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Smart City Results and Sustainability: Current Progress and Emergent Opportunities for Future Research

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Abstract: The notion of sustainability has gained increasing popularity in smart city research. While numerous studies have focused on how smart city initiatives either undermine or contribute to sustainability, a few essential questions remain unanswered. First, a vast body of knowledge has been accumulated on the results of smart cities, particularly their short-term outputs. However, it is not clear how those results can be sustained over time. Second, most of the existing literature touches on environmental and economic sustainability, whereas other perspectives, such as social and cultural sustainability, are still underexplored. Given these gaps, this study seeks to contribute to the sustainability and smart city literature by answering the following research questions: (1) To what extent have the results of smart city initiatives been addressed in previous studies? and (2) To what extent have smart city scholars addressed the different dimensions of sustainability? A narrative literature review was conducted. Our findings indicate that the sustainability of smart cities can be understood in two ways—the duration of results and the multi-dimensional long-term sustainability goals. Based on the findings, this study proposes a few intersections of the two concepts and an agenda to guide future research on sustainability in smart cities.

Keywords: smart city; sustainable city; smart city results; smart city outcomes; urban development; short-term outputs; long-term impacts; environmental sustainability; economic sustainability; social sustainability

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1. Introduction

As the urban population has continued growing in recent decades, cities from around the world have faced wicked social, economic, and environmental challenges and have been exploring creative solutions to tackle them. Consistent with the information revolution, emerging technologies have become essential tools for cities to mitigate the negative impacts of urban development and increase their residents' quality of life, thereby creating a global "smart city" trend [1,2]. Scholars have made several efforts to make sense of smart city development. While there seems to be a lack of consistent definitions and practices of smart cities in the preliminary stage of knowledge building [3], recently, researchers have gained a deeper understanding of what makes a city smart. In this respect, it is now recognized that a smart city is not a technology-centric phenomenon, but rather a socio-technical one [1,3–5]. Therefore, a contingency approach is necessary to understand and effectively implement smart city initiatives [6,7].

While technology and data plays a crucial role in smart city development [8,9], smart city initiatives also encompass other essential components, such as government, society, and the physical environment, all influence smart city development and its success [1,10,11]. It has also been noted that the design and implementation of smart city initiatives are interdisciplinary and require collaboration among multiple actors across the public, private,

and nonprofit sectors and with citizens [12]. Accordingly, the identification of key actors and their roles is paramount whenever studying smart cities [5]. Moreover, the literature recommends using a contingency approach to investigate the contextual factors influencing smart cities, thus developing governance models to enhance capacity and address challenges and define and measure the creation of public value that results from smart city development [13].

Recently, sustainability has gathered much more attention in smart city research. According to the World Commission on Environment and Development [14], sustainability refers to development that "meets the needs of the present without compromising the ability of future generations to meet their own needs (p. 15)." The concept was coined and promoted globally in response to problems, such as natural resource depletion, environmental pollution, and land overuse, that resulted from industrialization, urbanization, and globalization [15]. It advocated that cities ought to strike a balance between economic development and environmental protection. Further still, in 2015, the United Nations launched the "Sustainable Development Goals (SDGs)", an agenda consisting of seventeen goals spanning various topics that nations are expected to achieve by 2030. In this agenda, the definition of sustainable development has been expanded to encompass three core elements: economic development, social inclusion, and environmental protection [16]. As a result, both academics and practitioners are now working to better understand how a city can be both smart and sustainable, that is, how information and communication technologies (ICTs) can contribute to the sustainable development of a city [17]. Consistently, a growing body of research has now attempted to better understand how smart city initiatives can either undermine or boost sustainability [12,18–20].

Even though research on sustainability and smart cities, or as they are now known, "smart sustainable cities (SCC)", has been flourishing in recent years, several important questions remain unanswered. First, researchers do not have a consensus on the dimensions of sustainability and their definitions. Most of the literature focuses on environmental and economic sustainability, while other perspectives, such as social sustainability, still receive limited attention [20–24]. Moreover, although several results of different smart city initiatives have been identified (e.g., [25,26]), analyzing how those results may be sustained over time has still been largely neglected. The existence of these critical gaps indicates that a systematic and comprehensive understanding of the connections between smart cities and sustainability is still lacking. Therefore, this study attempts to explore how the literature so far has addressed the topic of sustainability in smart cities. In particular, we seek to answer the following two research questions: (1) To what extent have the results of smart city initiatives been addressed in previous studies? and (2) To what extent have smart city scholars addressed the different dimensions of sustainability? Exploring these research questions is valuable because it helps clarify the concept of sustainability in smart city research, enables a more consistent use of the concept, and maps out key crucial directions that will require more attention both in future research and actual practice.

