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Management of Smart and Sustainable Cities in the Post-COVID-19 Era: Lessons and Implications

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Abstract: Nowadays, the concept of smart sustainable governance is wrapped around basic principles such as: (i) transparency, (ii) accountability, (iii) stakeholders' involvement, and iv) citizens' participation. It is through these principles that are influenced by information and communication technologies (ICT), Internet of Things (IoT), and artificial intelligence, that the practices employed by citizens and their interaction with electronic government (e-government) are diversified. Previously, the misleading concepts of the smart city implied only the objective of the local level or public officials to utilize technology. However, the recent European experience and research studies have led to a more comprehensive notion that refers to the search for intelligent solutions which allow modern sustainable cities to enhance the quality of services provided to citizens and to improve the management of urban mobility. The smart city is based on the usage of connected sensors, data management, and analytics platforms to improve the quality and functioning of built-environment systems. The aim of this paper is to understand the effects of the pandemic on smart cities and to accentuate major exercises that can be learned for post-COVID sustainable urban management and patterns. The lessons and implications outlined in this paper can be used to enforce social distancing community measures in an effective and timely way, and to optimize the use of resources in smart and sustainable cities in critical situations. The paper offers a conceptual overview and serves as a stepping-stone to extensive research and the deployment of sustainable smart city platforms and intelligent transportation systems (a sub-area of smart city applications) after the COVID-19 pandemic using a case study from Russia. Overall, our results demonstrate that the COVID-19 crisis encompasses an excellent opportunity for urban planners and policy makers to take transformative actions towards creating cities that are more intelligent and sustainable.

Keywords: smart city; sustainability; city management; intelligent transport systems; artificial intelligence; machine learning

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1. Introduction

The outbreak of the COVID-19 pandemic in March 2020 was an unprecedented event that affected the lives of millions of citizens in every country across the globe [1,2]. However, the pandemic opened several research challenges and opportunities that global communities had to address in order to prepare themselves for the future. The consequences of such disruption differed across countries depending on what measures governments took and how productive and timely those tools eventually happened to be [3,4]. This put the countries in dire need for a new generation of public administration officials and city managers, those who are able to operate in a globalized world, expand the practices of sustainable governance, and meet the challenges of world integration.

The world community demonstrated different levels of management skills in dealing with the crisis, such as migration flows and unemployment, as well as fighting the COVID-19 pandemic [5,6]. Meanwhile, we are witnessing certain adversities:

1. Social, ecological, and any other self-organizing system, finding itself in an extreme situation, inevitably faces a deficit of managerial potential;
2. When coping with the growing difficulties in an emergency, the system should make a qualitative leap in management and re-adjust or create in the shortest possible time qualitatively different structures and management mechanisms capable of adequately responding to a rapidly changing, often unfavorable environment. In extreme situations, vital resources become very limited and inaccessible for the majority of the population;
3. A lack of competence in management structures due to the combination of both transboundary and inter-agency management issues.

All of the above are especially relevant for the case of Russia, a country that experienced the devastating blow of the COVID-19 pandemic in a number of ways that even included higher education. For instance, Russian universities do not train specialists of public administration to work in crises. Therefore, efficient measures for solving problems as they are tackled in the European countries should be scrutinized. European countries are aiming to ratify the idea of the smart city in their towns and accomplish big data projects to bolster smart city features to target the desired level of sustainable development, thus improving the quality of life [7–10]. Smart cities are meant to be areas with advanced technologies that are capable of comprehending the environment by scrutinizing the data to make it more sustainable [11,12]. In such cities, diverse meters and smart sensors are aimed at gathering massive amounts of data to learn critical measurements to control resources, services, and infrastructure effectively [13]. Numerous innovations, such as artificial intelligence and blockchain serve to increase the efficiency of its residents' ways of travelling, educating, and spending resources, thus resulting in a higher level of comfort [14,15].

The Internet of Things (IoT) revolutionized the way people interact worldwide. Many users started setting up various applications on their smartphones and that changed the way they manage data [16,17]. Another very important aspect of IoT in smart cities is the data collected from IoT-connected sensors and infrastructure (e.g., smart building and smart home devices for occupancy, traffic cameras, radar detector sensors, loop detectors). IoT-connect sensors play very important roles in intelligent transport systems as well as smart city applications for the mitigation of the COVID-19 pandemic and its outcomes.

Smart city and intelligent transportation systems solutions offer a futuristic vision of an efficient, secure, and safe experience to the end user, and at the same time efficiently manage sparse resources and optimize the efficiency of city operations [18,19]. However, the COVID-19 pandemic exposed the limitations of the existing deployments in the cities (either smart cities or "regular" ones). Therefore, it is clear that architecture, applications, and technology systems need to be developed for the swift and timely enforcement of guidelines, rules, and government orders to contain such future outbreaks [20–23].

With higher rates of COVID-19 in urban areas and the need to contain the spread of the virus, cities and large urban centers worldwide appeared at the forefront of the fight against the pandemic [24,25]. In order to respond to this unusual situation, smart cities in developed countries launched a pandemic resilience strategy for urban areas in the wake of COVID-19 [26]. The emergency then led to the development of pandemic-resilient urban planning and management to deal with the infectious disease during the COVID-19 lockdowns and hospital overcrowding [27,28]. In general terms, the COVID-19 pandemic and all its adverse effects provided new information, but it also brought renewed attention to resilience in the mid- and long-term response to the pandemic and urban recovery planning even more than before [29].

Our study's novelty is in its focus on the main lessons and implications that can be learned for post-pandemic sustainable urban planning related to disaster management and climate change adaptation, in addition to avoiding extended resilience challenges. Specifically, we tackle the important issue of urban mobility management using intelligent transport systems fostered by the information and communication technologies, Internet of Things (IoT), and artificial intelligence (AI)-based applications and solutions. Moreover, this study highlights the conceptual basis for a pandemic resilient urban strategy in a unique way by incorporating resilience into urban planning and design in response to the ongoing COVID-19 crisis. We elaborate upon the ways in which inclusive urban planning can be a hallmark of urban recovery efforts in the wake of the COVID-19 pandemic and a way to tackle urban inequalities. Rethinking the idea of cities, COVID-19 has brought attention to some neglected issues in sustainable urban planning and urban mobility management. It becomes clear that smart cities must engage in the post-COVID-19 recovery as key partners to build an inclusive and resilient Europe [30].

The purpose as well as the additional value of our research was to analyze comprehensive technological solutions and assess how these can be integrated into sustainable smart city management in the era of COVID-19. Specifically, we focused on the role of ICT solutions and AI-driven technologies as well as their acceptance by the citizens. The method used to achieve this objective was a literature review integrated with journal data sources and a case study and our own survey carried out in Russia that yielded some interesting and novel results.

This paper is structured as follows: Section 2 offers a concise literature review on AI, COVID-19, and smart cities. Section 3 features materials and methods. Section 4 provides an analysis of smart cities in Russia. Section 5 yields the results and discussions related to the smart city management in the post-COVID-19 era using the examples from Russia. Finally, Section 6 provides the overall conclusions and implications, as well as pathways for further research.

2. Literature Review

In general, AI-based technology was widely used for the COVID-19 response. Cities are now becoming smarter, which can be effectively managed through various infrastructures and facilities. Many more technologies and solutions have contributed to laying down the foundations and developing dynamic smart cities.

Immediately after the announcement of the COVID-19 pandemic in March 2020, the World Health Organization (WHO) signaled that artificial intelligence (AI) could be an important technology to help overcome the crisis caused by the virus [31,32]. Today, numerous AI-based projects based on data science, machine learning, or Big Data solutions are being used in a wide variety of fields to predict, explain, and manage various scenarios caused by the COVID-19 pandemic [33–36]. From the first signs of the COVID-19 pandemic and the first predictions of its spread and impact made by a group of scientists who presented their findings at the AAAS Annual Meeting in February 2020, to the use of AI in vaccine development, AI has played a central role [37,38]. The application of artificial intelligence in the economic and social fields is flourishing in the era of coronavirus disease due to its useful aspects, such as the analysis of data reported by users, the interpretation of this data, image recognition, speech processing, and management of the Big Data [39,40]. AI tools and techniques can help policy makers and the medical community understand the coronavirus and accelerate treatment research by rapidly analyzing large amounts of research data [41]. AI helped researchers to learn just about everything about SARS-CoV-2, the virus that causes COVID-19 infections [42]. Using machine learning, they managed to develop new methods to quantify undiagnosed infections by analyzing how this pandemic changed as it spread through the population to infer how many transmissions were lost [43]. Thus, they contributed to the pandemic response efforts and developed a fully automated

AI tool that detects COVID-19 [44]. AI has been successfully used to identify disease clusters, monitor cases, predict future outbreaks and risk of mortality, diagnose COVID-19, and treat diseases by allocating resources, facilitate learning, maintain registries, and recognize patterns for research in the course of the disease [45].

