Towards Developing An Integrated Framework For Evaluation Smart Sustainable Cites

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Abstract. *Modern cities face increasing challenges, including rapid population growth, resource depletion, and rising pollution levels. Addressing these issues necessitates innovative solutions that combine advanced technologies such as the Internet of Things (IoT) and artificial intelligence (AI) with environmental sustainability and social equity. This paper proposes an integrated evaluation framework for smart sustainable cities, focusing on harmonizing technological advancements with environmental conservation, social inclusivity, and economic growth. The framework assesses existing evaluation methodologies, identifies their strengths and limitations, and introduces a cohesive model to enhance urban resilience and livability.*
Keywords: *Smart Sustainable Cities, IoT, Urban Sustainability, Technological Integration, City Assessment Framework*

INTRODUCTION

Rapid urbanization in the 21st century has intensified the challenges faced by cities worldwide, including resource scarcity, environmental degradation, and socioeconomic inequality. At the intersection of these challenges lies the concept of smart, sustainable cities, which leverage technology and sustainability principles to improve urban living conditions. This paper explores the integration of information and communication technologies (ICTs) and environmental policies to create an actionable evaluation framework for smart sustainable cities.

Research Problem: Existing city assessment systems lack a unified methodology that effectively integrates smart technologies and sustainability goals. This paper aims to bridge this gap.

Research Objective: To propose a comprehensive evaluation framework for smart sustainable cities by analyzing existing assessment models and introducing an integrated system. (Nam, 2012)

Theoretical Framework

Smart Cities

Smart cities utilize IoT, AI, and big data technologies to enhance urban services, improve citizen engagement, and optimize resource usage. The key components include the following (Khansari, 2013): 1) 1- Smart mobility, 2- Smart Environment, 3- Smart Governance.

Sustainable Cities

Sustainable cities emphasize resource efficiency, environmental conservation, and social inclusivity. The key principles include the following (Ferraro, 2013, March) (Holland, 2008): 1- Renewable energy adoption; 2- Waste minimization; and 3- Community development.

Synergy between Smart and Sustainable Cities

Smart and sustainable cities are deeply interconnected. Smart technologies facilitate data-driven decision-making, whereas sustainability ensures long-term environmental and social benefits. :

Figure 1: Conceptual Model of Smart Sustainable City Integration (by the researchers)
This model illustrates the integration of smart city technologies and sustainability principles across five core dimensions: economic impact, technological innovation, environmental sustainability, social inclusivity, and governance. Each dimension interacts dynamically to ensure cities achieve resilience, efficiency, and inclusivity. The model emphasizes the role of the IoT, AI, and data analytics in driving sustainable urban development while addressing environmental concerns and social equity showing figure 1.

Table 1. Review of Existing Assessment Systems

	LEED	BREEAM	CASBEE	Estidama
Developer	Leadership in Energy and Environmental Design. U.S	Building Research Establishment Environmental Assessment Method UK	Comprehensive Assessment System for Built Environment Efficiency Japan	Estidama is a building design methodology for sustainably constructing and operating buildings and communities. Abu Dhabi
Year	1998	1990	2001	2008
Focus Areas	Energy efficiency, sustainable materials, indoor environmental quality	Environmental impact, resource management, innovation	Building quality, energy efficiency, material sustainability	Environmental, economic, and cultural sustainability
Strengths	Internationally recognized, well-structured criteria	Comprehensive environmental criteria, flexible application	Strong focus on environmental performance	Adapted to regional context, holistic approach
Weaknesses	Costly certification, limited to specific building types	Complex evaluation process, regional variations	Limited international recognition	Limited scalability outside the region

Logo	(Humbert, 2007)	(Global, 25May,2013)	(Environmental, 31st August, 2008)	(Municipality, April 2010)
Rating	Platinum, Gold, Silver And Certified.	Outstanding, Excellent, Very Good, Good and Pass	Superior (S), Very Good (A), Good(B+) , Slightly Poor(B-) and Poor (c)	5 Pearl, 4 Pearl, 3 Pearl, 2 Pearl, 1 Pearl

Table 1 provides a comparative analysis of four major city assessment frameworks: **LEED (USA), BREEAM (UK), CASBEE (Japan), and Estidama (UAE)**. Each system evaluates urban sustainability based on key focus areas such as energy efficiency, resource management, and environmental impact.

- **LEED** is globally recognized with structured sustainability criteria but has high certification costs.
- **BREEAM** offers a flexible and comprehensive environmental assessment but varies regionally.
- **CASBEE** emphasizes environmental performance but has limited international recognition.
- **Estidama** integrates regional sustainability principles but lacks scalability beyond Abu Dhabi.

