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# Rethinking the Role of Technology for Citizens' Engagement and Sustainable Development in Smart Cities

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**Abstract:** Recognizing the interdisciplinary debate about the digital devices and infrastructure needed to support the emergence and viability of smart cities, the latter can be considered one of the most challenging topics within recent decades due to its relevant role in supporting and enhancing citizens' participation in public management. Using a deductive approach, in this paper, we propose a sustainability-based conceptual framework to support both policymakers and managers in better understanding at which level to act to improve citizens' engagement as a way to ensure sustainable development in smart cities. The purpose of this paper is to explore how citizens' involvement in smart cities can be steered toward positive attitudes and behaviors within the context of sustainable development. Drawing on a managerial perspective, we aim to provide preliminary reflections about the key role that digital technologies on which smart cities are based can play in promoting effective sustainable development for all.

**Keywords:** smart cities (SCs); sustainable development (SD); citizens' engagement; sustainability; digital technologies



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## 1. Preliminary Reflections

In recent decades, multiple research strands have been proposed with the goal of proposing theories [1], models [2], and tools [3] that can support both academics and practitioners in the development of new approaches for dealing with the digital dimension of the ongoing transition. Managerial and social studies have underlined the key role of digital transformation issues in influencing social and economic behaviors with respect to inclusive and sustainable development [4–7]. Reflecting upon consolidated managerial studies, it is possible to note how digital transition is usually approached as something not directly related to sustainable development [8].

With the aim of further investigating the relationship between digital transformation and sustainable development, in this paper, we adopt the interpretative lens provided by sustainability science [9–11] to depict a possible interpretative framework in which digital technologies and sustainability challenges are closely linked. In such a vein, the intriguing domain of smart cities (SCs) [12–15], a conceptual and theoretical field in which citizens are strongly committed to common goals and in which they play a key role in defining and supporting public management, is used to outline possible levers that can be used to engage actors in sustainability-based pathways and strategies [16].

Proposed reflections are used to extend the conceptual pillars upon which the Cities Circular Economy (CCE) suggested by Caputo et al. [17] is based, with the aim of highlighting main actions and plans through which policymakers, researchers, and practitioners can have the opportunity to capture and stimulate the multiple existing connections between digital technologies and sustainable development. In such a direction, we propose a conceptual framework that identifies and classifies six levels that can influence the ability of city management to engage citizens in sustainability paths thanks to the contributions provided by technology with the aim of supporting both policy makers and researchers to link sustainability and technology development in the domain of city management.

In accordance with the conceptual flow summarized above, the remainder of this paper is organized as follows. Section 2 provides a synthesis of the theoretical framework underpinning the suggested reflections to explain how the meaning of sustainable development is changing as a result of digital transformation and to detail how citizens' involvement in SCs can facilitate the formulation of patterns to promote an inclusive digital and green transition. Section 3 describes and extends the CCE conceptual model to illustrate the key role that digital technologies can play in ensuring more effective sustainable development. Finally, Section 4 provides preliminary conclusions, implications, and possible new directions for inspiring research.

## 2. The Theoretical Framework

### *2.1. Depicting the Transformation of Sustainable Development in the Digital Era*

The pervasive dissemination of new technologies is totally reshaping all consolidated managerial and social models [18,19]. The emergent Society 5.0 is a challenging domain that "involves a human-centric community which is capable of striking a balance between the economic proliferation and resolving societal liabilities by the core combination of cyber and physical space" [20] (p. 1). The main aim of Society 5.0 is to exploit "the role of the relationship between people and technology in improving the quality of life of every person by means of a super-intelligent society" [18], calling for a profound change in the methods and perspectives with which markets and societal relations are approached and managed [21].

Society 5.0 aims to build a sustainable society and to support people's security and well-being on the basis of a specific cyberphysical system [22,23]. Society 5.0 describes a system of systems within which different systems (such as energy and highway transport systems, for example) are interconnected via the Internet to alleviate both locally and globally relevant social problems (such as the minimization of carbon emissions).

The concept of Society 5.0 seeks to solve social problems through a new approach. In this modern era, several aspects are interrelated, and technologies come together in a superintelligent society through the full blending of big data, the Internet of Things (IoT) and artificial intelligence (AI), to simplify digital and physical infrastructure for humans.The objective is to create social contexts in which people may generate value anytime and anywhere in a natural and protected context, without restrictions, such as those currently in place.

Therefore, a sustainable society is committed to and deals with its present while not undermining future possibilities, thereby arranging itself to enhance its citizens' quality of life. Sustainability is considered to be a comprehensive approach that considers several domains, among which societal issues are an essential element [24].

The technologies associated with Society 5.0, shaping future smart cities, may provide a link connecting citizens and key policy makers to broaden the participation of other stakeholders and ultimately to impact sustainability decision making [25].

As a result, the idea is that every country would be more sustainable by means of better social policies, honest labor, inclusion and equality, offering consistency of policy to embrace the issues in a more cross-cutting way.

Regarding economic sustainability, emergent digital technologies have the potential to guide the transformation towards a more sustainable circular economy, the digital sharing economy, and determine a sustainable design of production and infrastructure.All economic sectors are demonstrating a growing interest in the opportunities made available by big data technologies and analytics [26] to better understand the market's expectations and needs, with the aim of discovering new routes to meet market demands in a more sustainable manner [27].

Emerging digital technologies have changed how companies and citizens conduct their daily life and business activities, resulting in a digital transition. The concept of digital transition describes the transition from analog to digital processes, enabling digital tools to shape processes and operations, thereby making improvements in performance and productivity. Additionally, the digital transition has enhanced the ability to create and implement sustainable solutions.

While manufacturing practices are linked with the improvement of human well-being, they have also been associated with today's environmental and industrial threats. Consequently, scholars and practitioners have recognized digital technologies as pragmatic means for the transition of production processes towards sustainability [28].

Digital technologies have the potential to support industrial sustainability in several ways, including by determining the changes needed at the corporate level to improve organizational performance towards sustainability, optimizing organizational planning processes to forecast demand and identify opportunities presented by sustainability, and enabling companies to experiment with new, efficient business models [29].

Therefore, relying on the ability to collect, organize, and utilize data in wide-ranging processes, new tendencies for the creation of value are arising [30], and new paths for sustainable development are appearing [31].

As one of the cornerstones of Society 5.0, technological innovation may exploit the main characteristics, such as digital alignment, reduced costs of information and reporting, and the rise of cross-border networks, with a resulting effect on sustainability [32]. In short, digital transformation is driving the emergence of a new key path for value creation in business–market relations: the use of information to ensure sustainable development [33]. The current relevance of information undoubtedly thanks to the power provided by the ongoing digital transition [34].

However, information still appears to be undervalued in the sense of a "domain" for value creation and sustainable development through the definition of innovative and widely diffused knowledge management practices [35]. In such a vein, several studies have underlined how the challenging aim of sustainable development can be achieved only if all players are oriented toward shared goals and are able to exchange data and information to attain those goals. [36]. According to this perspective, current managerial literature has identified the key elements of digital technologies that ensure the required alignment in purpose among actors and related information sharing [37]. Unfortunately, the digital transition alone seems to be unable to ensure the required change in perspective due to several cognitive phenomena, such as knowledge hiding [38], knowledge speculation [26], and knowledge brokerage [39].

Reflecting upon the possible reasons why digital transformation and (consequentially) digital technologies are not enough to ensure the expected alignment in actors' purposes and approach to information sharing required to ensure sustainable development for all, a possible motivation can be identified in the challenging concept of cognitive distance, which refers to the different ways in which subjects build their personal representations of the world and of all the processes in which they are involved [40].

This "distance" affects the way in which actors deal with information flows, reducing their willingness and orientation toward information sharing every time they perceive the possibility of obtaining a personal advantage from the exclusive use of owned information [41]. In such a vein, increasing attention on sustainability and sustainable development can offer a possible solution because they can be considered the consequence of the necessary fundamental reassessment of perspectives through which several actors and interests could agree on shared purposes toward which they should direct their forces and resources [42]. Actors sensitized to sustainability challenges and sustainable development are more inclined to share personal information and data [43]. Sustainable development, therefore, provides the possibility to 'see and touch' steps and processes through which a more inclusive society can be built, providing chances to overcome individual reluctance with respect to knowledge and information sharing, which are needed to guarantee the success of the journey [44]. In this regard, some of the several contributions of significant role of multistakeholder collaboration are ensuring the success of the sustainability-based model [45] and the necessity of a multidisciplinary and transdisciplinary setting capable of ensuring the combination of various (and sometimes diverging) perspectives are mentioned [46].

Pomponi and Moncaster [47] focused on the circular economy and recognized "six pillars" required in a holistic approach to ensure sustainable development: (1) the governmental dimension, (2) the economic dimension. (3) the environmental dimension, (4) the behavioral dimension, (5) the social dimension, and (6) the technological dimension.

In the authors' opinion, to promote an efficient model for sustainable development, such as the circular economy, it is necessary to define a governmental approach capable of addressing the behavior of individuals by defining precise and strict rules; reimagining economical dimensions to overcome the simplistic view of 'profit'; encouraging alternative and more efficient ways of using energy and raw materials; promoting responsible behavior by providing more information on products and brand life cycles; ensuring a collaborative, inclusive, and participation-based use of available resources within the social dimensions; and facilitating access to and equal use of technologies. Through these pillars, it is possible to highlight that the logic of the circular economy and (more generally) sustainable development is strongly based on cooperation between multiple actors who—guided by a shared goal—may transcend their individuality to ensure collectivity and an inclusive development.

