

Article

# Datafication Process in the Concept of Smart Cities

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**Abstract:** Datafication, currently visible in almost all areas of the human life, turned out to be a very good basis for the development of the concept of smart cities. Smart city authorities use various types of information and communication technologies (ICT) in the process of managing individual urban infrastructure systems. Modern ICT solutions enable city authorities to collect and process data about citizens. The purpose of this article is to determine the correlation between datafication and a city's position in the global smart cities ranking, with particular emphasis on the role of social media. To achieve the goal, the method of examining documents was used. Two independent reports were thoroughly analyzed: the Smart City Index 2020 and the Digital 2021 Local Country Headlines. The study showed that the more residents use social media, the better a city performs in the ranking. Additionally, a directly proportional relationship between the level of urbanization and the percentage of people using the Internet was demonstrated. The results of the presented study may be important primarily for people and institutions responsible for creating modern urban space.

**Keywords:** smart city; datafication; social media



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## 1. Introduction

The process of collecting and processing digital data has become an inseparable element of today's world. Initially, data digitization was used, i.e., the process of converting analogue data, usually in paper format, into digital [1]. We also encounter digitization in this form today, e.g., during computer transcription of recordings or video conversion from a video home system (VHS) tape to a digital version [2]. Then, digitalization became more and more common. As defined by Gartner's IT Glossary, digitalization is the process of transition to digital business, involving the use of digital technologies to change the existing business model and create new revenue-generation opportunities [3].

Currently, digitization is visible in all areas of human life, i.e., private, business, social, educational, and even spiritual life. Data has become an extremely valuable resource which, when used properly, can generate huge revenues for organizations and individuals. After realizing the existence of this phenomenon, many people and enterprises began to create digital representations of various elements of reality on a large scale, acquire data of people and institutions interested in these representations, and consequently benefit from the possibility of processing their data. This type of quantification and conversion of real-life areas into digital data, combined with obtaining specific economic, political, or social values from the data, is called datafication [4].

Datafication turned out to be the ideal basis for the development of the smart city concept. It is understood as a sustainable and efficient city characterized by a high quality of life and focused on improving mobility, optimizing the use of resources, security, social, and economic development. The key issue here is the use of information and communication technology (ICT) in individual urban infrastructure systems [5]. Smart cities use a variety of information and communication technologies (ICT) in the process of managing heating or cooling systems, power, gas and water supply, public safety, waste, and mobility of residents [6]. The use of information and communication technologies enables not only the efficient functioning of individual systems, but also cooperation between the most

important urban stakeholders: citizens, city authorities, universities, financial institutions, and enterprises, while respecting the natural environment.

The purpose of this article is to determine the correlation between datafication and a city's position in the global smart cities ranking, with particular emphasis on the role of social media. The article is divided into several main parts. First, a review of the literature on datafication and smart cities was carried out. Second, the methods and materials used in the study are described. In the next step, the results and discussion are presented. The final part of the article is the conclusion. The method of examining documents was used. Two reports were analyzed: Smart City Index 2020 and Digital 2021 Local Country Headlines.

The phenomenon of datafication and the smart city concept have been the subject of scientific research for only several years (datafication) or less than twenty years (smart cities). Nevertheless, many publications have been written about the above subjects. Researchers have attempted to create a definition of datafication [4,7] and presented it in the context of specific areas of human life, e.g., in the areas of business or health [8–11]. The key elements of the smart city strategy have also been described [12–15], including the use of power in smart cities [16] or the importance of the smart city strategy for maintaining ecological balance [17]. The datafication process in smart cities has also been studied [18,19]. However, there are no publications on the impact of datafication when using social media on the city's position in the smart cities ranking. Due to their validity and global reach, the results of the research presented in this article constitute a significant contribution into the science of management and quality, while presenting important data for people and institutions responsible for creating modern urban space.

## 2. Literature Review

The idea of datafication dates back to the 1980s, when local computer networks, used mainly by companies and public institutions, were becoming more and more popular. Another milestone on the way to datafication was digitalization, i.e., the use of digital technologies to influence the way work is performed, and to create opportunities to generate digital income. Digitalization, however, can be understood in a much broader sense, i.e., as the use of digital systems on the economic, social, and political levels [4]. According to Gray and Rumpe [20], digitalization relates to all aspects of our lives. Examples include smart homes and cities, e-medicine, or e-administration.

All of the changes described above would not be possible without the development of information and communication technologies. Initially, ICT solutions were mainly used in the spheres of business and state administration. In the 1990s, scientific publications on the use of ICT solutions in education [21–23], economics [24,25], logistics [26], research [27], and tourism [28] began to appear. The main ICT tool used at that time was a mobile phone (initially without Internet access) and a personal computer [29], which was mainly used to perform calculations, create texts, learn, and play simple games. Computer floppy disks were used as a data carrier, and then, with time, CDs. The Internet was also becoming more and more common [30]. Along with technological development, a laptop was an increasingly used tool [31].

The smartphone has become an ICT solution, significantly accelerating interpersonal contact [32]. It enabled the rapid development of social media [33] and online forms of business. Smartphone users with Internet access could at any time purchase the necessary product, reserve seats, e.g., on a plane, or contact their friends via social platforms such as Facebook. The widespread use of social networks and online stores has become the ideal basis for the next process in the history of digital transformation: datafication.

Datafication is a trend that goes well beyond digitization and digitalization. The concept of datafication was first used by Mayer-Schönberger and Cukier in 2013 and meant presenting real phenomena in a digital format for their later compilation and analysis [7]. In subsequent years, researchers dealt with various aspects of the phenomenon of datafication. Datafication in business has been described [8,10], as well as datafication of personal information [34], health datafication [9,35], datafication in education [11,36],

and the increasingly popular datafication of love resources, made possible thanks to dating portals and applications, equipped with algorithms for matching couples [37]. Attention has also been drawn to the datafication of children [38], whose data is shared by parents on social media platforms, but also collected by smart toys or monitoring devices worn by a child [39].