These systems highlight the strengths and limitations of current evaluation methodologies, underscoring the need for a **more integrated and adaptable framework** for assessing smart sustainable cities

Table 2. Measures of frequency standards for variables in sustainable systems

Sustainable Rating systems / Sustainable Components		variables	Leed	Breeam	Casbee	Estidama
1	Governance	Consultation plan		●		
		Consultation and engagement	●			
		Community management	●	●		●
		Design review	●	●		
		Environmental Management Plan	●		●	
		Innovation	●	●		●
		Sustainability Awareness	●		●	
		Accredited Professional	●			
			87.5%	50%	25%	25%
2	Economy	Economic impact	●	●		●
		Local Food Production	●			
		Digital Economy				●
		Regional Materials			●	●
			50%	25%	0%	75%
3	Transport and	Transport assessment		●		
		Bicycle facilities	●			●

		Network Public transport facilities		●	●	
		cycling network	●			
			50%	50%	25%	25%
4	Social and cultural	Community Development		●		●
			0%	100%	0%	100%
5	Environmental	Ecology strategy		●		
		Low impact materials		●		
		Energy strategy		●		
		Renewable Energy Production	●		●	●
		Natural Systems			●	●
		Rainwater Management	●			
		Solar orientation	●			●
		Rainwater Management	●			
			50%	37.5%	25%	37.5%
	TOALL	100	37.5	27.5	15	25

Table 2 evaluates sustainable rating systems (**LEED, BREEAM, CASBEE, and Estidama**) based on their incorporation of key sustainability components, including **governance, economy, transport, social and cultural factors, and environment**.

- **Governance**: LEED and BREEAM emphasize consultation, engagement, and innovation, while CASBEE and Estidama show limited focus.
- **Economy**: LEED and Estidama consider economic impact and regional material use, whereas CASBEE lacks strong economic indicators.
- **Transport**: BREEAM and LEED prioritize public transport and cycling networks, while CASBEE and Estidama have lower emphasis.
- **Social & Cultural**: BREEAM leads in community development, whereas LEED and CASBEE show minimal focus.
- **Environmental**: All systems integrate energy strategies, but LEED and BREEAM emphasize renewable energy and resource management more effectively.

This comparison highlights **the fragmented approach in existing systems** and reinforces the need for a **comprehensive evaluation framework** that balances technological advancements with sustainability objectives.

Figure 2: Proposed Smart Sustainable City Assessment Framework (by the researchers)
This framework highlights six core dimensions: the smart economy, smart governance, smart mobility, the smart environment, smart living, and smart people. The surrounding layers represent each dimension's key performance indicators (KPIs). Dynamic arrows illustrate the integration and interaction between dimensions, emphasizing a comprehensive and data-driven approach to evaluating smart sustainable cities showing in figure 2.

- **Smart Economy**: Focuses on innovation, entrepreneurship, and digital transformation to drive economic growth.
- **Smart Governance**: Ensures transparency, stakeholder engagement, and data-driven decision-making.
- **Smart Mobility**: Integrates intelligent transport systems, sustainable mobility solutions, and urban connectivity.
- **Smart Environment**: Emphasizes resource efficiency, pollution reduction, and green infrastructure.
- **Smart Living**: Enhances citizens' quality of life through digital inclusion, health services, and smart urban planning.
- **Smart People**: Promotes education, social engagement, and skill development for a knowledge-driven society.

Smart city
"A creative metropolis that blends elements of intellect and utilizing technology to enhance services and infrastructure while integrating stakeholder engagement into governance along with "Greater reliance on technologies, such as remote sensing and communications and information technologies, to improve the efficiency of energy networks, transportation, and other systems, making the city more coordinated, networked, and smart in its actions and initiatives. Logistics services" are two definitions that characterize a smart city completely. Technology can help improve communication between services and actors. The requirements of the present generation are satisfied through sustainable urban expansion, improved social, administrative, economic, environmental, logistical, and competitive outcomes, and the provision of a sustainable living environment for its residents. (Bouskela, 2016) (.Sumarsono. Surahyo)

Key groups to describe smart cities.
Smart cities leverage technology to enhance urban efficiency, sustainability, and quality of life. The core components include the following: 1- **Smart Mobility:** Advanced transportation systems reducing congestion and emissions; 2- **Smart Economy:** Fostering innovation, digital commerce, and local entrepreneurship; 3- **Smart Environment:** Sustainable energy practices and pollution control; 4- **Smart Governance:** Transparent, participatory decision-making processes., as shown in Table 3.