### *2.2. Sustainable and Inclusive Development through Citizens' Engagement in Smart Cities*

As briefly summarized in the previous section, due to the sudden spread of new digital technologies, there has been a growing focus on the digital domain, which has produced multiple effects in various socioeconomic domains [48]. Governance over towns and municipalities appears to be a challenging task as a result of the growing popularity of the 'smart city' concept in the scientific and professional communities [49].

Although the smart city notion was formulated more than 20 years ago [50], it has long been perceived as an area of interest only for computer scientists, for whom it constituted an 'empirical field' in which to test the application and viability of new digital technologies and devices [51].

In more recent times, the subject has captured the attention of social and management scientists, who are intrigued by its potential employability as a pathway for the promotion of e-public government and citizens' involvement in policymakers' decisions and projects [52]. Concerning this point, the authors of [53] argue that when focusing on "smartness", "Integration is a key dimension that characterizes smartness in the system of the government. Communication, responsiveness, coordination, and service deliveries for citizens can be improved through integration and inter-organizational information sharing in government agencies, making government smarter", opening a considerable debate to which several researchers and practitioners have contributed, proposing tools [54] and practical experiences [55] to support the integration of citizens in new models of city governance [56].

Testoni and Boeri [57] suggested that the management of smart city dynamics necessitates a fresh governance model and robust local government coordination to sustain the handling of complex cooperation procedures with a multitude of actors, particularly citizens. Such a scenario would require redesigning the functions of governments, citizens, and other societal players, as well as the exploration of emerging information technologies to provide a novel form of governance that includes new relationships, new processes, and new governance structures [58].

More specifically, the awareness of diverse stakeholders is significant because sustainability issues are likely to have unforeseeable and simultaneous economic, social, and ecological impacts. Therefore, each individual player has relevant information pertaining to how their own community is being impacted and by which problems, as well as different approaches necessary to understand such problems and, therefore, to deal with them appropriately [59].

Consequently, key success factors of smart city initiatives include the "reorganization of administrative structures and processes between multiple agencies and departments of local government" and the "involvement of stakeholders in governance" [60] (p. 2953). The creation of smart governance frameworks for urban policies is a method of refining decision-making processes and increasing the standard of public service delivery [61]. The significance of the transformation of the government–citizen relationship and collaborative governance as the core aspect of smart governance introduces the concept of participatory governance, which is strongly linked to the new model of governance (as a method) in fostering communication, interaction, collaboration, involvement in decision making, and direct democracy. The growing demands and expectations citizens in favor of practices that are more democratic and more involved in affairs of the government, along with advancements and investments in ICTs and the subsequent improvement of interaction and dialogue between government and citizens, influence e-government strategies. As a result, these strategies increasingly emphasize the citizen-centered component. Such a component concentrates on the relevance and function of citizens, both as 'clients' to create customer-oriented services by employing a less technocentric approach [62,63] and as partners in the coproduction of government services.

A successful process of engaging citizens must integrate everyone's voices and requirements and expand their understanding of a public issue, then encourage them to put this awareness into practice to contribute to improving their standard of living and the community [64,65]. Providing opportunities for citizen involvement and ensuring that these chances are regular and ongoing can contribute to the long-term success of these initiatives. As anticipated in the previous subsections, emerging technologies and digital transformation have an essential function in citizens' involvement and active participation in processes aimed at long-term sustainability, contributing to the reshaping of social relationships and the empowerment of citizens, connecting individuals and smoothing the interchange of knowledge across increasingly broad specificities [66]. Therefore, several engagement tools, mainly of technological origin, have been developed to involve people in their physical communities and allow for participation [64].

Concerning the general usability of ICT-based engagement practices for social issues, the authors of [67] conducted a comprehensive review of 32 case studies aimed at examining citizen involvement in city water management. By exploring crowdsourcing and platform-based solutions, including social media, opensource software, blogs, and e-learning platforms, the authors noted advances in the effectiveness and efficiency of urban water management [68].

Greater focus on citizens enables them to intensify their engagement, which is focused on cooperation, participation, and community empowerment [69–71] and can result in enhanced government transparency [72] and augmented citizen trust and satisfaction [72]. High satisfaction levels lead to increased use of digital government and an enhancement of its future development. More significant roles of citizens and their closer cooperation with the government bring about a smart government model in which the relationship transcends the improvement and the provision of services and extends to the fields of policy making, broader social concerns, and more extensive stakeholder networks.

Pursuing the theoretical flow outlined in [53] and recapitulating the extensive management literature provided in recent years on smart city models [73], and their contribution in fostering and securing citizens' participation [74], it is possible to individuate in the studies conducted by Anttiroiko et al. [75] on the validity of smartness support to visualize the six levels on which SCs act to ensure citizens' participation: (1) governmental, (2) sociocultural, (3) logistical, (4) productive, (5) ecological, and (6) semantic levels.

On a very specific level, the proposed framework allows for the assertion that the involvement of citizens in SC operations and planning is facilitated by the establishment of governmental frameworks concerned with ensuring equitable sociocultural participation, wherein logistical infrastructures are designed and run to support production activities guided by a shared ecological vision and made available through a comprehensive and clear communication flow.

## 3. The Conceptual Model

Recognizing the validity of the suggested theoretical framework, the digital transition and sustainable development are not to be treated as separate and unrelated domains but are to be treated as interrelated components, both of which are necessary to ensure an effective, inclusive, and adequate development for everyone [8].

In such a direction, Caputo et al. [17] hypothesized that the digital and green dimensions can be merged to build a relevant theoretical model that would assist policy makers, researchers, and practitioners in driving the engagement of actors in sustainability-based pathways inside strongly interrelated domains and proposed and applied the conceptual model named Cities Circular Economy (CCE) in the context of a smart city because of the large amount of relationships it relies on, the manifold stakeholders' perspectives by which it is governed, and the central role that citizens' engagement plays in influencing its functioning and existence through time. The concept of the Cities Circular Economy (CCE) was designed to represent the layers in which sustainability pathways are promoted in each type of ecosystem on the basis of the relationships between different and divergent outlooks. According to the authors, the city can evolve as a socioeconomical organization toward a 'sustainability' pattern when the six dimensions suggested in [47] are handled by means of a comprehensive approach, while this pattern 'evolves' into a 'circular' composition when the dimensions are addressed and administered through the identification of the various levels of action listed in [75], each of which is aimed at achieving a specific goal.

Following the conceptual logic upon which the Cities Circular Economy (CCE) is based, thanks to the adoption of a deductive approach [76], it is possible to identify six levels able to influence the ability of city management to engage citizens in sustainability paths thanks to the contributions provided by the technology. The six levels are as follow:

- The ecological level only considers the environmental dimension because of its crucial role in guaranteeing the survival of socioeconomic organizations through time;
- The sociocultural level, in which the environmental dimension is enhanced by the social dimension to explain how stakeholders relate to and exploit available resources;
- The semantic level, in which the technological dimension is added to explain how actors are interconnected and exchange information within socioeconomic organizations to utilize available resources;
- The productive level, in which the economic dimension is incorporated to explain the benefits achieved by interrelated actors within the city ecosystem;
- The logistic level, in which the behavioral dimension is seen to explain how the relationships between actors within the city ecosystem may be effectively implemented by means of a structural arrangement of available resources;
- The governmental level, in which the governmental dimension is included to explain rules, logics, and holistic outlooks that are supposed to drive and direct the behavior and decisions of the actors within the city ecosystem.

Reflecting upon the ways in which these six levels can support citizens' engagement and sustainable development in smart cities thanks to the support provided by digital technologies, the conceptual representation shown in Figure 1 can be hypothesized.

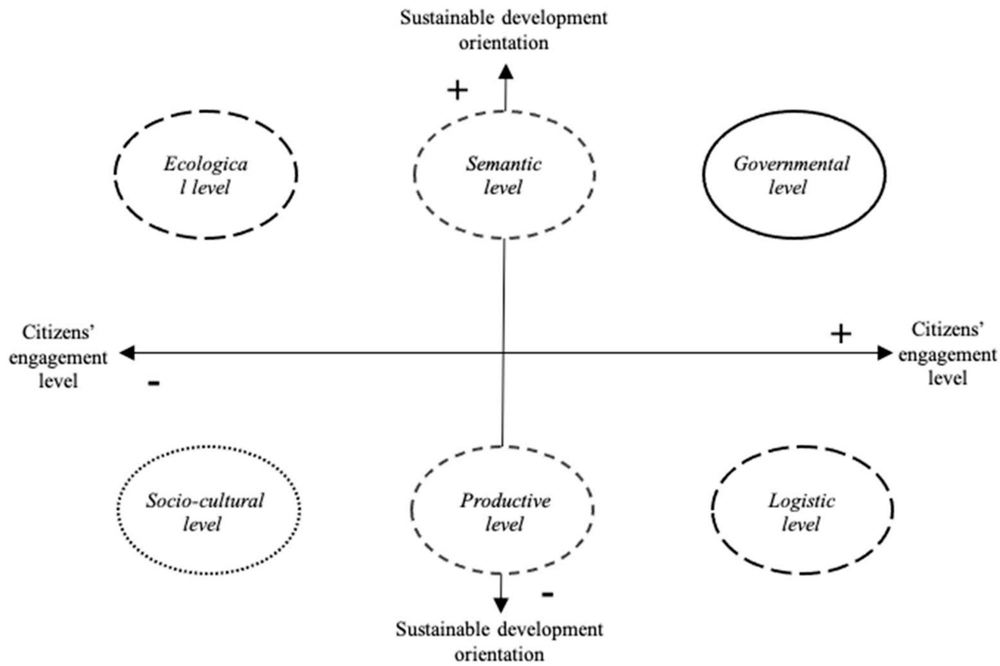


**Figure 1.** Sustainable development orientation and citizen engagement levels in smart cities.

As summarized in Figure 1, sustainable development orientation and the citizen engagement level can be considered as correlated dimensions, and six configurations can be derived from their combination in which digital technologies can play a relevant role, as detailed in the following sections. According to this point, it is possible to note how the sociocultural level, productive level, and logistic level are associated with a low level of sustainable development orientation because they typically represent the results of an individualistic approach through which actors prefix personal aims despite collective interests. These three scenarios are associated with three different citizen engagement levels because the sociocultural level strictly refers to the individualistic representation of reality (each actor does not recognize the whole and is not engaged in it), the productive level requires recognition of the existence of the actors involved in specific processes (each actor recognizes only a part of the whole and is only engaged in it), and the logistic level requires recognition of the complex of processes through which a system is organized (each actor recognizes the whole and is engaged in it).

