource availability (Borruso and Balletto, 2022). Optimizing service consumption through these indicators can significantly advance smart city governance. By fostering a cooperative environment and ensuring strict adherence to agreements and resource commitments, cities can achieve a higher level of interoperability, ultimately improving the quality of urban life (Vercruysse et al., 2019). So, the relevant hypothesis is:

> *Hypothesis 12 (H_{12})*: Service Consumption has a significant influence on Smart City Governance.

3.7 Governance contribution (GC)

Governance in interoperability is not merely a facilitative component but a transformative framework that can significantly advance the capabilities of smart city governance. Through meticulous implementation of its indicators, cities can become more integrated, efficient, and responsive to the needs of their inhabitants (Caird and Hallett, 2019). Relevant hypotheses are:

> *Hypothesis 13 (H_{13})*: Governance Contribution has an influence on Change Management.

> *Hypothesis 14 (H_{14})*: Governance Contribution has an influence on the Design Process.
>
> *Hypothesis 15 (H_{15})*: Governance Contribution has an influence on Smart City Governance.

4 Research methods and design

This research employs quantitative methodology, specifically utilizing regression analysis through Structural Equation Modeling (SEM) with Partial Least Squares (PLS-SEM). This approach facilitates a detailed examination of interoperability within smart city governance, as depicted in the research model (see Figure 3). Data were collected through a comprehensive survey involving 315 respondents from 47 institutions across the city governments of Yogyakarta and Makassar. The survey included 93 statement items across eight variables, rigorously tested to ensure both the validity and reliability of the data.

Quantitative methods are chosen for their ability to leverage standardized and reliable government data, enabling large-scale, objective analysis and statistical generalization, which are essential for comprehensively assessing interoperability's impact on human security and informing evidence-based policy decisions.

The research model was empirically tested through a survey method, using research instruments designed to measure 95 items that capture interoperability attributes. These items were evaluated on a 5-point Likert scale, with 1 = Strongly Disagree (STS), 2 = Disagree (TS), 3 = Less Agree (KS), 4 = Agree (S), and 5 = Strongly Agree (SS).

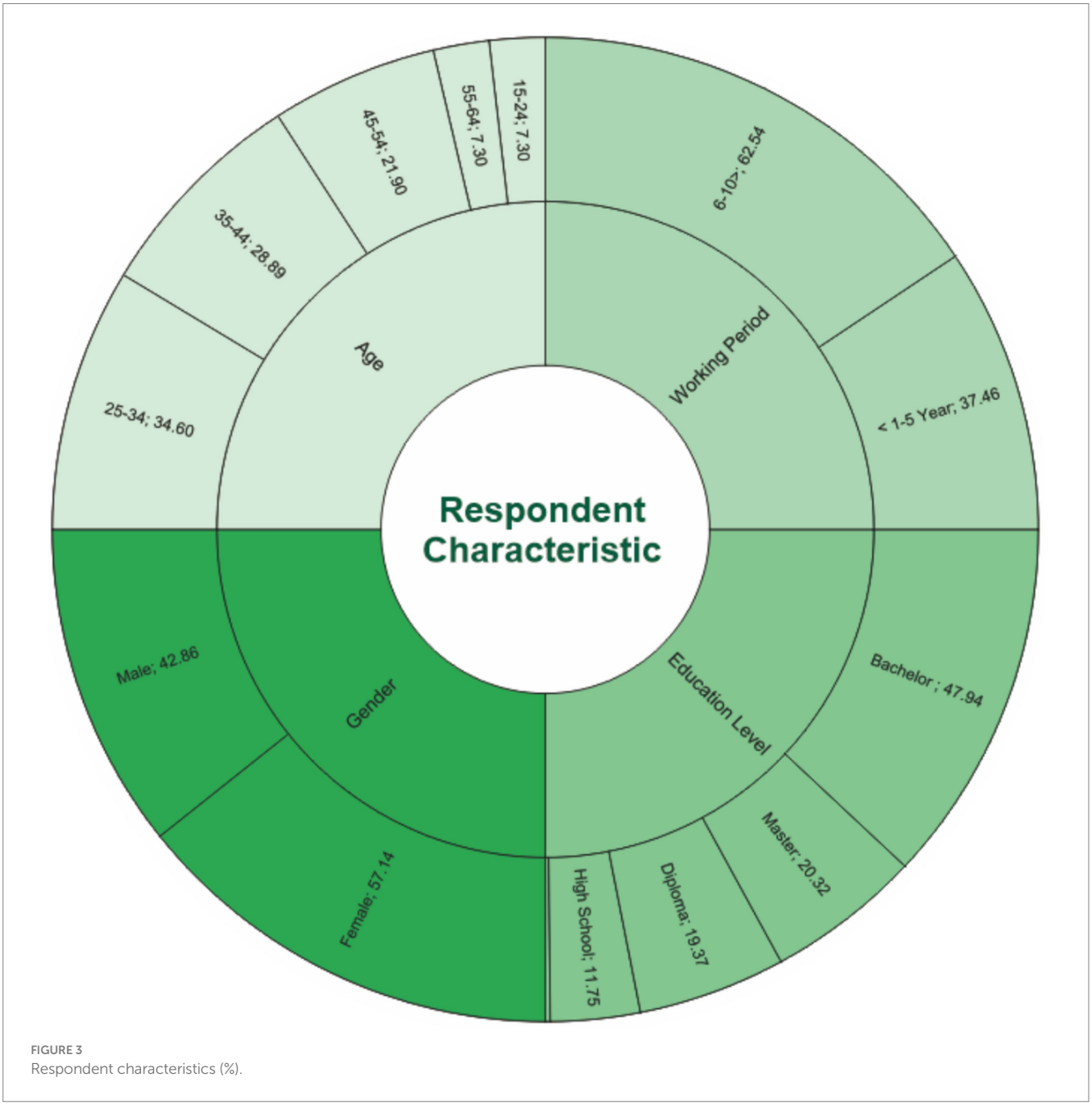

FIGURE 3
Respondent characteristics (%).

The theoretical foundation for the hypotheses in the smart city governance framework underscores the significance of integrating innovative design, effective government processes, proactive user engagement, efficient service delivery, adaptive change management, supportive policies and regulations, and collaborative contributions from various stakeholders. When design and implementation consider these aspects, it is expected to improve governance effectiveness, enhance operational sustainability, and strengthen citizen participation and satisfaction, thereby advancing the achievement of smart city goals in creating a responsive and sustainable environment for human security (Margariti et al., 2022).

Figure 4 presents a conceptual model illustrating the theoretical relationship between the dimensions of Interoperability Attributes and smart city governance, which serves as the foundation for service networks within city governments. This model highlights how effective management of interoperability can mitigate urban vulnerabilities and enhance socio-economic inclusiveness. To address the challenges of smart cities successfully, city governments must effectively manage all seven dimensions of interoperability attributes. This conceptualization establishes a theoretical framework for analyzing integrative services in urban governance and provides a basis for empirical research aimed at improving outcomes by strengthening interoperability in smart city governance.

5 Analysis and results

5.1 Data analysis

The data was analyzed using the Partial Least Squares Structural Equation Modeling (PLS-SEM) method for validation of the research model and hypothesis testing. PLS-SEM has adaptability to a wide range of research scenarios, resilience in handling complex relationships, and suitability for predictive modeling and analysis in a variety of fields.

5.2 Reliability and validity testing

The descriptive statistics of all survey items are presented in Table 2. The results show that most of the respondents surveyed are within the scope of local government employees. This shows that most of the respondents are very familiar with interoperability and smart city activities. The working period of respondents doing activities as employees in the city governments of Yogyakarta and Makassar City is 1–5 years (37.46%) and from 6 to more than 10 years (62.54%). This shows that respondents are familiar with the city governance system in both regions, and the survey information reflects the interoperability attribute framework toward smart city governance. Characteristics of all respondents (percentage) in Figure 3.

