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Smart Mobility in a Smart City in the Context of Generation Z Sustainability, Use of ICT, and Participation

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Abstract: Smart sustainable cities represent a great challenge for the modern world. Generation Z (Gen Z), whose representatives are now entering adult life, will play a key role in the implementation of this concept. The purpose of this study is to investigate the nature of the relationship between the evaluation of smart mobility's importance for a smart city and the attitudes and behaviours of Generation Z members in the context of sustainability, use of ICT, and their declarative and actual participation in smart city activities. The diagnostic survey method was used to achieve the research objective. The authors designed the questionnaire based on a literature analysis. The research sample consisted of 484 representatives of Generation Z—students of universities located in a smart city, Lublin (Poland). The collected data was statistically analysed using the following methods and statistical tests: Cronbach's alpha, Pearson's chi-square test for independence, symmetric measures: Cramer's V, and the contingency coefficient. The analysis of the obtained research results confirms that the conscious approach of Generation Z to sustainability has a significant and positive impact on their evaluation of actions taken in the field of smart mobility for a smart city. A similar relationship was confirmed with regard to the relationship between ICT use and smart mobility evaluation. The significant and positive impact of young people's participation in smart cities on their evaluation of smart mobility solutions' importance was not fully and unequivocally confirmed. In conclusion, the Generation Z representatives' awareness of the importance of sustainability and caring for the natural environment was confirmed by their desire to be pro-ecological in the areas of smart mobility studied in the paper. Moreover, young people who constantly use the latest technologies see their huge potential for the development of smart mobility in cities. However, despite the growing expectations of citizens' active attitudes and their increasing participation in smart mobility development, it seems that the representatives of Generation Z are not really interested in it. Their declarations of willingness to join various opinion-forming and decision making processes do not actually transform them into active co-creators of smart mobility solutions. Changing this approach can be an educational, organisational and technological challenge for smart city authorities. The obtained research results could be used as guidelines for facilitating the search for innovative solutions in the area of smart mobility, improving the quality of life of smart city residents based on the principle of sustainable development.

Keywords: sustainability; smart city; smart mobility; ICT; participation; Generation Z

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1. Introduction

One of the key challenges of the modern world is to balance the human impact on the environment. Sustainable development means using available natural resources in such a way as to satisfy the needs of the present without compromising the ability of

future generations to satisfy their own needs [1]. This theme seems particularly relevant in relation to cities, which, as recent demographic trends indicate, are the place of residence for more than half of humanity [2]. Rapidly advancing technology allows cities to introduce solutions that can ensure their development in a sustainable manner. Cities that use such solutions are called smart cities. Smart sustainable cities are developed based on several pillars to ensure their effective functioning in the economic, sociocultural and environmental spheres [3]. The key areas of activity include: smart economy, smart people, smart environment, smart governance, smart living and smart mobility [4]. The participation of local communities in these processes is the basis of their management in smart cities [5]. In the urban context, smart energy and mobility seem to be particularly relevant aspects of smart sustainability [6].

Generational changes are considered to be one of the key factors in the development of society and its different spheres of functioning: political, cultural, economic, but also environmental [7–9]. Generation Z, which is now entering adulthood and in some countries already accounts for more than 40% of consumers in the market, plays an important role in this context [10]. This generation is characterised by an extremely open attitude towards information and communication technologies (ICT), which have accompanied them since birth. They have constant access to information, thanks to which they are more aware of the changes taking place in the world around them [11–15]. Therefore, the issues related to the natural environment and the phenomena that occur in it are important to them [16–18]. That is because it is they who will experience them to the greatest extent in the years to come. These issues also seem to determine the behaviour of young people in the context of their mobility, motivating them to choose means of transport other than private cars [19]. Generation Z also places importance on social issues. This is because they are the most diverse generation in human history in terms of various demographic characteristics [11,20,21]. Their tolerance towards emerging differences is also reflected in their activity and participation in various social movements [10,12,20].

The two research areas briefly outlined above, sustainable smart cities and smart mobility, as well as Generation Z, formed the basis of the literature analysis conducted by the authors, the results of which are described in more detail in the next section of the paper. Based on the analysis of the main literature sources related to the mentioned areas, a research gap was identified. Despite the identified thematic convergence regarding technology, and the approach towards sustainability and participation, which appear both in the context of analyses of sustainable smart cities, including smart mobility, and in papers describing the specific characteristics of Generation Z, no research has yet been undertaken to identify relationships between these research areas. Therefore, the main research objective of the authors was to identify the relationship between the evaluation of smart mobility solutions' importance for a smart city, attitudes and behaviours of Generation Z in the context of sustainability, their use of ICT as well as declarations and actual participation in smart city activities.