There are many use-cases of detailed AI applications for the COVID-19 response in the context of smart city management [46–48]. A framework for machine learning driven by data, dependencies, or sensing devices would enable an AI-driven, machine learning-driven deployment framework in smart cities for curbing COVID-19 that would also help to design better compartmentalized prediction and analysis tools, which has a promise of mitigating the spread of COVID-19 and any future similar diseases pandemics [49,50]. In general terms, the purpose of machine learning is to reproduce the way humans would evaluate a given problem set using the best data available, mostly by building up a multi-layered network of smaller, discrete steps in a larger whole known as a neural network [51].

The recent pandemic showed the importance of data sharing, and put the infrastructure and legal frameworks, particularly around privacy, to the test. In an age of Big Data, governments in different countries are using this data to control the COVID-19 pandemic in real-time, acting as a major response entity for a public emergency [52]. As a connected urban society, smart cities involve collecting data at each instant from multiple embedded devices, meaning that smart cities could effectively use machine-learning approaches during the COVID-19 pandemic [53]. For example, Ebadi et al. [54] used multiple data sources (PubMed or ArXiv) for building several machine learning models to characterize the landscape of current COVID-19 research by identifying the latent topics and analyzing the temporal evolution of the extracted research themes as well as the similarity of the publications.

Since the beginning of this pandemic, several smartphone apps were developed to diagnose and monitor COVID-19. For instance, the identification of the speed and the scope of the COVID-19 spread in certain geographical areas could be completed quickly with an AI framework using mobile phone-based surveys during the time cities and towns were quarantined. Li et al. [55] described using AI for trajectory tracking and targeting the infected persons under the current COVID-19 epidemic in order to understand the itinerary of the new virus-infected persons and to find out all the suspected contacts that the infected persons may come into contact with in an accurate and timely way.

Furthermore, NPL applications can be applied to analyze social media data to summarize city residents' emotional states and opinions during the quarantine or lockdown. In addition, AI-based methods are used to analyze origin–destination data to extract vehicle trajectories or vehicle re-identification for tracking potential pandemic spread over large urban areas. For instance, Dantas et al. [56] showed the role of the unmanned aerial vehicles (UAVs) in supporting logistical support for the COVID-19 pandemic.

Classifying the various emotional undertones of public sentiment/technological anxiety can help smart city management in the new type of the modern-day innovative city that utilizes information and communication technologies and other tools to improve the quality of life, the efficiency of city operations and services, and competitiveness, while meeting the economic, social, and economic needs of present and future generations taking into account the environmental aspects and sustainable development.

3. Materials and Methods

3.1. Smart City Concept

In the recent research literature, there is an increasing interest in the "smart city" concept that is visibly linked to the recent COVID-19 pandemic. Nevertheless, it has be mentioned that the concept itself is not quite new. The first mention of a "smart city" was during the Annual Lecture of the Auckland Branch of the New Zealand Geographical Society at the University of Auckland in October 1998 [57]. It continued with speculating on "the urban center of the future" during the 2nd International Life Extension Technology Workshop in Paris, France on 28 September 2000 [58].

The real rise in conceptualizing the idea of smart city was in the early 2010s [59]. This can be associated with initiatives related to the integration of ICT smart systems in technologically advanced European cities, such as Barcelona or Amsterdam [60]. In Amsterdam, there were over 170 projects run by local residents, government, and private companies. Innovations such as interconnected platforms through wireless devices to enhance the city's real-time decision-making abilities were integrated in the city of Amsterdam [61]. In the case of Barcelona, there were a number of projects that can be considered as a "smart city system" within its "CityOS" strategy. For example, the bus network was designed based on data analysis of the most common traffic in the city. Smart traffic lights were also designed as a part of the program. These were the first attempts to implement the concept of the smart city in practice. However, there was also a logical issue of the government or company surveillance.

The concept evolved from being understood only as a green technology first [62], and then further progressed to an explanation and encompassing of the organizational, collaborative, and experimental dimensions [63].

The pandemic urged the question of cities' digitalization and the use of ICT [64] in the first place, especially for healthcare organizations. Delivery services, monitoring of infected persons, driverless transportation, as well as urban logistics were among the widespread uses of ICT.

One can appreciate the different evolution of attitudes towards the changes introduced by COVID-19 in other international sustainable smart cities. As a result, COVID-19 recovery packages can contribute to sustainable and smart urban transformation. If cities recover without returning to the pre-COVID operating modes, some of these benefits could be locked in and could facilitate the transition to sustainable urban development. Turning smart cities into livable and sustainable hubs will not be easy in the post-COVID-19 era as many governments face severe budget cuts. Nevertheless, some of the smart decisions made in cities will persist in the pre-COVID world, such as the digitization of energy management systems. The strong digitalization of cities represents a step forward in strengthening the low-carbon urban agenda that will have far-reaching implications for them once they emerge from the COVID-19 pandemic. By focusing on the intersection of these three factors, and as long as they are followed by supportive public policies (at the local, national, as well as regional levels), COVID-19 can accelerate the transition towards sustainable and smart cities. While some projects have failed or been canceled collectively, the importance of cities in supporting change, the climate crisis, and post-COVID-19 recovery has the momentum to accelerate the transition to sustainable and smart cities. Recognizing the fact that recovering from the COVID-19 crisis presents an opportunity to make their economies greener, many cities are now trying to address pressing environmental issues to reduce air pollution and create jobs. The key role of digitization in response to the pandemic prompted many cities to normalize the use of smart city applications and solutions. Indeed, the transition to the new normal—lockdowns, remote work, and travel restrictions—during the COVID-19 pandemic prompted accelerated partnerships between cities and the private sector to co-create innovative digital-enabled smart climate solutions and sustainable growth.

During the pandemic, people had to lock themselves at home, so it is arguable that online platforms became the most popular way to connect with the outside world. For example, streaming services such as Netflix became ubiquitous worldwide and the numbers of their subscribers are growing every day [65].

3.2. Smart Cities in Russia

Even in the light of the recent Russian–Ukrainian conflict and all the grim consequences it might bring about in both countries in question (as well as in the whole world), not mentioning the devastating effect of economic sanctions on the Russian economy, the issue of smart cities in Russia still occupies the minds of many researchers and policymakers in Russia and beyond.

There are several major cities in Russia that have implemented the elements of smart city governance and e-government in recent years with Moscow in the lead [66]. Over the past decade, Moscow has given itself the task of becoming a smart city. With the mayor expected to sign off on the Smart Moscow 2030 strategy by the end of the year, it remains to be seen whether Moscow can continue to be a leading smart city [67]. The final costs and exact funding of the Smart Moscow 2030 strategy have yet to be determined, but the city would be more open to direct investment by businesses. Artificial intelligence plays an important role in this strategy, and Moscow has boldly said it would replace city officials who handle application forms and approval processes [68]. Russian policymakers actively support the introduction of smart city technology in large Russian administrative entities. However, our findings reveal significant differences in the level of innovation and development of “smart cities” in Russia [69].

The researchers compiled a classified list of Russian cities that already have favorable conditions for smart city development and identified that Russian cities may be better prepared than others for smart city development. Most of the cities that top the list are in the European part of Russia, which is more densely populated and therefore has more human resources; some cities with high potential for smart development are located in the Asian part of Russia [70]. Now authorities are looking into what other major cities around the world are doing to become smarter so Moscow can keep up. Moscow’s path to the status of a “smart city” by world standards was quite short-lived. For instance, Moscow’s intelligent traffic control system is an important part of the smart city [71]. Smart city projects (outdoor video surveillance cameras, engineering networks, intelligent transportation systems, etc.) in metropolitan areas are closely linked. The system is designed for subways, surface transport, pedestrian spaces, Moscow’s bike-sharing network, and transport hubs, making routes on the ground and in the subway easier to navigate. The system is already being used with great success in government buildings and is expected to be approved for use in all residential buildings in Moscow [72]. Moreover, the city was one of the first to implement blockchain in e-voting, and as part of the ActiveCitizen program, residents vote on government proposals, and users can follow the polls in real time and verify the authenticity of the results. Moscow became the first Russian region to launch a website where the population can pay various fees, receive city services, as well as transfer permits and documents to the cloud, which allows users to receive different services in one package [73]. Moscow received a special mention in the category of e-government services, and in 2021, the Intelligent Community Forum included Moscow in the top seven finalists of the Smartest Cities competition [74].