Based on construct reliability and validity data (Table 3) on the relationship of interoperability variables with SCG, it is explained that the reliability and validity metrics of constructs, including Cronbach's alpha, composite reliability (rho_a dan rho_c), and the average variance is extracted (AVE), demonstrates strong reliability and validity for this construct. In particular, Cronbach's alpha value for all variables exceeds the generally accepted threshold (i.e., between 0.931 and 0.985) of 0.7, which indicates high internal consistency. The combined reliability score (rho_a and rho_c) is also above the recommended threshold of 0.7, which further confirms the reliability of the construct. The AVE value for most variables exceeded the threshold of 0.5, demonstrate sufficient

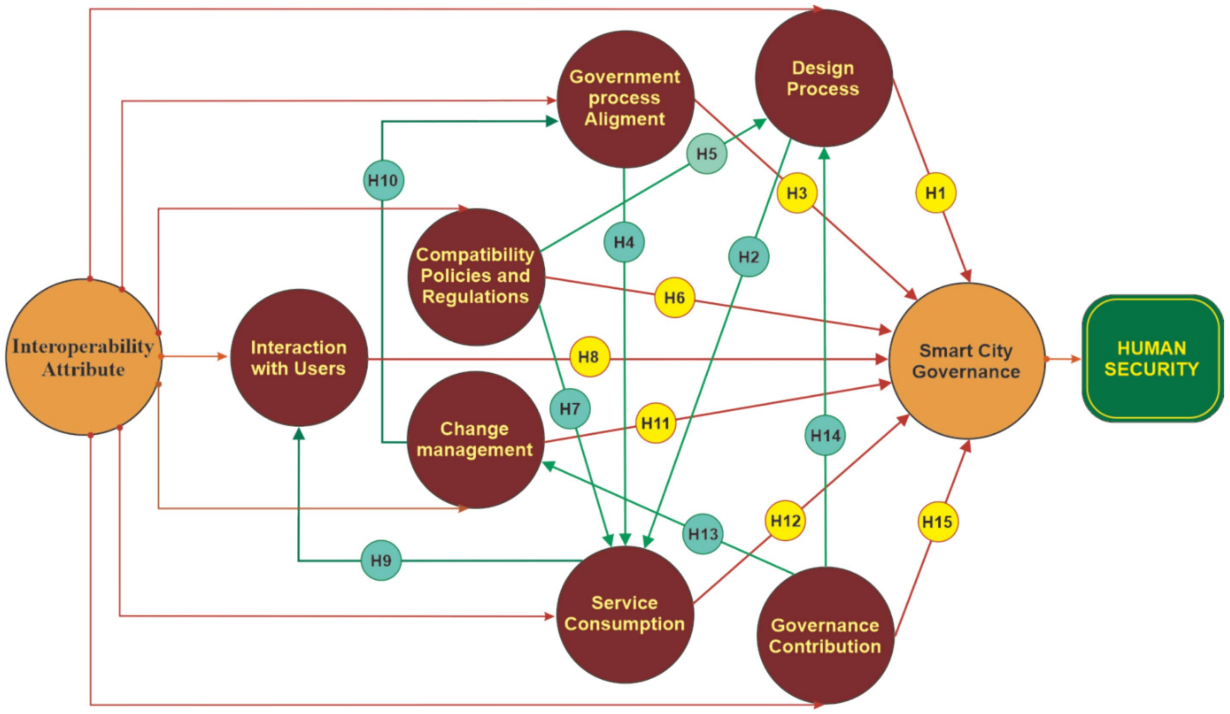

FIGURE 4
Conceptual model of the relationship between interoperability attributes and smart city governance for human security.

TABLE 3 Construct reliability and validity.

Variable	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Change _Management	0.931	0.931	0.942	0.645
Compatibility _Policies and _Regulations	0.983	0.988	0.985	0.880
Design _Process	0.956	0.957	0.960	0.571
Governance _Contribution	0.985	0.988	0.986	0.801
Government _Process _Alignment	0.931	0.934	0.942	0.644
Interaction _with Users	0.948	0.954	0.954	0.636
Service _Consumption	0.949	0.950	0.956	0.686
Smart City _Governance	0.940	0.941	0.949	0.651

convergent validity. In particular, constructions related to Compatibility policies and regulations as well as Governance Contributions show very high reliability and validity, with Cronbach's alpha and composite reliability values approaching 1, and AVE values well above 0.8.

In Table 4, Government Process Alignment (GPA) shows an HTMT value of 0.363 with Smart City Governance (SCG), indicating that GPA and SCG are separate but related constructs. This means that while GPA influences SCG, it stands alone as an independent factor. Effective alignment of government processes significantly impacts SCG, necessitating the overcoming of obstacles in GPA indicators such as legislation, certification, and alignment with national digital strategies to achieve more efficient smart city governance.

The validity of discrimination for Table 4 is the degree at which constructs that should not be correlated with each other are indeed completely uncorrelated. This ensures that each construct in the model is unique and captures a different phenomenon. Discriminatory validity is important to ensure that the analysis performed is accurate and that the constructs used in the model are truly representative of the concept being measured. Heterotrait-Monotrait Ratio (HTMT) calculates the ratio between the mean of the inter-construct correlation (heterotrait) and the mean of the in-construct correlation (monotrait). An HTMT value lower than 0.85 generally indicates good discriminatory validity. Values between 0.85 and 0.90 are still acceptable in some contexts but need further attention. A score above 0.90 indicates a serious criminal validity issue.

Based on the analysis of HTMT values (Table 4), it can be concluded that most of the variables show good discriminatory validity with Smart City Governance, except for Design Process (0.843) and Service Consumption (0.802) which show a very high correlation. This suggests that there is a very close relationship between smart city governance and the Design Process and service consumption, which may require further analysis to ensure adequate validity of discrimination.

5.3 Results testing hypotheses

The path coefficients (Figure 5 and Table 5) are ascertained after running the SEM-PLS algorithm. The algorithm is designed to reject a set of path specific null hypothesis of no effect. Also, the path coefficient from behavioral intention, to use behavior, was both strong and significant. In Figure 6, it is explained that each cell represents the strength of a relationship for a particular combination of relationships and variables, where a higher absolute value indicates a stronger relationship.

5.3.1 Design process for service consumption and SCG

The interoperability attribute of process design significantly affects SCG (H_1). Path coefficients (Table 5) of 0.561 show that every increase of one unit in the process design variable increases SCG by 0.561 units, indicating a strong relationship between these two variables. The statistical value of T of 6,395, well above the significant threshold of 1.96 for a significance level of 0.05, indicates that this result is not a statistical coincidence, but rather shows a real relationship between process design and SCG. The *p*-value of 0.000 underscores the significant impact of the process design variable on SCG, highlighting the critical need for investing in well-designed and structured procurement processes to achieve efficient and effective smart city objectives. Meticulous development and implementation of process design indicators can greatly enhance the quality of SCG. Moreover, the process design for service users (H_2), with path coefficients of 0.631, a T value of 10.629, and a *p* value of 0.000, demonstrates that improvements in process design boost service consumption, thereby reinforcing SCG.

5.3.2 Government process alignment (GPA) on service consumption and SCG

GPA significantly hinders SCG (H_3), as evidenced by a path coefficient of −0.188, a T-value of 3.665, and a *p*-value of 0.000. This finding highlights that misalignments in governance processes can reduce the effectiveness of SCG. Conversely, GPA exhibits a very weak and statistically insignificant positive effect on Service Consumption (H_4), with a path coefficient of 0.063, a *p*-value of 0.328, and a T-value of 0.979. This suggests that GPA does not reliably impact Service Consumption, implying that other factors such as service quality, accessibility, and user interaction may play a more significant role in smart city service usage.

Furthermore, the indirect effect of GPA on SCG via Service Consumption (SC) is minimal and not statistically significant. This effect, calculated by multiplying the path coefficients of the two relationships, results in a small positive value of 0.02268. Given the insignificance of the GPA-SC relationship, this indirect effect does not meaningfully impact SCG. Thus, aligning government processes may not directly or significantly influence SCG through changes in service

TABLE 4 Discriminant validity: Heterotrait-Monotrait Ratio (HTMT).

Variable	Change _ Management	Compatibility _Policies and _ Regulations	Design _ Process	Governance _ Contribution	Government _Process _ Alignment	Interaction _with Users	Service _ Consumption	Smart City _ Governance
Change _ Management								
Compatibility _Policies and _ Regulations	0.111							
Design _Process	0.333	0.122						
Governance _ Contribution	0.273	0.222	0.168					
Government _ Process _Alignment	0.529	0.281	0.445	0.284				
Interaction _with Users	0.532	0.208	0.312	0.280	0.703			
Service _ Consumption	0.399	0.139	0.753	0.248	0.499	0.462		
Smart City _ Governance	0.378	0.172	0.843	0.132	0.363	0.384	0.802	