Bridging the identified research gap made it possible to formulate the following research questions:

1. Does Generation Z's conscious approach towards sustainability influence their evaluation of smart mobility's importance for a smart city?
2. Does the extent to which Generation Z uses information and communication technologies (ICT) influence their evaluation of smart mobility's importance for a smart city?
3. Does the participation of Generation Z in smart city initiatives and activities influence their evaluation of smart mobility's importance for a smart city?

The research conducted and described in the article fills the research gap and provides conclusions for other researchers. The obtained research results confirm that there is a significant and positive influence of Generation Z's conscious approach to sustainability and their evaluation of the solutions introduced in the area of smart mobility for a smart city. A similar relationship was confirmed with regard to the relationship between ICT use

and smart mobility's importance evaluation. However, a significant and positive impact of young people's participation on their evaluation of smart mobility solutions' importance for a smart city was not fully and unambiguously confirmed.

2. Literature Review

2.1. Sustainability

The modern world has been facing many challenges, and overcoming them is necessary to ensure the wellbeing of present and future generations. Such an approach is called sustainable development. It is based on the sense of responsibility for the influence of man on the environment and the use of available resources in such a way as not to worsen the condition of our planet and the species that live on it.

There are two key dimensions of sustainability. Firstly, a temporal dimension that takes into account the consequences of currently made decisions for generations to come. This aspect was formalised in 1987 by the World Commission on the Environment and Development (WCED) Brundtland Report "Our Common Future" [22]. As Galanakis defines it, sustainability "reflects the principle that we must meet the needs of the present generation without compromising the ability of future generations to meet their own needs" [1] (p. xiii). The second dimension concerns the areas of interest, among which the most frequently mentioned aspects are the environment, social issues and economic returns [23,24].

In 2015, these three areas became the foundation for the UN 2030 Agenda for Sustainable Development strategy to achieve the Sustainable Development Goals (SDGs). The goals above cover 17 areas (169 targets altogether). For this paper, the goal that deserves special attention is Objective 11, which concerns creating Sustainable Cities and Communities, especially its Target 2—access to safe, affordable, accessible and sustainable transport systems [25].

According to UN research, most of the world's population has lived in cities and metropolitan areas since 2007, and by 2030 this indicator is to exceed 60% [26]. Hence, the critical importance of ensuring the sustainable development of cities means creating an integrated system supporting an ongoing process of permanent change, adaptation and learning to increase the citizens' quality of life without endangering the needs of future generations [27–29]. Among the most frequently mentioned challenges the authorities of sustainable cities face are human and social capital development, energy efficiency, efficient use of resources, transport and social and economic equity [30,31].

Nowadays, local authorities are increasingly interested in taking steps to ensure the sustainable development of their cities [32,33]. However, one of the critical success factors in such initiatives is the engagement of its citizens [34–36]. The management model of a sustainable city should be created through the cooperation of local governments, residents of the community and organisations of a support network [37]. Involvement in the strategic planning of sustainable development initiatives in the city allows its residents to gain new knowledge and awareness of the environmental, economic and social challenges their authorities face [38,39]. This might change their attitudes towards these challenges, becoming less resistant to various sustainability-friendly local initiatives and accepting greater environmental responsibility in their daily lives [40,41].

Sustainable urban mobility ensures city residents' access to goods and services but also satisfies the need for free movement, access to desired locations, communication, negotiations and maintaining relationships with others, all with respect for other values, for example, related to the environment, economic and social development [42]. However, cities have to face a number of challenges in the area of urban mobility, including the rapid and unplanned growth of urban centres, the increasing number of private cars and the lack of an adequately managed transportation system [43,44].

The activities aimed at ensuring the sustainability of urban mobility systems can be classified into three main areas. They include caring for the environment (reduction in CO_2 emissions, efficient use of energy and the use of renewable energy sources), improving the

existing transport systems and methods of their management (digitisation, adapting the connection network to the users' needs, technological innovations, improving traffic in the city) and influencing a change in the behaviour of residents (use of public transport, appropriate urban planning, participation of residents, encouraging the choice of transportation other than cars) [42,45–49].

2.2. The Smart City Concept

Two different approaches to analysing the smart city concept are the most common in the literature. One of them focuses on the importance of technology [50–53] and the other on the participation of local communities [5,54]. However, smart cities often seem far more focused on the technology used to solve urban problems than on citizens [55]. This is due to the increase in the use of technologies such as mobile devices, cloud computing and the Internet of Things [56]. Daneva and Lazarov reviewed 32 articles on smart cities in relation to ICT [57]. They proved that security and privacy issues were a key theme in many of the analysed publications. According to a report by the European Union Agency for Network and Information Security, smart cities should pay special attention to the manner of obtaining, processing and exchanging data securely, using modern ICT [58].