Table 3. Key features and dimensions of smart cities

Dimension	Description	Examples
Smart Economy	Focuses on innovation, entrepreneurship, and competitiveness.	Digital marketplaces, e-commerce hubs.
Smart Governance	Promotes transparency, participatory decision-making, and efficient public services.	E-government, open data platforms.
Smart Mobility	Ensures efficient and sustainable transportation systems with integrated digital infrastructure.	Autonomous vehicles, smart traffic systems.
Smart Environment	Aims for sustainable resource management and reducing environmental impact.	Renewable energy grids, green buildings.
Smart Living	Enhances quality of life through improved healthcare, safety, and cultural access.	Telemedicine, smart security systems.

Smart People	Encourages education, creativity, and active community participation.	Online learning platforms, community apps.
Smart Infrastructure	Provides the digital and physical backbone for city operations, ensuring efficiency and scalability.	IoT networks, cloud computing systems.

This table highlights the **complementary nature** of sustainable and smart cities, where sustainability focuses on long-term environmental and social goals. In contrast, smart cities emphasize leveraging **technology** to achieve efficiency, innovation, and improved quality of life. (Cities, 2014)

Smart and sustainable cities
Table 4: Comparison between the sustainable city and the smart city

Aspect	Sustainable City	Smart City
Focus	Environmental protection, resource efficiency, and long-term sustainability.	Technology-driven solutions, innovation, and digital transformation.
Primary Goal	Achieving environmental, social, and economic sustainability.	Enhancing quality of life, efficiency, and connectivity.
Key Technologies	Renewable energy, waste management systems, green infrastructure.	IoT, AI, big data, cloud computing, smart devices.
Governance	Policies and regulations for sustainability and environmental conservation.	Digital governance, open data platforms, e-governance.
Mobility	Sustainable transportation, reduced carbon emissions.	Smart traffic systems, autonomous vehicles.
Community Role	Active participation in sustainability initiatives.	Engagement through digital platforms and apps.
Infrastructure	Eco-friendly buildings, green spaces, resilient infrastructure.	Digital infrastructure, IoT networks, smart grids
Measurement	Environmental and social impact assessments.	Data analytics, real-time monitoring, performance KPIs.
Outlook	Long-term environmental and social balance.	Real-time adaptability, innovation, and efficiency.

A comparison between sustainable and smart cities highlights their complementary approaches to urban development. Sustainable cities focus on environmental protection, resource efficiency, and long-term balance and rely on renewable energy, green infrastructure, and eco-friendly policies. In contrast, smart cities leverage advanced technologies such as the IoT, AI, and big data to enhance efficiency, innovation, and citizen engagement. While sustainable cities prioritize long-term environmental and social goals, smart cities emphasize real-time adaptability and digital integration. Together, they create a resilient, connected, and future-ready urban environment. (ESCWA., 2019)

Smart systems
The authors chose four classification systems based on their importance. It reflects diverse regional contexts and presents the most important strengths and weaknesses, as well as the method for evaluating each system to see an integrated picture of the systems and reach a unified, intelligent integrated system, as shown in Tables 5 and 6.

Table 5. Comparison of TWD, IMD, and BSI

	TUW	IMD	BSI
Developer	The Economist Intelligence Unit Limited, Vienna UT, (Giffinger, October 2007)	The IMD World Competitiveness Centre, Singapore	The British Standards Institution UK (BSI., 2013)
Year	2007	2019	2015
Categories	• Smart mobility • Smart Economy • Smart environment • Smart governance • Smart living • Smart people • Social and Human Capital It is calculated by taking the average by summing the values and dividing them by their number instead of summing all the indicators. (Sarma, October 2016)	Five major areas are used to evaluate each pillar: • Governance • Activities, • Safety, • Mobility, • Activities, • Opportunities, • Health. A "rating scale" (ranging from AAA to D) is awarded to each HDI group of cities according to how that city's views compare to those of all the other cities in that group.	Datasets needed to support city projects. • Health = 2% • Energy = 6% • Transport and Mobility = 12% • Technology = 13% • Infrastructure = 13% • Innovation = 3% • Social/community = 18% • Geo-spatial = 5% • Natural Environment = 2% • Water = 2% • Built Environment = 5% • Economic = 9% • Logistics = 2% • Communications = 8%
Deidentification	These comparative studies assess and rank cities based on many economic, social, and geographic factors to identify the best (and worst) locations for particular types of activity. A top ranking in a well-known city enhances its international image, making it a valuable tool for marketing strategies. As a result, cities frequently use city rankings to raise their profile and strengthen their position in the competition amongst cities.	"Systematically verify the facts" on the ground and continue to prioritize the opinions of citizens and local actors. This index will remain a "work in progress" as new data, issues, and opinions gather around it and the questions it raises. Its coverage will also increase over time, significantly exceeding the 102 cities in this first edition. (Lanvin, 2019)	Smart city infrastructure sectors, such as communications, IT, and electronics, enable and support this interaction. A common theme in smart city prototyping is using sensors to collect data from the city, which can, through platforms, be integrated, stored, analyzed, and displayed. This provides decision support to city actors who can then act and make changes, whose impact can, in turn, be measured (Department for Business, October 2013) (Consultants, 2013)