From a different viewpoint, the ecological level, semantic level, and governmental level are associated with a high level of sustainable development orientation because they typically represent the results of a collective approach through which actors prefix collective interests despite personal aims. These three scenarios are also associated with three citizen engagement levels because the ecological level is typically affected by an individualistic and subjective representation of natural resources (each actor does not recognize the whole and is not engaged in it), the semantic level requires paths and approaches be built to ensure communication and information sharing inside defined processes (each actor recognizes only a part of the whole and is only engaged in it), and the governmental approach requires that all actors' needs and expectations be considered and jointly approached in sharable, organized processes (each actor recognizes the whole and is engaged in it).

### 3.1. Digital Technologies and Citizens' Engagement in Smart Cities

According to the conceptual model presented in Figure 1, the whole domain related to actors' interests and orientations toward sustainability and sustainable development is simplified in two dyadic representations: low and high sustainable development orientation. Specifically, these two levels aim to decode the existence of an effective interest of socioeconomic actors in sustainability and sustainable development challenges as a first step in supporting practitioners and scientists in addressing the development and use of technological devices in a more effective way. According to this representation, when socioeconomic configurations show a low level of sustainable development orientation, it is possible to identify three different fields of action acting on a different approach to citizen engagement.

The first configuration, the 'sociocultural level', shows a low level of citizen engagement and is usually characterized by low levels of attention of socioeconomic actors in the topics of sustainability and sustainable development. This configuration, in the domain of smart cities, requires activating technologies that can be easily used by citizens and policy makers to collect information about the structure and infrastructure within which they develop their activity. Possible examples that can be improved by smart cities to stimulate citizens toward sustainable development in such a configuration include the use of QR codes to provide more information about food tracking and environmental impacts and applications for digital reservation of public services (transportation, meeting in a public office, hospital services, etc.).

The importance of supply chain integration to improve the coordination of smart cities was discussed by Yan et al. [77]. Adequate data exchange and agile creation properties must be matched in smart cities, which require supply chain integration to improve responsiveness.

For example, Regattieri et al. [78] proposed a framework for food traceability that includes product data, routing, traceability devices, and product identification. Several technologies were discussed by the authors, such as radio frequency identification (RFID), barcodes, and alphanumeric codes. In addition, Kelepouris et al. [79] debated the 'practical circumstances of using RFID in food chain tracking'.

However, efforts remain far from adequate, as safety and quality problems such as counterfeits, excessive and unhealthy additions, and expired and spoiled food continue to occur frequently. Effective traceability of prepacked food along the entire supply chain is expected to be an important tool to overcome such issues and is being widely acknowledged and tested in the food industry [80–82]. The explosion of Internet of Things (IoT) technologies means that many real-time tracking and tracing (RT3 S) systems have been deployed in the food supply chain to ensure food security [83]. RT3 S allows for the detection of potential security threats and rapid response to emergencies [84]. In addition, it may also raise customers' trust in buying these foods [85].

QR (quick response) codes, which consist of two-dimensional images that, when scanned by a smartphone camera or scanner, cause the smartphone to open a web page or display an image, video, or text, have become prominent in the food supply chain thanks to their rapid legibility, high storage capacity, and comparatively reasonable cost in full implementations. For example, Qiao et al. [86] proposed a vegetable supply chain traceability model incorporating two-dimensional barcode technology and web services technology. To realize traceability and retraceability in the agri-product supply chain, Gao [87] investigated the application of QR-code technology in the tracking system and the development of a traceable logistics information system based on QR codes, applying QR-code technology in the information transfer process of the vegetable supply chain, encompassing the planting, processing/packaging, and distribution/retail stages. Tavares et al. [88] developed a solution for traceability and retraceability in procurement chains using a QR code for tag generation, image capture and preprocessing, product inventory, and traceability. Additionally, it is worth noting that the implementation of smart parking technologies, such as online parking reservation applications, has the potential to help operators gather and analyze accurate parking data to improve customer satisfaction, enhance the parking experience, and make parking and actual revenue as efficient as possible.

In terms of environmental protection, the reliance on printed tickets is eliminated, since the ticket would be a QR code on the application.

Paper-based ticketing systems are time-consuming and labor-intensive, resulting in increased costs and longer processing times.

By using QR codes in smart car parks, people can pick any empty parking space of their choice via the application. The user only has to scan the QR code on the QR scanner first before parking and dispatching the vehicle. The user's operation is then recorded in the facility's database. The suggested system reduces the time needed to find a free parking space, thereby reducing fuel consumption and user frustration [89].

The second configuration, named the 'productive level', refers to actors' perception about the advantages that they can obtain from collaboration inside a defined ecosystem. In such a configuration, smart city managers should promote technologies able to emphasize in which ways citizens can collaborate to support and facilitate the achievement of sustainable development goals. Possible examples of contributions that digital technologies can provide in such a configuration include the development of a digital app to stimulating the sharing economy (e.g., car sharing, bike sharing, office sharing, etc.) and to the implementation of platforms in which citizens can easily interact to identify collaborative actions and programs (e.g., city gardens, shuttles to take children to school, thematic events, etc.).

One of the primary foundations of the smart city idea is smart mobility, which is centered on improving urban transportation [90]. By implementing cutting-edge solutions for residents via information and communication technology, mobility may be optimized [91]. ICT is a key component of smart mobility (SM), which is used in both backward and forward applications to support traffic flow optimization, enable the multiplication of solutions, and improve user-friendliness [92,93]. Social media is also used to gather citizen feedback on the usefulness and quality of these services.

SM provides a number of alternatives to traditional public transportation options, including mobility sharing, mobility as a service (MaaS), mobility on demand, and autonomous transportation systems. The primary objectives of SM are to reduce pollution and traffic congestion, increase people's safety, decrease noise pollution, improve transfer speed, and reduce transfer costs [92].

It is possible to lessen the negative environmental consequences of automobile use by improving urban transportation services [94]. Despite bold initiatives to promote sustainable mobility, these adverse environmental effects are especially significant given the sector's growing percentage of total final energy consumption in the EU [95]. For an urban transportation system to be efficient and successful, both personal mobility and connection of public transportation must be taken into account [96].

The term "sharing mobility" describes the shared use of vehicles such as motorcycles, scooters, bicycles, and electric micromobility. One of the most cutting-edge transportation methods that enables individuals to quickly access means of transportation in accordance with their demands is sharing mobility. One-way services (by bicycle or car) that can be returned to another place and round-trip services (by bicycle or car) that may be returned to the starting point or anywhere within a defined geographic area are both examples of shared mobility [97].

The usage of conventional and private modes of transportation must be drastically reduced in favor of effective modes such as electric public transportation, walking, bicycling, and car sharing [98].

The third configuration, named the 'logistic level', requires a high level of actor engagement because it refers to the definition of stable configurations through which actors can interact over time to exchange resources. With a specific domain of a smart city, the logistic level refers to the ability to code processes that are useful in supporting citizens in their daily activities. With reference to this configuration, digital devices can provide multiple contributions by optimizing the use of energy for public and private buildings (e.g., smart grid, home automation, remote control, etc.) and/or supporting citizens in selecting sustainable alternatives in light of the city's state at a specific time (e.g., choice of better food suppliers, table reservation in a restaurant, choice among alternative transportation services, etc.). To offer sustainable, dependable, safe, and high-quality energy to all users, smart grid technologies are specifically described as self-sufficient systems that can swiftly repair issues in an existing system while reducing the need for human labor [99].

Smart electricity grids provide the possibility of monitoring distributed energy production through remote reading tools and of reducing the load in case of emergencies [100]. Additionally, historical data on energy output and consumption are used to estimate demand, guaranteeing an exact balance between energy supply and load demand [101,102].

The concept of the smart grid can be defined in different ways, but the shared aspect is the two-way or bidirectional communication, together with the flow of energy between the two involved entities, i.e., the consumer and the grid. The flow of energy has been present for a long time, but the incorporation of communication technologies has made the two-way communication aspect possible. The main features of smart grids or intelligent grids concern monitoring, protection, automation, optimization, integration, and security of the energy flow from utility generators to end-user devices. This leads to energy storage and efficient energy utilization for both power and infrastructure applications.