This article is organized into seven sections, including the foregoing introduction, which is Section 1. Section 2 briefly describes our methodological approach. We then address our first research question on the results of smart city initiatives in Sections 3 and 4. In particular, in Section 3, we identify and classify the results that have been documented in the existing research into outputs, outcomes, and impacts. Based on those findings, in Section 4, we discuss one interpretation of smart city sustainability, that is, the duration of those results, identify the gaps remaining in this line of research, and briefly discuss the primary factors that can affect the duration of smart city results. Section 5 addresses our second research question by showing how sustainability has been addressed in the smart city literature. We identify and synthesize the different dimensions of sustainability found in smart cities, including their definitions and operationalizations. Based on these findings and the discussion offered in the previous sections, Section 6 proposes some ideas for future research. Finally, we conclude the article with an overview of our main findings, our contributions to the topic, and some suggestions for further development.

2. Methodological Approach

This study employs a narrative literature review approach to address its research questions. Typically, narrative literature reviews are devoted specifically to reviewing the literature on a particular topic, thereby forming a bridge between scattered research publications and readers who do not have either the time or resources to follow the ongoing evolvement of a topic [27]. More specifically, the approach is particularly suitable for this study, as it can demonstrate the major accomplishments in the field, the critical issues under dispute, and the most pressing research gaps that still remain [28]. Although narrative literature reviews, in contrast to systematic literature reviews, do not adhere to a standardized protocol or have a defined search approach, we provide a brief outline of the process we followed in conducting the narrative review in this section.

For the literature search process, we first conducted an initial search on the literature with the title containing the keywords of ("smart city" OR "smart cities") AND (("output*" OR "outcome*" OR "impact*" OR "result*" OR "effect*") OR ("sustainability")) via Web of Science (WoS) and Google Scholar to identify the publications that relate to sustainability in a smart city context and to the results of smart city initiatives, including their outputs, outcomes, and impacts. We then expanded our literature search by checking the list of references cited in those publications and included those that were relevant but neglected in the initial search.

In addition, given a lack of research on the duration of smart city results, we used the digital government literature to inform our efforts. We did so by searching the literature related to the sustainability of digital government via WoS and Google Scholar too. More specifically, we searched publications with titles containing the keywords of [("digital government" OR "e-government") AND ("sustainability")]. As the scope, magnitude, and political, social, and economic context of smart city initiatives can vary significantly from one to another, in order to provide as many insights as possible, we did not limit the literature on digital government sustainability to a specific level of government. Both searches targeted literature published between 2003 and 2022.

Once we had all the literature identified, we disregarded publications not written in English and publications whose full text was unavailable. Next, we filtered out the most relevant publications by assessing the title and the abstract. We then looked through the full text of each article to identify its research questions, arguments, and primary findings and excluded the ones irrelevant to our focus.

Our coding approach involved both deductive and inductive methods for analyzing the literature on smart cities. We conducted a deductive coding of the smart city results mentioned in the literature by categorizing the results into three groups: short-term outputs, medium-term outcomes, and long-term impacts, based on the definitions used by Mergel et al. [29] and Huovila et al. [30]. Acknowledging that the distinction between these categories is not always clear in the literature, and outcomes and impacts are sometimes used interchangeably, they attempted to provide a conceptual distinction between these categories. Following their conceptualization, we define *output* as a quantitative result (e.g., the number of smart city projects and the number of smart meters distributed); *outcome* as the consequences that the implementation of a smart city initiative may have on the city (e.g., changes in processes and the quality of the relationships that exist among different stakeholders); and *impact* as the changes in the entire public administration or society as a whole (e.g., the creation of more public value or the reinforcement of democratic principles). In addition, in order to consistently understand and compare the outputs, outcomes, and impacts, we categorized the results into five aspects: (1) environment, (2) technology and infrastructure, (3) business and economy, (4) people and communities, and (5) government, which are derived and adapted from existing studies on smart city results [31,32]. As for the dimensions of smart city sustainability and digital government sustainability, an inductive method was employed to identify the primary themes in the literature. Lastly, after coding, we synthesized the findings we gathered and identified the relationships between concepts and the topics noted within the selected studies.

3. Identifying the Results of Smart City Initiatives

Existing studies that discuss smart city results face some limitations. First, it is often indicated that smart city initiatives can lead to a myriad of benefits in the economy, society, government, and environment of a city [33,34]. The studies look at these benefits as desired results for smart cities but do not necessarily analyze and discuss their actual achievements in specific terms [33]. Furthermore, there is no consensus on how researchers classify these results. In some studies, the results of smart cities are referred to as public value [35]. Public value is understood in various ways, including dimensions, such as economic growth, employment, social inclusion, and well-being [35]. Other authors identify the public value as facets of sustainability, creativity, effectiveness, efficiency, equality, citizen engagement, openness, resiliency, innovation, and evidence-based decision-making [36]. In contrast, other studies report smart city results as medium-term outcomes, such as a reduction in energy consumption and easier access to high-quality services, or as long-term impacts, such as fair employment and strengthened democracy [31,37,38]. Nevertheless, the ways that scholars conceptualize outcomes and impacts and, therefore, classify the results of smart city initiatives are highly inconsistent, which can be confusing for readers.