In the field of education, Moscow is also taking the next steps to phase out all paper documents while moving to more processes based on artificial intelligence technologies, digital technologies, and the Internet of Things. In addition, Moscow is rapidly gaining a similar reputation for its digital infrastructure and was recently ranked by major consulting firms including KPMG and PwC as one of the top 10 smart cities in the world [75]. Plans are already underway to leverage the city’s digital assets, which include an impressive 99% 4G coverage, 82.5% fixed broadband for families, about 70% smartphone usage, and a Wi-Fi zone (one of the best connectivity indicators in the world) [76]. The 68 smart city projects include the Unified Medical Information and Analysis System (UMIAS), the Moscow Electronic School, the official website of the Moscow Mayor (mos.ru), the Moscow Innovation Cluster (i.moscow), the 5G Demonstration Center, and the Moscow government’s efforts in the field of artificial intelligence experimental legal system. The directory, a joint project of ICT.Moscow and the Moscow government, contains the latest information on 68 smart city projects, including datasets and analyses [77]. In Russia, the concepts of smart cities were implemented in the Moscow agglomeration (Skolkovo), in the Republic of Tatarstan (e.g., Kazan Smart City), in the Krasnodar Territory (the Olympic cluster of Sochi), as well as in the Leningrad and Ulyanovsk regions [78]. This has been completed in accordance with the experience from the other smart urban development solutions that have been implemented in major cities such as New York, Tokyo, Shanghai, Seoul, Vienna, Amsterdam, and Dubai. Resident-friendly cities are a popular concept that is hard to implement in such a diverse country as Russia, but that is what smart cities are all about. The smart city is, in fact, an urban model that provides the sustainability of urban development on the one hand, and the comfort of its residents on the other. This principle should be implemented when creating new Siberian cities. At the same time, it is important that migration flows be directed to the new Siberian cities, and not only to the European part of Russia. Thus, not only residents of this region can migrate to new cities, but also specialists from other major centers, including Moscow and Saint Petersburg. Moscow is also maneuvering towards a smart grid, led by the world's leading smart cities such as Barcelona and Amsterdam, even though the recent events and an array of economic sanctions against Russia might hinder the transformation of Moscow from a chaotic metropolis into a smart city of the future.

3.3. Service-Oriented Approaches in Smart Cities

Service-oriented architecture (SOA) is often used in smart cities for integrating and managing the city services via the framework that connects and promotes the components of the city infrastructure. Its main objective is to use complex IT processes that yield effective and useful business and social outcomes. Nevertheless, it is not the only major architecture or approach used for building smart city applications. Another more recent approach is the microservice architecture. As Krylovskiy et al. [79] have pointed out, designing a smart city Internet of Things platform with microservice architecture might be quite cumbersome, so the microservice architecture might offer the tools that are simpler, cheaper, and easier to manage. Furthermore, Krämer et al. [80] discussed the use of microservices in smart cities and cloud storages and advocate for the microservices architecture that allows data to be shared across multiple administrations and makes efficient use of cloud resources [81].

Figure 1 shows the IoT architecture for the smart city indicating communications (dashed lines) among different actors. In simple terms, this architecture provides the common basis for planners and engineers to conceive, design, and implement the system together with concerns relevant to a large number of stakeholders to offer services, alerts, and data driven applications. This service-oriented architecture is scalable to offer applications in a wide geographic location offering quality of service (QoS).

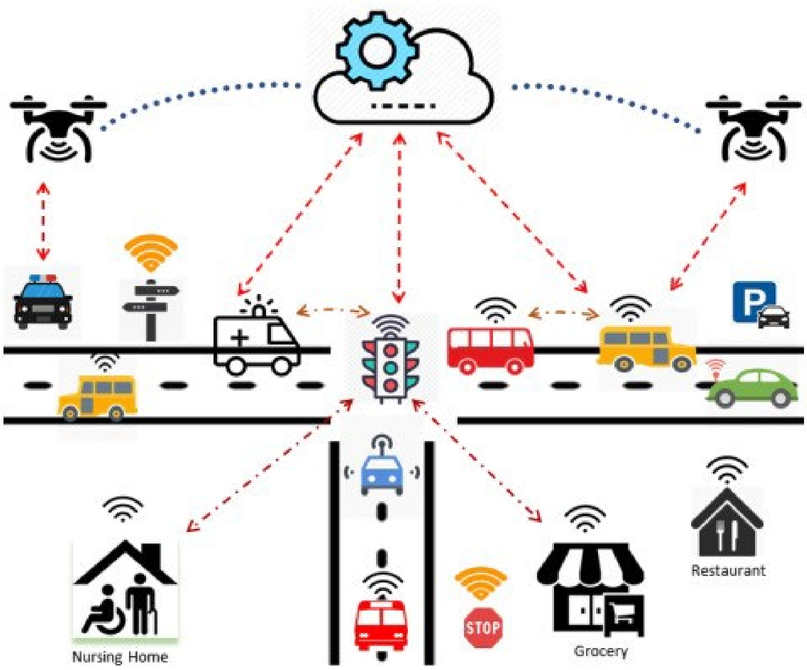

Figure 1. The IoT- architecture for a smart city. Source: own results.

Overall, the architecture consists of physical devices, including road-side sensors, smart traffic lights, and connected cars with the ability to record real time data and exchange messages with nearby entities and upload relevant information to central cloud facilities for processing. At the same time, such smart physical devices can also replicate edge computes to offer the capability for real time low latency communication supported by ITS such as vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), or vehicle-to-everything (V2X). The flexibility of the architecture to adapt to various use-case requirements can be achieved by having a hybrid edge cloud-supported model which enables dynamic real time needs, and at the same time offer infinite computation on data captured using central cloud infrastructures. Basic Safety Messages (BSMs) can also be used to enable V2X communication with information pertaining to an event, location, or even severity. It is also viable to create digital twins for various smart devices to offer a virtual counterpart for each physical object. These twins, based on the data collected in the real environment, can provide insights to improve the operations, increase efficiency, and discover issues [82,83].

There are many areas where AI has been used for a long time. These are search, navigation, machine translation, and personal assistants. Another important and very promising area is urban (driverless) transport. For example, machine learning is used in different applications, e.g., Yandex.Taxi, which has integrated the technology that advises the driver which area to go to.

One way or another, the discussion of AI technologies should not be separated from the IoT or the smart city architecture. In many smart city applications or ITS, the AI technologies are often embedded into the smart city platform, IoT devices (e.g., vehicle detection at traffic camera), or web services (yes, AI-powered data analytics as a web-based or cloud-based API). AI is often integrated into V2X or V2I to optimize the control of cyber-physical systems as well.

During the pandemic, people were literally locked at home, so it might be arguable that online platforms became the most popular way to connect with the other world. As a result, the delivery services, and streaming websites, exemplified by Okko, IVI.ru and Kinopoisk HD boosted their sales by over 40% for the last year (see Figure 2).