Communication technologies have played an important role in the concrete implementation of the core characteristics of smart grids. Advances in wired and wireless communication and the widespread accessibility of low-cost interworking devices have led to the emergence of many smart grid applications [103].

In addition, the smart grid must perform very efficiently, with considerable reliability and improved power quality. This key feature provides many advantages and future perspectives in the electricity sector. Customers will be more in charge of and accountable for their energy use. Long disruptions will not happen, owing to the self-healing function. Because smart grids facilitate the integration of renewable energy sources, they would be more efficient and affordable than the current energy system [104].

Carbon emissions may be decreased by prioritizing renewable energy sources. Energy storage prioritization of renewable energy sources can achieve the grid's goal of maintaining a balance between supply and demand. In order to provide a regulated stream of energy through distribution networks, the grid must have a dynamic structure [105].

Smart grids enable applications in terms of distribution, transmission, and management and prioritize renewable energy sources for energy continuity [106].

The many types of applications developed to support citizens' choices include mobile applications for searching and/or booking restaurants (MARSR). A MARSR application is a free program created to run on mobile devices that enables users to perform informational searches; choose and reserve restaurants; and, more specifically, locate restaurants (53%), browse menus (49%), research new restaurants (37%), and place orders for pick-up or delivery (35%) [107].

MARSR provides users with information about restaurant capacity, how busy restaurants are in real time, and when tables will be available, as for other tourist services [108].

This removes uncertainty about schedules and avoids customer waiting times and overcrowding, which are usually linked to environmental damage [109]. This type of app can be understood as a process of the customer service experience [110], i.e., it is part of the tourist experience process when consuming food services.

According to a study by Palau-Saumell et al. [107], mobile apps have evolved into a crucial strategic component in the hospitality industry, especially for restaurants. The customer's job is made easier for restaurants that use mobile apps to take online reservations at specific times and on specific days. Additionally, restaurants may target direct marketing campaigns to anyone they want and whenever they want by doing away with mobile apps for bookings because they have access to the data of their past reservation-making consumers [111].

Customers' habits, perceived legitimacy, hedonic incentive, performance expectations, effort expectations, savings orientation, social influence, and enabling conditions are the key factors that affect how often they utilize mobile apps to make restaurant reservations [107].

### *3.2. Digital Technologies for Sustainable Development in Smart Cities*

Following the conceptual flow proposed in the previous subsection and shifting the attention from a configuration characterized by a low level of sustainable development orientation to a configuration influenced by a high level of sustainable development orientation, it is possible to define scenarios in which a different approach is required in the management of digital devices within smart city configurations. Specifically, the three configurations related to a high level of sustainable development orientation, as shown in Figure 1, require identification of which ways digital technologies can be used to provide an effective response to 'sustainability-based' needs and expectations that are clear and well understood by citizens. Focusing attention on these three configurations, it is possible to note the radical changes required in the approach of smart city management with respect to digital devices and technologies.

The first configuration, named the 'ecological level', is basically related to the availability and accessibility of resources required to satisfy actors' needs. In the smart city configuration, such a level refers to the opportunity to support citizens in easily knowing, understanding, and selecting services and opportunities provided by the smart city. In such a configuration, the digital device should support citizens by analyzing their expectations to propose personalized (cultural, work, and recreative) programs to stimulate sustainability-based behaviors by ensuring personal satisfaction and gratification. With reference to this configuration, a key contribution can be provided by artificial intelligence (AI) and by big data analytics technologies.

The capacity of computers to solve issues and accomplish objectives is referred to as artificial intelligence (AI). Three categories can be made distinguished among these abilities: (1) learning and comprehending from external data [112]; (2) AI systems attempting to mimic human cognitive processes, such as vision and language [113]; and (3) AI systems dealing with the complicated ways in which people think and feel [114].

The ability of robots to "learn from experience, adapt to new inputs, and perform human-like tasks" [115] (p. 63) is one of the potential applications of artificial intelligence (AI). Three key benefits are offered by AI technologies. First, AI enables the automation of pertinent but time-consuming and repetitive operations, freeing up human focus for higher-value work. Second, AI reveals information that would otherwise be hidden in vast amounts of unstructured data that previously needed to be handled and analyzed by humans, such as information derived from videos, images, written reports, business documents, social media posts, or email messages. Thirdly, AI can use countless computers and other resources to tackle even the most challenging problems. Therefore, it is important to use AI's capabilities to identify solutions for the environmental dilemma.

Additionally, knowledge asymmetries and human emotional biases, two issues that hinder the development of solutions for environmental sustainability, may be solved by AI [116].

Humans now have the ability to consider, plan, and implement comprehensive solutions to environmental disasters and climate change, free from reductionist thinking and the narrow interests of individuals and small groups. Although humans design the initial architecture of AI systems, as computers consume and learn from massive volumes of data, the decisions they make will differ from those made by skilled humans, since they are based on objective data and free from cognitive and emotional biases. AI also provides chances for sophisticated extraction methods (such as mining in space) and management of extremely volatile materials (such as nuclear waste) without endangering human health. These places and situations are considered to be high-risk.

In other contexts, artificial intelligence can identify the variables that have a positive or negative impact on environmental performance. Aside from managing increasingly frequent and severe natural disasters, artificial intelligence can help uncover ways to reduce emissions, water footprints, biodiversity concerns, and other environmental impacts [117]. A smart city's governance, culture, and metabolism can also be supported by AI analysis of big data produced by the Internet of Things (IoT) [118].

Finally, Nishant et al. [117] assert that environmental psychology and sociology viewpoints should be incorporated into AI for sustainability, since effective long-term solutions depend on an understanding of the psychological and sociological foundations of human reaction.

The second configuration, named the 'semantic level', refers to the opportunity to define a common and sharable language among the actors engaged in the defined configuration to stimulate and facilitate their interaction and resource exchange. With specific reference to the smart city domain, the semantic level refers to the opportunity to build locally based interexchange platforms that support local (public and private) actors in easily accessing all the information needed to evaluate citizens' services and activities and in terms of sustainability impact. The contributions that digital technologies can provide with reference to this field are multiple, and they are well-summarized by the multiple challenging applications that are available thanks to augmented reality (AR).

A concurrent mix of the real environment and virtual things that can interact in real time and have a three-dimensional recording of the virtual items is known as an augmented reality (AR) system [119,120].

According to Azuma [121], augmented reality (AR) systems combine the real and virtual worlds, are real-time interactive, and are registered in three dimensions. This allows other technologies, such as mobile devices, monitor-based interfaces, and monocular systems, to superimpose virtual objects on top of the real world.

Human environmental perception has been changed thanks to modern technology. In this regard, AR is the most important technology, adding virtual information to real environments, with effects on user cognition [122,123].

AR increases intangible virtual information in the tangible world. Through AR technology, an intuitive, contextual, and immersive way to represent and overlay various data in the urban context is created.

Overlaying information on the real environment may be a considerable advantage in smart cities. The main goal of smart cities is to link everything together and to people. Therefore, AR technology can help citizens to connect instantly and immersively with everything around them [124]. Additionally, augmented reality (AR) can enhance interactions between people and computers in intelligent surroundings in a fun and exciting way that also has advantages for sustainability. Grande [125] noted that by lowering costs and emissions brought on by logistics, AR is a technology that promotes the triple bottom line (TBL). Additionally, SDG 4 and AR can work together to advance sustainable development [126].

The literature has frequently referenced AR technologies as those that can lower facility, manufacturing, engineering, and educational expenses while also resulting in more environmentally friendly outcomes for the physical environment [127–129].

Because it allows users to experience nature without affecting it, AR is the perfect tool for preserving the environment.

The third configuration, named the 'governmental level', is related to opportunities to identify efficient ways in which to address actors' decisions and behaviors with respect to higher ethical and sustainable standards. With specific reference to the smart city domain, this level requires rethinking of the processes through which new rules are introduced and new laws are applied, with the aim of promoting a more democratic logic and extensive participation. Useful contributions to this domain can be provided by digital technologies thanks to so-called virtual reality (VR), through which it is possible to simulate citizens' reactions and perceptions with respect to new rules and guidelines.

The physical environment is completely replaced by a virtual environment in virtual reality (VR), and everything is produced by a visual device [130].

Immersive virtual reality (VR) provides a life-like first-person experience in a three-dimensional virtual environment augmented by multisensory feedback using a head-mounted display, hand controllers, stereoscopic sound, and haptic feedback.

Virtual experiences have become more engaging thanks to technological developments that increased the sensory information supplied, enabling users to feel more connected to virtual experiences. Bailenson [131] argued that VR is most appropriate when simulating otherwise dangerous, impossible, counterproductive, or expensive experiences. In the domains of understanding, emotions, and behavior, along with communication and planning to handle environmental issues, VR has shown encouraging outcomes.

As an alternative, users can learn fundamental concepts about climate change and coastal risks through interactive and secure learning environments provided by virtual reality (VR) simulations. This idea is in line with research that has argued for the necessity of creating a collection of engaging “management flight simulators” for the general public and policy makers to enhance the risk communication process [132]. Virtual reality (VR) experiences can simulate some impending effects of climate change, such as coastal flooding, which cannot be taught through a real (as opposed to virtual) experience without placing people in danger. In order to overcome some of these difficulties, users can learn crucial concepts regarding climate change and coastal threats in an immersive, participatory, and secure learning environment through virtual reality (VR) simulations [133].