As emphasized by Mejias and Couldry [7], the datafication process can be divided into two separate subprocesses: the transformation of elements of human life into digital data through quantification, and generation of values from the data obtained as a result of this transformation. Quantifying reality involves collecting data. Dedicated applications or online platforms (e.g., Facebook, Instagram) are increasingly more often used for this purpose. Their task is to collect various types of data about users. These platforms are equipped with special algorithms that facilitate the processing and selection of data, and as a result—the sale of a product, service, or transfer of information. The values generated as a result of data verification may take both monetary form, in the case of selling a product or service, and on-monetary form, related to such things as building a positive image of a company or convincing a specific group of people to share an opinion. Table 1 shows popular online applications and platforms and provides an estimated volume of data collected through them in just one minute.

**Table 1.** Data collected by online platforms in one minute, 2021.

No.	Internet Platform	Type and Amount of Data Generated within 1 Min
1	Instagram	69,000 photos and videos shared
2	Snapchat	21,000,000 snaps created
3	Facebook	510,000 comments added
4	Twitter	350,000 tweets
5	LinkedIn	7000 active users use the platform
6	Pinterest	1300 tagged photos
7	YouTube	3,470,000 videos watched
8	TikTok	694,000 TikToks watched
9	Google	4,200,000 searches
10	Amazon	USD 283,000 spent on purchases

Source: author's work based on [40].

According to the above data, in one minute, Instagram users share nearly 70,000 photos and videos, over 20 million snaps are created on Snapchat, 510,000 comments are added on Facebook, and 350,000 tweets are posted on Twitter. In just 60 s, seven thousand users use LinkedIn simultaneously, and as many as 1300 photos are tagged on Pinterest. YouTube users watch nearly three and a half million videos within that short period, and TikTok displays almost 700,000 videos. One of the most popular search engines, Google.com, records over four million searches. People using the above platforms are more or less “datafied”: their data is collected, processed, and then used to display advertisements thematically matched to the preferences and interests of individual users, etc. The entire structure of the functioning of Internet platforms has the features of a very complex business. This is evidenced by the amount spent during one minute on purchases on Amazon: as much as USD 283,000.

The networks mentioned above use various types of technologies and devices. The aim is to reach the potential customer/user. Śledziewska and Włoch [4] consider computer, Internet, and smartphone technologies as the basic data technologies, because these technologies/inventions enable the collection, processing, and analysis of data on a scale unimaginable just a few decades ago. In order to achieve datafication, loyalty card systems, smartwatches, the aforementioned smart toys, or virtual assistants are also used.

Datafication has a huge impact on the life of a modern human. Having access to an increasing amount of digital data, a human can more effectively make decisions, both in life and work, and as a consumer [4]. The negative aspect, however, is the invasive acquisition of private data of people using digital technologies for later utilization of such data.

The process of transition from digitization through digitalization to datafication has impacted the emergence of new business models [20] and also created a change in the approach of decision-makers to the issue of urban space management. Scientific publications more and more often are discussing the use of ICT solutions in planning and management of urban space [41,42]. The use of communication and information technologies has been described, including in transport [17] and healthcare. The intensification of the possibilities of obtaining digital data, combined with a change in the perception of data by creators and users of modern technologies, has become the basis for the emergence of the recently increasingly popular concept of smart cities.

The need to create more efficient urban systems has appeared due to the constantly growing number of people and the systematically deepening processes of urbanization. According to [43], currently there are nearly 7.87 billion people living on Earth. According to DataReportal [44], more than 56% of the population now lives in cities. This number is constantly growing. It is estimated that by 2050 it will increase to 9.1 billion, with urbanization level reaching 70% [12].

As mentioned in the introduction, the key elements for defining the city as a smart city are the efficiencies of individual elements of urban infrastructure, resulting in an increase in the quality of life of its residents. However, there are various explications in the literature regarding smart cities. Some researchers emphasize the corporate factor in their definitions, while others support anthropocentric views. For example, Béliçsent [12] refers to the Forrester Research definition, according to which, in a smart city, information and communication technologies are used to improve the efficiency of administration, education, public safety, communication, and other elements of urban systems. In turn, Horbaty (2013) emphasizes the importance of the human factor. According to Horbaty, the smart city offers the maximum comfort of living with the minimum use of resources to its residents. The minimum use of resources in a smart city is possible thanks to the optimum coexistence of urban infrastructure systems [45]. Zuccalà and Verga [13] emphasize the aspect of sustainability. According to them, a smart city is a sustainable urban center characterized by ICT support in every aspect of life, as well as effective and integrated management of energy systems, building resources, mobility, and climate change.

The basic infrastructure systems in the smart cities concept are transport, heating and cooling systems, education, administration, public safety, healthcare, housing construction, spaces for recreation and leisure, waste management, and energy obtained from renewable sources [9]. They are presented in Table 2.

From Table 2, it can be seen that in order for the city to be considered smart, administrative authorities should pay attention to all sectors of urban infrastructure in the budget-setting process. It is not enough to focus only on transport, ignoring heating systems, or providing residents with green spaces. It is also important to quickly and conveniently finalize official matters, e.g., via e-office platforms, and to ensure the security of public transactions.

In transport, the optimization of transport routes is extremely important [46], involving appropriate traffic management, both in terms of public transport as well as passenger cars and lorries. The comfort of life of residents is also influenced by intelligent systems informing about bus departure times and free parking spaces, as well as enabling quick purchase of transport and parking tickets. Electric cars are also becoming more and more popular, as they contribute significantly to reducing CO<sub>2</sub> emissions in the atmosphere [17]. In the construction sector, special emphasis is placed on automation, own energy sources, and the optimum use of energy resources. Responsible waste management is also associated with optimum management of buildings. As part of the smart city strategy, the zero-waste attitude should be promoted, i.e., the use of consumer goods while minimizing the amount of waste. Systems supporting the segregation and recycling of waste should also be used, and citizens should be constantly informed about the social and environmental benefits of reusing waste. Waste containers equipped with special sensors that signal

their fullness and are opened with the use of electronic cards are an example of modern solutions in city waste management.