However, an analysis of the literature clearly indicates that the approach to smart cities is changing over time—from being focused on providing infrastructure and ICT to improving the quality of life and ensuring sustainable city development [56]. Information and communication technologies (ICT) should be seen as key tools for institutions and managers, used to support social and urban development and to provide citizens with better life conditions and improve their quality of life [59,60]. Oliveira et al. examined the impact of ICT and e-government on public decision making and highlighted that citizen participation in social decision making is a major factor in improving overall quality of life [61]. Thomas et al. conducted a systematic review of 30 papers related to citizens' participation in smart cities and stressed that the role of citizens is changing significantly, from consumers of information to producers and providers of information [55]. According to Zanella et al., smart cities improve citizens' quality of life through databases, advanced transport systems and smart buildings that connect people and enable the sharing of information [62].

The above considerations confirm that the smart city concept is multifaceted and can be analysed from many points of view [63]. According to Monzon, smart cities are systems where humans and social capital interact through technology-based solutions. Based on partnerships through local autonomy, smart cities aim for efficient, sustainable, and stable development and a high quality of life [64]. One of the often-cited definitions of a smart city was formulated by Caragliu et al. According to the authors: "A city can be defined as 'smart' when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory governance" [65] (p. 70).

Another definition highlights the social aspects even more clearly: "Smart cities of the future will need sustainable urban development policies where all residents, including the poor, can live well and the attraction of the towns and cities is preserved. [...] Smart cities should also be sustainable, converging economic, social, and environmental goals" [66] (p. 96).

Caragliu et al. identified key characteristics proper to a smart city:

1. "The «utilization of networked infrastructure to improve economic and political efficiency and enable social, cultural, and urban development»;
2. An «underlying emphasis on business-led urban development»;
3. A strong focus on the aim of achieving the social inclusion of various urban residents in public services;
4. A stress on the crucial role of high-tech and creative industries in long-run urban growth;
5. Profound attention to the role of social and relational capital in urban development;

6. Finally, social and environmental sustainability as a major strategic component of smart cities" [65] (pp. 67–69).

The above definitions and characteristics of smart cities are translated into metrics used to assess smart cities that range from the most technological ones to aspects related to citizen participation and engagement [63]. Most smart city indexes are based on six dimensions: smart economy (competitiveness), smart mobility (transport and ICT), smart environment (natural resources), smart people (social and human capital), smart living (quality of life), and smart governance (participation of societies in cities) [65,67].

As already mentioned, there has been an evolution of the understanding of the essence of the smart city. For many years, the concept focused on testing technical solutions to the advantage of large technology companies. This approach is now changing. The need for citizens' proactiveness has transformed local community members into the main actors of urban solutions [68]. This means that the citizen must not be a passive recipient and user of smart city solutions, but an active subject providing the authorities with the data necessary for decision making processes [69]. This change in the approach to the role of residents relates to the concept of the three generations of smart cities (Table 1) [70]. In the smart city 3.0 concept, the citizen becomes a full participant in decision making processes [71].

Table 1. The three generations of smart cities.

Smart City 1.0	Smart City 2.0	Smart City 3.0
The creators of technological advancements encourage cities to implement their solutions, with the aim of improving the efficiency of urban management. Technology is the key element of the smart city-1.0 concept. Technological innovations are often implemented in cities that are not fully prepared for this process.	Local authorities play the key role in the development of smart city 2.0. They focus on new technologies, to explore various options for improving the quality of life in cities. Cities introduce programs and projects that support the implementation of modern technologies in various areas of life. In a smart city 2.0, the significance of the quality of life and local governance is equated with that of modern technology.	This is the latest and the most advanced generation of smart cities. Citizens play the key role in urban development. Local residents consciously choose to participate in the process of building modern cities; they rely on modern social participation tools, and are creative. In the smart city 3.0, urban space is created for users and with their involvement.

Source: [70].

As city activities are designed for citizens, it is important to take their opinions and insights into account. Nowadays, however, city authorities do not have a deep enough understanding of their citizens to actively and effectively involve them in various processes [35,72]. Although people are currently considered a key actor in the planning and operation of managing smart cities, citizen participation has received significantly less attention than technological innovation, infrastructure development or other features of smart cities [5].

The analysis of reports published by the European Commission in 2017 and 2018 on citizen participation in various Horizon 2020 projects shows that projects aimed at developing smart cities currently use citizen participation to a very limited extent [73]. Smart cities should be more focused on the interrelationships of the actors involved and their contribution to mutual success [61]. Bielińska-Dusza et al. believe that cities of the future bring not only the use of new technologies, but, increasingly, the interfusion of technological and social aspects, while engaging the users of urban space [74].