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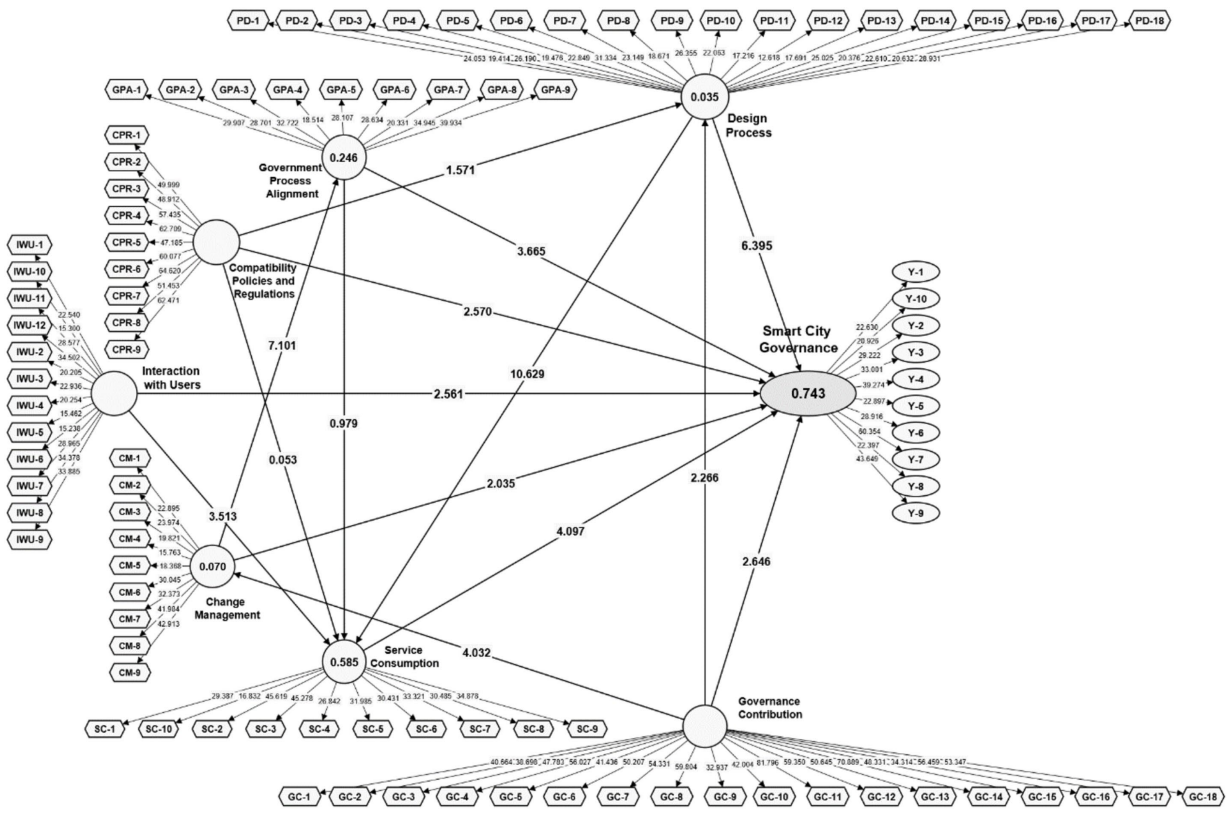

FIGURE 5
Results SEM-PLS.

consumption. Instead, factors like service quality, accessibility, and user interaction likely have a more substantial impact.

5.3.3 Compatibility policies and regulations (CPR) on DP, SC, and SCG

The study indicates that CPR exerts a significant positive effect on SCG (H_5), as evidenced by a path coefficient of 0.086, a T value of 2.570, and a *p*-value of 0.010. This demonstrates that policies and regulations aligned with smart city initiatives enhance the effectiveness of SCG. However, the relatively modest coefficient value suggests that while CPR is important, it must operate in conjunction with other factors such as the DP and SC to holistically influence SCG. Therefore, improvements in CPR should be accompanied by advancements in other areas of SCG to achieve optimal effectiveness.

Furthermore, the alignment of government processes with the DP (H_6) is shown to have a positive impact, with a path coefficient of 0.146. This indicates that enhancing government process alignment can improve the effectiveness of the design process. The statistical significance of this effect is confirmed by a *p*-value of 0.023, which is below the 5% significance level, suggesting that this positive relationship is unlikely to be due to chance. The T-statistic of 2.266 further supports the strength and significance of this effect, surpassing the commonly accepted threshold of 2.0 in statistical assessments.

The relationship between CPR and SC (H_7) demonstrates that CPR exerts a very weak and statistically insignificant influence on SC. The path coefficient is −0.002, indicating a negligible negative relationship, while the T-statistic of 0.053 and *p*-value of 0.958 are well beyond the conventional significance thresholds of 1.96 and 0.05, respectively. These findings clearly indicate the lack of a statistically significant relationship. Consequently, it can be concluded that CPR does not significantly impact SC within the context of this study, and policy or decision-making should not consider CPR as a factor affecting SC. Conversely, the relationship between Service Consumption and SCG is highly significant, with a *p*-value of 0.000 and a positive path coefficient of 0.360, indicating a strong and positive influence of SC on SCG.

5.3.4 Interaction with users (IwU) on SC and SCG

IwU significantly and positively impacts SCG (H_8), as evidenced by a path coefficient of 0.124, a T-statistic of 2.561, and a *p*-value of 0.010. These statistics indicate robust evidence that enhanced user interaction contributes positively to SCG. It underscores the necessity of fostering an environment where citizens feel engaged, heard, and supported in the government's endeavors to implement effective and efficient smart city initiatives. Consequently, city governments must prioritize strengthening user interaction to ensure the success and sustainability of smart city programs.

Furthermore, the direct relationship between IwU and SC (H_9) is significant, with a positive path coefficient of 0.216, a T-statistic of 3.513, and a *p*-value of 0.000. This finding suggests that increased SC substantially improves SCG, contributing an additional 0.07776 to SCG through SC.

5.3.5 Change management (CM) on GPA and SCG

CM significantly influences GPA (H_{10}), with path coefficients of 0.496, a T-statistic value of 7.101, and a *p*-value of 0.000, indicating a

TABLE 5 Path coefficients and the significance of relationships between variables in smart city governance.

The impact relationships variable	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	*p* values	Signifikansi (Decision)
Change _Management → Government _Process _Alignment	0.496	0.501	0.070	7.101	0.000	Accepted
Change _Management → Smart City _Governance	0.081	0.080	0.040	2.035	0.042	Accepted
Compatibility _Policies and _Regulations → Design _Process	0.089	0.093	0.057	1.571	0.116	Rejected
Compatibility _Policies and _Regulations → Service _Consumption	−0.002	−0.001	0.039	0.053	0.958	Rejected
Compatibility _Policies and _Regulations → Smart City _Governance	0.086	0.087	0.033	2.570	0.010	Accepted
Design _Process → Service _Consumption	0.631	0.632	0.059	10.629	0.000	Accepted
Design _Process → Smart City _Governance	0.561	0.575	0.088	6.395	0.000	Accepted
Governance _Contribution → Change _Management	0.264	0.269	0.065	4.032	0.000	Accepted
Governance _Contribution → Design _Process	0.146	0.148	0.064	2.266	0.023	Accepted
Governance _Contribution → Smart City _Governance	−0.074	−0.072	0.028	2.646	0.008	Accepted
Government _Process _Alignment → Service _Consumption	0.063	0.059	0.064	0.979	0.328	Rejected
Government _Process _Alignment → Smart City _Governance	−0.188	−0.188	0.051	3.665	0.000	Accepted
Interaction _with Users → Service _Consumption	0.216	0.219	0.061	3.513	0.000	Accepted
Interaction _with Users → Smart City _Governance	0.124	0.125	0.048	2.561	0.010	Accepted
Service _Consumption → Smart City _Governance	0.360	0.346	0.088	4.097	0.000	Accepted