**Table 2.** Basic infrastructure systems in a smart city according to Bélissent [12]; Zuccalà and Verga [13].

No.	System Infrastructure	Examples of System Features in the Smart City Concept
1	Administration	<ul style="list-style-type: none"> <li>• Solutions supporting inter-system city management.</li> <li>• Technologies supporting the budgeting process.</li> <li>• The possibility of electronic handling of official matters by clients (e-office).</li> <li>• Ensuring security for public administrative transactions (data encryption, etc.).</li> <li>• Real-time traffic management.</li> </ul>
2	Transport	<ul style="list-style-type: none"> <li>• Optimization of transport routes.</li> <li>• Intelligent redirection of buses to designated lanes.</li> <li>• Integrated ticketing systems.</li> <li>• Available parking space sensors.</li> <li>• Convenient parking mobile payments.</li> <li>• Electric car charging station system.</li> </ul>
3	Construction	<ul style="list-style-type: none"> <li>• Smart homes (Internet of Things, photovoltaic systems, heat pumps).</li> <li>• Intelligent systems for controlling HVAC systems.</li> <li>• Monitoring public utility buildings.</li> <li>• Building automation.</li> </ul>
4	Waste management	<ul style="list-style-type: none"> <li>• Circular economy (waste segregation + reuse).</li> <li>• Promoting “zero waste” attitudes among citizens.</li> <li>• Card-based garbage cans equipped with filling sensors.</li> <li>• E-learning combined with the possibility of videoconferencing.</li> </ul>
5	Education	<ul style="list-style-type: none"> <li>• Communication and information technologies for conducting scientific research.</li> <li>• Intelligent security and building management on student campuses (e.g., monitoring system, student access to media).</li> </ul>
6	Healthcare	<ul style="list-style-type: none"> <li>• Electronic patient records and telemedicine.</li> <li>• Information exchange between hospitals and pharmacies.</li> <li>• Remote monitoring of specific groups of patients (e.g., elderly people).</li> <li>• Promoting healthy lifestyle.</li> <li>• Modern crisis command center.</li> </ul>
7	Public security	<ul style="list-style-type: none"> <li>• Quick notification of citizens about a threat (e.g., by sms).</li> <li>• Optimization of capacity and response time of emergency services.</li> <li>• Securing mass events.</li> <li>• Intelligent monitoring of public places (connected to emergency services systems).</li> <li>• Access to live images and archived images from city cameras.</li> </ul>
8	Spaces for recreation and leisure	<ul style="list-style-type: none"> <li>• Numerous green areas, enabling outdoors relaxation.</li> <li>• Infrastructure contributing to sports (e.g., bike lanes).</li> <li>• Websites providing information on tourist attractions.</li> <li>• Intuitive interactive maps of attractions and events.</li> <li>• Intelligent green space monitoring (in real time).</li> <li>• Quick access to information about accommodation and restaurants.</li> </ul>

Source: author’s work based on [12,13].

On the other hand, intelligent education is related to the possibility of quick access to knowledge (e.g., in the form of e-learning and videoconferences), the use of ICT to improve educational systems [14,47], and to more effective research. Along with the creation of modern educational systems, it is necessary to teach the society to use these systems at the same time and to dispel fears related to the use of technology in education [48].

Examples of intelligent healthcare are electronic patient registers available to hospitals and pharmacies, telemedicine, and systems for monitoring the health of specific groups of patients connected to a mobile phone. The promotion of a healthy lifestyle is of great importance for the general condition of citizens, e.g., by popularizing an application offering personalized recommendations regarding physical activity to residents [49].

City authorities should use modern technologies to care for the safety of their citizens. For this purpose, some smart cities create crisis command centers, systems for quickly informing residents about a threat (e.g., by sms), optimizing the response time of emer-

agency services and equipping urban spaces with intelligent monitoring, thanks to which emergency services have access to images in real time. The obligatory element in smart cities are spaces enabling residents to rest and move in the open air: city parks secured by monitoring, a developed network of bike lanes, interactive tourist portals, or access to information about accommodation and restaurants.

Sustainable energy resources are necessary to create the infrastructure systems mentioned above in line with the smart city trend [13]. Its production is crucial for all economic activities, and thus for the development of individual territorial units [16]. Energy is necessary for the functioning of single-family houses, plants, city cameras and lights, various types of sensors, the Internet of Things, and electric cars, as well as online platforms and social media. The optimum solution is to obtain energy from renewable sources, such as photovoltaic farms or wind farms.

Information is another element essential for the proper operation of smart city infrastructure systems. Nowadays, information takes the form of digital data, often obtained with a view to acquiring various types of benefits (financial and nonfinancial). Datafication processes are visible not only in business, but also in the administrative area. The city datafies data about the people living in it; in particular, about the energy resources they use, their mobile devices, or diseases. The collected data is used, among others, to shape sustainable development of urban spaces [13], to change the lifestyle of residents towards a pro-health one, or to inform them about a potential threat, e.g., via an application or text message. At the same time, in order to effectively implement information technology (IT) platforms prepared to obtain and process information about citizens, cooperation between the public and private sectors is required [15].

The use of ICT and social media technologies is extremely important in the era of the COVID-19 coronavirus pandemic. From the second quarter of 2020, many scientific publications have focused on this issue [50–53]. Thanks to the possibility of using communication and information solutions, a significant number of societies around the world could perform work, obtain information on the geopolitical situation [52], shop, and maintain contacts with family and friends.

### 3. Materials and Methods

The presented study was conducted in May 2021. Its purpose was to determine the correlation between datafication and a city's position in the global smart cities ranking. An additional goal was to check the relationship between the degree of urbanization of the country and the level of Internet use by its citizens. The method of examining documents was used. Two independent reports were analyzed: the Smart City Index 2020 [54] and the Digital 2021 [44] Local Country Headlines.