In light of these gaps, we classify the results in the literature using Mergel et al. [29]'s typology. Results are shown in Table 1 (outputs), Table 2 (outcomes), and Table 3 (impacts). The tables provide information on the dimensions and definitions/measures of observed or desired results, along with examples of relevant studies. In general, very few studies ever develop precise measurements to report the outcomes and impacts. In contrast, research on the outputs has still generated more empirical insights, showing the exact number of results for technology/infrastructure, business and economy, people and communities, and government. Furthermore, it was noted that smart cities could produce negative results, such as increasing polarization and inequity and harm to personal privacy rights. Finally, several of the results have received more attention than others, including those on innovation and institutional transformation outcomes, economic growth, well-being and quality of life, and fairness and equality.

Table 1. Outputs of Smart Cities.

Dimension	Definition/Measure	Observed/Desired	Source
Environment	# of CO_2 emissions reduced	Observed	[39]
	# of water amounts saved	Observed	[39]
	Not provided	Desired	[38]
	# of SO_2 reduced# of wastewater units reduced	Observed	[40]
Technology and Infrastructure	# of new telecommunication networks	Observed	[39]
	# of LED bulbs installed	Observed	[39]
	# of sensors installed	Observed	[39]
	# of orthogonal bus networks created	Observed	[39]
	# of hybrid vehicles or electric bikes added	Observed	[39]
	# of kiosks available	Observed	[39]
	# of apps created	Observed	[39]
	% of apps downloaded	Observed	[39]
	# of technological development events held and # of people participating in these events	Observed	[39]
Business and Economy	# of pilot project proposals received	Observed	[39]
	# of pilot projects conducted	Observed	[39]
	# of companies created	Observed	[41]
People and Communities	# of citizens involved in fablabs	Observed	[39]
	# of new housing units provided	Observed	[41]
	Increased polarization and inequity (e.g., data collection and analysis based on racial and class lines)	Observed	[42]
Government	# and quality of datasets available	Observed	[39]
	# of procedures performed virtually	Observed	[39]

Table 2. Outcomes of Smart Cities.

Dimension	Item	Measure/Definition	Observed/Desired	Source
Business and Economy	Innovation	Patent applications	Observed	[43]
		# of new products generated	Observed	[41]
		# of new patents generated	Observed	[41]
		Not provided	Desired	[35]
		Not provided	Desired	[37]
		Not provided	Desired	[38]
	Enhanced cost-effectiveness of provided services	Not provided	Desired	[35]
	Increased employment	Not provided	Desired	[35]
		# of jobs created	Observed	[39,41]
	Increased GDP	Amount of GDP added	Observed	[41]
	Increased investment	Amount of investment added	Observed	[41]
People and Communities	Better-informed individual choices and behaviors	Not provided	Desired	[37]
			Desired	[38]
	Enhanced healthcare system	Access to high-quality healthcare services (including e-health or remote healthcare monitoring), electronic health records management, home automation, smart home, and building services, and easier access	Desired	[38]
	Higher user satisfaction	Not provided	Desired	[35]
	Higher service adoption	Not provided	Desired	[35]
Government	Transformation of institutional practices	Not provided	Desired	[37]
		Efficiency	Desired	[36,38]
		Effectiveness	Desired	[36,38]
		Transparency	Desired	[36,38]
		Accountability	Desired	[38]
		Evidence-based decision-making	Desired	[36,44]
		Collaboration	Desired	[44,45]
	Enhanced citizen engagement	Engaging citizens in decision-making and other activities	Desired	[36]

More specifically, as shown in Table 1, smart city outputs can be measured in terms of the amount of newly developed technological applications and infrastructure and their uses. Environmental outcomes involve the reduction in CO_2 emissions, water consumption, energy use, and emissions of pollutants. Regarding the economy, the number of new companies and pilot projects are some of the common indicators. For people and communities, outputs can be the number of citizens involved in a project, the level of service provided, and certain measures related to social equity. As for the government, some examples of short-term results are the number and quality of open datasets and the number of virtual procedures or online services available and used.

Based on these short-term outputs, several subsequent, medium-term outcomes can be noted (Table 2). For instance, increases in innovation, cost-effectiveness, employment, GDP, and investment are the most mentioned economic and business-related outcomes. For the government dimension, outcomes encompass (1) the transformation of institutional practices, conceptualized as changes in terms of efficiency, effectiveness, transparency, accountability, evidence-based decision-making, and collaboration; and (2) a higher degree of citizen engagement. For residents and communities, smart cities can enhance the healthcare system, improve service adoption, increase user satisfaction, and better inform residents' choices and behaviors by providing more information.

Table 3. Impacts of Smart Cities.