Advantages and disadvantages of evaluation This evaluation is characterized by its focus on details, which gives applicable results, but it can reinforce existing stereotypical models. The methodological aspects of the assessment are not transparent in data collection and processing, as shown in Table 5 (BEHZADFAR, 2017).
Accordingly, it can be concluded that IDMand BSI occupy first place among the components of sustainability standards and second place among TUW.

Table 6. Measures of frequency standards for variables in smart systems TUW, IDM, and BSI

	variables		TUW	IDM	BSI
1	Smart Government 1-	Contributing to the innovation industry	●		
		Consultation and engagement	●	●	●
		Community management	●	●	●
			100%	67%	67%
2	Smart Transport	Local mobility	●	●	
		Car-sharing Apps		●	●
		Vehicle recognition			●
		Safe and sustainable transportation systems	●	●	●
			50%	75%	75%
3	Smart environment	Energy ratings			●
		pollution	●	●	
		environment protection	●	●	●
		Recycling services		●	●
			50%	75%	75%
4	Smart life	CCTV cameras			●
		Online reporting of city maintenance		●	
		Free public Wi-Fi	●	●	●
		Traffic monitoring			●
		Educational events	●	●	
		Arranging medical appointments online		●	●
		Tourism (tourist attraction)	●	●	●
			42.9%	71.5%	71.5%
5	Smart individuals	Minorities feel welcome	●	●	
		Contributing to long-term education	●	●	●
		Ethnic and social pluralism	●		●
		Flexibility	●		●
		creativity	●	●	
		Most children have access to a good school.		●	●
		Contributing to public life	●	●	
			85.8%	71.5%	57.2%
6	Smart Economy	Innovative spirit	●	●	
		Businesses are creating new jobs.		●	●
		Economic image and branding	●	●	●
		Productivity	●		
		Labor market flexibility		●	●
		International Relations	●		●
			50%	50%	67%
	TOTAL	100	31.8	34.3	33.9

Table 6 compares three smart city evaluation systems—**TUW, IDM, and BSI**—based on key smart city components, including **governance, transport, environment, smart living, smart individuals, and economy**.

- **Smart Governance**: All systems emphasize community engagement and innovation, with TUW having the highest contribution.
- **Smart Transport**: IDM and BSI prioritize sustainable mobility and vehicle recognition, while TUW focuses more on local transport solutions.
- **Smart Environment**: BSI and IDM integrate pollution control and energy efficiency, whereas TUW has a lower emphasis.
- **Smart Living**: Free public Wi-Fi, city maintenance reporting, and tourism services are widely supported, with IDM and BSI having stronger implementations.
- **Smart Individuals**: TUW leads in promoting social diversity and education, while IDM and BSI emphasize flexibility and public engagement.
- **Smart Economy**: All systems assess innovation, economic branding, and job creation, but BSI shows a broader focus.

This comparison reveals **variations in smart city evaluation methodologies**, highlighting the need for **an integrated framework that aligns technology with sustainability and social well-being**

Proposed Smart City Assessment Criteria

Since smart cities may help achieve sustainability and ultimately become smart and sustainable cities based on their respective indicators, there is a close and significant connection between smart cities and sustainable cities. In Table No. 7, to empower planners and decision makers and make room for evaluating each city to meet the requirements of a smart, sustainable city, the goal is to build a unified system for assessing smart cities and sustainable cities by linking indicators.

Table 7. Proposed assessment of the sustainable and smart city framework (by the researchers)
Sustainable City (Criteria) – Smart City (Criteria)

Category	Sustainable City Indicators	Smart City Indicators
Economy	• Economic Impact	• Innovative Spirit
	• Local Food Production	• Businesses Creating New Jobs
	• Regional Materials	• Digital Economy
	• Productivity	• Economic Image and Branding
Government	• Consultation Plan	• Contributing to Innovation Industry
	• Community Management	• Transparency via Technology
	• Sustainability Awareness	• E-Governance Implementation
Transport	• Transport Assessment	• Smart Mobility (e.g., EV Charging)
	• Public Transport Facilities	• Car-Sharing Apps
	• Cycling Network	• Sustainable Transport Systems
Social and Cultural	• Community Development	
	• Equity and Inclusion	• Social Pluralism
Environmental	• Renewable Energy Production	• Pollution Control
	• Low Impact Materials	• Recycling Services
	• Rainwater Management	• Energy Efficiency Ratings
Smart Individuals	• Contributing to Long-Term Education	