The first of the abovementioned reports, the Smart City Index 2020, was prepared by the Institute for Management Development, an international business school based in Switzerland, in cooperation with the Singapore University of Technology and Design. The authors of the report conducted a survey in April and May 2020 among citizens of 109 cities from around the world. Respondents were asked a number of questions about technological solutions in their city. The ranking was created on the basis of technology scoring in the following areas: health and safety, mobility, activity, educational and professional opportunities, and city management systems. Apart from the position in the ranking, each city received a letter designation (rating): AAA for the most "smart" cities, and then AA, A, BBB, BB, B, CCC, CC, C, and D for cities with the lowest scoring.

The second of the analyzed documents, the Digital 2021 Local Country Headlines [44], was created in January 2021 for the purpose of [www.datareportal.com](http://www.datareportal.com) with the participation of international websites: [www.hootsuite.com](http://www.hootsuite.com) and [www.wearesocial.com](http://www.wearesocial.com). The report included information on the number of city residents, the number of SIM cards in circulation, and the number of active Internet and social networking users in 243 countries around the world. Active users are people who log into social networks regularly. After logging in, these people add their own entries, comment on others' entries, and view

interesting content, and thus leave digital information in the network about their lives, interests, views, and preferences, e.g., when it comes to shopping.

The data presented in both analyzed reports refer to a similar time period of time: the year 2020 (months after the pandemic COVID-19 began). The different dates (2020 and 2021) in the titles of the reports result from the fact that the Smart City Index 2020 was published in the second half of 2020 [54], and the Digital 2021 Local Country Headlines report was published in January 2021 [44]. This is extremely important from the point of view of the geopolitical situation in 2020 related to the outbreak of the COVID-19 pandemic. The coronavirus changed the situation in all countries around the world, drastically influenced the level of social isolation of residents, and increased their interest in social media. On March 13, 2020, the WHO announced the global COVID-19 coronavirus pandemic [55]. Since March, many countries have introduced national quarantines to protect residents. The Internet and social media began to be massively used, mainly for the purpose of working and maintaining interpersonal relationships. However, the data presented in the Smart City Index 2020 report was carried out in the period April–May 2020, so after the pandemic began, and the data presented in Digital 2021 Local Country Headlines concern the second half of 2020. Thus, it is reasonable to compare both reports, because they contain data for a similar time period (several months after the pandemic began) and after increasing the interest of citizens of the surveyed countries in using the Internet and social media.

During the study, the data related to the use of social networking sites by citizens of individual countries was primarily taken into account. Two research hypotheses were formulated:

**Hypothesis 1 (H1):** *There is a strong correlation between the level of use of social media by the inhabitants of the country and the position of the city in the Smart Cities Index.*

**Hypothesis 2 (H2):** *The degree of urbanization of a country is strongly correlated with the level of Internet use by its citizens.*

The research process began with a precise analysis of the abovementioned reports. A table was created in which all countries from the Smart Cities 2021 ranking were included, along with the specification of countries and continents. At a later stage, the Digital 2021 ranking selected data on the level of urbanization and the percentage of the population of a given country actively using the Internet and social media. Some of the data collected to verify the hypotheses is presented in Table 3 (the full version of the table is added as an Appendix A).

The table shows the top ten and the last ten cities in the Smart City Index 2020 ranking. Leading the smart city ranking is Singapore, which is the only one to receive an AAA rating. It was followed by Helsinki, Zurich, Auckland, Oslo, Copenhagen, Geneva, Taipei, Amsterdam, and New York. The least smart city was Lagos in Nigeria, with a level of urbanization of 16.7%, percentage of people using the Internet at 13.6%, and percentage of people using social media at 2.4%.

**Table 3.** The importance of the Internet and social networks in countries with smart cities.

No.	Smart City	Rating	Country	Continent	Percentage of Citizens of the Country Who:		
					Live in Cities	Use Internet	Use Social Media
1	Singapore	AAA	Singapore	Asia	100.0%	90.0%	84.4%
2	Helsinki	AA	Finland	Europe	85.6%	95.0%	80.4%
3	Zurich	AA	Switzerland	Europe	74.0%	97.0%	81.8%
4	Auckland	AA	New Zealand	Oceania	86.7%	84.0%	82.0%
5	Oslo	AA	Norway	Europe	83.1%	99.0%	83.2%
6	Copenhagen	AA	Denmark	Europe	88.2%	98.1%	83.6%
7	Geneva	AA	Switzerland	Europe	74.0%	97.0%	81.8%
8	Taipei	A	Taiwan	Asia	79.1%	90.0%	82.6%
9	Amsterdam	A	The Netherlands	Europe	92.4%	96.0%	88.0%
10	New York	A	USA	North America	82.8%	90.0%	72.3%
100	Sao Paulo	C	Brazil	South America	87.2%	75.0%	70.3%
101	Rome	C	Italy	Europe	71.2%	83.7%	67.9%
102	Rio de Janeiro	C	Brazil	South America	87.2%	75.0%	70.3%
103	Cape Town	D	South Africa	Africa	67.6%	64.0%	41.9%
104	Manila	D	Philippines	Asia	47.6%	67.0%	80.7%
105	Rabat	D	Morocco	Africa	63.8%	74.4%	59.3%
106	Cairo	D	Egypt	Africa	42.8%	57.3%	47.4%
107	Abuja	D	Nigeria	Africa	16.7%	13.6%	2.4%
108	Nairobi	D	Kenya	Africa	28.2%	40.0%	20.2%
109	Lagos	D	Nigeria	Africa	16.7%	13.6%	2.4%

Source: author's work based on [44,54].

#### 4. Results and Discussion

After preliminary data processing, it was established that the ranking included cities from 55 countries around the world. It was then confirmed how many inhabitants of each continent live in cities, how many actively use the Internet, and how many use social media. During the calculations, only countries with at least one city included in the Smart City Index 2020 ranking were taken into account. The results are presented in Table 4.