Dimension	Item	Measure/Definition	Observed/Desired	Source
Environment	Environmental protection	Not provided	Desired	[26]
Business and Economy	Economic growth	Not provided	Desired	[35]
			Desired	[26]
			Desired	[31]
	Creativity	How to open our minds to new ways of conceptualizing situations and problems	Desired	[36]
People and Communities	Well-being and quality of life	Not provided	Desired	[35]
		Not provided	Desired	[31]
		Not provided	Desired	[26]
		Healthy food	Desired	[37]
		Clean air and water	Desired	[37]
		Affordable and sustainable energy and housing	Desired	[37]
	Fairness and equality	Employment, affordable healthcare, education, and mobility	Desired	[37]
		Equal and fair treatment for all people, independent of race, gender, income, age, and other socio-demographic characteristics	Desired	[36]
		Social equity and intergenerational equity in resource consumption	Desired	[37]
	Resiliency	The capacity of the city to face and recover from catastrophic events and other emergencies	Desired	[36]
	Harm to citizen privacy	Not provided	Desired	[46]
	Increase polarization and inequality	Loss of land rights	Observed	[47]
		Distribution of benefits to the marginalized residents	Observed	[48]
Government	Democracy and freedom	Not provided	Desired	[37]
	Better governance and planning	Not provided	Desired	[31]

In the long term, frequently intangible outcomes are more complex and, thereby, harder to measure (Table 3). For example, impacts on the economic dimension are economic growth and creativity. For the government dimension, improved democracy and freedom or better governance and planning could be seen as some of the primary impacts. For residents and communities, improved well-being and quality of life, fairness and equality, and city resiliency are some of the potential positive impacts. Nevertheless, smart cities can also potentially lead to an increase in social inequality and a reduction in privacy as examples of negative impacts. Lastly, the improvement of the environment is a major potential impact that represents the environmental dimension.

4. Duration of Results as a Way to Understand Sustainability in Smart Cities

One way to conceptualize sustainability in smart cities—and one that has received scant attention in academia—is the duration of smart city results, which can be seen as the ultimate test of a smart city strategy and its success since duration indicates if the smart city positive results will last through time, regardless the technical or environmental changes that may take place [49]. To the best of our knowledge, the literature does not report on empirical research that evaluates the duration of smart city results. Consequently, it is unclear whether and how the smart city outputs, as shown in Table 1, can be translated into medium-term outcomes (see Table 2) and long-term impacts (see Table 3). The literature does not discuss either to what extent a specific output, outcome, or impact may be sustained over time. Given this key limitation, we turned our attention to the digital

government literature in search of other perspectives that can help smart city scholars think about the duration of these initiatives and their results.

Nurdin et al. [50] define digital government sustainability as "the ability of government organizations to continuously operate and use digital government systems over a long period of time to provide continuous benefit for both government organizations and stakeholders (p. 2265)". The vast literature on digital government shows that successful experiences with digital government projects in the short run may not sustain over time; to the contrary, the majority of those efforts end up in total or partial failure due to a variety of factors [50–55]. Accordingly, it is crucial to understand what determines the medium- or long-term duration of smart city initiatives and their related technical or non-technical enablers and challenges. To lay a foundation for exploring this topic further, we next present the findings from a series of studies on digital government sustainability, particularly focusing on the key factors that cause either long-term failure or success. We argue that these insights can help identify success factors that could also be important to help sustain results in the long term.

First, *financial and economic factors* seem to be key. Sufficient financial resources are essential for a smart city project to survive [51,52,55]. Kumar and Best [54] suggest that projects that depend on donations face the risk of losing funding after a period of operation and thus have to be terminated. Tolbert et al. [56]'s study on digital government sustainability across the U.S. also revealed that affluent states have higher performance when maintaining digital government websites. Some of the crucial indicators are the cost efficiency of the services provided, knowledge management capability, the use of resource planning management systems, and the utilization of activity-based cost systems [57]. Second, *social and cultural factors* also seem to matter. For example, equitable distribution of digital government benefits to social groups within a community will make a project more tenable and thus face relatively fewer challenges [54]. Additionally, societal conditions, such as a higher median household income, education level, and urbanization level, are conducive to a longer duration of digital government efforts, as the government will then have more resources and knowledge to implement the program [56]. Moreover, it is further accepted that a persistent implementation of digital government initiatives needs collaboration between both governmental and non-governmental actors. Hence, the government must be aware of each stakeholder's roles, needs, and behaviors in order to build and maintain any continuing partnerships [50,55]. The third factor is *technology*. This component includes, among other elements, the maintenance and upgrading of existing hardware and software [54].

The last, and perhaps the most studied, are the *political and institutional factors*, which focus on the political and administrative infrastructure that supports digital government initiatives. For example, the legislative body performs a vital role not only in allocating budgetary resources but also in shaping digital government policies. Therefore, legislative professionalism and the existence of an IT committee in the legislature are factors that have been found to be conducive to the digital government's long-term success [56]. From the perspective of administration and public organizations, the actors that pertain to different levels and roles and the existing rules and the culture of the organization have various degrees of impact on project sustainability. In addition, the support from the highest level of authority, political leaders, and the ruling party's enduring commitment and support are influential for the success of any digital government project [50,58].