Citizen participation can take many forms. On the basic level, a citizen may solicit a right to vote by participating in committees or formal procedures, or be the data provider mentioned earlier. However, this is a baseline level of engagement. The use of technology enables citizens to monitor solutions on an ongoing basis and, if required, intervene in public affairs [75]. The highest level of activity is participation through individual and

team contribution and engagement. The authorities should develop the smart city together with the citizens, designing it with their needs in mind. Such principles of cooperation are referred to as open participation platforms or co-creation spaces [73].

Citizen participation in the smart city can be described through three categories: citizens as democratic participants, citizens as co-creators and citizens as ICT users [5]. Cardullo and Kitchin developed the "Scaffold of Smart Citizen Participation"—a conceptual tool to unpack the diverse ways in which the smart city frames citizens. This model has been used to measure smart-citizen inclusion, participation, and empowerment in smart city initiatives in Dublin, Ireland [76]. The authors described four forms and corresponding levels as well as 16 roles of smart-citizen participation that shift from active and responsible to passive and lacking control:

1. Citizen power: citizen control (leader, member); delegated power (decision maker, maker); partnership (co-creator);
2. Tokenism: placation (proposer); consultation (participant, tester, player); information (recipient);
3. Consumerism: choice (resident, consumer);
4. Non-participation: therapy and manipulation (patient, learner, user, product, data point).

Smart cities should value the role of citizens as service users who can provide important input and feedback on public–private partnerships that have a direct impact on the quality of delivered services [77]. The more citizens are aware of public projects being launched, the more likely they are to engage in the various activities associated with them. Authorities managing a smart city should take as many measures as possible to work in partnership with smart citizens, provide them with a co-creator role and involve them in decision making and control processes [54,70]. Since the smart city concept is citizen-centric, a strategy to collect citizens' opinions and surveys about the degree of awareness of the smart city concept should be promoted. Here, social media should play a significant role as a tool for communication and interaction with citizens, especially young people. Such a strategy for raising awareness of the smart city concept can be very effective [78].

To summarise the above discussion, it is worth quoting Kamnuansilpa et al.:

> "The smart city purports to support "smart people" by encouraging participation, inclusiveness, and creativity. "Smart people" values include plural participation and open-mindedness. In the smart city, "smart people" are engaged in "smart governance," which involves strengthening connections, interactions, and governance partnerships among city government and stakeholders, including citizens and civil society" [79] (p. 499).

The definitions of smart city mentioned earlier and the presented literature indicate that citizen participation is one of the key dimensions of the smart city. In regards to the thematic scope of this paper, the second important dimension is smart mobility, as the smart city vision is closely related to both the concept of sustainability and smart mobility.

2.3. The smart mobility Concept

2.3.1. Essence and Dimensions of Smart Mobility

The importance of mobility and its impact on other smart city dimensions such as sustainability, economy and lifestyle make it a key issue for residents and local governments [80]. One of the main concerns when talking about smart cities is their mobility and the future of their transportation systems [81].

The concept of smart mobility is related to the term smart city and is analysed in the context of the use of ICT for sustainable transport technologies [63]. According to Giffinger et al., smart mobility elements include infrastructure and transport and can be measured by indicators such as the availability of ICT infrastructure; a sustainable, innovative and safe transport system; and local and international accessibility [67].

Some smart mobility solutions arise from the search for innovative and sustainable ways to provide mobility to city residents, such as the development of environmentally friendly fuels used for public transport, supported by advanced technology and proactive citizen behaviour [80].

When considering smart mobility, various issues that affect mobility in urban areas should be analysed, distinguishing the following domains [82]:

1. Technical-infrastructure indicators (roads and intersections, bicycle routes, car parks/parking spaces, infrastructure allowing travel beyond the city limits);
2. Information infrastructure (mobile devices and internet access, applications, information collection, traffic management systems, information systems for people travelling);
3. Mobility methods and vehicles used for this purpose (public transport, private carriers, travel by private car, travel by bike, travel on foot);
4. Legislation (assessment of various vehicle types, assessment of various forms of transport, other aspects).

An important issue in this discussion is to identify the difference between mobility and smart mobility. Unlike mobility, smart mobility allows public access to real-time information in order to shorten travel time and make journeys more efficient, saving money, as well as focusing on improving the quality of the transportation services, providing up-to-date information and, with regard to sustainability objectives, primarily reducing CO_2 emissions [83].

In the area of smart mobility, city authorities are undertaking various activities to develop a low-carbon economy. These include [84]:

1. Creating limited-emission zones in cities, for example, entry into the zone is only possible with a vehicle that meets the emission standards;
2. Transportation activities:
3. Initiatives promoting public transport, walking and cycling;
4. Promoting public cars or non-commercial car rental;
5. Arranging joint commuting;
6. Setting car bans or charging fees to enter various city zones;
7. Installing free car chargers for electric cars.