**Table 4.** SC Index 2020 and the importance of the Internet and social networks on individual continent.

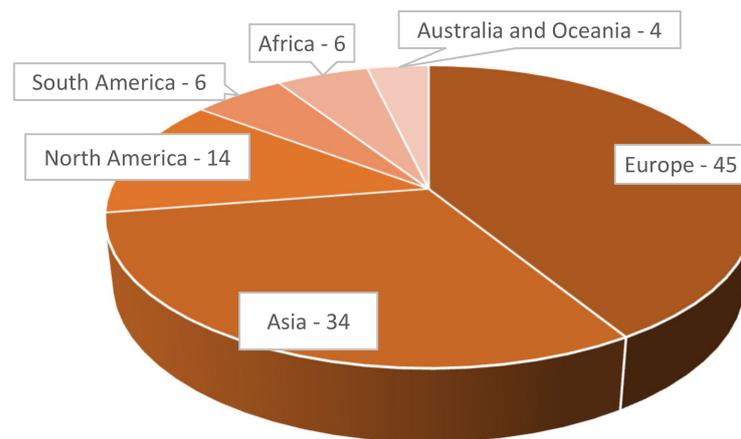
Continent	Number of Countries	Total Number of Residents Included in the Ranking of Countries (Million)	City Residents		Internet Users		Social Media Users	
			Million	%	Million	%	Million	%
Europe	25	703.90	533.3	75.8	617.1	87.7	512.70	72.8
Asia	15	3761.13	1981.5	52.7	2296.4	61.1	2061.9	54.8
North America	3	499.5	410.7	82.2	426.4	85.2	372.2	74.5
South America	4	328.93	286.4	87.1	246.8	75.0	241.0	73.3
Africa	5	279.69	127.7	45.7	150.1	53.7	107.6	38.5
Oceania	2	30.48	26.3	86.4	26.9	88.2	24.5	80.3

Source: author's work based on [44,54].

According to the data from Table 4, Europe is the continent with the largest number of countries whose cities are included in the Smart Cities ranking (25 countries). Next on the list are Asia (15 countries), North America (3 countries), South America (4 countries), Africa (5 countries), Australia, and Oceania. Countries on two continents (e.g., Turkey, Russia) were assigned to the continent which included the Smart City Index.

Among the countries included in the Smart City Index 2020, the highest percentage of people living in cities was found in South America: 87.05%, and the lowest in Africa: 45.7%. The inhabitants of Australia and Oceania (88.2%), Europe (87.7%), and North America (85.4%) most often use the Internet. South America reached 75.0%, and Asia, 61.1%. The weakest interest in the Internet was recorded in Africa (53.7%). The highest percentage of active social media users are in Australia and Oceania (80.3%), North America (74.5%), South America (73.3%), and Europe (72.8%), and the lowest in Asia (54.8%) and Africa (38.5%).

The number of cities in the Smart City Index 2020 broken down by continent was also observed. The results are shown in Figure 1.

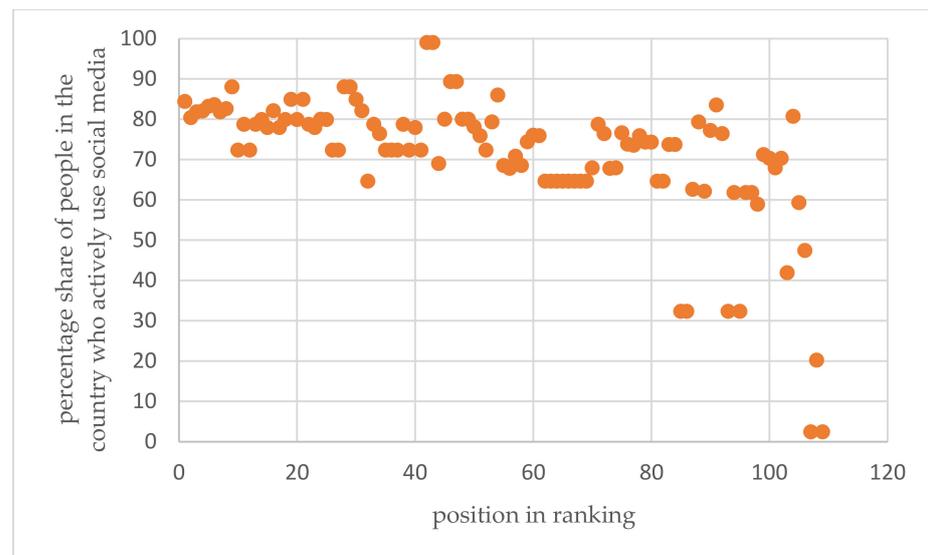


**Figure 1.** Number of cities in the Smart City Index 2020 ranking by particular continents. Source: author's work based on [54].

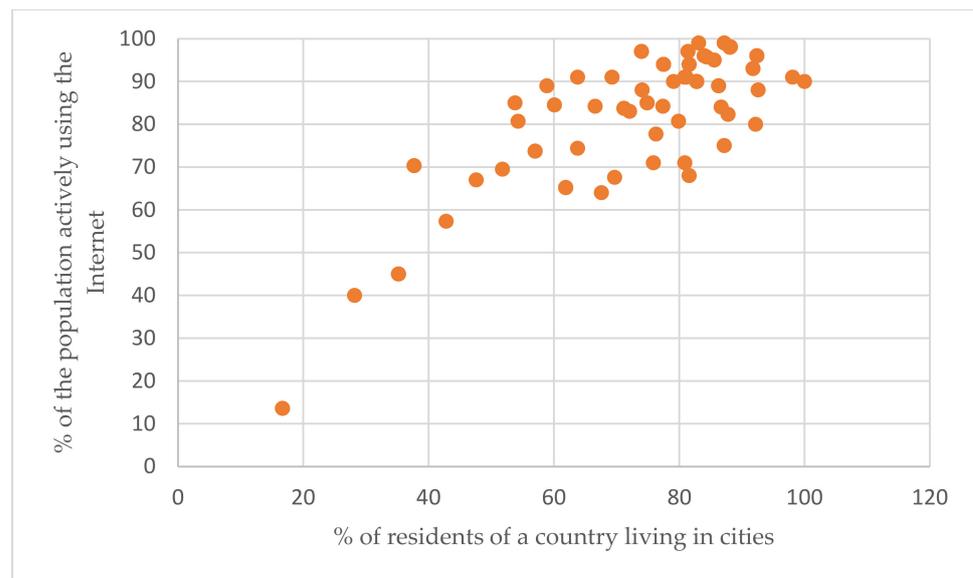
As shown in Figure 1, the ranking includes cities from all continents permanently inhabited by people (Antarctica is not a continuously inhabited continent). According to the index mentioned above, the largest number of smart cities is in Europe: as many as 45. A total of 34 Asian cities were included in the Smart Cities list. North America rates much worse, with 14 cities. South America and Africa are ranked only six times, and Australia and Oceania four times.