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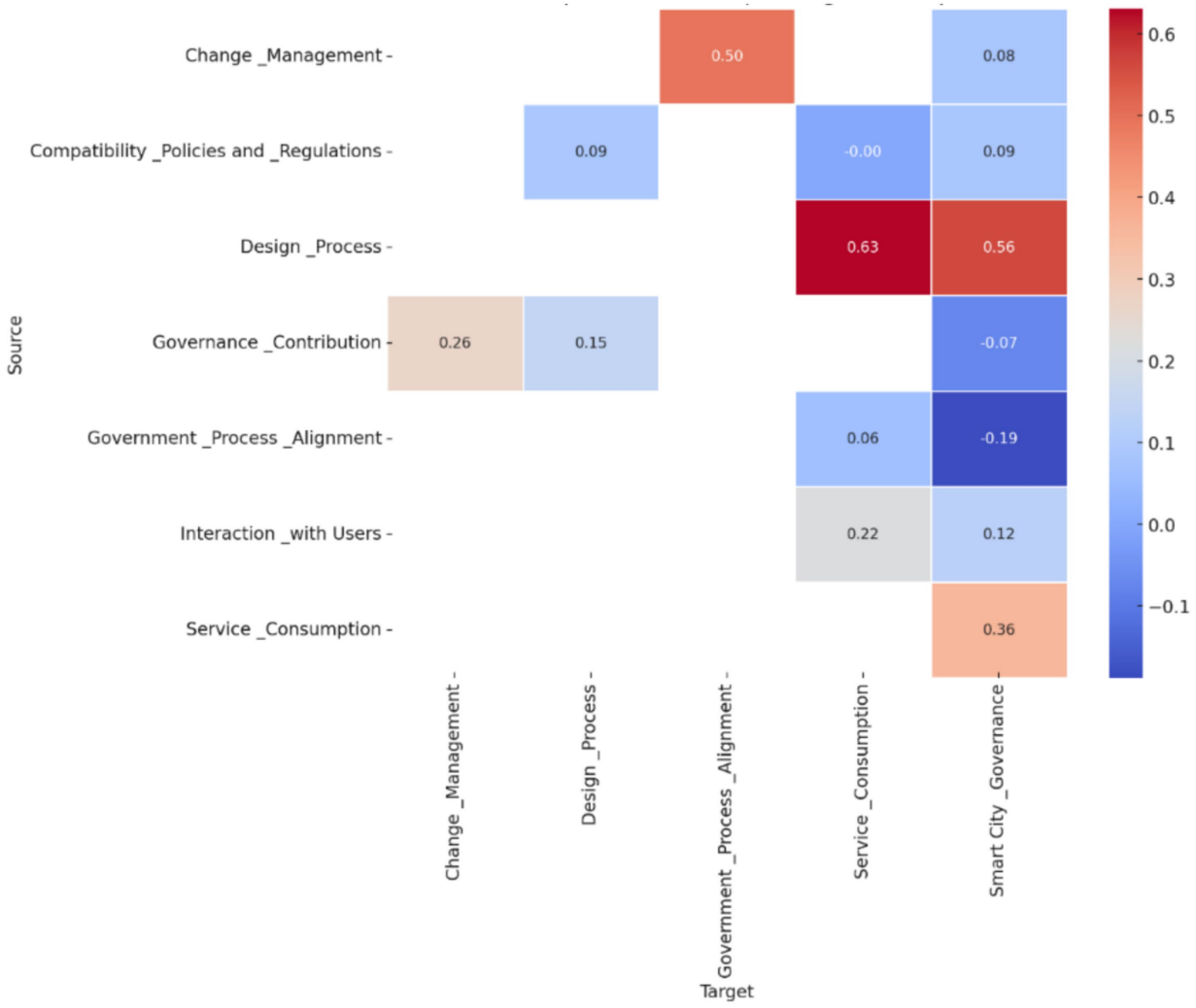

FIGURE 6
The impact relationships variable.

positive and strong effect. Additionally, CM also positively impacts SCG (H_{11}), demonstrated by path coefficients of 0.081, a T-statistic of 2.035, and a *p*-value of 0.042, providing substantial evidence that enhancing CM contributes positively to SCG. However, the indirect relationship between CM and SCG through GPA reveals a negative indirect effect of −0.093248. This suggests that while CM directly improves GPA, better alignment of government processes indirectly reduces the effectiveness of SCG.

5.3.6 Service Consumption (SC) on SCG

SC significantly and positively impacts SCG (H_{12}), as indicated by path coefficients of 0.360, a T-statistic value of 4.097, and a *p*-value of 0.000. These results demonstrate that this relationship is statistically significant, confirming that increased SC directly enhances SCG.

5.3.7 Governance contribution (GC) on CM, DP, and SCG

GC to CM (H13) is highly significant, with path coefficients of 0.264, a T-statistic of 4.032, and a *p*-value of 0.000, indicating a strong positive influence on CM. The indirect effect of GC on SCG through CM is 0.021384, showing that while the direct influence of GC on SCG is negative, its indirect effect via CM is positive. Additionally, the relationship between GC and DP (H_{14}) is significant, with path coefficients of 0.146, a T-statistic of 2.266, and a *p*-value of 0.023, demonstrating a positive influence. The direct relationship between DP and SCG is also significant, with path coefficients of 0.561, a T-statistic of 6.395, and a *p*-value of 0.000, indicating a very strong positive influence. Conversely, the relationship between GC and SCG (H_{15}) shows a negative path coefficient of −0.074, with a T-statistic of 2.646 and a *p*-value of 0.008, indicating a statistically significant but negative influence. However, the indirect influence of GC on SCG through DP is 0.081906, suggesting that despite its direct negative impact, the indirect effect through improvements in DP is positive.

6 Discussion

This study analyzes the 'interoperability attributes' fundamental to Smart City Governance (SCG) in Yogyakarta and Makassar.

Although differing in governance frameworks, both cities demonstrate how interoperability strengthens human security by addressing urban vulnerabilities, providing a robust model for scalable and adaptive urban governance.

6.1 Application of careful aspects of interoperability process design

The integration of interoperability theory into SCG in Yogyakarta and Makassar reflects a vital alignment with human security theory by emphasizing inclusivity, sustainability, and resilience. Interoperability—defined by standardized protocols and strategic procurement (Seth et al., 2025)—ensures that diverse systems communicate effectively, fostering a secure and adaptive urban infrastructure. Yogyakarta's adherence to international technical standards (Colleena and Djunaedi, 2023) demonstrates a commitment to global best practices, while Makassar's engagement with stakeholders highlights the importance of local relevance and scalability in addressing diverse urban needs (Inka, 2024). This collaborative and standardized approach to SCG directly supports human security by prioritizing sustainable development, protecting individuals from systemic vulnerabilities, and ensuring equitable access to resources and services, aligning with the broader goals of innovation and sustainable urban development (Pigola et al., 2022). Such efforts underscore the critical role of governance in safeguarding both individual and collective well-being within dynamic urban environments.

6.2 Harmonization GPA in the human security framework

The findings of the study reveal that the improvement of Government Process Alignment (GPA), encompassing Conformity with Intergovernmental Legislation, Certification, and the National Digital Strategy, does not significantly influence the utilization of Smart Cities (SC) or Sustainable City Governance (SCG) in Yogyakarta and Makassar. This challenges conventional assumptions, suggesting the applicability of institutional theory, particularly institutional isomorphism, wherein coercive, mimetic, and normative pressures promote organizational homogeneity across contexts (Fany, 2022). The diversity of regulations and standards across jurisdictions creates integration challenges that are crucial for advancing smart city initiatives (He et al., 2022). Although certification plays a critical role in ensuring interoperability, its complexity and regional variability underscore the necessity of adopting standardized certification processes (Copei et al., 2021). Moreover, misalignment between local governments and national digital strategies frequently results in fragmented implementation of smart city programs, highlighting the need for improved coordination and alignment to mitigate these challenges (Cranefield and Pries-Heje, 2020). Within the framework of human security theory, these findings emphasize the importance of cohesive governance systems in fostering equitable, inclusive, and resilient urban development.

6.3 Ensuring CPR interoperability in SCG

Interoperability in Smart City Governance necessitates the alignment of policies and standards among systems and entities, with conformance testing serving as a critical mechanism to validate compliance and facilitate seamless data exchange, integration, and collaboration (Sylim et al., 2022). In Indonesia, the IT Law provides a robust legal framework for regulating digital transactions, data management, and cybersecurity within smart cities, fostering public trust and enabling secure interactions across urban services (Sudirman et al., 2024). Complementing this, the Electronic-Based Government System (SPBE) framework promotes an integrated electronic government system by reducing redundancies and enhancing public service delivery through interoperable systems and collaborative governance practices (Asianto et al., 2023). Furthermore, adherence to the One Data Indonesia initiative is essential for ensuring high-quality, accountable data, which underpins effective decision-making processes and strengthens data interoperability (Okafor et al., 2023). When viewed through the lens of human security theory, these initiatives collectively contribute to inclusive and sustainable urban development by enhancing institutional resilience, fostering equitable access to resources, and ensuring the safety and well-being of urban populations through improved governance and service delivery.

6.4 Increased interaction with users (IwU)

Increased interaction with users (IwU) plays a pivotal role in enhancing smart city services (SC) and smart city governance (SCG) by fostering a citizen-centered approach that values user engagement as a driving force for service usage and collaborative governance (Lee, 2023). Transparency in decision-making and well-designed feedback mechanisms not only build trust and accountability but also enable governments to evaluate community satisfaction and adjust policies, accordingly, thereby strengthening the interconnection between SC and SCG (Marfuah and Tobirin, 2024). Sustainable public procurement benefits significantly from user feedback, as input from citizens and suppliers informs governance decisions, ensuring more inclusive and responsive policymaking (Langseth and Moe, 2022). Open feedback channels empower citizens to monitor urban conditions and actively participate in governance processes, promoting transparency and inclusivity (Soegiono and Asmorowati, 2018). Service Level Agreements (SLAs) establish quality benchmarks for SC services, improving urban living standards and enhancing satisfaction, while help desk systems further boost service quality by providing prompt assistance and fostering stronger user engagement (Georgiadis et al., 2021; Nam and Pardo, 2012). These findings underscore the direct influence of IwU on SC usage and its indirect yet critical contribution to SCG, aligning with Human Security Theory by emphasizing the importance of participatory governance, equitable access to resources, and the empowerment of citizens to ensure safety, resilience, and well-being in urban environments.