Next, hiring a professional leader who can help guide and sustain digital government initiatives, as either a Chief Data Officer (CDO), a Chief Information Officer (CIO), or a Chief Technology Officer (CTO), is a powerful way to ensure the sustainability of digital government results [51,59]. Coupled with the aforementioned professional leadership, establishing specific organizational rules and a formal, autonomous IT board or department that oversees, aligns, and coordinates different stakeholders' efforts is instrumental [6,51,56]. As for public employees, according to [53], all the following are important aspects to consider: the capacity and competence that will derive from a staff's willingness to work,

understanding and handling task complexity, and their satisfaction from the work and its rewards. Their experiences and perceptions of communication and procedural legitimacy, training, learning culture, and organizational leadership, are also vital. While performance management is a common strategy, its use in the sense of the New Public Management paradigm has been criticized for its short-sightedness and, thus, becoming detrimental to achieving the sustainability of digital government initiatives [58]. To avoid this shortcoming, performance indicators should focus on momentum building instead of just short-term hard targets [51].

The brief overview of digital government sustainability above offers valuable insights into both technical and non-technical factors that contribute to project implementation and long-term results, which could be applied to analyze the functioning of smart city initiatives. However, it is important to note that current studies on digital government sustainability primarily focus on the duration of project operations and their outcomes during the project's lifespan without providing any insights into the post-termination stage. Interestingly, there is also a lack of scholarly understanding of the long-term effects of smart city initiatives after their termination. In our view, ensuring that the positive outcomes of smart city initiatives persist and continue to benefit stakeholders beyond the termination of the initiative is crucial. Despite this, the issue of the duration of the smart city results in both during and after the project period remains an unaddressed knowledge gap in the current literature.

5. Different Perspectives and Dimensions of Sustainability in Smart Cities

The duration of smart city results is not the only way to conceptualize sustainability in smart cities; indeed, it is one of the least used definitions that have not received the attention they deserve. In most recent studies in the context of smart cities, sustainability has been conceptualized using an environmental perspective. For example, Höjer and Wangel [15] define a smart, sustainable city (SSC) as "a city that meets the needs of its present inhabitants without compromising the ability for other people or future generations to meet their needs, and thus, does not exceed local or planetary environmental limitations, and where this is supported by ICT (p. 342)". This definition generally accepts the WCED's perspective for what environmental sustainability means, but with an additional emphasis placed on the use of ICTs. Additional studies have expanded this notion of sustainability and now acknowledge that sustainability can be understood from different points of view, which these studies refer to as dimensions, but can also be understood as potential outcomes or impacts.

In this respect, Bifulco et al. [19] discuss three dimensions of sustainability—the preservation of natural resources, social equity, and economic development [20,60]—the so-called "triple bottom line" for sustainable community development [61]. In the same vein, the United Nations proposes a comprehensive conceptualization of smart, sustainable cities, which are "innovative cities that use information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, cultural and environmental aspects. [62] (p. 3)". The normative assumption behind this concept of sustainability is that government should take a long-term view of city development and ensure that emerging technologies serve diverse values and several generations [34].

That said, it is acknowledged that the smart city literature tends to assign more weight to economic or environmental sustainability while missing other crucial aspects [20–24]. Historically, the concept of smart cities was coined and developed mainly in Europe, where the vast majority of research projects and investments were dedicated to achieving environmental goals, such as energy savings, pollution reduction, and green transportation, via the use of technology. Additionally, the phenomenon may be due partially to disciplinary differences. Ahvenniemi et al. [18]'s comparison of the urban sustainability and smart city frameworks showed that the former contains more indicators for environmental sustain-

ability; in contrast, the smart city frameworks have more indicators related to social and economic aspects. Therefore, a broader conceptualization of sustainability is necessary to bridge these gaps and develop a more holistic understanding of sustainability in smart cities. To this end, we reviewed and synthesized the existing relevant studies in terms of three primary dimensions of sustainability—environmental, economic, and social. Within each domain, we lay out the definition adopted by scholars and how those ideas can be discussed further in the context of the definition and development of smart cities.

Studies on environmental sustainability suggest that smart city initiatives are expected to preserve natural resources, mitigate environmental problems, and enhance awareness about diverse environmental issues. Several of the common indicators are related to energy consumption, pollution, air quality, and biodiversity [62–64]. For instance, Bibri [65] showed that the implementation of the Internet of Things (IoT), sensor-based big data applications, is conducive to improving the efficiency of operations and services, the optimization of natural resources, and the intelligent management of infrastructures and facilities. Additionally, Bracco et al. [63] illustrated that ICTs can help enhance the energy efficiency, reduce the carbon dioxide emissions of mobiles, and enable the collection and reuse of rainwater. Despite the great potential of smart cities to promote environmental sustainability, some of the challenges might prevent their policies from achieving their intended targets during the implementation stage. By combining the academic literature with practical experiences from 22 smart, sustainable energy projects within the European Union, Mosannenzadeh et al. [66] identified four categories of such barriers: (1) Financial and economic; (2) policy, institutional, and regulatory; (3) behavioral; and (4) technical. In order to make the projects more feasible, specific measures must be taken to cope with these potential challenges.