In order to verify H1 (There is a strong correlation between the level of use of social media by the inhabitants of the country and the position of the city in the Smart Cities Index), the researchers focused on checking the relationship between the number of people in individual countries using social media (in percentage) and the position of individual cities in the ranking. The Pearson correlation coefficient was used. Statistica and Excel were used for the calculations. The obtained result ( $-0.6022$ ), with  $p < 0.05$ , evidences a strong correlation between the use of social media by the society and the position in the ranking. H1 has been positively verified. A minus shown next to the result indicates an inversely proportional correlation. In other words: the greater the percentage of people using social media, the better the city's position in the ranking. This dependence, despite being somewhat dispersed, can be seen in Figure 2.

To analyze H2 (*the degree of urbanization of a country is strongly correlated with the level of Internet use by its citizens*), the relationship between the percentage of inhabitants of individual countries appearing in the Smart City Index 2020 ranking and the percentage of people actively using the Internet was checked. Pearson's correlation coefficient was 0.8339 with  $p < 0.05$ , which proves a very strong correlation between the level of urbanization in the country and the number of people using the Internet. Hypothesis H2 was verified positively. A positive sign with the correlation coefficient indicates a directly proportional relationship: the higher the level of urbanization, the greater the percentage of people using the Internet. This trend is shown in Figure 3.



**Figure 2.** Social media use and the position in the Smart City Index 2020 ranking. Source: author's work based on [44,54].



**Figure 3.** Country urbanization and the percentage of people using the Internet. Source: author's work based on [44,54].

The study highlighted the estimates presented by Bélissent [9] regarding urbanization reaching 70% in 2050. The total number of inhabitants of countries whose cities are included in the Smart City Index 2020 is 5603.6 million. The number of people living in cities is as high as 3365.8 million, which is as much as 60.1%. Reaching the 70% level in the next 30 years is extremely realistic.

The analysis of the abovementioned documents confirmed the importance of social media for people actively using the Internet. On average, as many as 59.2% of residents of countries included in the Smart City Index 2020 visit social networks. Such a high result is consistent with the trend shown by [www.localiq.com](http://www.localiq.com) [42], presenting millions of data processed by social networking sites in just one minute. It is true that, as emphasized by Zuccalà and Verga [13], data collected by the administration of smart cities is used, among others, for the sustainable management of energy resources in smart cities, as well as for the improvement of transport and education [14] or healthcare [49]. Data collected in social

networks can also be used to determine the level of happiness and satisfaction with life of city residents [56].

At the same time, however, attention should be paid to the dangers of too far-reaching data acquisition strategy. According to the report entitled “Internet Use Around the World” [57], the number of Internet users in April 2021 was 4.72 billion globally. As many as 92.8% of people used the Internet via a smartphone. The average Internet user spent 6 h and 56 min online every day. In all this “mass data flow madness”, private data is very often shared, which absolutely should not be uploaded to the network in an unsecured form. Disclosing this information creates a risk of being used by cybercriminals or by people seeking to damage the reputation of the data owner.

A significant part of the data processed regards children, which was pointed out by Lupton and Williamson [38]. Data about children is often shared by parents and public organizations (e.g., kindergartens). It is worth approaching this issue carefully, because in today’s digital reality, all the data that is digitized leaves a trace “on the web”. For example, deleting a private photo shared on Facebook does not guarantee that it has not been copied by third parties for their own (not necessarily ethical) purposes in the future.

Another possible threat is some kind of withdrawal of individuals from public life. The fact that the Internet enables us to reach digital representations of the real world means that we spend more and more time alone using a computer/smartphone, limiting direct contacts with family and friends. This type of “technological desocialization” can cause difficulties in building and maintaining interpersonal relationships, especially in the case of young people: children and adolescents.

## 5. Conclusions

The concepts of smart cities and progressive datafication are inseparable components of our reality. The term “smart cities” means a new way of living in cities, which involves optimizing the already available smart technological solutions and investing in new ones [6]. Appropriate use of the smart cities concept will contribute to increasing the comfort of life of residents while maintaining the ecofriendly, economic, energy, and information balance of cities. On the other hand, the progressive datafication process may affect the convenience and comfort of people living in a given city, for example by increasing the quality of medical treatment, education, or administrative services for citizens. It can also reduce the time they take to make decisions related to choosing a service provider and purchasing.

The presented study confirms that there is a strong correlation between a city’s position in the smart cities ranking and the level of use of social media by the country’s residents. The higher the city scored in the ranking, that is, the smarter it is, the greater the percentage of people who used social media. At the same time, it has been shown that the level of Internet use increases with increasing level of urbanization. It seems reasonable to conclude that in the future, the number of people browsing websites and Internet portals will also increase.

The results of the study are important for responsible risk management in urban space. The confirmation of the strong correlation between city development and the level of social media use by its citizens should draw the attention of the city administration to three basic aspects. These are: protection of the privacy of Internet users, creation of emergency systems allowing for the coordination of urban activities in smart cities in the face of failure of the main management systems, and encouraging residents to be physically active [58,59].