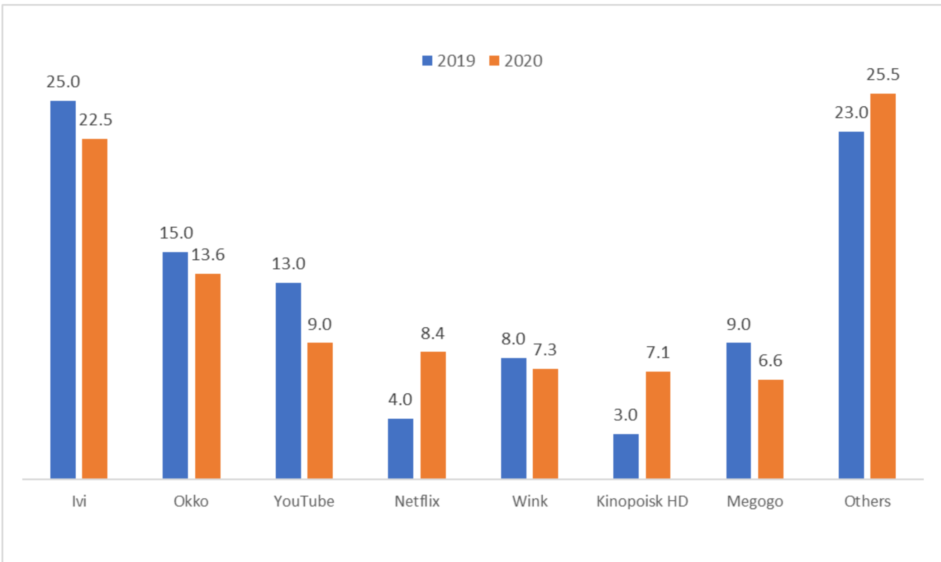

Figure 2. Largest streaming services in Russia (in %). Source: own results.

As one can see, the revenue of online streaming services was distributed evenly during the pandemic. This can be explained as follows (see Figure 3). When the pandemic hit hard, more streaming services were founded in Russia. New platforms such as Kinopoisk HD and Netflix started to lure new customers by free trial promo codes. This is one of the examples from the area of entertainment, though the people were mostly concerned with social distancing and health issues. This is due to the fact that streaming services constitute an integral part of the development of smart cities. The smart city environment is controlled and monitored with advanced technologies and new types of communication are used for improving the quality of life of its inhabitants with innovative services. One of the key challenges facing communication in smart cities is multimedia communication, and most importantly, video streaming that can be of high benefit for smart transport traffic management, as well as for providing entertainment and advertising services.

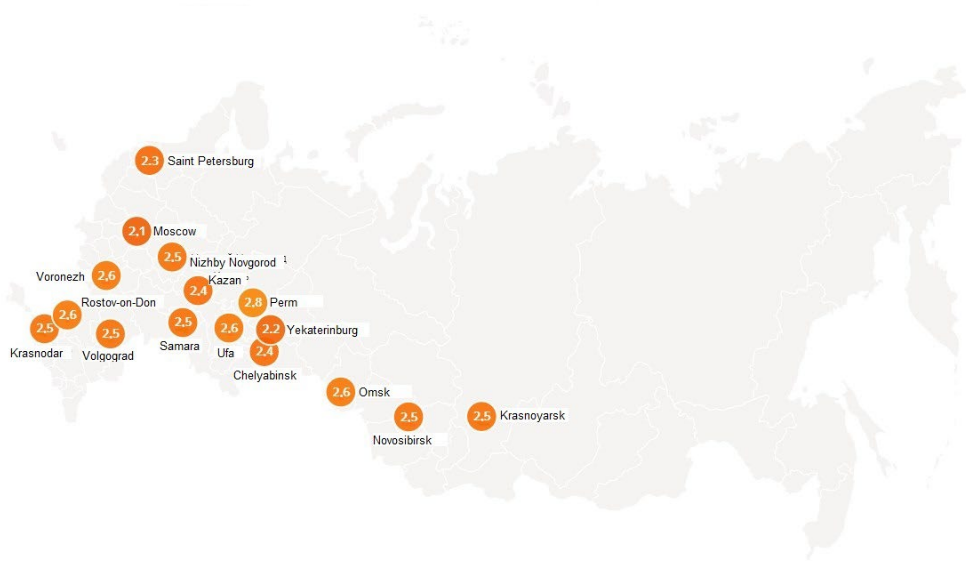

Figure 3. Index of self-isolation by city (April 2021). Source: own results.

An example of tracking social crowding was realized by the Russian giant Yandex. This service helps people to stay away from crowded areas to avoid being infected (see Figure 4).

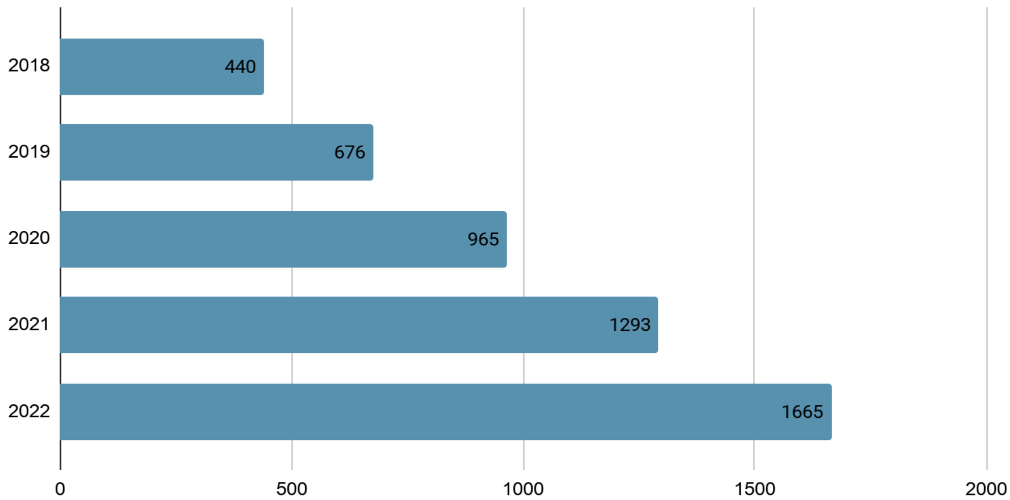

Figure 4. Food delivery in Russian cities (in millions of dollars). Source: own results.

According to the data presented in Figure 4, there was a boom in delivery services during the pandemic. This was caused by self-isolation measures as a hundred percent of restaurants and public places were closed and did not serve people. However, they still ran delivery services. Eventually, those who managed to include the delivery in their strategic vision survived the pandemic, while those who did not went bankrupt. Researchers have projected that by the year 2022 the delivery service will bolster and probably will increase by four times compared to 2018.

The participating entities including vehicles, law enforcement, drones, parking sensors, or other roadside units (RSUs) must enroll with a central authority to receive certificates and ensure the trustworthiness of messages exchanged among entities. The communication technologies which can enable the exchange of messages can include LTE, Wi-Fi, 5G, or Dedicated Short Range Communication (DSRC). In addition, Message Queuing Telemetry Transport (MQTT) messaging protocol has been widely used to support physical entity to cloud service providers such as Amazon Web Services (AWS) or Microsoft Azure. This architecture will need multiple technologies and communication protocols to cater different use cases. Communication can happen among different physical entities, using cloud-supported services, edge-assisted messaging, or even the peer-to-peer model [84–87]. Such infrastructures and supported technologies will need long term investment and partnership among public and private entities to enable hundreds of smart devices to interact with each other.

4. Empirical Model: Acceptance of Smart Technologies in the Post-COVID Era

4.1. The Data

In this section of the paper, we conduct an empirical analysis of the acceptance and usage of novel smart technologies by the inhabitants of smart cities (Moscow, Krasnodar, Kazan, and Saint Petersburg) in Russia during and after the COVID-19 pandemic. Our data come from our own survey administered in the Russian Federation between September 2020 and March 2021. We used the quasi-random sampling and utilized both the elements of the snowball technique assisted by opportunity sampling. We recruited the participants taking part in our survey both in person via social networks and messenger apps (WhatsApp and Telegram) or using the personal e-mail letters addressed to the participants.

In total, we obtained a sample of 264 respondents from the Russian Federation (58% women and 42% men, $M \pm SD = 45.53 \pm 11.46$, median age 44 years) who completed our questionnaire voluntarily and anonymously. All of the respondents lived in cities and towns (urban areas) and had higher degree education (master’s degree or higher). The majority of the respondents worked as managers (73%), analysts (14%), and top managers of the business and state-owned companies represented by CEOs and CFOs (13%). The majority of our respondents worked in business, finance, accounting, and consulting (71%), as well as the ICT companies (15%), education providers such as private schools, and higher educational institutions (HEIs) (11%), and other services (3%).

The survey covered a number of topics related to the digitalization and novel technologies fostered by the COVID-19 pandemic and its outcomes. However, for the purpose of this paper, we selected just a handful of questions that are analyzed and depicted below. The questions were composed on a 5-point scale, which ranged from 1 (strongly agree) to 5 (strongly disagree).