6.5 Consistence of CM contribution to SCG

The study demonstrates that both CM and GPA significantly and positively contribute to SCG, with CM playing a crucial role through staff restructuring, training, and interoperability learning. Staff restructuring ensures the strategic alignment of human resources with the evolving demands of smart cities, thereby enhancing organizational efficiency, productivity, and competitiveness (Habibi et al., 2023). Training programs are instrumental in equipping personnel with the necessary skills to operate smart city technologies, fostering

competencies in change management, strategic planning, and leadership, which are essential for effective governance in dynamic urban contexts (Ravaghi et al., 2021). Furthermore, coaching interventions that focus on improving the social climate or developing specific skills promote organizational readiness and acceptance of change, enabling institutions to adapt to continuous technological advancements (Taxman et al., 2014). When contextualized within the framework of Human Security Theory, these practices underscore the critical role of capacity building and institutional adaptability in achieving resilient and sustainable urban governance. By prioritizing workforce development and fostering a culture of innovation, CM and GPA contribute to the broader objectives of human security by enhancing safety, stability, and equitable access to resources in smart cities.

6.6 Governance contribution at smart city governance

Effective coordination among government agencies is essential to prevent fragmented efforts and resource duplication, a challenge that remains a significant barrier to achieving interoperability in smart city governance (Sienkiewicz-Małyjurek, 2022). The absence of a unified strategy often results in misaligned goals, further complicating efforts to integrate systems (Ganji Bidmeshk et al., 2022). While the Indonesian Government Agency Information System Interoperability Guidelines are designed to facilitate seamless cooperation across systems, inconsistent adherence to these guidelines fosters the creation of silos, thereby undermining the development of a cohesive smart city infrastructure (Kusumah, 2022). Access to the Indonesian Interoperability Knowledge Base, which offers best practices and technical solutions, is equally critical, as limited access hampers the effective adoption of interoperable solutions and leads to fragmented implementation (Mazimwe et al., 2019). Furthermore, the allocation of financial resources is pivotal for supporting infrastructure investment necessary to drive interoperability adoption. Financial inclusion efforts, such as mobile money services, also require substantial investments to overcome interoperability challenges, underscoring the critical role of financial resources in fostering collaborative governance environments (Senyo et al., 2022). Viewed through the lens of Human Security Theory, these findings emphasize the importance of effective governance, resource equity, and technological inclusivity to ensure the resilience, safety, and well-being of urban populations through integrated and interoperable smart city systems.

6.7 Increasing service consumption for smart city governance

Enhancing interoperability in service consumption is integral to strengthening smart city governance (SCG), as it ensures adherence to service standards, data protection, security, and compliance, thereby fostering citizen trust and satisfaction (Hernández et al., 2020; Schuch et al., 2024). Effective governance structures and an adaptive organizational culture are vital for managing service delivery, resolving coordination challenges, and improving public services to meet the complex demands of urban environments (Sirkoi et al., 2021). The availability of adequate resources—such as skilled personnel, budgetary support, and technological investments—further reinforces interoperability by enabling the adoption of advanced technologies, including cloud platforms and the Internet of Things (IoT), which facilitate seamless integration across systems (Wahyuni et al., 2023). These technologies are essential for promoting sustainable smart cities, as they enable the development of integrated services that reduce environmental impact and improve the efficiency of urban systems (Alanazi and Alenezi, 2023, 2024). Aligned with Human Security Theory, these advancements underscore the importance of inclusive and secure governance structures, equitable resource distribution, and the deployment of environmentally conscious technologies to safeguard the well-being, resilience, and sustainable development of urban populations.

7 Conclusion

This study highlights the importance of interoperability attributes in strengthening smart city governance (SCG) for enhancing human security in Indonesia, especially in Yogyakarta and Makassar. Both cities demonstrate that with the right design process, policy alignment, and increased user engagement, smart city governance can function more effectively and responsively to community needs. By embedding human security considerations, cities can mitigate urban vulnerabilities, ensuring that technological advancements translate into equitable growth and resilience. Interoperability processes that include cross-sector collaboration, use of international standards, and adjustments to local contexts have been shown to improve service quality and public trust.

User engagement, change management, and governance contributions are also important elements that strengthen the relationship between government and citizens, supporting transparency and accountability in decision-making. In addition, technology infrastructure such as IoT and cloud play a significant role in supporting smart service integration, strengthening efficiency, and supporting city sustainability.

Overall, this study underscores that interoperability, when aligned with human security principles, is an important foundation for realizing inclusive, effective, and sustainable smart city governance. By addressing regulatory challenges and increasing organizational capacity, cities in Indonesia can be better prepared for digital transformation and maximize the potential of smart cities to improve people's quality of life.

8 Limitations

This study provides valuable insights into the role of interoperability in enhancing smart city governance (SCG) and human security; however, it is subject to several limitations that should be considered when interpreting its findings. First, its focus on Yogyakarta and Makassar limits the generalizability of the results to other cities with different socio-political, economic, and technological contexts, as urban governance challenges, technological infrastructure, and policy frameworks vary significantly across regions. Second, the reliance on data collected from government agencies, while extensive, may not fully capture the perspectives of other key stakeholders, such as private sector actors, civil society organizations, or marginalized communities, potentially leading to a partial understanding of the broader dynamics

affecting SCG and human security. Lastly, the study's emphasis on integrating local policy frameworks with global standards offers a valuable blueprint but risks overlooking potential tensions between global norms and local priorities, particularly in addressing cultural and institutional specificities. Future research should address these limitations by incorporating diverse stakeholder perspectives, broadening the geographical scope, and employing methodologies capable of capturing non-linear and contextual dynamics to deepen the understanding of SCG's impact on human security.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants or participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

RH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AN: Conceptualization, Formal analysis, Funding acquisition, Project administration, Resources, Supervision, Validation, Writing – review & editing. TP: Conceptualization, Funding acquisition, Supervision, Validation, Writing – review & editing. HM: Data curation, Supervision, Validation, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

References

Alanazi, F., and Alenezi, M. (2023). Software engineering techniques for building sustainable cities with electric vehicles. *Appl. Sci.* 13:8741. doi: 10.3390/app13158741

Alanazi, F., and Alenezi, M. (2024). Interoperability for intelligent traffic management systems in smart cities. *Int. J. Electrical Comput. Eng.* 14, 1864–1874. doi: 10.11591/ijece.v14i2.pp1864-1874

Aljeraisy, A., Barati, M., Rana, O., and Perera, C. (2022). Privacy laws and privacy by design schemes for the internet of things. *ACM Comput. Surv.* 54, 1–38. doi: 10.1145/3450965

Alshwaheen, G. I. A. L. (2022). Urban model of city planning smart cities. *Int. J. Sci. Res. Publ.* 12, 365–367. doi: 10.29322/IJSRP.12.09.2022.p12947

Alsoghayer, R., and Djemame, K. (2014). Resource failures risk assessment modelling in distributed environments. *J. Syst. Softw.* 88, 42–53. doi: 10.1016/j.jss.2013.09.017

Amin, M. M., Sutrisman, A., Stiawan, D., Ermatita, E., Alzahrani, M. Y., and Budiarto, R. (2020). Interoperability framework for integrated e-health services. *Bull. Electrical Eng. Inf.* 9, 354–361. doi: 10.11591/eei.v9i1.1825

Anthopoulos, L. (2015). Defining smart city architecture for sustainability. Electronic government and electronic participation: joint proceedings of ongoing research and projects of IFIP WG 8.5 EGOV and EPart 2015, August 2015, 140–147.

Anthopoulos, L. G. (2017). "Understanding smart cities: the rise of the smart city" in Understanding smart cities: a tool for smart government or an industrial trick? vol. 22.

Asianto, A., Fatonah, N. S., Firmansyah, G., and Akbar, H. (2023). Journal series on governance and management of IT in electronic-based government systems (SPBE) in Indonesia. *Jurnal Indonesia Sosial Sains* 4, 802–814. doi: 10.59141/jiss.v4i09.880

Asmorowati, S., Setijaningrum, E., Suaedi, F., and Fatmawati Dewi, Y. (2019). Smart governance in public financial management: a study of government resources management system (GRMS) in the City of Surabaya. Iapa Proceedings Conference, 481

Belli, L., Davoli, L., and Ferrari, G. (2023). Smart city as an urban intelligent digital system: the case of Parma. *Computer* 56, 106–109. doi: 10.1109/MC.2023.3267245

Blanc-Serrier, S., Ducq, Y., and Vallespir, B. (2018). Organisational interoperability characterisation and evaluation using enterprise modelling and graph theory. *Comput. Ind.* 101, 67–80. doi: 10.1016/j.compind.2018.04.012

Bokhari, S. A. A., and Seunghwan, M. (2024). How do institutional and technological innovations influence the Smart City governance? Focused on stakeholder satisfaction and crime rate. *Sustainability (Switzerland)* 16:4246. doi: 10.3390/su16104246

Bolívar, M. P. R. (2016). "Mapping dimensions of governance in smart cities. Practitioners versus prior research" in ACM international conference proceeding series. eds. Y. Kim and M. Liu, vol. *8-10*. (New York, United States: Association for Computing Machinery), 312–324.