According to Pinna et al., in Europe, promoting the use of low-emission vehicles is already being performed by encouraging citizens to travel actively (cycling and walking), use public transport, carshare and carpool, which help to reduce congestion and pollution [85].

The business perspective of smart mobility perception points to three key areas: transportation safety and security; traffic and vehicle management; and sales, fees and charges [58]. Passengers receive the information they need (for example online routes, timetables, real-time traffic information), presented in public places (for example at bus stops or via on-board displays) or made available on demand (for example via a website or app). They can also use an e-ticketing service, and receive travel, ticket and payment details via an operator's website or a specific application [58].

Areas of interest and cooperation for various stakeholders in smart mobility should include issues such as smart streetlight control, smart parking, ticketing and real-time passenger information, IT security, and web development. In more mature smart cities, the focus is on centralised online services to provide passengers with detailed information on the availability of self-service cars and bicycles, bus schedules, and surveillance video recordings shared with security control centres managed by the police.

The smart mobility approach in cities emphasises the possibilities of real-time traffic management, parking management and bicycle use, the possibility to use electric vehicles, car-sharing services and the tracking of various activities via apps, as well as citizen decision making in terms of travel, including the right travel time and safety [86].

In conclusion, smart mobility refers to the availability and accessibility of services and information and communication technology as well as sustainable transport [87]. Smart services based on ICT and Internet of Things are therefore the key element [52].

Without smart services, it would not be possible to respond to citizens' needs and meet their expectations in terms of smart mobility [88].

2.3.2. The Use of ICT in Smart Mobility

Transport-related technology is becoming so commonplace that citizens are not even aware of its presence and daily use. However, conscious use of ICT by citizens in different areas of smart mobility is becoming a key aspect [89].

One of the most common needs is to be able to choose between different routes to reach a destination, taking into account data collected in real time. For this purpose, various applications provide information about possible routes. Suggesting different modes of transport to the user, they predict reaching the destination at the desired time, taking into account traffic information [90].

In urban areas, access to parking spaces is a major problem for citizens. The difficulty of parking a car and the need to drive around a planned parking area to find a vacant space leads to, among other things, increased environmental pollution through higher fuel consumption and higher CO_2 emissions. A reservation system for on-street parking can play a significant role in minimising this problem [91]. Smart parking is considered an important element of a sustainable transport system in smart cities. An example of the potential use of ICT in smart parking was developed by Ji et al., an IoT cloud-based intelligent car-parking system [92]. It consists of three layers: sensor, communication and application. Such a system provides the driver with information about the best available parking with free spaces. This information is transmitted to the user's mobile app.

Alternative transport systems such as e-scooters [93] and e-bikes [94] are currently becoming increasingly popular as they provide significant advantages including hassle-free parking and their efficiency in getting around the city. These benefits of e-transport in smart cities foster the development of dedicated logistics platforms. One of the first such platforms in Europe, entirely dedicated to e-vans and e-bikes, has been created in Milan. Studies indicate tangible social and environmental effects in terms of reduced CO_2 emissions and energy savings in city logistics resulting from the introduction of e-vans and e-bikes [94]. Bike sharing has become a popular transport system in urban centres [95]. Real-time solutions for managing bike-sharing systems appear in many smart city projects. They use different technologies to find free stations, such as: the use of soft sensors, the use of apps, as well as the use of drones [90]. The use of all these solutions requires specific digital competences, which people from older generations have to acquire and which people from Generation Z have naturally gained by growing up in a digital world. This is a manifestation of the digital gap between people representing different generations [96].

2.4. Generation Z

2.4.1. Idea of Generational Stratification

One of the key features of human societies is that people of a certain generation function in the same physical and temporal space and experience various economic, social, political and technological phenomena. These experiences can be different for different generations and, at the same time, similar for people of the same generation. This assumption underlies the concept of "generation", understood as "an identifiable group that shares birth years, age, location and significant life events at critical developmental stages" [97] (p. 79). Therefore, there is a certain social "proximity" resulting from the sharing of specific social and cultural events and phenomena within the community of people of a given generation, which at the same time constitutes its distinctiveness in relation to other generations (generation gap), called the cohort effect [12,13,97].

There are also differences in how certain phenomena proceed, even though they are global in nature; the intensity and scope of their impact on a given community and their cultural perception in different parts of the world [12]. For this reason, although some shared features appear in each generation, their local differentiation may also occur. In general, it is assumed that there are currently five generations of adults living in the

world: Veterans (born between 1925 and1946), Baby Boomers (1943–1964), Generation X (1961–1981), Generation Y (1978–2000) and Generation Z (1995–2010) [18,97–101]. This paper focuses primarily on Generation Z.