It has been argued that focusing on a personal connection, relevance, and learner agency is more effective [134,135], as direct experience of an environmental issue is stronger than second-hand information [136]. The provision of information by itself is not sufficient to trigger behavioral or attitudinal change [137,138]. Not only experience but also behavioral responses influence the ways individuals learn and perceive risks. The ‘Experience-Perception Link’ field of research [139] explores how the experience of the causes of environmental problems (such as extreme weather phenomena) influences individuals’ attitudes and behavior towards these problems.

The capability of virtual reality to swiftly visualize and modify environments in response to user feedback enables a greater understanding of design aspects for a specific context and/or user spatial perception [140]. Virtual reality has been used predominantly in the context of urban development to submit proposals in an intuitive and interactive manner. Allowing everyone involved, such as policymakers, local communities, and urban planners, to participate in and better understand the anticipated changes in an environment prior to the implementation of a development improves information sharing and consensus building during the planning process [141,142].

Diverse research studies have demonstrated that the ability to experience VR scenarios from multiple perspectives has a profound influence on how users perceive problems. For instance, a study on 3D replicas of press events revealed that virtual reality (VR) scenarios foster empathy and have the potential to significantly influence and even alter public opinion on current issues [143]. VR can establish an emotional connection between the audience and the subject, and this emotional connection motivates users to pursue additional information to contextualize what they experienced in the VR scenario.

Participatory approaches involving multiple stakeholders are essential for intelligent and widely accepted urban development. However, only a few cities have established a connection between citizen participation and urban planning. Innovative virtual reality (VR) enters into play here. The technological advancements in VR now permit individuals to be virtually integrated into the future. Using gamification techniques, it is possible to construct educational instruments with lasting effects. Untapped potential must be uncovered, and it must be investigated how serious gaming in a high-level VR environment can increase citizen participation in a smart city. In addition, VR systems have recently emerged as a powerful instrument for interactive and three-dimensional visualization. Citizens are immersed in an emergent future through a high-end VR environment, where they learn how to use new technologies in innovative ways and exploit their potential.

It is anticipated that through VR activities, users will recognize the experience and, in a broader sense, utilize a web-based innovation platforms to develop the potential of smart cities even further [144].

## 4. Conclusions, Implications, and Future Directions for the Research

Over a long period of time, digital technologies and sustainability issues have been considered linked but not complementary domains. Specifically, digital technologies have been approached using an ‘instrumental’ view, according to which technologies are only efficient tools to use in the race toward sustainability balance. Nowadays, both researchers and practitioners have discussed and demonstrated that technologies are not only instruments due to their ability to create new ‘environments’ in which new rules, behaviors, aims, and needs are emerging. According to this perspective, in this paper, we showed how it is possible to link citizen engagement and sustainable development thanks to the challenging role that technologies can play. Using the definitions of six alternative scenarios, in this paper, we explained how technologies can orient citizens toward sustainability-based behaviors.

Based on the reflections presented herein, several implications can be derived both from theoretical and practical viewpoints. This paper enriches the theoretical debate about the role of technologies in influencing actors’ behaviors in socioeconomic configurations, calling attention to the multiple interpretative domains that can be built thanks to the ‘interpretative role’ that technologies are acquiring. This paper also offers practitioners and policymakers with a preliminary dashboard for understanding the ways in which to approach both citizen engagement and sustainable development using technologies.

According to these implications, this paper should be considered a first step in a longer research path interested in explaining the ways in which the six proposed scenarios impact companies’ strategies and survival.

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## References

1. Zhang, W.; Xu, F.; Wang, X. How green transformational leadership affects green creativity: Creative process engagement as intermediary bond and green innovation strategy as boundary spanner. *Sustainability* **2020**, *12*, 3841. [CrossRef]
2. Gil-Gomez, H.; Guerola-Navarro, V.; Oltra-Badenes, R.; Lozano-Quilis, J.A. Customer relationship management: Digital transformation and sustainable business model innovation. *Econ. Res.-Ekon. Istraživanja* **2020**, *33*, 2733–2750. [CrossRef]
3. Pavlidis, G. The digital transformation of the global green bonds market: New-fashioned international standards for a new generation of financial instruments. In *Data Governance in AI, FinTech and LegalTech*; Lee, J., Darbellay, A., Eds.; Edward Elgar Publishing: Cheltenham, UK, 2022; pp. 263–278.
4. Dempsey, N.; Bramley, G.; Power, S.; Brown, C. The social dimension of sustainable development: Defining urban social sustainability. *Sustain. Dev.* **2011**, *19*, 289–300. [CrossRef]
5. Arts, K. Inclusive sustainable development: A human rights perspective. *Curr. Opin. Environ. Sustain.* **2017**, *24*, 58–62. [CrossRef]
6. Saito, O.; Managi, S.; Kanie, N.; Kauffman, J.; Takeuchi, K. Sustainability science and implementing the sustainable development goals. *Sustain. Sci.* **2017**, *12*, 907–910. [CrossRef]
7. Saviano, M.; Barile, S.; Caputo, F.; Lettieri, M.; Zanda, S. From rare to neglected diseases: A sustainable and inclusive healthcare perspective for reframing the orphan drugs issue. *Sustainability* **2019**, *11*, 1289. [CrossRef]
8. Prisco, A.; Del Regno, C.; Lettieri, M.; Caputo, F. Exploiting sustainability pillars for ensuring digital transition in systems functioning. In Proceedings of the 17th IRDO International Conference, Socially Responsibile Society Challenges 2022: Green, Digital, and Inclusive Transition: How to Make it Happen? Maribor, Slovenia, 2−3 June 2022.
9. Kates, R.W.; Clark, W.C.; Corell, R.; Hall, J.M.; Jaeger, C.C.; Lowe, I.; McCarthy, J.J.; Schellnhuber, H.J.; Bolin, B.; Dickson, N.M.; et al. Sustainability science. *Science* **2001**, *292*, 641–642. [CrossRef]
10. De Vries, B.J. *Sustainability Science*; Cambridge University Press: Cambridge, UK, 2012.
11. Heinrichs, H.; Martens, P.; Wiek, A. *Sustainability Science*; Springer: Dordrecht, Germania, 2016.
12. Campbell, T. *Beyond Smart Cities: How Cities Network, Learn and Innovate*; Earthscan from Routledge: New York, NY, USA, 2012.
13. Song, H.; Srinivasan, R.; Sookoor, T.; Jeschke, S. *Smart Cities: Foundations, Principles, and Applications*; John Wiley & Sons: Hoboken, NJ, USA, 2017.
14. Caputo, F.; Walletzky, L.; Štepánek, P. Towards a systems thinking based view for the governance of a smart city’s ecosystem: A bridge to link Smart Technologies and Big Data. *Kybernetes* **2018**, *48*, 108–123. [CrossRef]