4.2. Model Specifications

Table 1 reports the cross-tabulation of the responses showing the motivation to use novel technologies (such as Zoom, MS Teams, Google Meet, etc.), to start working in a home office to enhance productivity, and to use e-government tools and facilities (such as digitally signing documents, downloading QR codes, or communicating with the governmental authorities).

Table 1. Motivation for smart living (cross-tabulations of responses).

	1-Disagree [a]	2 [a]	3 [a]	4 [a]	5-Agree [a]	Total
Using novel technologies	36%	24%	27%	7%	6%	100%
Working remotely in a home office	22%	20%	21%	19%	18%	100%
Using e-government facilities	25%	16%	20%	24%	15%	100%

Note: [a] The pandemic showed me how to use novel technologies for teleconferencing, remote work, video calls, and online collaboration; the pandemic made me start a home office to enhance productivity; the pandemic made me start using e-government facilities (downloading health pass, QR codes, using electronic identity, etc.), 1—strongly disagree, 5—strongly agree. Source: own results.

In general, we can see that even though the use of e-government facilities increased during the COVID-19 pandemic, the percentage of people who strongly supported the new technologies and remote home office work, was not that big. This might be explained by the fact that while the coronavirus has introduced many changes into the ways business and social interactions are performed, these changes are yet to become rooted in the society, which might take some time.

Additionally, our data were used for the ordinal regression analysis to scrutinize the factors related to motivation for "smart" living. The formal model can be expressed in a form of the Equation (1) that follows:

$$motivation = logit\ (\alpha_0 Age + \alpha_1 Gender + \alpha_2 Country + \alpha_3\ b\_type + \alpha_4 Position + e) \quad (1)$$

where:

motivation—motivation for smart living (i.e., "going smart");

Age—age of the respondent;

Gender—gender of the respondent;

b_type—type of business (business, finance, accounting and consulting, ICT, education, or other);

Position—position at the company or institution: analyst, manager, top manager, CEO/CFO, etc.;

e—is an error term.

4.3. Results of the Model Estimation

Table 2 reports the results of our ordinal regression empirical model spread over three categories (novel technologies, working remotely (being in a home office), and exploiting the e-government facilities).

Our results demonstrate that demographic factors such as age tend to be negatively related to the motivation for using novel technologies and experiencing "smart" living. Gender does not have any significant effect on embracing the digitalization in the smart cities. On the other hand, factors such as the level of education, business type, and belonging to a certain industry (e.g., ICT) increase the acceptance of the smart way of living. Furthermore, it becomes apparent that managers and analysts are keener on accepting the digital surge induced by the COVID-19 pandemic while people working in business and economics fields are not (the result came through as insignificant).

All in all, the results obtained from our unique data set from the Russian smart cities show that the COVID-19 pandemic altered the ways people perceived their daily routine and professional lives and had an effect on forming up the smart cities with a smart and digitally enhanced way of living and entertaining. Smart city management should be targeted at the inhabitants of such smart cities and should take into account their preferences and needs.

Table 2. Motivation for "going smart" during the COVID-19 pandemic (ordinal regression analysis).

	Novel Technologies		Working Remotely in a Home Office		Using e-Government Facilities	
	Estimate	**Sig.**	**Estimate**	**Sig.**	**Estimate**	**Sig.**
Threshold 1	2.174	0.346	−0.374	0.911	2.721	0.074
Threshold 2	3.325	0.017	0.984	0.401	3.731	0.003
Threshold 3	4.787	0.000	2.882	0.038	4.485	0.000
Threshold 4	6.242	0.000	4.358	0.000	5.877	0.000
Age	−0.024 *	0.101	−0.027 **	0.046	−0.021	0.218
Gender (men)	0.221	0.731	−0.412	0.475	0.562 **	0.078
Educ	0.409 **	0.478	0.546 ***	0.296	0.371 *	0.536
ICT	0.058 **	0.967	0.055 *	0.949	0.262 *	0.967
BusEcon	0.381	0.682	0.351	0.746	0.093	0.850
Manager	0.835 **	0.006	0.575 **	0.240	0.487 *	0.251
Analyst	0.721 **	0.075	0.009 *	0.982	0.754 *	0.077
Cox and Snell	0.082		0.072		0.081	
Nagelkerke	0.098		0.063		0.081	
McFadden	0.045		0.041		0.038	
Sig.		0.000		0.001		0.002
N			264			

Note: *** Significant at the 0.01 level; ** Significant at the 0.05 level; * Significant at the 0.1 level Source: own results.

5. Discussion

Overall, it is apparent that the COVID-19 outbreak represented an unprecedented event which disrupted the lives of millions of people across the globe. However, at the same time, the pandemic has opened various research challenges and opportunities that our community must address to equip itself for the future. Scientists and philanthropists (e.g., Bill Gates) keep warning the world community that COVID-19 is one of many similar diseases that might strike again in the near future (during the time when this paper was written, the viral monkeypox outbreak was recorded in multiple countries with the WHO issuing a warning about its spread while also mentioning that COVID-19 might produce new variants due to the general negligence and forgetfulness of people who wanted to be relieved that the pandemic was over). Large cities would be the first to feel the consequences if these threats materialized.

Sustainable urban planning for smart cities must be inclusive in order to effectively respond to public health and economic crises in the future. Rather than focusing solely on the negative externalities of density, there needs to be a dialogue about urban vulnerabilities that can exacerbate public health crises. The need for people to feel safe using public transport and living in densely populated areas is key to ensuring that the post-COVID world does not lead to increased personal vehicle use or decreased population density.

Furthermore, it becomes clear that artificial intelligence is also a potentially powerful tool in the fight against the COVID-19 pandemic. Artificial intelligence is being used as a tool to support the fight against the viral pandemic that has gripped the whole world since the beginning of 2020. The proposed architecture and AI-assisted applications discussed in our paper can be used to enforce social distancing community measures in an effective and timely manner and optimize the use of resources in critical situations. This paper offers a conceptual overview and serves as a stepping-stone to extensive research and the deployment of automated data-driven technologies in the smart city and intelligent transportation systems. Speaking about the pathways for future research, we envision that these AI-driven applications will be developed for wider adoption in the community and that there will be a further enhancement of smart cities not only in Russia but all around the globe.

In spite of some research limitations (the current situation with the Russia–Ukraine conflict and the unclear future for the further development of sustainable smart cities in Russia, the limited number of respondents included in our survey, a lack of comparison among a larger sample of countries), our findings may be useful for healthcare professionals and policymakers considering the use of artificial intelligence to complement public health efforts in response to the COVID-19 pandemic. More recently, artificial intelligence has used multidimensional data to help identify and predict COVID-19 outbreaks. Machine learning is also helping researchers and practitioners analyze vast amounts of data to predict the spread of this epidemic, serve as an early warning system for future epidemics, and identify vulnerable groups.

6. Conclusions and Implications

Our paper has discussed how smart city solutions and technologies could help cities better prepare for and respond to similar future disasters. We are taking a closer look at the role that smart city technologies can play in disaster management and improving the well-being of citizens in the face of the COVID-19 pandemic. Our results show the importance of data in supporting the rapid deployment of 5G networks and that smart city technologies can help manage the COVID-19 crisis in both the near and long term. The new combination of people, technology, and data is providing innovative approaches to the COVID-19 crisis, and the lessons learned from their use of technology in smart cities. The critical role of digitization in responding to the COVID-19 crisis has prompted many cities (such as Moscow) to regulate the use of smart city tools. In fact, the transition to a new normal (lockdowns, remote work, and travel restrictions) during the COVID-19 pandemic has spurred an accelerated collaboration between cities and the private sector to co-create innovative digital smart climate solutions.

We have shown that since the start of the COVID-19 pandemic, smart city solutions have helped authorities and stakeholders in Russia and around the world accelerate their response to health emergencies through their innovative digital approach. While evidence of the lasting impact of national policies on economic resilience during the COVID-19 pandemic remains elusive, the role of smart cities in responding to the pandemic is threefold. The pandemic could lead to a complete shift in how technology is used in smart cities, towards something primarily related to community building. Cities and communities are also beginning to develop new ways to respond to the COVID-19 pandemic to maximize the collective intelligence of urban areas. The COVID-19 crisis has highlighted the need for accelerated digital city planning and an enhanced communication with citizens if these population levels are to be sustainable.