The idea of generational stratification seems to a be a valuable concept that enables creating a general characteristic of a cohort of people born in a similar period of time. However, it is important to state that, as with every generalisation, it also creates a very simplified model of reality that does not address the heterogeneity of Gen Z members. The characteristics of young people in the Anglo-Saxon countries has been widely adopted as describing Generation Z in general and to some extent they actually seem to be prevalent worldwide. However, it is important to stress that there might also be significant differences between characteristics and behaviours of Gen Z members growing up in different economic, political, religious or cultural contexts [102,103].

2.4.2. Background of Generation Z

Young people representing Generation Z (or Gen Z) face a highly dynamic, demanding and turbulent environment. The key challenges posed by such an environment result from technological, social, political and cultural factors.

Technological progress and its ever-increasing pace are factors shaping the present times, as emerging new solutions change people's everyday lives. Gen Z representatives are surrounded by various digital technology solutions and the internet from birth. The importance of using ICT in everyday life, its dynamic changes and constant learning are entirely natural for them. That is why this generation are often called "digital natives" as opposed to older generations ("digital immigrants"), who had to get used to and learn to work and live in the digital world [104,105].

Advances in ICT are particularly prominent in developing and using the internet. It is an almost infinite source of information and an effective communication tool because it removes geographical, temporal, social and cultural barriers and obstacles, allowing access to sources never available before [11,20,106,107].

Nowadays, the paradigm that is becoming quite ubiquitous is the so-called Internet of Things (IoT), which usually is the basis for creating so-called smart solutions. In this system, the world is perceived in the context of the network of "billions of smart, interacting things capable of offering all sorts of services to near and remote entities" [108]. The latest trends in this area concern concepts such as virtual/augmented reality (VR/AR), high-resolution video streaming (HD/UHD), self-driven cars (autonomous vehicles), the smart environment and e-health care [109–114]. IoT is often applied in automation, smart supply chains and transportation, remote monitoring and logistics [115]. The applications of IoT-based solutions are visible in many different areas of social life, such as healthcare, monitoring systems, smart environment (smart home/office, smart retail, smart city, smart agriculture/forest, smart water, smart transportation), smart grid (electricity networks that integrate information and communication technology (ICT) into the grid), surveillance, water network monitoring, smart transportation and logistics [116].

Another critical technological development is the advancement of available hardware enabling the use of the internet. From desktop personal computers (PCs) and portable laptops to mobile tablets and smartphones, the evolution of these devices has been moving towards the availability of constant access to the internet. Thanks to one device, it has become possible to "communicate freely, to be net-worked, to be informed, to be entertained, to be mobile" [117]. As a result, the number of mobile devices providing access to the internet is growing dynamically every year. As the Ericsson 2021 report indicates, currently, around 6260 million users have smartphone subscriptions, and, by contrast, around 300 million people have mobile PC, tablet and mobile router subscriptions [118]. In the year ending June 2021, smartphones accounted for the majority of the mobile device market (70.8%). The remaining mobile devices were less popular—smart tablet with 9.8% and smart wearable/other, 7.3% [119]. This trend is also visible in the amount of time people spend online [120]. According to Kim, Viswanathan and Lee, there is an upward trend

for mobile devices and a declining trend for PCs [121]. The turning point took place in October 2016, when the number of users accessing the internet from mobile devices started to dominate.

Smartphones are quite universal in their functions: communication, media, entertainment, etc. The number of their uses seems to increase constantly following the advancements of technological progress. That is why smartphones are the main devices of choice for young people. Hence, some authors use the term "mobile generation" when referring to the representatives of Gen Z [14]. The political and economic environment was also a significant source of challenges in the Gen Z representatives' growing-up processes. For example, 2001 brought the Al-Quaeda attack on the US (9/11), a series of terrorist attacks in other countries, and US and NATO combat missions in Afghanistan that lasted till 2014 (with full withdrawal of troops in 2021). Between 2014 and 2019, terrorist attacks tripled in North America, Western Europe and Oceania [122]. In addition, 2022 brought the war in Europe—in Ukraine.

The economic sphere of social life also posed many challenges during Gen Zs' adolescence. For example, the great recession of 2008 has led to a persistent worldwide economic stagnation and demographic crises. To make things worse, the 2020 SARS-CoV-2 virus pandemic followed, creating psychological discomfort related to both health and economic safety [123]. Although the strategies to deal with the spread of the disease differed across various countries, the resulting economic and social crises caused by various lockdown regulations followed.

Another factor that had an extremely significant impact on the attitudes of Generation Z was the increased intensity of social movements. Supported by the use of the internet and social media, which enable relatively easy diffusion of information, various types of organisations and social movements and communities of individuals have gained the power to influence authorities to ensure fair treatment of all groups of citizens [124,125].