15. Polese, F.; Barile, S.; Caputo, F.; Carrubbo, L.; Waletzky, L. Determinants for value cocreation and collaborative paths in complex service systems: A focus on (smart) cities. *Serv. Sci.* **2018**, *10*, 397–407. [CrossRef]
16. Caputo, F.; Buhnova, B.; Walletzký, L. Investigating the role of smartness for sustainability: Insights from the Smart Grid domain. *Sustain. Sci.* **2018**, *13*, 1299–1309. [CrossRef]
17. Caputo, F.; Prisco, A.; Lettieri, M.; Crescenzo, M. Citizens' engagement in smart cities for promoting circular economy. In Proceedings of the International Conference on Exploring Service Science (IESS 2.3), Geneva, Switzerland, 16–17 February 2023; Carrubbo, L., Ralyté, J., Eds.; ITM Web of Conferences: Geneva, Switzerland, 2023; Volume 51, pp. 1–11. [CrossRef]
18. Ferreira, C.M.; Serpa, S. Society 5.0 and social development. *Manag. Organ. Stud.* **2018**, *5*, 26–31.
19. Salgues, B. *Society 5.0: Industry of the Future, Technologies, Methods and Tools*; John Wiley & Sons: Hoboken, NJ, USA, 2018.
20. Nair, M.M.; Tyagi, A.K.; Sreenath, N. The future with industry 4.0 at the core of society 5.0: Open issues, future opportunities and challenges. In Proceedings of the 2021 International Conference On Computer Communication and Informatics (ICCCI), Coimbatore, India, 27–29 January 2021; pp. 1–7. [CrossRef]
21. Del Giudice, M.; Caputo, F.; Evangelista, F. How are decision systems changing? The contribution of social media to the management of decisional liquefaction. *J. Decis. Syst.* **2016**, *25*, 214–226. [CrossRef]
22. Fujii, T.; Guo, T.; Kamoshida, A. A Consideration of Service Strategy of Japanese Electric Manufacturers to Realize Super Smart Society (SOCIETY 5.0). In Proceedings of the Knowledge Management in Organizations KMO 2018 Programmieren für Ingenieure und Naturwissenschaftler, Žilina, Slovakia, 6–10 August 2018; Uden, L., Hadzima, B., Ting, I.H., Eds.; Springer Science and Business Media LLC: Berlin/Heidelberg, Germany, 2018; pp. 634–645.
23. Nagahara, M. A Research Project of Society 5.0 in Kitakyushu, Japan. In Proceedings of the IEEE Conference on Control Technology and Applications (CCTA), Hong Kong, China, 19–21 August 2019; pp. 803–804.
24. Narvaez Rojas, C.; Alomia Peñafiel, G.A.; Loaiza Buitrago, D.F.; Tavera Romero, C.A. Society 5.0: A Japanese Concept for a Superintelligent Society. *Sustainability* **2021**, *13*, 6567. [CrossRef]
25. Abbasi, A.; Kamal, M.M. Adopting Industry 4.0 Technologies in Citizens' Electronic-Engagement Considering Sustainability Development. In Proceedings of the Information Systems: 16th European, Mediterranean, and Middle Eastern Conference, EMCIS 2019, Dubai, United Arab Emirates, 9–10 December 2019; Themistocleous, M., Papadaki, M., Eds.; Springer International Publishing: Berlin/Heidelberg, Germany, 2020; Volume 381, pp. 304–313.
26. Milgrom, P.; Stokey, N. Information, trade and common knowledge. *J. Econ. Theory* **1982**, *26*, 17–27. [CrossRef]
27. Kharrazi, A.; Qin, H.; Zhang, Y. Urban big data and sustainable development goals: Challenges and opportunities. *Sustainability* **2016**, *8*, 1293. [CrossRef]
28. Liu, Y.; Zhu, Q.; Seuring, S. New technologies in operations and supply chains: Implications for sustainability. *Int. J. Prod. Econ.* **2020**, *229*, 107889. [CrossRef]
29. Demartini, M.; Evans, S.; Tonelli, F. Digitalization technologies for industrial sustainability. *Procedia Manuf.* **2019**, *33*, 264–271. [CrossRef]
30. Fathi, M.; Khakifirooz, M.; Pardalos, P.M. *Optimization in Large Scale Problems: Industry 4.0 and Society 5.0 Applications*; Springer: Berlin/Heidelberg, Germany, 2019; Volume 152.
31. Etzion, D.; Aragon-Correa, J.A. Big data, management, and sustainability: Strategic opportunities ahead. *Organ. Environ.* **2016**, *29*, 147–155. [CrossRef]
32. Mavrodieva, A.V.; Shaw, R. Disaster and Climate Change Issues in Japan's Society 5.0—A Discussion. *Sustainability* **2020**, *12*, 1893. [CrossRef]
33. Majchrzak, A.; Markus, M.L.; Wareham, J. Designing for digital transformation. *MIS Q.* **2016**, *40*, 267–278. [CrossRef]
34. Oh, W.; Pinsonneault, A. On the assessment of the strategic value of information technologies: Conceptual and analytical approaches. *MIS Q.* **2007**, *31*, 239–265. [CrossRef]
35. Barrero, J.M. The micro and macro of managerial beliefs. *J. Financ. Econ.* **2022**, *143*, 640–667. [CrossRef]
36. Caputo, F. Reflecting upon knowledge management studies: Insights from systems thinking. *Int. J. Knowl. Manag. Stud.* **2017**, *8*, 177–199.
37. Riso, T.; Morrone, C. To Align Technological Advancement and Ethical Conduct: An Analysis of the Relationship between Digital Technologies and Sustainable Decision-Making Processes. *Sustainability* **2023**, *15*, 1911. [CrossRef]
38. Connelly, C.E.; Zweig, D.; Webster, J.; Trougakos, J.P. Knowledge hiding in organizations. *J. Organ. Behav.* **2012**, *33*, 64–88. [CrossRef]
39. Hinloopen, J. The market for knowledge brokers. *Small Bus. Econ.* **2004**, *22*, 407–415. [CrossRef]
40. Montello, D.R. The measurement of cognitive distance: Methods and construct validity. *J. Environ. Psychol.* **1991**, *11*, 101–122. [CrossRef]
41. Caputo, F. Towards a holistic view of corporate social responsibility. The antecedent role of information asymmetry and cognitive distance. *Kybernetes* **2021**, *50*, 639–655. [CrossRef]
42. Magyari, J.; Zavarkó, M.; Csedő, Z. Smart knowledge management driving green transformation: A comparative case study. *Smart Energy* **2022**, *7*, 100085. [CrossRef]
43. Barwińska-Małajowicz, A.; Knapková, M. Selected Social Aspects of the Green Transformation. In *Green Energy*; Bąk, I., Cheba, K., Eds.; Springer: Cham, Switzerland, 2023; pp. 71–84.

44. Leach, M. What Is Green?: Transformation imperatives and knowledge politics. In *The Politics of Green Transformations*; Scoones, I., Leach, M., Newell, P., Eds.; Routledge: London, UK, 2015; pp. 25–38.
45. MacDonald, A.; Clarke, A.; Huang, L. Multi-stakeholder partnerships for sustainability: Designing decision-making processes for partnership capacity. In *Business and the Ethical Implications of Technology*; Kirsten, M., Shilton, K., Smith, J., Eds.; Springer Nature Switzerland: Cham, Switzerland, 2022; pp. 103–120.
46. Liu, Z.; Liu, J.; Osmani, M. Integration of digital economy and circular economy: Current status and future directions. *Sustainability* **2021**, *13*, 7217. [CrossRef]
47. Pomponi, F.; Moncaster, A. Circular economy for the built environment: A research framework. *J. Clean. Prod.* **2017**, *143*, 710–718. [CrossRef]
48. Vial, G. Understanding digital transformation: A review and a research agenda. *J. Strateg. Inf. Syst.* **2019**, *28*, 118–144. [CrossRef]
49. Anthony Jnr, B. Managing digital transformation of smart cities through enterprise architecture—A review and research agenda. *Enterp. Inf. Syst.* **2021**, *15*, 299–331. [CrossRef]
50. Van Bastelaer, B. Digital cities and transferability of results. In Proceedings of the European Digital Cities: 4th Conference: Changing Patterns of Urban Life, Salzburg, Austria, 29–30 October 1998; pp. 61–70.
51. Talari, S.; Shafie-Khah, M.; Siano, P.; Loia, V.; Tommasetti, A.; Catalão, J.P. A review of smart cities based on the internet of things concept. *Energies* **2017**, *10*, 421. [CrossRef]
52. Kopackova, H.; Komarkova, J.; Horak, O. Enhancing the diffusion of e-participation tools in smart cities. *Cities* **2022**, *125*, 103640. [CrossRef]
53. Gil-Garcia, J.R.; Zhang, J.; Puron-Cid, G. Conceptualizing smartness in government: An integrative and multi-dimensional view. *Gov. Inf. Quaterly* **2016**, *33*, 524. [CrossRef]
54. Giffinger, R.; Gudrun, H. Smart cities ranking: An effective instrument for the positioning of the cities? *ACE Archit. City Environ.* **2010**, *4*, 7–26. [CrossRef]
55. Yigitcanlar, T.; Kamruzzaman, M.; Foth, M.; Sabatini-Marques, J.; da Costa, E.; Ioppolo, G. Can cities become smart without being sustainable? A systematic review of the literature. *Sustain. Cities Soc.* **2019**, *45*, 348–365. [CrossRef]
56. Joshi, S.; Saxena, S.; Godbole, T. Developing smart cities: An integrated framework. *Procedia Comput. Sci.* **2016**, *93*, 902–909. [CrossRef]
57. Boeri, A.; Testoni, C. Smart Governance: Urban regeneration and integration policies in Europe. Turin and Malmö case studies. *Int. J. Sci. Eng. Res.* **2015**, *6*, 527–533.
58. Gil-Garcia, J.R. Towards a smart State? Inter-agency collaboration, information integration, and beyond. *Inf. Policy* **2012**, *17*, 269–280. [CrossRef]
59. Owen, A.L.; Videras, J. Trust, cooperation, and implementation of sustainability programs: The case of Local Agenda 21. *Ecol. Econ.* **2008**, *68*, 259–272. [CrossRef]
60. Alawadhi, S.; Scholl, H.J. Smart Governance: A Cross-Case Analysis of Smart City Initiatives. In Proceedings of the 2016 49th Hawaii International Conference on System Sciences (HICSS), Washington, DC, USA, 5–8 January 2016; IEEE: Piscataway, NJ, USA, 2016; pp. 2953–2963.
61. Elisei, P.; D'Orazio, A.; Prezioso, M. Smart Governance Answers to Metropolitan Peripheries: Regenerating the Deprived Area of the Morandi Block in the Tor Sapienza Neighbourhood (Rome). In Proceedings of the REAL CORP 2014, Vienna, Austria, 21–23 May 2014; Available online: http://www.corp.at/archive/CORP2014_161.pdf (accessed on 13 April 2023).
62. Janssen, M.; Estevez, E. Lean government and platform-based governance—Doing more with less. *Gov. Inf. Q.* **2013**, *30* (Suppl. S1), S1–S8. [CrossRef]
63. Helbig, N.; Gil-García, J.R.; Ferro, E. Understanding the complexity of electronic government: Implications from the digital divide literature. *Gov. Inf. Q.* **2009**, *26*, 89–97. [CrossRef]
64. Olphert, W.; Damodaran, L. Citizen participation and engagement in the design of e-government services: The missing link in effective ICT design and delivery. *J. Assoc. Inf. Syst.* **2007**, *8*, 27. [CrossRef]
65. Church, S. Photovoice as a Community Engagement Tool in Place-Based Sustainable Neighborhood Design: A Review of Literature. Bachelor's Thesis, Montana State University, Bozeman, MT, USA, 18 September 2020.
66. Lekan, M.; Rogers, H.A. Digitally enabled diverse economies: Exploring socially inclusive access to the circular economy in the city. *Urban Geogr.* **2020**, *41*, 898–901. [CrossRef]
67. Mukhtarov, F.; Dieperink, C.; Driessen, P. The influence of information and communication technologies on public participation in urban water governance: A review of place-based research. *Environ. Sci. Policy* **2018**, *89*, 430–438. [CrossRef]
68. Katika, T.; Karaseitanidis, I.; Tsiakou, D.; Makropoulos, C.; Amditis, A. Augmented Reality (AR) Supporting Citizen Engagement in Circular Economy. *Circ. Econ. Sustain.* **2022**, *2*, 1077–1104. [CrossRef]
69. Rose, J.; Persson, J.S.; Heeager, L.T. How e-Government managers prioritise rival value positions: The efficiency imperative. *Inf. Polity* **2015**, *20*, 35–59. [CrossRef]
70. Lambert, F. Seeking electronic information from government resources: A comparative analysis of two communities' web searching of municipal government websites. *Gov. Inf. Q.* **2013**, *30*, 99–109. [CrossRef]
71. Linders, D. From e-government to we-government: Defining a typology for citizen coproduction in the age of social media. *Gov. Inf. Q.* **2012**, *29*, 446–454. [CrossRef]