Bolívar, M. P. R. (2018). Governance in smart cities: a comparison of practitioners' perceptions and prior research. *Int. J. E-Plan. Res.* 7, 1–19. doi: 10.4018/IJEPR.2018040101

Borruso, G., and Balletto, G. (2022). The image of the smart city: new challenges. *Urban Sci.* 6:5. doi: 10.3390/urbansci6010005

Bradley, S., Mahmoud, I., and Arlati, A. (2022). Integrated collaborative governance approaches towards urban transformation: experiences from the CLEVER cities project. *Sustain. For.* 14:15566. doi: 10.3390/su142315566

Broccardo, L., Culasso, F., and Mauro, S. G. (2019). Smart city governance: exploring the institutional work of multiple actors towards collaboration. *Int. J. Public Sect. Manag.* 32, 367–387. doi: 10.1108/IJPSM-05-2018-0126

Caird, S. P., and Hallett, S. H. (2019). Towards evaluation design for smart city development. *J. Urban Des.* 24, 188–209. doi: 10.1080/13574809.2018.1469402

Chin Sa, N., Baker, R., Mohd Zainol, N. A., Mohd Zahari, H., Mohd Saud, N. S., and Zainal Ariffin, Z. (2021). Natural disaster: its implication to human security. *J. Defence Manag. Soc. Sci. Human.* 4, 23–35. doi: 10.58247/jdmssh-2021-0401-03

Clark, T., Jones, R., Jones, L., and Pty, C. (1999). Organisational interoperability maturity model for C2. Architecture. Available online at: https://www.semanticscholar.org/paper/Organisational-Interoperability-Maturity-Model-for-Clark/cafb145a69ba790bd3f9fd634fab5a7e865af0e0 (Accessed January 26, 2024).

Colclough, G., González-Gómez, A., Velasco, M., Stevens, J., Goodey, P., Henderson, R., et al. (2021). Governance of City resilience. *Int. J. Urban Plan. Smart Cities* 2, 70–93. doi: 10.4018/IJUPSC.2021070105

Colleena, M., and Djunaedi, A. (2023). Ketersediaan Data dalam Mendukung Pemantauan dan Evaluasi Smart City Maturity (Studi Kasus Kota Yogyakarta). *Jurnal Perencanaan Dan Pengembangan Kebijakan* 3:227. doi: 10.35472/jppk.v3i3.1597

Copei, S., Wickert, M., and Zündorf, A. (2021) in Implementation of a microservice-based certification platform BT - agile processes in software engineering and extreme programming – Workshops. eds. P. Gregory and P. Kruchten (Cham, Switzerland: Springer International Publishing), 186–191.

Coutinho, L. R., Brandão, A. A. F., Boissier, O., and Sichman, J. S. (2019). Towards agent organizations interoperability: a model driven engineering approach. *Appl. Sci.* 9:2420. doi: 10.3390/APP9122420

Cranefield, J., and Pries-Heje, J. (2020). "Moving beyond showcasing: the five faces of leadership in smart city transformation" in 27th European conference on information systems - information systems for a sharing society, ECIS 2019, 1–16.

Egeberg, M., and Trondal, J. (2016). Why strong coordination at one level of government is incompatible with strong coordination across levels (and how to live with it): the case of the European Union. *Public Adm.* 94, 579–592. doi: 10.1111/padm.12236

Emetole, C. C. (2024). Implications of democratic governance on human security in Nigeria. *J. Glob. Soc. Sci.* 5, 110–121. doi: 10.58934/jgss.v5i20.310

Eyita-Okon, E. (2022). Urbanization and human security in post-colonial Africa. *Front. Sustain. Cities* 4:917764. doi: 10.3389/frsc.2022.917764

Fany, Y. G. (2022). Coercive, mimetic, and normative isomorphism studies on the implementation of teacher certification policies in Indonesia. *Int. J. Soc. Sci. Bus.* 6, 77–82. doi: 10.23887/ijssb.v6i1.42609

Farhan, A. A. (2023). Challenges to sustainable development in Iraq: human security issues. *Tikrit J. Polit. Sci.* 2, 3–22. doi: 10.25130/tjfps.v2i32.188

Finger, M., Crettenand, N., and Lemstra, W. (2015). The alignment framework. *Compet. Regul. Netw. Ind.* 16, 89–105. doi: 10.1177/178359171501600202

Ganji Bidmeshk, O., Mehraeen, M., Pooya, A., and Maharati, Y. (2022). Exploring the factors in aligning information systems and organizational strategies in tall organizational structures in an uncertain environment. *Electronic J. Inf. Syst. Dev. Countries* 88:e12205. doi: 10.1002/isd2.12205

Gao, Z., Wang, S., and Gu, J. (2020). Public participation in smart-city governance: a qualitative content analysis of public comments in urban China. *Sustain. For.* 12:8605. doi: 10.3390/SU12208605

Georgiadis, A., Christodoulou, P., and Zinonos, Z. (2021). Citizens' perception of smart cities: a case study. *Appl. Sci.* 11:2517. doi: 10.3390/app11062517

Ghorbel, L., Zayani, C. A., and Amous, I. (2016) in A novel architecture for learner's profiles interoperability. ed. R. Lee (Cham, Switzerland: Springer International Publishing), 97–108.

Gracias, J. S., Parnell, G. S., Specking, E., Pohl, E. A., and Buchanan, R. (2023). Smart cities—a structured literature review. *Smart Cities* 6, 1719–1743. doi: 10.3390/smartcities6040080

Habibi, F., Sumartono, S., Santoso Haryono, B., and Khairul Muluk, M. (2023). Downsizing organization: a systematic literature review. *J. World Sci.* 2, 1542–1552. doi: 10.58344/jws.v2i10.435

Hamdala, M. R., Perdana, D., and Tri Hanurato, I. A. (2022). Capacity & coverage analysis for planning Yogyakarta smart city's network (use case: LoRaWAN). 2022 IEEE Asia Pacific conference on wireless and Mobile (APWiMob), 1–6.

He, W., Li, W., and Deng, P. L. (2022). Legal governance in the smart cities of China: functions, problems, and solutions. *Sustain. For.* 14:9738. doi: 10.3390/su14159738

Hernández, J. L., García, R., Schonowski, J., Atlan, D., Chanson, G., and Ruohomäki, T. (2020). Interoperable open specifications framework for the implementation of standardized urban platforms. *Sensors* 20:2402. doi: 10.3390/s20082402

Hwang, S. (2017). Collaborative governance and information technology innovation: public–nonprofit partnerships to build neighborhood information systems. *Int. Rev. Public Adm.* 22, 321–343. doi: 10.1080/12294659.2017.1368005

Inka. (2024). Smart City Makassar Terbaik, Duduki Peringkat Ketiga se-Asia Tenggara. Https://Rakyatsulsel.Fajar.Co.Id. Available online at: https://rakyatsulsel.fajar.co.id/2024/05/05/makassar-smart-city-terbaik-duduki-peringkat-ketiga-se-asia-tenggara/ (Accessed July 15, 2024).

Ivars-Baidal, J., Casado-Díaz, A. B., Navarro-Ruiz, S., and Fuster-Uguet, M. (2024). Smart tourism city governance: exploring the impact on stakeholder networks. *Int. J. Contemp. Hosp. Manag.* 36, 582–601. doi: 10.1108/IJCHM-03-2022-0322

Jawaheer, G., Weller, P., and Kostkova, P. (2014). Modeling user preferences in recommender systems. *ACM Trans. Interact. Intell. Syst.* 4, 1–26. doi: 10.1145/2512208

Karinda, K., Nursin, E., Sawir, M., and Sriyakul, T. (2024). Potential and challenges of digital governance at the local level in Central Sulawesi, Indonesia. *J. Contemp. Govern. Public Policy* 5, 135–152. doi: 10.46507/jcgpp.v5i2.246

Kim, C., and Kim, K. (2021). The institutional change from E-government toward smarter city; comparative analysis between Royal Borough of Greenwich, UK, and Seongdong-gu, South Korea. *J. Open Innov.: Technol. Mark. Complex.* 7:42. doi: 10.3390/joitmc7010042

Kruger, B. (2022). Interoperability – the key enabler of e- government. The Interoperable Europe Academy, 8–10. Available online at: https://joinup.ec.europa.eu/node/705192 (Accessed April 23, 2024).