	• Ethnic and Social Pluralism •Most Children Have Access to a Good School	• Flexibility •Participation •Creativity

This study relied on the descriptive-analytical approach, considered the most appropriate for analyzing the reality of the study's aspects. This approach suits the research topic and objectives and helps achieve more accurate and realistic results. This approach also enables the effective use of research tools, with a focus on logical analysis, to extract reliable results that reflect the actual reality of the study. The study aims to establish an international classification system for sustainable smart cities by evaluating the various factors and variables contributing to their development.

After completing the data collection process from all sample members, the researcher carefully reviewed the questionnaire to ensure the completeness of the data and the accuracy of the information entered, in addition to verifying the response rate and the percentage of missing data. After completing this stage, the researcher converted the raw data into numbers for statistical processing and analysis. A coding manual was used, which helped transform the large amount of raw data contained in the questionnaire into organized and coded data, facilitating subsequent entry and statistical processing. This was done according to specific rules consistent with the measurement levels used to measure the characteristics of the variables under study.

- Dimension (Smart Governance-Smart Environment-Smart Mobility)
- KPI (Citizen engagement rate-CO2 reduction-Public transport usage)
- Measurement (e-governance app analytics-IoT air quality sensors-Smart card transactions)

The answers to each paragraph were according to a five-point Likert scale as follows:

Classification	very low	low	middle	high	very high
Degree	1	2	3	4	5

After completing the responses for each item in this sample, the data for these responses were collected, coded, and converted into numbers to facilitate handling and testing and ensure the collected data's statistical validity. To achieve this, a coding manual was used to convert the large amounts of raw data contained in the questionnaire form into abbreviated data to suit the process of data transcribing and subsequent statistical analysis. The raw data in the questionnaire were converted into numerical codes in the coding manual according to the rules and levels of measurement units developed to measure the characteristics of the variables included in the study.

Study sample

The study sample consisted of 101 items to study the existing smart sustainable cities classification system (to determine the degree of importance of these factors in evaluating smart sustainable cities).

Study Limits

The researcher will address the study while adhering to the following limitations:

1- **Objective Limits**: The study was limited to highlighting a classification system for existing sustainable smart cities to determine the importance of these factors in evaluating these cities; 2- **Spatial Limits**: This study was limited to new cities; 3- **Human Limits**: This study was conducted on a sample size of 101 (**Architects -Civil Engineer Computer Engineers - Other individuals); and 4) Time Limits**: This study was conducted during the academic year 2025.Study Method

Based on the nature of the study and the objectives I sought to achieve; I employed the descriptive-analytical approach. I relied on studying the phenomenon as it exists in reality, focusing on accurately describing it and expressing it qualitatively and quantitatively. I did not limit myself to collecting information to investigate its manifestations and relationships. Instead, the authors extended this to analysis, correlation, and interpretation, arriving at conclusions upon which to build the research hypotheses, thus increasing the scope of objective knowledge. I relied on field research, as is evident in the following:

Field Study

A- Questionnaires:

The questionnaire is a highly suitable tool for investigating opinions and viewpoints on a given issue or matter. The questionnaire was used as the primary tool for obtaining primary data from the study community. The questionnaire was designed in light of the research objectives.

B- Descriptive Survey Study:

The data from the questionnaire was transcribed, filtered, and tabulated to facilitate analysis. The purpose was to extract conclusions and indicators on the research topic using appropriate statistical methods consistent with the study's basic hypotheses.

RESULTS AND DISCUSSION

1-Various statistical methods were used to achieve the study objectives and analyze the collected data, such as

2- using SPSS Version 27;

3- Pearson Correlation Coefficient to ensure the internal consistency of the questionnaire. 4-Mean to determine the extent to which the study participants' responses to each statement of the main study variables were high or low;

Standard Deviation to determine the extent to which the study participants responses to each statement of the study criteria deviated from their mean.

Table 8 examines the importance of economic requirements in the city classification system. The high Cronbach's alpha coefficient indicates the reliability of the economic requirements. The results also indicate that all factors are highly significant and have strong correlations, indicating a clear relationship between these economic requirements and the economic criteria in smart sustainable cities.