In order to achieve greater resilience during the pandemics (post, current, or future ones that are predicted by many scientists due to the severe climate changes and narrowing down the proximity of the human and animal habitats), cities in Russia (as well as in other parts of the world) must implement a range of smart technologies. Emergencies such as the COVID-19 pandemic have led to the development of urban planning and management. The COVID-19 pandemic has also disrupted several smart city projects and created new obstacles for city officials. The recent crisis has forced many cities to accelerate their telecommuting smart city projects, a top item on the digitalization agenda. While COVID-19 is an ongoing crisis and evaluating the effectiveness of this planning approach is problematic, our results have highlighted the benefits of implementing smart city projects to combat COVID-19. Mapping is critical to promoting safe and sustainable and smart cities in post-COVID-19 era, and governments have a relatively limited role in implementing smart solutions. They also contain broader valuable lessons about how cities can work better with their citizens by using technology to solve social problems. Smart cities' strong digitalization represents a step forward in strengthening the low-carbon urban agenda that will have far-reaching implications for them once they emerge from the COVID-19 pandemic and face new challenges such as the soaring prices of oil, natural gas, or food supplies. This can be achieved through a human-led, top-down approach that encourages citizens to develop and improve their capital by deploying the necessary smart technologies in cities. In the event of future pandemics, smart sustainable cities need to adopt a technological approach in line with the framework of smart cities and the framework of disaster risk management strategies. In terms of policy implications, our results have demonstrated that the development of smart cities is not possible only through the use of technology to improve urban functions and should also include a consideration of other aspects and actors such as people and institutions.

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References

1. Yeganeh, H. Emerging social and business trends associated with the COVID-19 pandemic. *Crit. Perspect. Int. Bus.* **2021**, *17*, 188–209. [CrossRef]
2. Weder, F.; Yarnold, J.; Mertl, S.; Hübner, R.; Elmenreich, W.; Sposato, R. Social Learning of Sustainability in a Pandemic—Changes to Sustainability Understandings, Attitudes, and Behaviors during the Global Pandemic in a Higher Education Setting. *Sustainability* **2022**, *14*, 3416. [CrossRef]
3. Panneer, S.; Kantamaneni, K.; Palaniswamy, U.; Bhat, L.; Pushparaj, R.R.B.; Nayar, K.R.; Manuel, H.S.; Flower, F.; Rice, L. Health, Economic and Social Development Challenges of the COVID-19 Pandemic: Strategies for Multiple and Interconnected Issues. *Healthcare* **2022**, *10*, 770. [CrossRef] [PubMed]
4. Alasmari, A.; Addawood, A.; Nouh, M.; Rayes, W.; Al-Wabil, A. A Retrospective Analysis of the COVID-19 Infodemic in Saudi Arabia. *Future Internet* **2021**, *13*, 254. [CrossRef]
5. Casado-Aranda, L.-A.; Sánchez-Fernández, J.; Bastidas-Manzano, A.-B. Tourism research after the COVID-19 outbreak: Insights for more sustainable, local and smart cities. *Sustain. Cities Soc.* **2021**, *73*, 103126. [CrossRef]
6. Benita, F. Human mobility behavior in COVID-19: A systematic literature review and bibliometric analysis. *Sustain. Cities Soc.* **2021**, *70*, 102916. [CrossRef]
7. Čábelková, I.; Strielkowski, W.; Wende, F.; Krayneva, R. Factors influencing the threats for urban energy networks: The inhabitants' point of view. *Energies* **2020**, *13*, 5659. [CrossRef]
8. Polukhina, A.; Sheresheva, M.; Efremova, M.; Suranova, O.; Agalakova, O.; Antonov-Ovseenko, A. The concept of sustainable rural tourism development in the face of COVID-19 crisis: Evidence from Russia. *J. Risk Financ. Manag.* **2021**, *14*, 38. [CrossRef]
9. Mark, R.; Anya, G. Ethics of Using Smart City AI and Big Data: The Case of Four Large European Cities. *ORBIT J.* **2019**, *2*, 1–36. [CrossRef]
10. Chubarova, T.; Maly, I.; Nemec, J. Public policy responses to the spread of COVID-19 as a potential factor determining health results: A comparative study of the Czech Republic, the Russian Federation, and the Slovak Republic. *Cent. Eur. J. Public Policy* **2020**, *14*, 60–67. [CrossRef]
11. Bibri, S.E.; Krogstie, J. The emerging data-driven Smart City and its innovative applied solutions for sustainability: The cases of London and Barcelona. *Energy Inform.* **2020**, *3*, 5. [CrossRef]
12. Ivars-Baidal, J.A.; Vera-Rebollo, J.F.; Perles-Ribes, J.; Femenia-Serra, F.; Celdrán-Bernabeu, M.A. Sustainable tourism indicators: What's new within the smart city/destination approach? *J. Sustain. Tour.* **2021**, 1–24. [CrossRef]
13. Bellini, E.; Bellini, P.; Cenni, D.; Nesi, P.; Pantaleo, G.; Paoli, I.; Paolucci, M. An IOE and big multimedia data approach for urban transport system resilience management in smart cities. *Sensors* **2021**, *21*, 435. [CrossRef] [PubMed]
14. Zgórska, B.; Kamrowska-Załuska, D.; Lorens, P. Can the Pandemic Be a Catalyst of Spatial Changes Leading Towards the Smart City? *Urban Plan.* **2021**, *6*, 216–227. [CrossRef]
15. Li, Z.; Kai, N. Minority Tourist Information Service and Sustainable Development of Tourism under the Background of Smart City. *Mob. Inf. Syst.* **2021**, *2021*, 6547186. [CrossRef]