The public administration’s disregard for the existence of a strong relationship between the development of cities and the level of social media use by their inhabitants may result in negative consequences both for individuals and for the entire society. First of all: there can be numerous crimes related to data theft (including financial fraud, defamation, etc.). Due to excessive use of the Internet, city dwellers may feel mentally burned out and have a reduced physical condition. As a consequence, they may suffer more often (e.g.,

becoming overweight, developing hypertension and coronary diseases, etc.). On the other hand, without creating emergency management systems, cities may have a problem with maintaining orderly traffic and taking care of public safety in the event of a sudden failure of the ICT infrastructure.

In the face of the abovementioned risks, every Internet user should pay great attention to the protection of personal data and be more careful when posting their private photos or opinions on networks such as Facebook, Instagram, or Twitter. Administrative authorities should also educate citizens about the need to filter information and data posted on social media. Second, it is also important to secure ICT systems properly [58–61]. Actions of this type are needed chiefly in smart cities, because the amount of data submitted on social networks is particularly large in their case.

In view of the popular use of the Internet, and, in particular, the use of social media, smart city managers should convince residents to spend time outdoors and take care of physical activity. For this purpose, it is worth planning green areas in the city space and preparing infrastructure and devices increasing the level of physical activity (e.g., city bikes).

This study should mobilize the city's administrative authorities to develop certain types of procedures related to risk management resulting from the daily use of ICT solutions of smart city residents. It seems important to conduct detailed research on the knowledge of city residents about the potential threats resulting from the daily use of the technological simplifications present in smart cities. An example of responsible management of the technological wellbeing of inhabitants may be, among others, an educational campaign on the risks resulting from the publication of personal data on social networking sites.

As part of taking care of public safety, the administrative authorities should also prepare an alternative procedure for servicing the municipal infrastructure. It must contain a detailed description of actions in the event of a general failure of ICT solutions (e.g., how to quickly respond to the failure of computer-controlled traffic lights in the entire city, or panic caused by a computer virus sent to public administration units).

It is also worth regularly checking how the digitization that surrounds us affects our physical and mental health. City authorities, both smart cities and those claiming to be smart, should pay special attention to the security of data obtained by city systems, and, to an even greater extent, encourage citizens to engage in physical activity and with direct personal contacts, as long as it is permitted due to sanitary and epidemiological reasons. Communication and information technologies contribute to increasing the quality of life of city dwellers, but cannot become a substitute for everyday human activity and creating direct relationships with other people.

Constant monitoring of the use of ICT solutions in urban space (with respect to the principles of protection of citizens' privacy) and the development of procedures related to technological risk may involve higher costs for the city. Among others, these would be the costs of creating specific organizational units and preparing tools and developing appropriate organizational methods. However, as a result, activities of this type will contribute to increasing the city's safety level.

Due to the rapid development and increasing popularity of ICT, it seems justified to conduct a detailed study that shows the reasons for the increased interest in using social media in cities occupying the leading positions in the Smart City Index ranking. They will be helpful for people managing urban space, among others, in the process of building a positive opinion about the city, informing residents about new regulations, and ensuring their safety.

It seems important to check which social media platforms are most often used as a communication channels between administrative units and city residents, and which applications based on social media are supported by residents of smart cities. Taking into account the wider access to information and communication technologies and social media, also in small administrative units (e.g., villages and small towns), it is worth conducting

research in the future showing the difference in the level of datafication in rural areas and cities located in different countries and on different continents.

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## Appendix A

**Table A1.** The full version of Table 3: The importance of the Internet and social networks in countries with smart cities.

No.	Smart City	Rating	Country	Continent	Percentage of Citizens of the Country Who:		
					Live In Cities	Use Internet	Use Social Media
1	Singapore	AAA	Singapore	Asia	100	90	84.4
2	Helsinki	AA	Finlandia	Europe	85.6	95	80.4
3	Zurich	AA	Switzerland	Europe	74	97	81.8
4	Auckland	AA	New Zealand	Oceania	86.7	84	82
5	Oslo	AA	Norway	Europe	83.1	99	83.2
6	Copenhagen	AA	Denmark	Europe	88.2	98.1	83.6
7	Geneva	AA	Switzerland	Europe	74	97	81.8
8	Taipei City	A	Taiwan	Asia	79.1	90	82.6
9	Amsterdam	A	The Netherland	Europe	92.4	96	88
10	New York	A	USA	North America	82.8	90	72.3
11	Munich	A	Germany	Europe	77.5	94	78.7
12	Washington D.C.	A	USA	North America	82.8	90	72.3
13	Dusseldorf	A	Germany	Europe	77.5	94	78.7
14	Brisbane	A	Australia	Oceania	86.3	89	79.9
15	London	A	England	Europe	84	96	77.9
16	Stockholm	A	Sweden	Europe	88.1	98	82.1
17	Manchester	A	England	Europe	84	96	77.9
18	Sydney	A	Australia	Oceania	86.3	89	79.9
19	Vancouver	A	Canada	North America	81.6	94	84.9
20	Melbourne	A	Australia	Oceania	86.3	89	79.9
21	Montreal	A	Canada	North America	81.6	94	84.9
22	Hamburg	A	Germany	Europe	77.5	94	78.7
23	Newcastle	A	England	Europe	84	96	77.9
24	Bilbao	BBB	Spain	Europe	80.9	91	80
25	Vienna	BBB	Austria	Europe	58.9	89	79.9
26	Los Angeles	BBB	USA	North America	82.8	90	72.3
27	San Francisco	BBB	USA	North America	82.8	90	72.3
28	The Hague	BBB	The Netherland	Europe	92.4	96	88

Table A1. Cont.