Social sustainability is related to several themes: Inclusion, equity, quality of life, citizen participation, and the preservation of cultural capital [67,68]. Consistently, in some of the existing studies, social sustainability is viewed as using ICTs to address social problems, promote equity, enhance citizens' quality of life, and improve livability [22,60,62]. These goals are derived from several scholars' critiques of the existing practices of smart cities. First, it is suggested that smart city initiatives tend to be built on biased assumptions and ideologies held by businesses and IT vendors that are applying IT solutions to revitalize the economy as the top priority for urban development see [63,65–67,69]. In addition, existing research indicates that smart cities can have different impacts on various populations, disproportionately benefiting educated and middle-class individuals and disregarding and neglecting the uneducated and poor [70].

Furthermore, given that some people lack access to digital tools or the capacity to navigate technology, the efforts of smart cities may actually deepen some of the existing social divides [71]. Such societal inequalities have a detrimental impact not only on the current residents' quality of life but also on future generations' well-being. Taking this view, citizens or communities are or should be the primary targets that smart city initiatives strive to serve. Common policy issues encompass wealth, education, employment, activity rate, security, business crisis, health, housing, migration, and social inclusion [62,63]. Trencher and Karvonen [22]'s case study of a smart city in Japan—which incorporated the usage of wearable health monitors, public education, and incentive design—shows the great potential of smart city initiatives to impact residents' lifestyles. For example, digital health and daily activity records can be used to provide customized suggestions and further public education to promote users' active lifestyles and health. Nevertheless, the authors also identified a few key challenges, namely, low interest in long-term commercialization, privacy concerns, and the limited participation of residents.

Another way that smart cities can support social equity, inclusion, and residents' well-being is through using inclusive community engagement and citizen participation, where individuals, communities, and societies can have the autonomy to choose the development models [23,70,72–74]. This approach contends that cities are context-specific and embedded in certain meanings that are shared by their residents [75,76]. As a result, residents and the

different communities' values, culture, and knowledge are instrumental in planning and implementing successful smart city projects [24,75]. However, in reality, it was found that smart cities are primarily driven by urban entrepreneurialism and technocentrism, thereby leaving little space for citizens to participate in making the key decisions [76]. A persistent lack of equal distribution of political power among the different stakeholders in smart city planning will instead lead to continual inequitable distributions of benefits and costs to the heterogeneous populations within any urban society.

To avoid de-contextualization and social exclusion, empowering citizens and communities to participate in the actual decision-making process for developing smart city initiatives is necessary [77]. For instance, Paskaleva et al. [78] argue that an ideal data governance model for smart, sustainable cities requires engagement with the stakeholders to identify, collect, generate, and utilize data. Citizens can thus become sensors and provide critical information for both better planning and delivery of user-centered services [57]. Additionally, Trivellato's [23] empirical study showed that citizens and stakeholders can deliberately shape a government's smart city policy. Finally, ICTs-mediated online participation can bring together the local community of citizens and businesses, the various levels of government, and IT experts and jointly design a smart city [79]. In light of these current development trends, recent approaches to smart city development, such as the circular city or the fab city, and many others, have taken myriad measures to ensure that smart cities are designed by and for the residents of a city.

Another theme related to social sustainability concerns the conservation and preservation of cultural capital, including tangible and intangible heritages, artistic production, and the knowledge and skills of various social groups, communities, and nations [21,80]. Based on this definition, cultural sustainability is similar to social sustainability, especially since both underscore the value of social entities' knowledge and skills. Indeed, Errichiello and Micera [21] found that culture is exclusively seen as part of the broader social dimension in the literature. Similarly, although the United Nations [62] added cultural sustainability as a solo dimension when defining the smart, sustainable city, it failed to draw a clear enough distinction between the two when presenting the indicators. Accordingly, whether cultural sustainability can become an independent dimension of the smart city or should be seen as a subset of social sustainability is still debatable. Notwithstanding this issue, some empirical studies that touch on cultural sustainability have investigated how ICTs can be exploited to establish or maintain historical sites and cultural services. More specifically, it has been shown that visitor-flow monitoring tools, when coupled with geographic information systems (GIS), have a great potential for managing the over-tourism of historical centers [81]. Further still, Errichiello and Micera [21] showcased that cultural heritage can be an element of smart city development by integrating technology into the provision of cultural services, and thus a stakeholder engagement approach can assist in its service design, the transfer of cultural skills and knowledge, and thus construct a public memory and a holistic sense of identity.