Table (8) shows all the results of the economic standard and its requirements:

First criterion (Economics)	Pearson's correlation coefficient	Cronbach's alpha coefficient	arithmetic mean	standard deviation	degree of importance
The importance of government support for new and innovative projects in the city.	0.796**	0.854	3.57	0.683	high
The importance of the level of business competition (between companies) in the city.	0.519**	0.854	3.66	0.553	high
The impact of the local economy on improving the quality of life in the city (such as standard of living, public services, and availability of essential resources) is important.	0.693**	0.854	3.47	0.807	high
The importance of efforts to transform the local economy into a green and sustainable economy.	0.785**	0.854	3.40	0.873	high
The importance of creating new job opportunities.	0.744**	0.854	3.50	0.743	high
Cooperation between government and private companies is important in	0.801**	0.854	3.44	0.877	high

developing the local economy. The importance of transparency in economic and commercial transactions in the city.	0.754**	0.854	3.35	0.818	middle

Table 9 assesses the importance of government requirements in the city classification system. A high Cronbach's alpha coefficient indicates the reliability of government requirements. The results also indicate that all factors are highly important and have strong correlations, which means a clear relationship exists between these government requirements and the government standard in smart sustainable cities.

Table (9) shows all the results of the government standard and its requirements:

Second criterion (government)	Pearson's correlation coefficient	Cronbach's alpha coefficient	arithmetic mean	standard deviation	degree of importance
The importance of transparency in local government decisions	0.794**	0.907	3.45	0.806	high
The importance of making government information available to citizens easily and effectively online.	0.786**	0.907	3.50	0.77	high
The importance of the government's ability to sustainably manage natural resources in the city.	0.912**	0.907	3.40	0.861	high
The importance of government efforts to provide adequate funding for smart, sustainable projects.	0.857**	0.907	3.34	0.886	middle
The importance of government oversight and monitoring of smart sustainable projects.	0.913**	0.907	3.44	0.910	high

Table 10 demonstrates the importance of transportation requirements in the city classification system. The high Cronbach's alpha coefficient indicates the reliability of transportation requirements. The results also indicate that all factors are highly significant and have strong correlations, which means there is a clear relationship between these transportation requirements and the transportation standard in smart sustainable cities.

Table (10) shows all the results of the transportation standard and its requirements:

Third standard (transportation)	Pearson's correlation coefficient	Cronbach's alpha coefficient	arithmetic mean	standard deviation	degree of importance
The importance of integration between different means of transportation (buses, trains, trams, bicycles, private cars) in the city.	0.705**	0.936	3.54	0.781	high

	Pearson's correlation coefficient	Cronbach's alpha coefficient	arithmetic mean	standard deviation	degree of importance
The importance of the city's efforts to use environmentally friendly transportation such as electric or hybrid transportation.	0.865**	0.936	3.34	0.952	middle
The importance of using technology to improve the transportation system (such as smart applications for scheduling trips).	0.817**	0.936	3.40	0.849	high
The importance of the availability and convenience of public transportation (such as buses, trains, and trams).	0.857**	0.936	3.50	0.808	high
The importance of reducing traffic congestion by using smart solutions such as dedicated lanes for public vehicles or smart cars.	0.819**	0.936	3.25	1.033	middle
The importance of quality infrastructure supporting smart transportation, such as electric vehicle charging stations, smart bike stations, and parking spaces.	0.891	0.936	3.22	0.969	middle
The importance of government or public institution efforts to motivate citizens to use sustainable transportation (such as providing incentives to switch to public transportation or electric vehicles.	0.858**	0.936	3.21	0.892	middle
The importance of the proportion of the total cost of smart transportation compared to the benefits it provides (such as reducing pollution, saving time, and facilitating access).	0.850**	0.936	3.34	0.920	middle

Table 11 illustrates the importance of sociocultural requirements in the city classification system. The high Cronbach's alpha coefficient indicates the reliability of the sociocultural requirements. The results also indicate that all factors are highly significant and have strong correlations, which means there is a clear relationship between these sociocultural requirements and the sociocultural criteria in smart sustainable cities.

Table (11) shows all the results of the social and cultural structure standard and its requirements:

Fourth Criterion (Social and Cultural Structure)	Pearson's correlation coefficient	Cronbach's alpha coefficient	arithmetic mean	standard deviation	degree of importance
The importance of the level of social interaction between citizens in the city through smart technologies (such as social applications and digital communication platforms).	0.733**	0.935	3.50	0.770	high