Kubicek, H., Cimander, R., and Scholl, H. J. (2011). Organizational interoperability in E-government. *Angew. Chem. Int. Edit.* 6, 951–952. doi: 10.1007/978-3-642-22502-4

Kusumah, M. I. (2022). Information system interoperability strategy to support command and control of border security operations in the north Natuna Sea. *Int. J. Soc. Sci. Hum. Res.* 5, 295–304. doi: 10.47191/ijsshr/v5-i1-40

Kuzior, A., Pakhnenko, O., Tiutiunyk, I., and Lyeonov, S. (2023). E-governance in smart cities: global trends and key enablers. *Smart Cities* 6, 1663–1689. doi: 10.3390/smartcities6040078

La Adu, A. (2023). Evaluation of SPBE service maturity level in Central Maluku District government using SPBE 2020 framework. *JIKO (Jurnal Informatika Dan Komputer)* 6, 13–20. doi: 10.33387/jiko.v6i1.5422

Lahiry, S. (2020). The changing narrative of security discourse: from state security to human security in South Asia? *World Affairs* 183, 183–205. doi: 10.1177/0043820020921153

Lahiry, S. (2024). Gender-human security interface: critical perspectives with special reference to India. *Discover Glob. Soc.* 2:13. doi: 10.1007/s44282-024-00037-9

Langseth, M., and Moe, H. T. (2022). Driving through dense fog: a study of the effects and control of sustainable public procurement of electric cars. *Environ. Syst. Decis.* 42, 572–585. doi: 10.1007/s10669-022-09854-2

Lee, S. (2023). The acceptance model of smart city service: focused on Seoul. *Sustain. For.* 15:2695. doi: 10.3390/su15032695

Linkov, I., Trump, B. D., Poinsatte-Jones, K., and Florin, M. V. (2018). Governance strategies for a sustainable digital world. *Sustainability (Switzerland)* 10, 1–8. doi: 10.3390/su10020440

Liu, Y., and Yang, K. (2022). Communication, sensing, computing and energy harvesting in smart cities. *IET Smart Cities* 4, 265–274. doi: 10.1049/smc2.12041

Lupo, G., and Carnevali, D. (2021). "Lawyers and smart technologies: experiences of apps' development in a justice environment" in CEUR workshop proceedings. eds. S. Virkar, N. Edelmann, M. Janssen, T. Lampoltshammer, I. Lindgren and L. A. Munozet al., vol. *3049*. (Aachen, Germany: CEUR-WS), 177–189.

Maail, A. G., and Cañares, M. P. (2018). Policy recommendations for the implementation of "one data" policy at sub-national level in Indonesia. *SSRN Electron. J.* doi: 10.2139/ssrn.3275137

Madani, M., and Nasrulhaq, M. (2017). Concept of smart city governance in Makassar City. Proceedings of the international conference on administrative science (ICAS 2017), 154–156.

Mańka-Szulik, M., and Krawczyk, D. (2022). Optimizing the provision of public services by local administration as a component of the smart city concept on the example of Zabrze. *Manag. Syst. Prod. Eng.* 30, 192–199. doi: 10.2478/mspe-2022-0024

Marfuah, S. R., and Tobirin. (2024). Analysis of the role of agile governance in the development of the smart city concept: a qualitative study of the Banyumas regency government, Indonesia. *Open Access Indonesia J. Soc. Sci.* 7, 1659–1670. doi: 10.37275/oaijss.v7i4.260

Margariti, Vicky, Anagnostopoulos, D., Papastilianou, A., Stamati, T., and Angeli, S. (2020). Assessment of organizational interoperability in e-government. Proceedings of the 13th international conference on theory and practice of electronic governance, 298–308.

Margariti, V., Stamati, T., Anagnostopoulos, D., Nikolaidou, M., and Papastilianou, A. (2022). A holistic model for assessing organizational interoperability in public administration. *Gov. Inf. Q.* 39:101712. doi: 10.1016/j.giq.2022.101712

Mazimwe, A., Hammouda, I., and Gidudu, A. (2019). An empirical evaluation of data interoperability—a case of the disaster management sector in Uganda. *ISPRS Int. J. Geo Inf.* 8:484. doi: 10.3390/ijgi8110484

McAleavy, T. (2021). Interoperability and standardization: lessons from the fruit-bowl. *Disaster Prevent. Manag. Int. J.* 30, 480–493. doi: 10.1108/DPM-12-2020-0359

Mehta, S. K., and Yadav, K. K. (2016). Planning for a smart city with a human face in developing India. *Int. J. Sustain. Built Environ.* 3, 13–20. doi: 10.24102/IJSLUP.V3I2.708

Meijer, A., and Bolívar, M. P. R. (2016). Governing the smart city: a review of the literature on smart urban governance. *Int. Rev. Adm. Sci.* 82, 392–408. doi: 10.1177/0020852314564308

Mrabet, M., and Sliti, M. (2024). Integrating machine learning for the sustainable development of smart cities. *Front. Sustain. Cities* 6:1449404. doi: 10.3389/frsc.2024.1449404

Muhtadibillah, A., Sukmana, H. T., and Rozy, N. F. (2021). An evaluation of helpdesk with gamification using Indeks Kepuasan Masyarakat (IKM). *IAIC Trans. Sustain. Digit. Innov. (ITSDI)* 1, 8–17. doi: 10.34306/itsdi.v1i1.8

Mupfumira, P., Mutingi, M., and Sony, M. (2024). Smart city frameworks SWOT analysis: a systematic literature review. *Front. Sustain. Cities* 6:1449983. doi: 10.3389/frsc.2024.1449983

Myeong, S., and Bokhari, S. A. A. (2023). Building participative E-governance in smart cities: moderating role of institutional and technological innovation. *Sustainability (Switzerland)* 15:5075. doi: 10.3390/su152015075

Nabi, A. U., Snoussi, T., and Abdalkareem, Z. A. (2023). A review of IoT convergence in healthcare and smart cities: challenges, innovations, and future perspectives. *Babylonian J. Internet Things* 2023, 23–30. doi: 10.58496/BJIoT/2023/004

Nam, T., and Pardo, T. A. (2012). Transforming city government. Proceedings of the 6th international conference on theory and practice of electronic governance, 310–319.

Nehiri, N., and Aknin, N. (2021). A proposed Learner's data model: integrating informal learning and enhancing personalization and interoperability. *Int. J. Emerg. Technol. Learn. (IJET)* 16:173. doi: 10.3991/ijet.v16i08.19833

Nesti, G. (2020). Defining and assessing the transformational nature of smart city governance: insights from four European cases. *Int. Rev. Adm. Sci.* 86, 20–37. doi: 10.1177/0020852318757063

Neubaum, G., Metzger, M., Krämer, N., and Kyewski, E. (2023). How subjective norms relate to personal privacy regulation in social media: a cross-national approach. *Soc. Media Soc.* 9, 1–12. doi: 10.1177/20563051231182365

Noman, E. P., and Emanuel, A. W. R. (2024). E-government maturity analysis using the Layne and Lee, Hiller and Belanger, and SPBE models. *JITK (Jurnal Ilmu Pengetahuan Dan Teknologi Komputer)* 9, 284–291. doi: 10.33480/jitk.v9i2.5110

Okafor, C. C., Ferrer-Conill, R., and Helle, S. (2023). Data quality assessment in smart cities datafication. Paper presented at AoIR2023: The 24th Annual Conference of the Association of Internet Researchers. Philadelphia, PA, USA: AoIR, 2–3.

Palomo-Navarro, Á., and Navío-Marco, J. (2018). Smart city networks' governance: the Spanish smart city network case study. *Telecommun. Policy* 42, 872–880. doi: 10.1016/j.telpol.2017.10.002

Pathak, T. (2021). Engagement of constructivism with the human security theory. *J. Manag. Public Policy* 13, 49–61. doi: 10.47914/jmpp.2021.v13i1.004

Pigola, A., Da Costa, P. R., Mazieri, M. R., and Scafuto, I. C. (2022). Collaborative innovation: a technological perspective. *Int. J. Innov.* 10, 204–211. doi: 10.5585/iji.v10i2.22256

Principale, S., Cosentino, A., Lombardi, R., and Rocchi, A. (2023). Public administration in smart city: a bibliometric analysis. *J. Public Aff.* 23:e2863. doi: 10.1002/pa.2863

Quek, H. Y., Sielker, F., Akroyd, J., Bhave, A. N., von Richthofen, A., Herthogs, P., et al. (2023). The conundrum in smart city governance: interoperability and compatibility in an ever-growing ecosystem of digital twins. *Data Policy* 5:e6. doi: 10.1017/dap.2023.1

Raghava Rao, K., and Kumar, D. S. (2022). "Smart City governance using big data technologies" in Advanced analytics and deep learning models. (Hoboken, New Jersey, United States: Wiley), 311–324.