Economic sustainability in smart cities refers to establishing competitive cities and sustaining economic vitality and diversity with the support of a hard infrastructure and soft capital [19,60]. The United Nations [62] proposed that economic sustainability can manifest in multiple ways—via ICTs, innovation, employment, trade, productivity, and physical infrastructure. It is widely accepted that the economic aspect of sustainability has indeed received dominant attention in the literature. This view is, to a certain extent, reasonable since ICTs perform a central role in smart city development, which does require a considerable amount of human and economic capital investment and engagement with the industrial and financial sectors. Such features also fit with the current global trend of fostering a "knowledge economy," the goal of which is to capitalize on science, technology, and innovation to boost employment and economic growth [41,82]. Consistently, a few studies have examined the relationships between smart cities and innovation (e.g., [43,83]), employment (e.g., [41,84]), service design and product development (e.g., [85,86]), and investments (e.g., [87]).

6. Understanding Smart City Results via a Sustainability Lens: Towards a Research Agenda

By comparing the two different conceptualizations of smart city sustainability—duration of results versus the sustainability of goals for future generations—a few issues deserve more attention. First, these concepts seem to be referring to different aspects of sustainability, although in some ways, they are also consistent, especially in terms of the distinction between medium-term outcomes and long-term impacts. In terms of the economic dimension, both views consider innovation, employment, productivity, creativity, and economic growth as crucial economic results that smart city initiatives could lead to in the medium or long term. For the social dimension, the sustainability goals mainly refer to the impacts of smart cities on people and communities. Both accentuate the quality of life and overall fairness and equality as crucial intended results or broad sustainability goals. However, citizen participation has received more attention within the discussion of social sustainability than in the existing literature on smart city results. In contrast, resiliency and harm to citizens' privacy are conceived as long-term impacts by multiple scholars but are yet not regarded as elements of social sustainability. In terms of the environmental dimension, the measures that environmental sustainability looks at are congruent with the desired environmental outputs. Finally, and interestingly, although the transformation of institutional practices and citizen engagement, and democratic values and enhanced governance and planning, are reported as being vital outcomes and future impacts of smart cities, these aspects are not found in the current research on smart city sustainability.

The research on the duration of results for smart cities is considerably limited, which makes it a challenging task to disentangle the relationships among all the identified outputs, outcomes, and impacts. There is also currently a lack of perspectives regarding to what extent the sustainability goals of smart cities can really be sustained over time. For example, it is unclear whether and how citizen participation can lead to persistent social benefits to society as a whole, simply because most studies do not track their cases over a long period of time. That same limitation can also be observed in current research on other sustainability dimensions.

Given these gaps, to better clarify and strengthen our current understanding of the different types of results of smart city initiatives and their sustainability or duration over time, this study proposes several related topics for future research as follows:

Identifying and distinguishing between outputs, outcomes, and impacts of smart city initiatives. As mentioned in Section 3, despite a considerable volume of research that has been dedicated to the results that smart city projects can deliver, those studies generally do not take the time dimension into account, thereby failing to distinguish between short-term outputs, medium-term outcomes, and longer-term sustainable impacts. This distinction is crucial and necessary to recognize, as it enables scholars to comprehensively evaluate the effectiveness of a smart city project, that is, whether and to what extent an initiative achieves its intended purposes and values, even if they may take months, years, or even decades to materialize. Future studies could build on the conceptualizations developed in this study to factor the time aspect into more precisely identifying the results of smart cities. Qualitative case studies and interviews can be conducted to investigate whether and how the three kinds of results are addressed in actual practice. A time-series or longitudinal quantitative approach can also contribute to that goal by quantifying and tracking a smart city initiative's outputs, outcomes, and long-term, sustainable impacts. In addition to methodological recommendations, we also encourage future studies to address the political dimensions of sustainability, that is, the government-related outcomes and impacts already present in the existing literature on smart city results.

Connecting smart city results and sustainability. Interestingly, we found that there is an unclear boundary between smart city results (including short-term outputs, medium-term outcomes, and long-term impacts) and how different authors characterize sustainability (different perspectives and dimensions). One of the critical elements that make these two notions meaningfully different, in our view, is the intergenerational perspective. By taking

inter-generationality into account, we can better identify how short-term smart city outputs (and/or medium-term outcomes) are both positively and negatively related to long-term environmental, economic, social, and cultural sustainability (impacts). In fact, even when they are not using the term long-term impacts when using the different dimensions of sustainability, many authors explicitly or implicitly refer to long-term impacts and, in a few cases, to impacts that could also affect multiple generations in the future. Therefore, future research should consider how the results of current smart city initiatives could have an impact on future generations by affecting environmental, economic, social, and cultural sustainability.

Examining the causal relationship between smart city initiatives and results. Another limitation in the existing literature is the lack of clarity about the relationship between the results that are intended to be realized and the results that are actually achieved. Most studies are conducted at the conceptual or theoretical level, proposing what types of results smart cities may eventually bring to government, businesses, and civil society. Even in existing empirical works, most researchers do not explicitly operationalize and measure the so-called observed results. Due to these constraints, the causal link between smart city initiatives and their outputs, outcomes, and impacts has been far from clear. In this respect, more empirical evidence is required to better make sense of the realized results that do arise from smart city projects.