16. Korneeva, E.; Olinder, N.; Strielkowski, W. Consumer Attitudes to the Smart Home Technologies and the Internet of Things (IoT). *Energies* **2021**, *14*, 7913. [CrossRef]
17. Guevara, L.; Cheein, F.A. The role of 5G technologies: Challenges in smart cities and intelligent transportation systems. *Sustainability* **2021**, *12*, 6469. [CrossRef]
18. Ma, C. Smart city and cyber-security; technologies used, leading challenges and future recommendations. *Energy Rep.* **2021**, *7*, 7999–8012. [CrossRef]
19. Lee, J.; Yoon, Y. Hierarchy table of indicators and measures for the current status assessment of urban roads in smart cities. *Sustain. Cities Soc.* **2022**, *77*, 103532. [CrossRef]
20. Gupta, D.; Bhatt, S.; Gupta, M.; Tosun, A.S. Future smart connected communities to fight COVID-19 outbreak. *Internet Things* **2021**, *13*, 100342. [CrossRef]
21. Kakderi, C.; Komninos, N.; Panori, A.; Oikonomaki, E. Next city: Learning from cities during COVID-19 to Tackle climate change. *Sustainability* **2021**, *13*, 3158. [CrossRef]
22. Yoo, K.J.; Kwon, S.; Choi, Y.; Bishai, D.M. Systematic assessment of South Korea's capabilities to control COVID-19. *Health Policy* **2021**, *125*, 568–576. [CrossRef] [PubMed]
23. Guazzini, A.; Fiorenza, M.; Panerai, G.; Duradoni, M. What Went Wrong? Predictors of Contact Tracing Adoption in Italy during COVID-19 Pandemic. *Future Internet* **2021**, *13*, 286. [CrossRef]
24. Karim, S.A.; Chen, H.F. Deaths from COVID-19 in rural, micropolitan, and metropolitan areas: A county-level comparison. *J. Rural. Health* **2021**, *37*, 124–132. [CrossRef]
25. Herrera, M.; Godoy-Faúndez, A. Exploring the roles of local mobility patterns, socioeconomic conditions, and lockdown policies in shaping the patterns of COVID-19 spread. *Future Internet* **2021**, *13*, 112. [CrossRef]
26. Yang, L.; Iwami, M.; Chen, Y.; Wu, M.; Van Dam, K.H. Computational decision-support tools for urban design to improve resilience against COVID-19 and other infectious diseases: A systematic review. *Prog. Plan.* **2022**, 100657, *in press*. [CrossRef]
27. Majewska, A.; Denis, M.; Jarecka-Bidzińska, E.; Jaroszewicz, J.; Krupowicz, W. Pandemic resilient cities: Possibilities of repairing Polish towns and cities during COVID-19 pandemic. *Land Use Policy* **2022**, *113*, 105904. [CrossRef]
28. AbouKorin, S.A.A.; Han, H.; Mahran, M.G.N. Role of urban planning characteristics in forming pandemic resilient cities-Case study of COVID-19 impacts on European cities within England, Germany and Italy. *Cities* **2021**, *118*, 103324. [CrossRef]
29. Sharifi, A.; Khavarian-Garmsir, A.R.; Kummitha, R.K.R. Contributions of smart city solutions and technologies to resilience against the COVID-19 pandemic: A literature review. *Sustainability* **2021**, *13*, 8018. [CrossRef]
30. Maestosi, P.C.; Andreucci, M.B.; Civiero, P. Sustainable urban areas for 2030 in a Post-COVID-19 scenario: Focus on innovative research and funding frameworks to boost transition towards 100 positive energy districts and 100 climate-neutral cities. *Energies* **2021**, *14*, 216. [CrossRef]
31. BMJ. Artificial Intelligence and COVID-19. 2022. Available online: https://www.bmj.com/AIcovid19 (accessed on 3 May 2022).
32. Kollu, P.K.; Kumar, K.; Kshirsagar, P.R.; Islam, S.; Naveed, Q.N.; Hussain, M.R.; Sundramurthy, V.P. Development of Advanced Artificial Intelligence and IoT Automation in the Crisis of COVID-19 Detection. *J. Healthc. Eng.* **2022**, *2022*, 1987917. [CrossRef] [PubMed]
33. Alsunaidi, S.J.; Almuhaideb, A.M.; Ibrahim, N.M.; Shaikh, F.S.; Alqudaihi, K.S.; Alhaidari, F.A.; Alshahrani, M.S. Applications of big data analytics to control COVID-19 pandemic. *Sensors* **2021**, *21*, 2282. [CrossRef] [PubMed]
34. Pham, Q.V.; Nguyen, D.C.; Huynh-The, T.; Hwang, W.J.; Pathirana, P.N. Artificial intelligence (AI) and big data for coronavirus (COVID-19) pandemic: A survey on the state-of-the-arts. *IEEE Access* **2020**, *8*, 130820. [CrossRef] [PubMed]
35. Rodríguez-Rodríguez, I.; Rodríguez, J.V.; Shirvanizadeh, N.; Ortiz, A.; Pardo-Quiles, D.J. Applications of artificial intelligence, machine learning, big data and the internet of things to the COVID-19 pandemic: A scientometric review using text mining. *Int. J. Environ. Res. Public Health* **2021**, *18*, 8578. [CrossRef] [PubMed]
36. Li, Z.; Li, X.; Porter, D.; Zhang, J.; Jiang, Y.; Olatosi, B.; Weissman, S. Monitoring the spatial spread of COVID-19 and effectiveness of control measures through human movement data: Proposal for a predictive model using big data analytics. *JMIR Res. Protoc.* **2020**, *9*, e24432. [CrossRef]
37. Santus, E.; Marino, N.; Cirillo, D.; Chersoni, E.; Montagud, A.; Chadha, A.S.; Lindvall, C. Artificial intelligence-aided precision medicine for COVID-19: Strategic areas of research and development. *J. Med. Internet Res.* **2021**, *23*, e22453. [CrossRef]
38. Lainjo, B. The Enigmatic COVID-19 Vulnerabilities and the Invaluable Artificial Intelligence (AI). *J. Multidiscip. Healthc.* **2021**, *14*, 2361. [CrossRef]
39. Sharifi, A.; Ahmadi, M.; Ala, A. The impact of artificial intelligence and digital style on industry and energy post-COVID-19 pandemic. *Environ. Sci. Pollut. Res.* **2021**, *28*, 46964–46984. [CrossRef]
40. Mhlanga, D. The Role of Artificial Intelligence and Machine Learning Amid the COVID-19 Pandemic: What Lessons Are We Learning on 4IR and the Sustainable Development Goals. *Int. J. Environ. Res. Public Health* **2022**, *19*, 1879. [CrossRef]
41. Firouzi, F.; Farahani, B.; Daneshmand, M.; Grise, K.; Song, J.; Saracco, R.; Luo, A. Harnessing the power of smart and connected health to tackle COVID-19: Iot, ai, robotics, and blockchain for a better world. *IEEE Internet Things J.* **2021**, *8*, 12826–12846. [CrossRef]
42. Belkacem, A.N.; Ouhbi, S.; Lakas, A.; Benkhelifa, E.; Chen, C. End-to-end AI-based point-of-care diagnosis system for classifying respiratory illnesses and early detection of COVID-19: A theoretical framework. *Front. Med.* **2021**, *8*, 372. [CrossRef] [PubMed]