No.	Smart City	Rating	Country	Continent	Percentage of Citizens of the Country Who:		
					Live In Cities	Use Internet	Use Social Media
29	Rotterdam	BBB	The Netherland	Europe	92.4	96	88
30	Toronto	BBB	Canada	North America	81.6	94	84.9
31	Gothenburg	BBB	Sweden	Europe	88.1	98	82.1
32	Hong Kong	BBB	China	Asia	61.9	65.2	64.6
33	Hanover	BBB	Germany	Europe	77.5	94	78.7
34	Dublin	BBB	Ireland	Europe	63.8	91	76.4
35	Denver	BBB	USA	North America	82.8	90	72.3
36	Boston	BBB	USA	North America	82.8	90	72.3
37	Seattle	BBB	USA	North America	82.8	90	72.3
38	Berlin	BBB	Germany	Europe	77.5	94	78.7
39	Phoenix	BBB	USA	North America	82.8	90	72.3
40	Birmingham	BBB	England	Europe	84	96	77.9
41	Chicago	BBB	USA	North America	82.8	90	72.3
42	Abu Dhabi	BB	The United Arab Emirates	Asia	87.2	99	99
43	Dubai	BB	The United Arab Emirates	Asia	87.2	99	99
44	Prague	BB	Czechia	Europe	74.1	88	69
45	Madrid	BB	Spain	Europe	80.9	91	80
46	Busan	BB	South Korea	Asia	81.4	97	89.3
47	Seoul	BB	South Korea	Asia	81.4	97	89.3
48	Zaragoza	BB	Spain	Europe	80.9	91	80
49	Barcelona	BB	Spain	Europe	80.9	91	80
50	Tel Aviv	BB	Israel	Asia	92.6	88	78.1
51	Lyon	BB	France	Europe	81.1	91	75.9
52	Philadelphia	BB	USA	North America	82.8	90	72.3
53	Riyadh	B	Saudi Arabia	Asia	84.4	95.7	79.3
54	Kuala Lumpur	B	Malesia	Asia	77.4	84.2	86
55	Warsaw	B	Poland	Europe	60.1	84.5	68.5
56	Moscow	B	Russia	Europe	74.9	85	67.8
57	Ankara	B	Turkey	Asia	76.3	77.7	70.8
58	Krakov	B	Poland	Europe	60.1	84.5	68.5
59	Tallinn	B	Estonia	Europe	69.3	91	74.4
60	Brussels	B	Belgium	Europe	98.1	91	76
61	Paris	B	France	Europe	81.1	91	75.9
62	Zhuhai	CCC	China	Asia	61.9	65.2	64.6
63	Tianjin	CCC	China	Asia	61.9	65.2	64.6
64	Chongqing	CCC	China	Asia	61.9	65.2	64.6
65	Hangzhou	CCC	China	Asia	61.9	65.2	64.6
66	Nanjing	CCC	China	Asia	61.9	65.2	64.6
67	Shenzhen	CCC	China	Asia	61.9	65.2	64.6
68	Guangzhou	CCC	China	Asia	61.9	65.2	64.6
69	Chengdu	CCC	China	Asia	61.9	65.2	64.6
70	Bologna	CCC	Italy	Europe	71.2	83.7	67.9

Table A1. Cont.

No.	Smart City	Rating	Country	Continent	Percentage of Citizens of the Country Who:		
					Live In Cities	Use Internet	Use Social Media
71	Bangkok	CCC	Thailand	Asia	51.8	69.5	78.7
72	Medellin	CCC	Colombia	South America	81.6	68	76.4
73	St. Petersburg	CCC	Russia	Europe	74.9	85	67.8
74	Milan	CCC	Italy	Europe	71.2	83.7	67.9
75	Lisbon	CCC	Portugal	Europe	66.6	84.2	76.6
76	Bratislava	CCC	Slovakia	Europe	53.8	85	73.8
77	Budapest	CCC	Hungary	Europe	72.1	83	73.5
78	Marseille	CCC	France	Europe	81.1	91	75.9
79	Tokyo	CCC	Japan	Asia	91.8	93	74.3
80	Osaka	CCC	Japan	Asia	91.8	93	74.3
81	Shanghai	CC	China	Asia	61.9	65.2	64.6
82	Beijing	CC	China	Asia	61.9	65.2	64.6
83	Ho Chi Minh City	CC	Vietnam	Asia	37.7	70.3	73.7
84	Hanoi	CC	Vietnam	Asia	37.7	70.3	73.7
85	Hyderabad	CC	India	Asia	35.2	45	32.3
86	New Delhi	CC	India	Asia	35.2	45	32.3
87	Bucharest	CC	Romania	Europe	54.3	80.7	62.6
88	Buenos Aires	CC	Argentina	South America	92.2	80	79.3
89	Sofia	CC	Bulgaria	Europe	75.9	71	62.1
90	Mexico City	CC	Mexico	North America	80.9	71	77.2
91	Santiago	CC	Chile	South America	87.8	82.3	83.5
92	Bogota	CC	Colombia	South America	81.6	68	76.4
93	Mumbai	C	India	Asia	35.2	45	32.3
94	Jakarta	C	Indonesia	Asia	57	73.7	61.8
95	Bengaluru	C	India	Asia	35.2	45	32.3
96	Makassar	C	Indonesia	Asia	57	73.7	61.8
97	Medan	C	Indonesia	Asia	57	73.7	61.8
98	Kiev	C	Ukraine	Europe	69.7	67.6	58.9
99	Athens	C	Greece	Europe	79.9	80.7	71.2
100	Sao Paulo	C	Brazil	South America	87.2	75	70.3
101	Rome	C	Italy	Europe	71.2	83.7	67.9
102	Rio de Janeiro	C	Brazil	South America	87.2	75	70.3
103	Cape Town	D	South Africa	Africa	67.6	64	41.9
104	Manila	D	Philippines	Asia	47.6	67	80.7
105	Rabat	D	Morocco	Africa	63.8	74.4	59.3
106	Cairo	D	Egypt	Africa	42.8	57.3	47.4
107	Abuja	D	Nigeria	Africa	16.7	13.6	2.4
108	Nairobi	D	Kenya	Africa	28.2	40	20.2
109	Lagos	D	Nigeria	Africa	16.7	13.6	2.4

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