Rao Bonagani, R. (2024). India's public policies for providing human security to its citizens: an analysis. *Res. J. Human. Soc. Sci.* 15, 225–237. doi: 10.52711/2321-5828.2024.00034

Ravaghi, H., Beyranvand, T., Mannion, R., Alijanzadeh, M., Aryankhesal, A., and Belorgeot, V. D. (2021). Effectiveness of training and educational programs for hospital managers: a systematic review. *Health Serv. Manag. Res.* 34, 113–126. doi: 10.1177/0951484820971460

Rezaei, R., Chiew, T. K., and Lee, S. P. (2014). An interoperability model for ultra large scale systems. *Adv. Eng. Softw.* 67, 22–46. doi: 10.1016/j.advengsoft.2013.07.003

Saiya, A. A., and Arman, A. A. (2018). Indonesian Enterprise architecture framework: a platform for integrated and connected government. 2018 International conference on ICT for smart society (ICISS), 1–6.

Samarakkody, A., Amaratunga, D., and Haigh, R. (2022). Characterising smartness to make smart cities resilient. *Sustainability (Switzerland)* 14:12716. doi: 10.3390/su141912716

Scholl, H. J., and AlAwadhi, S. (2016). Smart governance as key to multi-jurisdictional smart city initiatives: the case of the eCityGov Alliance. *Soc. Sci. Inf.* 55, 255–277. doi: 10.1177/0539018416629230

Scholl, H. J., Jurisch, M., Krcmar, H., and Scholl, M. C. (2014). Building sound foundations for smart city government. *Int. J. E-Plan. Res.* 3, 1–22. doi: 10.4018/ijepr.2014100101

Schuch, R., Frantz, R. Z., Bocanegra, J., Roos-Frantz, F., Sawicki, S., and Molina-Jiménez, C. (2024). "Digital services integration in smart cities: a trusted execution environment based solution" in Anais do XXVII Congresso Ibero-Americano Em Engenharia de software (CIbSE 2024), 437–438.

Seifi, A., Razmkhah, N., and Pletnev, D. (2021). Economic dimension of the right to sustainable development: good governance and human security. *E3S Web Conf.* 258:05012. doi: 10.1051/e3sconf/202125805012

Senyo, P. K., Karanasios, S., Gozman, D., and Baba, M. (2022). FinTech ecosystem practices shaping financial inclusion: the case of mobile money in Ghana. *Eur. J. Inf. Syst.* 31, 112–127. doi: 10.1080/0960085X.2021.1978342

Seth, M., Jalo, H., Högstedt, Å., Medin, O., Sjöqvist, B. A., Candefjord, S., et al. (2025). Technologies for Interoperable Internet of Medical Things Platforms to Manage Medical Emergencies in Home and Prehospital Care: Scoping Review. *J Med Internet Res*, 27:e54470. doi: 10.2196/54470

Shahnawaz, S. (2022). State of human security in security state: a case study of Pakistan. *GMPI Conf. Ser.* 1, 54–62. doi: 10.53889/gmpics.v1.85

Shi, D., and Cao, X. (2022). Research on the effectiveness of government governance in the context of smart cities. In F. Cen and G. Tan (Eds.), International conference on intelligent traffic systems and smart city (ITSSC 2021) (Vol. 12165, p. 5). Zhengzhou, China: SPIE.

Sienkiewicz-Małyjurek, K. (2022). Interpretive structural modelling of inter-agency collaboration risk in public safety networks. *Qual. Quant.* 56, 1193–1221. doi: 10.1007/s11135-021-01172-0

Sinozic-Martinez, T., and Jahnel, J. (2024). TA for human security: aligning security cultures with human security in AI innovation. *TATuP - Zeitschrift Für Technikfolgenabschätzung in Theorie Und Praxis* 33, 16–21. doi: 10.14512/tatup.33.2.16

Sirkoi, K. R., Omboto, P., and Musebe, R. (2021). Perceived influence of performance standard on quality public service delivery in national government administration in Elgeyo Marakwet County, Kenya. *East African J. Interdis. Stud.* 3, 116–127. doi: 10.37284/eajis.3.1.318

Skraaning, G., and Jamieson, G. A. (2021). Human performance benefits of the automation transparency design principle. *Hum. Factors J. Hum. Factors Ergon. Soc.* 63, 379–401. doi: 10.1177/0018720819887252

Soegiono, A. N., and Asmorowati, S. (2018). Revitalising democratic local governance: enhancing citizen access and participation through smart city. Proceedings of the 2018 Annual Conference of Asian Association for Public Administration: "Reinventing Public Administration in a Globalized World: A Non-Western Perspective" (AAPA 2018), 191(Aapa), 483–492.

Sprincean, S., Sohotchi, T.-S., and Mitrofanov, G. (2021). Protection and safety of individuals: challenges of human security in a global context. *Int. Relat. Plus* 1, 188–199. doi: 10.52327/1857-4440.2021.1(19).22

Sudirman, L., Manurung, K. J. P., and Disemadi, H. S. (2024). Transforming Indonesian law: paving the way for smart city development. *Amnesti: Jurnal Hukum* 6, 1–24. doi: 10.37729/amnesti.v6i1.3418

Sylim, P. G., Lu, J. L., and Marcelo, P. G. F. (2022). Discoursing terminology standards and interoperability in relation to the Philippine eHealth strategy. *Acta Med. Philipp.* 56, 106–117. doi: 10.47895/amp.v56i1.3937

Tan, S. Y., and Taeihagh, A. (2020). Smart city governance in developing countries: a systematic literature review. *Sustain. For.* 12:899. doi: 10.3390/SU12030899

Taxman, F. S., Henderson, C., Young, D., and Farrell, J. (2014). The impact of training interventions on organizational readiness to support innovations in juvenile justice offices. *Adm. Policy Ment. Health Ment. Health Serv. Res.* 41, 177–188. doi: 10.1007/s10488-012-0445-5

Tian, L. (2021). Smart-city regulation. *McGill GLSA Res. Ser.* 1, 1–34. doi: 10.26443/glsars.v1i1.150

Tomor, Z., Meijer, A., Michels, A., and Geertman, S. (2019). Smart governance for sustainable cities: findings from a systematic literature review. *J. Urban Technol.* 26, 3–27. doi: 10.1080/10630732.2019.1651178

Tomor, Z., Przeybilovicz, E., and Leleux, C. (2021). Smart governance in institutional context: an in-depth analysis of Glasgow, Utrecht, and Curitiba. *Cities* 114:103195. doi: 10.1016/j.cities.2021.103195

Vaira, V. (2022). Smart city governance and the challenge of digital platforms within the public sector. 2022 IEEE international smart cities conference (ISC2), 1–7.

Vercruysse, K., Dawson, D. A., and Wright, N. (2019). Interoperability: a conceptual framework to bridge the gap between multifunctional and multisystem urban flood management. *J. Flood Risk Manag.* 12, 1–11. doi: 10.1111/jfr3.12535

Wahyuni, H., Mutiarin, D., Kumorotomo, W., Pribadi, U., and Ismail, N. S. A. (2023). Maturity of employment data interoperability in supporting one employment data at the ministry and regional government level. *Jurnal Studi Pemerintahan* 14, 326–346. doi: 10.18196/jsp.v14i3.325

Wasala, A., Buckley, J., Schäler, R., and Exton, C. (2015). An empirical framework for evaluating interoperability of data exchange standards based on their actual usage: A case study on XLIFF. *Comput. Stand. Interfaces* 42, 157–170. doi: 10.1016/j.csi.2015.05.006

Weichhart, G., and Stary, C. (2018) in Interoperable process design in production systems. eds. C. Debruyne, H. Panetto, G. Weichhart, P. Bollen, I. Ciuciu and M.-E. Vidalet al. (Cham, Switzerland: Springer International Publishing), 26–35.

Whitman, L. E., and Panetto, H. (2006). The missing link: culture and language barriers to interoperability. *Annu. Rev. Control.* 30, 233–241. doi: 10.1016/j.arcontrol.2006.09.008

Wirtz, B. W., and Müller, W. M. (2023). An integrative collaborative ecosystem for smart cities—a framework for organizational governance. *Int. J. Public Adm.* 46, 499–518. doi: 10.1080/01900692.2021.2001014

Xiong, J., Xu, Z., Li, L., and Liu, X. (2022). The effect of cross-boundary supply on the accessibility of public services in urban governance: an example of Shanghai. *Sustain. For.* 14:12771. doi: 10.3390/su141912771

Yolles, M. (2019). Governance through political bureaucracy: an agency approach. *Kybernetes* 48, 7–34. doi: 10.1108/K-09-2017-0329

Zhang, Y., Jiang, T., Sun, J., Fu, Z., and Yu, Y. (2022). Sustainable development of urbanization: from the perspective of social security and social attitude for migration. *Sustain. For.* 14:10777. doi: 10.3390/su141710777

Zua, B. (2022). Citizens without security in Nigeria's democratic dispensation. *Int. J. Educ. Soc. Sci. Res.* 5, 121–132. doi: 10.37500/IJESSR.2022.5308