43. Bharadwaj, H.K.; Agarwal, A.; Chamola, V.; Lakkaniga, N.R.; Hassija, V.; Guizani, M.; Sikdar, B. A review on the role of machine learning in enabling IoT based healthcare applications. *IEEE Access* **2021**, *9*, 38859–38890. [CrossRef]
44. Lin, Z.; He, Z.; Xie, S.; Wang, X.; Tan, J.; Lu, J.; Tan, B. AANet: Adaptive Attention Network for COVID-19 Detection From Chest X-Ray Images. *IEEE Trans. Neural Netw. Learn. Syst.* **2021**, *32*, 4781–4792. [CrossRef] [PubMed]
45. Yahya, B.M.; Yahya, F.S.; Thannoun, R.G. COVID-19 prediction analysis using artificial intelligence procedures and GIS spatial analyst: A case study for Iraq. *Appl. Geomat.* **2021**, *13*, 481–491. [CrossRef]
46. Shorfuzzaman, M.; Hossain, M.S.; Alhamid, M.F. Towards the sustainable development of smart cities through mass video surveillance: A response to the COVID-19 pandemic. *Sustain. Cities Soc.* **2021**, *64*, 102582. [CrossRef]
47. Umair, M.; Cheema, M.A.; Cheema, O.; Li, H.; Lu, H. Impact of COVID-19 on IoT adoption in healthcare, smart homes, smart buildings, smart cities, transportation and industrial IoT. *Sensors* **2021**, *21*, 3838. [CrossRef]
48. Pee, L.G.; Pan, S.L. Climate-intelligent cities and resilient urbanisation: Challenges and opportunities for information research. *Int. J. Inf. Manag.* **2022**, *63*, 102446. [CrossRef]
49. Jamshidi, M.B.; Roshani, S.; Daneshfar, F.; Lalbakhsh, A.; Roshani, S.; Parandin, F.; Malek, Z.; Talla, J.; Peroutka, Z.; Jamshidi, A.; et al. Hybrid Deep Learning Techniques for Predicting Complex Phenomena: A Review on COVID-19. *AI* **2022**, *3*, 416–433. [CrossRef]
50. Shahid, O.; Nasajpour, M.; Pouriyeh, S.; Parizi, R.M.; Han, M.; Valero, M.; Li, F.; Aledhari, M.; Sheng, Q.Z. Machine learning research towards combating COVID-19: Virus detection, spread prevention, and medical assistance. *J. Biomed. Inform.* **2021**, *117*, 103751. [CrossRef]
51. Di Franco, G.; Santurro, M. Machine learning, artificial neural networks and social research. *Qual. Quant.* **2021**, *55*, 1007–1025. [CrossRef]
52. Sheng, J.; Amankwah-Amoah, J.; Khan, Z.; Wang, X. COVID-19 pandemic in the new era of big data analytics: Methodological innovations and future research directions. *Br. J. Manag.* **2021**, *32*, 1164–1183. [CrossRef]
53. Ahmed, S.; Hossain, M.; Kaiser, M.S.; Noor, M.B.T.; Mahmud, M.; Chakraborty, C. Artificial Intelligence and Machine Learning for Ensuring Security in Smart Cities. In *Data-Driven Mining, Learning and Analytics for Secured Smart Cities*; Springer: Cham, Switzerland, 2021; pp. 23–47. [CrossRef]
54. Ebadi, A.; Xi, P.; Tremblay, S.; Spencer, B.; Pall, R.; Wong, A. Understanding the temporal evolution of COVID-19 research through machine learning and natural language processing. *Scientometrics* **2021**, *126*, 725–739. [CrossRef] [PubMed]
55. Li, Z.; Zuo, J.; Song, M.; Wei, Z.; Zhang, Y.; Xie, Y. Query and Clustering of Spatio-Temporal Trajectory Big Data Under the Background of COVID-19. In Proceedings of the 2021 International Conference on Control and Intelligent Robotics, Guangzhou, China, 18–20 June 2021; pp. 676–680. [CrossRef]
56. Dantas, A.J.; Jesus, L.D.; Ramos, A.C.B.; Hokama, P.; Mora-Camino, F.; Katarya, R.; Verma, O.; Gupta, P.; Singh, G.; Ouahada, K. Using UAV, IoMT and AI for Monitoring and Supplying of COVID-19 Patients. In Proceedings of the ITNG 2021 18th International Conference on Information Technology-New Generations, Las Vegas, NV, USA, 11–14 April 2021; Springer: Cham, Switzerland, 2021; pp. 383–386. [CrossRef]
57. Ismagilova, E.; Hughes, L.; Dwivedi, Y.K.; Raman, K.R. Smart cities: Advances in research—An information systems perspective. *Int. J. Inf. Manag.* **2019**, *47*, 88–100. [CrossRef]
58. Baig, Z.A.; Szewczyk, P.; Valli, C.; Rabadia, P.; Hannay, P.; Chernyshev, M.; Johnstone, M.; Kerai, P.; Ibrahim, A.; Sansurooah, K.; et al. Future challenges for smart cities: Cyber-security and digital forensics. *Digit. Investig.* **2017**, *22*, 3–13. [CrossRef]
59. Rathi, V.K.; Rajput, N.K.; Mishra, S.; Grover, B.A.; Tiwari, P.; Jaiswal, A.K.; Hossain, M.S. An edge AI-enabled IoT healthcare monitoring system for smart cities. *Comput. Electr. Eng.* **2021**, *96*, 107524. [CrossRef]
60. Troisi, O.; Fenza, G.; Grimaldi, M.; Loia, F. COVID-19 sentiments in smart cities: The role of technology anxiety before and during the pandemic. *Comput. Hum. Behav.* **2022**, *126*, 10698. [CrossRef]
61. Chiabai, A.; Platt, S.; Strielkowski, W. Eliciting users' preferences for cultural heritage and tourism-related e-services: A tale of three European cities. *Tour. Econ.* **2014**, *20*, 263–277. [CrossRef]
62. Sharifi, A.; Khavarian-Garmsir, A.R. The COVID-19 pandemic: Impacts on cities and major lessons for urban planning, design, and management. *Sci. Total Environ.* **2020**, *749*, 142391. [CrossRef]
63. Mnif, E.; Mouakhar, K.; Jarboui, A. Blockchain technology awareness on social media: Insights from twitter analytics. *J. High Technol. Manag. Res.* **2021**, *32*, 100416. [CrossRef]
64. Galanakis, C.M.; Rizou, M.; Aldawoud, T.M.S.; Ucak, I.; Rowan, N.J. Innovations and technology disruptions in the food sector within the COVID-19 pandemic and post-lockdown era. *Trends Food Sci. Technol.* **2021**, *110*, 193–200. [CrossRef]
65. Vlassis, A. Global online platforms, COVID-19, and culture: The global pandemic, an accelerator towards which direction? *Media Cult. Soc.* **2021**, *43*, 957–969. [CrossRef]
66. Yuloskov, A.; Bahrami, M.R.; Mazzara, M.; Kotorov, I. Smart cities in Russia: Current situation and insights for future development. *Future Internet* **2021**, *13*, 252. [CrossRef]
67. Shmelev, S.E.; Shmeleva, I.A. Global urban sustainability assessment: A multidimensional approach. *Sustain. Dev.* **2018**, *26*, 904–920. [CrossRef]
68. Golubchikov, O.; Thornbush, M. Artificial intelligence and robotics in smart city strategies and planned smart development. *Smart Cities* **2020**, *3*, 1133–1144. [CrossRef]

69. Mingaleva, Z.; Vukovic, N.; Volkova, I.; Salimova, T. Waste management in green and smart cities: A case study of Russia. *Sustainability* **2019**, *12*, 94. [CrossRef]
70. Vidiasova, L.; Cronemberger, F. Discrepancies in perceptions of smart city initiatives in Saint Petersburg, Russia. *Sustain. Cities Soc.* **2020**, *59*, 102158. [CrossRef]
71. Sokolov, A.; Veselitskaya, N.; Carabias, V.; Yildirim, O. Scenario-based identification of key factors for smart cities development policies. *Technol. Forecast. Soc. Chang.* **2019**, *148*, 119729. [CrossRef]
72. Kolobova, S. Evaluation of economic efficiency of the state programme of renovation of residential buildings in Moscow. *MATEC Web Conf.* **2018**, *193*, 05023. [CrossRef]
73. Kshetri, N.; Voas, J. Blockchain-enabled e-voting. *IEEE Softw.* **2018**, *35*, 95–99. [CrossRef]
74. The Intelligent Community. The Intelligent Community Forum Names the Global Top7 Intelligent Communities of 2021. 2021. Available online: https://www.intelligentcommunity.org/the_intelligent_community_forum_names_the_global_top7_intelligent_communities_of_2021 (accessed on 6 May 2022).
75. Kozlov, V. Moscow to Build on Its Smart City Credentials. 2017. Available online: https://www.computerweekly.com/news/450430676/Moscow-to-build-on-its-smart-city-credentials (accessed on 5 May 2022).
76. Intechnology. Moscow: The Smart City That's about to Get (a Lot) Smarter. 2022. Available online: https://www.intechnologysmartcities.com/blog/moscow-smart-city-to-get-much-smarter (accessed on 5 May 2022).
77. SmartCitiesWorld. Moscow Releases Catalogue of Smart City Projects. 2021. Available online: https://www.smartcitiesworld.net/news/news/moscow-releases-catalogue-of-smart-city-projects-6344 (accessed on 4 May 2022).
78. Ilina, I. Challenges of Building Smart Cities in Russia. 2016. Available online: https://iq.hse.ru/en/news/195419959.html (accessed on 5 May 2022).
79. Krylovskiy, A.; Jahn, M.; Patti, E. Designing a smart city internet of things platform with microservice architecture. In Proceedings of the 3rd International Conference on Future Internet of Things and Cloud, Rome, Italy, 24–26 August 2015; pp. 25–30. [CrossRef]
80. Krämer, M.; Frese, S.; Kuijper, A. Implementing secure applications in smart city clouds using microservices. *Future Gener. Comput. Syst.* **2019**, *99*, 308–320. [CrossRef]
81. König, P.D. Citizen-centered data governance in the smart city: From ethics to accountability. *Sustain. Cities Soc.* **2021**, *75*, 103308. [CrossRef]
82. Zekić-Sušac, M.; Mitrović, S.; Has, A. Machine learning based system for managing energy efficiency of public sector as an approach towards smart cities. *Int. J. Inf. Manag.* **2021**, *58*, 102074. [CrossRef]
83. Ullah, Z.; Al-Turjman, F.; Mostarda, L.; Gagliardi, R. Applications of Artificial Intelligence and Machine learning in smart cities. *Comput. Commun.* **2020**, *154*, 313–323. [CrossRef]
84. Majumdar, S.; Subhani, M.M.; Roullier, B.; Anjum, A.; Zhu, R. Congestion prediction for smart sustainable cities using IoT and machine learning approaches. *Sustain. Cities Soc.* **2021**, *64*, 102500. [CrossRef]
85. Strielkowski, W.; Veinbender, T.; Tvaronavičienė, M.; Lace, N. Economic efficiency and energy security of smart cities. *Econ. Res. Ekon. Istraživanja* **2020**, *33*, 788–803. [CrossRef]
86. Alaoui, E.A.A.; Tekouabou, S.C.K. Intelligent management of bike sharing in smart cities using machine learning and Internet of Things. *Sustain. Cities Soc.* **2021**, *67*, 102702. [CrossRef]
87. Sisinni, E.; Carvalho, D.; Ferrari, P. Emergency communication in IoT scenarios by means of a transparent LoRaWAN enhancement. *IEEE Internet Things J.* **2020**, *7*, 10684–10694. [CrossRef]