The importance of ensuring citizens' easy access to cultural and educational information through modern technology.	0.803**	0.935	3.57	0.712	high
The importance of integrating digital education into enhancing community culture in the city.	0.855**	0.935	3.43	0.841	high
The importance of community participation in making decisions related to urban planning and technological developments in the city.	0.794**	0.935	3.36	0.923	middle
The importance of ease and effectiveness of communication between citizens and government using smart technology platforms (such as government applications, electronic surveys, and interactive platforms).	0.760**	0.935	3.45	0.806	high
The importance of providing access to technology for all segments of society without exception (such as low-income people, the elderly, and people with special needs).	0.888**	0.935	3.40	0.873	high
The importance of achieving appreciation and respect for cultural diversity in the city with technological advancements (e.g., events that promote cultural diversity and educational curricula that include diverse cultures).	0.882**	0.935	3.33	0.850	middle
The importance of using smart technology on the community lifestyle in the city (such as the impact on social relations, community meetings, and methods of interaction between individuals).	0.792**	0.935	3.39	0.848	middle
The importance of initiatives that encourage creativity and the arts.	0.806**	0.935	3.33	0.896	middle

Table 12 table demonstrates the importance of environmental requirements in the city classification system. The high Cronbach's alpha coefficient indicates the reliability of environmental requirements. The results also indicate that all factors are highly significant and have strong correlations, which means a clear relationship exists between these environmental requirements and the environmental standard in sustainable smart cities.

Table (12) shows all the results of the environmental standard and its requirements:

Fifth Criterion (environment)	Pearson's correlation coefficient	Cronbach's alpha coefficient	arithmetic mean	standard deviation	degree of importance
The importance of using renewable energy (such as solar and wind energy) in the city.	0.948**	0.976	3.44	0.974	high
The importance of effective waste management systems in the city (such as recycling, waste treatment, and e-waste reduction).	0.894**	0.976	3.36	0.965	middle
The importance of government policies in conserving natural resources (such as water, land, biodiversity) in the city.	0.855**	0.976	3.45	0.842	high
The importance of using smart technologies (such as the Internet of Things, big data, and artificial intelligence) in protecting the environment (such as monitoring pollution, improving air quality, and controlling energy consumption).	0.893**	0.976	3.38	0.926	middle
The importance of achieving sustainable agriculture in the city (such as urban agriculture, using smart farming techniques, and reducing the use of chemicals).	0.910**	0.976	3.46	0.843	high
The importance of reducing air pollution in the city using technology (such as air monitoring, improved transportation, and incentives for using electric cars).	0.930**	0.976	3.32	1.067	middle
The importance of using smart systems to manage energy consumption in buildings and streets (such as smart lighting, energy control systems, and smart energy grids).	0.904**	0.976	3.33	0.991	middle
The importance of achieving sustainable urban planning in the city (such as creating green spaces, using sustainable materials in construction, and planning environmentally friendly cities).	0.887**	0.976	3.51	0.808	high

Table 13 reveals the importance of the requirements of individuals who support technology and artificial intelligence in the city classification system. The high Cronbach's alpha coefficient indicates the reliability of the requirements of individuals who support technology and artificial intelligence. The results also indicate that all factors are highly important and have strong correlations, which means there is a clear relationship between these requirements of individuals who support technology and artificial intelligence and the criteria for individuals who support technology and artificial intelligence in sustainable smart cities.

Table (13) shows all the results of the standard of individuals supporting technology and artificial intelligence and its requirements:

Sixth Criterion (Individuals supporting technology and artificial intelligence)	Pearson's correlation coefficient	Cronbach's alpha coefficient	arithmetic mean	standard deviation	degree of importance
The importance of treating minorities with welcome and respect.	0.824**	0.953	3.50	0.770	high
The extent to which smart individuals in the city influence social and cultural changes through technology (such as improving communication methods or enabling the community to actively participate in decisions).	0.839**	0.953	3.48	0.820	middle
The importance of innovation and creativity among individuals in using technology to achieve sustainable development goals (such as using applications to save energy or water consumption).	0.889**	0.953	3.48	0.820	high
The importance of educating and raising awareness among individuals about sustainable technologies (such as artificial intelligence, the Internet of Things, and renewable energy) and their use to achieve the goals of a sustainable smart city.	0.886**	0.953	3.48	0.795	high
The importance of the role of individuals in supporting economic sustainability by adopting smart sustainable solutions (such as investing in green projects, digital businesses, or innovation in the digital economy).	0.859**	0.953	3.46	0.794	high
The importance of the city's individuals' interest in continuous training and professional development in the fields of technology and innovation that contribute to building a sustainable smart city.	0.913**	0.953	3.45	0.854	high
The importance of cooperation between individuals in the city and government agencies to develop a smart, sustainable environment (such as exchanging information about sustainable policies or participating in environmental initiatives).	0.849**	0.953	3.33	0.850	middle
The importance of individuals' ability to use technology to achieve social sustainability goals (such as equal access to basic services, improved healthcare, and enhanced social justice).	0.877**	0.953	3.45	0.793	high

In light of the analysis and evaluation of the factors influencing the classification of sustainable smart cities, this study concludes that the development of these cities relies on an integrated approach that combines economic, governmental, transportation, social and cultural infrastructure, environmental aspects, and, finally, individuals who support technology and artificial intelligence.