Globally, the main areas of concern in recent years have been the environment (environmental justice, sustainability, climate change), diversity and inclusion (race, gender, social class, religion, disabilities), economic liberalism and the inequalities it causes, as well as international migration [106,126,127]. Climate change, pollution and other related issues have become pervasive in media and popular culture [105]. Young people nowadays are exposed to knowledge and discussions concerning the environmental, social and economic problems in almost every aspect of their everyday lives [20,128].

2.4.3. Generation Z Characteristics

Generation Z representatives function among very diverse populations [11]. This environmental feature made them very tolerant of otherness, spontaneous, curious about the world and open to new challenges and adventures [12,20].

As digital natives, Gen Z is technologically savvy [10,11,129,130]. They can use available technologies effectively and are open to new developments [130,131]. They are early adopters of various new technology-based solutions and gadgets, and using them is an integral part of their lives [17,132]. ICT is also an important factor influencing other areas of their lives, such as patterns of thinking and communicating, the need for control and personal and social values [105]. However, they are also internet and social media dependent, and it might be difficult for them to find information outside of online sources [133,134].

Gen Z spends a lot of time in front of computers or mobile devices, usually on the internet. Multitasking, understood in this context as skipping from task to task, is a norm for them, so they use it for a whole range of activities: communication, information retrieval and research, verifying fake news and checking reviews [15,99,132]. They use the internet for their entertainment and spend free time playing games, watching videos, streaming, following or sharing their interests, and for various social activities such as becoming involved in formatting public opinions and civic participation, mobilising civic protests and boycotts. The internet is a good tool for coordinating their activities, meeting new people, finding romantic partners and solving everyday problems [13,15,99,132].

Gen Z members are aware of various environmental, social and economic challenges emerging in the modern world and feel co-responsible for solving them [13]. They are honest, altruistic and socially responsible [10]. They want to make the world a better place and are willing to put effort into achieving it [106,107]. Hence, they engage in various social initiatives, and their activities often go beyond the existing systems and structures. In addition to significant benefits for solving a specific social issue, they are also motivated to act by the opportunity to gain new knowledge and experience skills that may prove useful in their future work [135]. Their social activities often concern the issue of climate change. For example, Greta Thunberg initiated a series of climate strikes at schools or a group of young activists in the US who brought legal charges against government bodies [16,136].

Environmental causes are important to Gen Z because they see the effects of the climate changes with their own eyes, as images of floods, hurricanes and forest fires appear more and more often in the media. However, they are also ready to take part in the responsibility for the planet's condition themselves because they believe in intergenerational justice. They want to provide future generations with the earth in a state at least no worse than it is now [135,137,138].

2.4.4. Generation Z Behaviours

The above-described features of Gen Z members translate into their behaviours in various spheres of life. First, they are pragmatic, so they approach their future in a planned manner. They are good at obtaining information, so they explore all the available options beforehand and are aware of the consequences of their decisions. Finally, they are responsible and committed to matters that they believe are relevant [107].

Gen Z representatives include sustainability as one of the factors influencing their purchasing decisions. The most important environmental issues for them concern climate change (global warming), renewable energy (reducing oil dependency), stopping pollution (reducing emissions, eliminating pesticides), recycling and reducing waste, protecting wildlife and optimising the use of resources [12,139].

Generation Z is sometimes referred to as the "Green Generation" because they have a high environmental awareness and try to consider the good of the environment in their consumption. For example, they have a positive attitude to electric cars; they try to buy local and seasonal food products and choose those producers who implement CSR strategies [17,107,140]. Although, sometimes, they have difficulties with some areas because they lack appropriate knowledge and experience [141]. This is the case, for example, in terms of reducing food waste habits and waste reduction [17,142].

3. Materials and Methods

3.1. Study Area—Lublin as a Smart City with Smart Mobility

Lublin is a city located in south-east Poland. It is the capital of the Lublin Voivodeship and Poviat, as well as the central hub of the Lublin Agglomeration. In terms of population, estimated at over 330,000 people, it ranks 9th in the country. The Lublin Metropolitan Area is the main multifunctional centre of the region, where economic, scientific and cultural functions are concentrated.

Lublin is also an important centre in the Polish higher education system. It is among the top academic centres in Poland in terms of its educational potential and is the largest one in the eastern part of the country. There are almost 65,000 students in 5 public and 4 non-public higher education institutions, which accounts for approximately 19% of the city's population [143]. Students are therefore a significant group of recipients of the city authorities' activities aimed at improving the quality of life of its citizens and of people staying in Lublin during their studies. In the context of a very large number of students being the beneficiaries of smart city solutions implemented in Lublin, the activities of the authorities, which have resulted in many successes in this respect, seem to be particularly important and worth analysing.