72. Bertot, J.C.; Jaeger, P.T.; Grimes, J.M. Using ICTs to create a culture of transparency: E-government and social media as openness and anti-corruption tools for societies. *Gov. Inf. Q.* **2010**, *27*, 264–271. [CrossRef]
73. Alshahadeh, T.; Marsap, A. Smart Cities, Smarter Management: Developing a Smart Framework for Smart Cities Management in Europe. *GE-Int. J. Manag. Res.* **2018**, *6*, 41–73. Available online: https://ssrn.com/abstract=3733911 (accessed on 13 April 2023).
74. Fernandez-Anez, V.; Fernández-Güell, J.M.; Giffinger, R. Smart City implementation and discourses: An integrated conceptual model. The case of Vienna. *Cities* **2018**, *78*, 4–16. [CrossRef]
75. Anttiroiko, A.-V.; Valkama, P.; Bailey, S.J. Smart cities in the new service economy: Building platforms for smart services. *AI Soc.* **2013**, *29*, 323–334. [CrossRef]
76. Reyes, M.Z. *Social Research: A Deductive Approach*; Rex Bookstore Inc.: Quezon City, Philippines, 2004.
77. Yan, B.; Hu, D.; Shi, P. A traceable platform of aquatic foods supply chain based on RFID and EPC Internet of Things. *Int. J. RF Technol.* **2012**, *4*, 55–70. [CrossRef]
78. Regattieri, A.; Gamberi, M.; Manzini, R. Traceability of food products: General framework and experimental evidence. *J. Food Eng.* **2007**, *81*, 347–356. [CrossRef]
79. Kelepouris, T.; Pramatari, K.; Doukidis, G. RFID-enabled traceability in the food supply chain. *Ind. Manag. Data Syst.* **2007**, *107*, 183–200. [CrossRef]
80. Heyder, M.; Theuvsen, L.; Hollmann-Hespos, T. Investments in tracking and tracing systems in the food industry: A PLS analysis. *Food Policy* **2012**, *37*, 102–113. [CrossRef]
81. Gandino, F.; Montrucchio, B.; Rebaudengo, M.; Sanchez, E.R. Analysis of an RFID-based information system for tracking and tracing in an agri-food chain. *RFID Eurasia* **2007**, *25*, 1–6.
82. Scholten, H.; Verdouw, C.N. Defining and analyzing traceability systems in food supply chains. In *Advances in Food Traceability Techniques and Technologies*; Espiñeira, M., Santaclara, F.J., Eds.; Elsevier: New York, NY, USA, 2016; pp. 9–33.
83. Trienekens, J.H.; van der Vorst, J.G.A.J.; Verdouw, C.N. Global Food Supply Chains. In *Encyclopedia of Agriculture and Food Systems*, 2nd ed.; van Alfen, N.K., Ed.; Academic Press: New York, NY, USA, 2014; pp. 499–517.
84. Aung, M.M.; Chang, Y.S. Traceability in a food supply chain: Safety and quality perspectives. *Food Control.* **2014**, *39*, 172–184. [CrossRef]
85. Liu, Y.; Han, W.L. An Internet-of-things solution for food safety and quality control: A pilot project in China. *J. Ind. Inf. Integr.* **2016**, *3*, 1–7. [CrossRef]
86. Qiao, S.; Wei, Z.; Yang, Y. Research on vegetable supply chain traceability model based on two-dimensional barcode. In Proceedings of the 6th International Symposium on Computational Intelligence and Design (ISCID), New York, NY, USA, 28–29 October 2013; pp. 317–320.
87. Gao, H.M. Study on the application of the QR code technology in the farm product supply chain traceability system. *Appl. Mech. Mater.* **2013**, *321–324*, 3056–3060. [CrossRef]
88. Tavares, D.M.; Bachega, S.J.; Caurin, G.A.D.P. Architecture proposal for the use of QR code in supply chain management. *Rev. Produção Online* **2012**, *12*, 73–90. [CrossRef]
89. Bagadiong, M.A.; De Leon, L.A.; Dizon, A.A.; Young, M. Car Park Reservation Using QR System: Proposed Flow. In Proceedings of the 2020 IEEE 7th International Conference on Engineering Technologies and Applied Sciences (ICETAS), Kuala Lumpur, Malaysia, 18–20 December 2020; pp. 1–5. [CrossRef]
90. OECD. *Smart Cities and Inclusive Growth, Building on the Outcomes of the 1st OECD Roundtable on Smart Cities and Inclusive Growth*; OECD Headquarters: Paris, France, 2019.
91. Falco, E.; Malavolta, I.; Radzimski, A.; Ruberto, S.; Iovino, L.; Gallo, F. Smart City L'Aquila: An Application of the "Infostructure" Approach to Public Urban Mobility in a Post-Disaster Context. *J. Urban Technol.* **2018**, *25*, 99–121. [CrossRef]
92. Benevolo, C.; Dameri, R.P.; D'auria, B. Smart mobility in smart city: Action taxonomy, ICT intensity and public benefits. In *Empowering Organizations: Enabling Platforms and Artefacts*; Torre, T., Braccini, A., Spinelli, R., Eds.; Springer International Publishing: Cham, Switzerland, 2016; Volume 11, pp. 13–28.
93. Osorio-Arjona, J.; García-Palomares, J.C. Social media and urban mobility: Using twitter to calculate home-work travel matrices. *Cities* **2019**, *89*, 268–280. [CrossRef]
94. Yatskiv, I.; Budilovich, E.; Gromule, V. Accessibility to Riga Public Transport Services for Transit Passengers. *Procedia Eng.* **2017**, *187*, 82–88. [CrossRef]
95. Yu, Z.; Streimikiene, D.; Balezentis, T.; Dapkus, R.; Jovovic, R.; Draskovic, V. Final Energy Consumption Trends and Drivers in Czech Republic and Latvia. *Amfiteatru Econ.* **2017**, *19*, 866.
96. Cheng, Y.H.; Chen, S.Y. Perceived accessibility, mobility, and connectivity of public transportation systems. *Transp. Res. Part A: Policy Pract.* **2015**, *77*, 386–403. [CrossRef]
97. Scalingi, A.; Savastano, M.; Ruggieri, R.; D'Ascenzo, F. Car sharing and relocation strategies: A case study comparison in the italian market. In *Organizing for Digital Economy: Societies, Communities and Individuals, Proceedings of the 14th annual conference of the Italian chapter of the AIS, Rome, Italy, 5–9 November 2018*; LUISS University Press: Rome, Italy, 2018.
98. Litman, T. Environmental reviews and case studies: Why and how to reduce the amount of land paved for roads and parking facilities. *Environ. Pract.* **2011**, *13*, 38–46. [CrossRef]
99. Bayindir, R.; Colak, I.; Fulli, G.; Demirtas, K. Smart grid technologies and applications. *Renew. Sustain. Energy Rev.* **2016**, *66*, 499–516. [CrossRef]