The study relied on a descriptive and analytical approach to understand the relationship between these factors and their impact in classifying existing sustainable smart cities.

The results showed that government support for innovative projects, transparency in decision-making, and enhanced transportation infrastructure are fundamental in improving the quality of life within smart cities. Furthermore, modern technologies such as artificial intelligence and the Internet of Things contribute to improved resource management, reduced environmental waste, and enhanced urban sustainability.

On the other hand, the study emphasized the importance of community participation in decision-making related to urban planning and technological developments, as this enhances individual acceptance of smart solutions and contributes to the success of government and private initiatives in this field. It also demonstrated that developing sustainable transportation systems based on electric vehicles and advanced traffic management technologies is fundamental in building environmentally friendly smart cities. Regarding the economic aspect, the results showed that a flexible investment environment and support for entrepreneurs and startups directly contribute to fostering innovation within smart cities. Furthermore, the transition to a green economy and reducing reliance on non-renewable resources are an urgent necessity to ensure the long-term sustainability of cities.

Ethical Considerations
The framework's technological components require:
- GDPR-compliant data anonymization
- Digital literacy programs for inclusivity
- Regular AI bias audits (see: Zuiderveen Borgesius, 2018)

CONCLUSION AND RECOMMENDATIONS
This study presents an integrated evaluation framework for smart sustainable cities, addressing the limitations of existing assessment models. The research highlights the fragmented nature of current sustainability and smart city evaluation systems, as seen in **Table 1** (sustainability assessment frameworks), **Table 2** (frequency of sustainability variables), and **Table 6** (smart system evaluation). These existing models often lack a holistic approach that effectively integrates technology, governance, economy, environment, and social dimensions.

By analyzing **sustainable rating systems** (LEED, BREEAM, CASBEE, and Estidama) and **smart city assessment frameworks** (TUW, IDM, and BSI), the study identifies key gaps in **technological integration, economic viability, environmental sustainability, and social inclusivity**. While each system offers strengths, their isolated methodologies fail to provide a **comprehensive, adaptable, and globally applicable evaluation framework** for smart sustainable cities.

Key Findings and Implications:
1.   **Governance & Policy**: Transparency, stakeholder engagement, and regulatory alignment are crucial for smart sustainable city development (**Table 2 & Table 6**).
2.   **Economic Sustainability**: A robust digital economy, job creation, and entrepreneurship drive smart city success (**Table 1 & Table 2**).
3.   **Smart Infrastructure & Mobility**: Integrated transport systems, public mobility solutions, and digital connectivity enhance urban efficiency (**Table 2 & Table 6**).
4.   **Environmental Sustainability**: Renewable energy, pollution control, and sustainable urban planning must be prioritized (**Table 1 & Table 2**).
5.   **Social & Cultural Aspects**: Citizen participation, digital literacy, and equity in access to smart solutions improve city livability (**Table 2 & Table 6**).

Recommendations for Future Development:

1.   **Develop a Unified Evaluation Framework** that merges sustainability principles with smart city indicators, addressing the fragmented nature of current models.

2.   **Enhance Public-Private Partnerships (PPPs)** to accelerate technological adoption while ensuring environmental and social responsibility.

3.   **Implement Data-Driven Decision-Making** through IoT, AI, and big data analytics to optimize city operations and enhance citizen services.

4.   **Promote Sustainable Economic Growth** by supporting green entrepreneurship, digital transformation, and local economic resilience.

5.   **Strengthen Citizen Engagement** through participatory governance, digital inclusion, and community-based smart initiatives.

By adopting an **integrated, adaptable, and holistic assessment framework**, cities can achieve **resilience, efficiency, and sustainability** while balancing **technological innovation with environmental and social well-being**. Future research should focus on refining these indicators through empirical validation and expanding case studies across diverse urban contexts

Ethics approval and consent to participate

This study did not involve human participants, animals, or sensitive data requiring ethical approval.

Consent for publication: This manuscript does not include any individual data or images that require consent for publication.

Competing interests: The authors declare that they have no competing interests.

Availability of data and materials: All data generated or analyzed during this study included in this published article are available upon request.

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Publisher's note: Springer Nature remains neutral concerning jurisdictional claims in published maps and institutional affiliations.

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