While we, of course, acknowledge that it will be difficult to isolate the effects of a specific smart city initiative, as multiple economic, social, political, and cultural factors can have a joint and continual influence on society, several methodological approaches can still be used to assess the correlation and causality between a smart city initiative and its actual results. In particular, a quantitative approach would be beneficial in measuring and evaluating the results of a smart city initiative. For example, future studies can look at the change in the number of a specific target indicator over the course of project deployment to determine whether or not and to what extent a specific result can be attributed to that project. Further still, researchers can take a quasi-experimental point of view to better assess the causal effects by introducing a comparison group of similar cities where no smart city projects have yet been implemented.

Differentiating the sustainability of operations from the sustainability of results. While our study shows multiple factors that can help ensure a more prolonged success of smart city results, a necessary condition underlying those factors is that the respective smart city project must remain active. Nevertheless, little has been studied in terms of examining what will happen after a given project has ended. This gap is relevant, as it is not rare for smart city projects to be terminated for various reasons, such as political turnover, stakeholders' lack of interest in continuing engagement, among others. The project termination may also make the benefits no longer available or recognizable to the involved parties, including the government, residents, businesses, and nonprofits. More empirical endeavors that explore how the results might evolve after the initiative comes to an end are necessary. It will also be fruitful to conceptually or empirically investigate how to maintain any positive results over the long run, even in the absence of the project that originally produced them. For instance, ideally, if a smart city project empowers the local stakeholders and helps them form stable collaborative ties, then the partners may be able to continue to cooperate in a different way even when the government cancels the initiative, thereby making the gained benefits last longer. Further research similar to this will certainly offer valuable insights into the overall life cycle of a smart city effort and discover how to determine the success of smart city initiatives from different points of view and assess their multiple dimensions and results.

7. Conclusions

The relationship between smart cities and sustainability is multi-dimensional. This paper attempts to understand and further fathom how the existing studies have dealt with the different dimensions of sustainability and how those different dimensions are

related to the medium-term and long-term results of smart cities. The review started by categorizing the smart city results commonly documented in the literature into three types—short-term outputs, medium-term outcomes, and long-term impacts. Then, we explained that sustainability can be understood in two ways: (1) the duration of results originating from those smart city initiatives and (2) a long-term and comprehensive view of the city that includes results in different dimensions. We compared these different conceptualizations and identified a few interesting gaps that scholars can further investigate in the near future. We argue that smart city researchers can benefit from these insights and thereby design future studies to better understand the results of smart city initiatives, including outputs, outcomes, and impacts.

Our literature review provides valuable contributions to the current research on smart cities and sustainability. Specifically, we thoroughly examine the diverse conceptualizations of sustainability in the context of smart cities. By identifying the variations in scholars' understanding of sustainability, our review enables researchers, both current and future, to easily navigate the different ways in which sustainability in smart cities is or could be defined. In addition, our review also highlights several gaps in the literature that warrant further investigation. Specifically, we recommend that future research should focus on (1) distinguishing between outputs, outcomes, and impacts of smart city initiatives; (2) evaluating the results of specific smart city strategies, initiatives, and projects; and (3) differentiating between the sustainability of operations and the sustainability of results. Addressing these gaps will provide a more comprehensive understanding of the relationship between smart cities and sustainability.

Numerous practical insights for the development and management of smart cities can also be derived from our study. First, decision-makers and managers should carefully plan the deployment of smart city initiatives to ensure both short-term and long-term success. In particular, as politicians may be less likely to see the long-term results of smart cities, it is crucial to involve a greater number of stakeholders in the planning process. Furthermore, it is essential to consider how to sustain positive results even after the termination of a smart city project. Second, our review highlights the importance of better evaluating and monitoring smart city results. Our comprehensive classification of outputs, outcomes, and impacts across different dimensions of smart cities can serve as a reference for practitioners. Finally, the multi-dimensional view of the social, environmental, and economic sustainability of smart cities underscores the importance of understanding and balancing the specific needs of each locality. These lessons drawn from our research could help ensure that smart cities are developed and managed effectively and that they provide sustainable and long-lasting benefits to their residents.

Finally, our research is not without limitations. Despite our efforts to include as many relevant studies as possible, it is possible that we may have missed some publications, particularly those not included in the WoS database. Additionally, while we used a typology of outputs, outcomes, and impacts in combination with multiple dimensions of smart cities to categorize our results, other approaches may exist that could also provide valuable insights into the topic (for example, [88,89]). To address these limitations, future research could consider conducting a more comprehensive and systematic review of the topic and exploring alternative ways of characterizing smart city results. By doing so, we can gain a deeper understanding of sustainability in the context of smart cities from multiple perspectives.

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