100. Bruno, S.; Lamonaca, S.; La Scala, M.; Rotondo, G.; Stecchi, U. Load control through smart-metering on distribution networks. In Proceedings of the 2009 IEEE Bucharest PowerTech Conference, Bucharest, Romania, 28 June–2 July 2009; pp. 1–8. [CrossRef]
101. Maharjan, S.; Zhu, Q.; Zhang, Y.; Gjessing, S.; Başar, T. Demand response management in the smart grid in a large population regime. *IEEE Trans. Smart Grid* **2015**, *7*, 189–199. [CrossRef]
102. Li, W.T.; Yuen, C.; Hassan, N.U.; Tushar, W.; Wen, C.K.; Wood, K.L.; Hu, K.; Liu, X. Demand response management for residential smart grid: From theory to practice. *IEEE Access* **2015**, *3*, 2431–2440. [CrossRef]
103. Usman, A.; Shami, S.H. Evolution of communication technologies for smart grid applications. *Renew. Sustain. Energy Rev.* **2013**, *19*, 191–199. [CrossRef]
104. Beidou, F.B.; Morsi, W.G.; Diduch, C.P.; Chang, L. Smart grid: Challenges, research directions and possible solutions. In Proceedings of the 2nd International Symposium on Power Electronics for Distributed Generation Systems, Hefei, China, 16–18 June 2010; pp. 670–673. [CrossRef]
105. Varaiya, P.P.; Wu, F.F.; Bialek, J.W. Smart operation of smart grid: Risk-limiting dispatch. *Proc. IEEE* **2010**, *99*, 40–57. [CrossRef]
106. Hamidi, V.; Smith, K.S.; Wilson, R.C. Smart grid technology review within the transmission and distribution sector. In Proceedings of the 2010 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT Europe), Gothenburg, Sweden, 11–13 October 2010; pp. 1–8.
107. Palau-Saumell, R.; Forgas-Coll, S.; Sanchez-García, J.; Robres, E. User acceptance of mobile apps for restaurants: An expanded and extended UTAUT-2. *Sustainability* **2019**, *11*, 1210. [CrossRef]
108. Dickinson, J.E.; Ghali, K.; Cherrett, T.; Speed, C.; Davies, N.; Norgate, S. Tourism and the smartphone app: Capabilities, emerging practice and scope in the travel domain. *Curr. Issues Tour.* **2014**, *17*, 84–101. [CrossRef]
109. Higham, J.; Hinch, T. *Sport Tourism Development*; Channel View Publications: Bristol, UK, 2018; Volume 84.
110. Pareigis, J.; Edvardsson, B.; Enquist, B. Exploring the role of the service environment in forming customer's service experience. *Int. J. Qual. Serv. Sci.* **2011**, *3*, 110–124. [CrossRef]
111. Gregorash, B.J. Restaurant revenue management: Apply reservation management? *Inf. Technol. Tour.* **2016**, *16*, 331–346. [CrossRef]
112. Kaplan, A.; Haenlein, M. Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence. *Bus. Horiz.* **2019**, *62*, 15–25. [CrossRef]
113. Russell, S.J.; Norvig, P. *Artificial Intelligence: A Modern Approach*; Pearson Education Limited: Kuala Lumpur, Malaysia, 2016.
114. Martınez-Miranda, J.; Aldea, A. Emotions in human and artificial intelligence. *Comput. Hum. Behav.* **2005**, *21*, 323–341. [CrossRef]
115. Duan, Y.; Edwards, J.S.; Dwivedi, Y.K. Artificial intelligence for decision making in the era of Big Data–evolution, challenges and research agenda. *Int. J. Inf. Manag.* **2019**, *48*, 63–71. [CrossRef]
116. Cullen-Knox, C.; Eccleston, R.; Haward, M.; Lester, E.; Vince, J. Contemporary Challenges in Environmental Governance: Technology, governance and the social licence. *Environ. Policy Gov.* **2017**, *27*, 3–13. [CrossRef]
117. Nishant, R.; Kennedy, M.; Corbett, J. Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda. *Int. J. Inf. Manag.* **2020**, *53*, 102104. [CrossRef]
118. Allam, Z.; Dhunny, Z.A. On big data, artificial intelligence and smart cities. *Cities* **2019**, *89*, 80–91. [CrossRef]
119. Azuma, R.T. A survey of augmented reality. *Teleoperators Virtual Environ.* **1997**, *6*, 355–385. [CrossRef]
120. Kolivand, H.; Hasan Zakaria, A.; Sunar, M.S. Shadow Generation in Mixed Reality: A Comprehensive Survey. *IETE Tech. Rev.* **2015**, *32*, 3–15. [CrossRef]
121. Azuma, R.T.; Bailot, Y.; Behringer, R.; Feiner, S.K.; Julier, S.; MacIntyre, B. Recent Advances in Augmented Reality. *IEEE Comput. Graph. Appl.* **2001**, *21*, 34–47. [CrossRef]
122. Tom Dieck, M.C.; Jung, T. A theoretical model of mobile augmented reality acceptance in urban heritage tourism. *Curr. Issues Tour.* **2015**, *21*, 154–174. [CrossRef]
123. Kolivand, H.; Billinghurst, M.; Sunar, M.S. LivePhantom: Retrieving Virtual World Light Data to Real Environments. *PLoS ONE* **2016**, *11*, e0166424. [CrossRef]
124. Kaji, S.; Kolivand, H.; Madani, R.; Salehinia, M.; Shafaie, M. Augmented reality in smart cities: A multimedia approach. *J. Eng. Technol.* **2018**, *6*, 28–45.
125. Grande, J. Can #AR Grow the Triple Bottom Line and Save Brick and Mortar Retail? 2018. Available online: https://www.linkedin.com/pulse/can-ar-grow-triple-bottom-line-save-brick-mortar-retail-jim-grande/ (accessed on 14 April 2023).
126. UNESCO. Sustainable Development Goal 4 (SDG 4). 2017. Available online: https://www.unesco.org/en/fieldoffice/brasilia (accessed on 14 April 2023).
127. Bacca, J.; Baldiris, S.; Fabregat, R.; Graf, S.; Kinshuk, G. Augmented Reality Trends in Education: A Systematic Review of Research and Applications. *Educ. Technol. Soc.* **2014**, *17*, 133–149.
128. Carbonell Carrera, C.; Bermejo Asensio, L.A. Augmented reality as a digital teaching environment to develop spatial thinking. *Cartogr. Geogr. Inf. Sci.* **2017**, *44*, 259–270. [CrossRef]
129. Ferrer-Torregrosa, J.; Torralba, J.; Jimenez, M.A.; García, S.; Barcia, J.M. ARBOOK: Development and assessment of a tool based on augmented reality for anatomy. *J. Sci. Educ. Technol.* **2015**, *24*, 119–124. [CrossRef]
130. Cook, A.; Jones, R.; Raghavan, A.; Saif, I. Tech Trends 2018. Available online: https://www2.deloitte.com/us/en/insights/focus/tech-trends/2018.html (accessed on 13 April 2023).
131. Bailenson, J. *Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do*; WW Norton & Company: New York, NY, USA, 2018.

132. Sterman, J.; Franck, T.; Fiddaman, T.; Jones, A.; McCauley, S.; Rice, P.; Sawin, E.; Siegel, L.; Rooney-Varga, J.N. WORLD CLIMATE: A Role-Play Simulation of Climate Negotiations. *Simul. Gaming* **2015**, *46*, 348–382. [CrossRef]
133. Calil, J.; Fauville, G.; Queiroz, A.; Leo, K.; Mann, A.; Wise-West, T.; Salvatore, P.; Bailenson, J.N. Using Virtual Reality in Sea Level Rise Planning and Community Engagement—An Overview. *Water* **2021**, *13*, 1142. [CrossRef]
134. Bamberg, S.; Möser, G. Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *J. Environ. Psychol.* **2007**, *27*, 14–25. [CrossRef]
135. Kollmuss, A.; Agyeman, J. Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ. Educ. Res.* **2002**, *8*, 239–260. [CrossRef]
136. Spence, A.; Poortinga, W.; Butler, C.; Pidgeon, N.F. Perceptions of climate change and willingness to save energy related to flood experience. *Nat. Clim. Chang.* **2011**, *1*, 46–49. [CrossRef]
137. Bray, B.J.; Cridge, A.G. Can education programmes effect long term behavioural change? *Int. J. Innov. Interdiscip. Res.* **2013**, *2*, 27–33.
138. Clayton, S.; Devine-Wright, P.; Stern, P.C.; Whitmarsh, L.; Carrico, A.; Steg, L.; Swim, J.; Bonnes, M. Psychological research and global climate change. *Nat. Clim. Chang.* **2015**, *5*, 640–646. [CrossRef]
139. Lang, C.; Ryder, J.D. The effect of tropical cyclones on climate change engagement. *Clim. Chang.* **2016**, *135*, 625–638. [CrossRef]
140. Liddicoat, S. Older Adults as Co-researchers for Built Environments: Virtual Reality as a Means of Engagement. In *Ageing and Digital Technology*; Neves, B.B., Vetere, F., Eds.; Springer: Singapore, 2019; pp. 151–169.
141. Axford, S.; Keltie, G.; Wallis, C. Virtual Reality in Urban Planning and Design. In *Multimedia Cartography*; Cartwright, W., Peterson, M.P., Gartner, G., Eds.; Springer: Berlin/Heidelberg, Germany, 2007; pp. 283–294.
142. Engel, J.; Döllner, J. Immersive Visualization of Virtual 3D City Models and its Applications in E-Planning. *Int. J. E-Plan. Res. (IJEPR)* **2012**, *1*, 18. [CrossRef]
143. de la Peña, N.; Weil, P.; Llobera, J.; Spanlang, B.; Friedman, D.; Sanchez-Vives, M.V.; Slater, M. Immersive Journalism: Immersive Virtual Reality for the First-Person Experience of News. *Presence* **2010**, *19*, 291–301. [CrossRef]
144. West, M.; Yildirim, O.; Harte, A.E.; Ramram, A.; Fleury, N.W.; Carabias-Hütter, V. Enhancing citizen participation through serious games in virtual reality. In *Proceedings of 24th International Conference on Urban Planning, Regional Development and Information Society, Karlsruche, Germany, 2–4 April 2019*; Schenk, M., Popovich, V.V., Zeile, P., Elisei, P., Beyer, C., Ryser, J., Eds.; Competence Center of Urban and Regional Planning: Essen, Germany, 2019; pp. 881–888. [CrossRef]