One notable achievement was the recognition of Lublin in 2019 for sustainable development. The city received the Smart City certificate issued by the Polish Committee for Standardisation for compliance with the standard PN-ISO 37120—Sustainable development in communities—Indicators of urban services and quality of life [144]. In Lublin, solutions for each dimension of the smart city are consistently implemented. The pace of their development is related to the investment priorities of the city and the needs of the inhabitants, which are important to the city authorities. One of the most developed dimensions is urban mobility, which receives the largest share of the city budget. The residents have at their disposal one of the most modern transport fleets in Poland, characterised by low emissions and equipped to meet the needs of passengers, taking care of both their comfort and safety.

In Lublin, there is an extensive city-wide communication network. In recent years, Lublin's authorities have carried out a comprehensive reconstruction of the public transport system. New trolleybus routes, depots, junctions and streets have been created, and a Public Transport Management System has been introduced to enable real-time monitoring of the position of a given vehicle on a digital map of the city, providing information on possible delays or accelerations of a particular line. In October 2021, the Agglomeration Transport Electronic Ticketing System—Lubika—was implemented. It is a comprehensive solution with a wide range of complementary infrastructural solutions, including stationary ticket machines, EMV cash dispensers with contactless payment, mobile ticket machines, recharge terminals, controller readers, an in-house mobile application and a passenger portal including a web shop where tickets can be purchased without recharging [145]. For the purposes of mobility, residents have the possibility to use the Internet free of charge via the Wi-Fi network of hotspots, available in many places in the city. Lublin's residents have also access to 5G mobile network.

Another important achievement of the city authorities is that since 2020 Lublin has been a member of the European Institute of Innovation and Technology (EIT), a partner organisation of the EIT Urban Mobility. As a result of this cooperation, international urban mobility projects have been implemented. Solutions from other cities, which are an inspiration for the future, concern the integration of different modes of transport. These include, for example, creating an optimal transport mix by increasing the importance of public transport, cycling and other alternative means of transport such as autonomous cars or electric scooters. The city authorities emphasise that mobility is one of the foundations of contemporary and future Lublin [146].

The measures taken by the municipality and aimed at mobility are very effective, which is reflected in the results of various lists and rankings. One of them is the report on the state of Polish metropolises prepared by PwC in 2019 [147]. A comparative analysis of 12 Polish cities and metropolitan areas has pointed to many strengths of Lublin:

1. Lublin's bus network is equipped with photovoltaic panels, and every third public transport vehicle is an ecological trolleybus.
2. An extensive, high-quality bicycle infrastructure—Lublin City Bicycle—is one of the most developed bicycle systems in Poland.
3. The city is working towards sustainable development and green transport, investing in a zero-emission public transport fleet, an electric scooter system (blinkee), car sharing (PANEK) and big car sharing (CityBee).
4. Unique in the country is the Green Civic Budget, which focuses on nature conservation and the development of urban greenery, making it possible to implement initiatives submitted by residents concerning green space management.
5. Strong social commitment is expressed by participation in local and presidential elections, as well as elections to the European Parliament. Both the turnout in the last presidential (61.35%) and local government (41.03%) elections were among the highest in the 12 metropolises analysed.

In addition to many important advantages of the city of Lublin, it should be emphasised that in the electromobility development strategy the authorities have set very ambitious targets, including a twenty-fold increase in the number of charging stations and

the number of registered electric cars by 2022 [148]. Undoubtedly, an element distinguishing Lublin from other cities is the constantly developed trolleybus network, which can be found in only two other locations in Poland.

At the same time, it is worth noting that the role of citizens of Lublin in the modernisation of the city is indisputable. The city's authorities are also positively inclined towards the Smart City 3.0 concept. Examples of activities indicating such attitude include the Citizen's Budget, which has been in operation for several years, and the creation of a City Hall website for residents called the Participatory Portal [149]. An important confirmation of the strategy of involving citizens in the implementation of smart city in Lublin is the development of the Sustainable Urban Mobility Plan (SUMP) in the first quarter of 2022. It is a comprehensive document, covering all communication and mobility issues and setting directions for their further development [150]. During the preparation of the SUMP, public consultations were held with the inhabitants of the Lublin Metropolitan Area regarding aspects such as public and car transport, pedestrian and cycling traffic, mobility and space management, environmental protection, mobility management, education and promotion of sustainable mobility, safety, environmental and climate protection.

The examples described above, presenting Lublin as a smart city and confirming the inhabitants' engagement in improving the quality of life, seem to be a good starting point for conducting empirical studies among students of Lublin universities, who are an important group of beneficiaries of the smart mobility solutions implemented in the city.

3.2. Objective, Hypotheses and Research Methods

The main research objective was to identify the relationship between the evaluation of smart mobility solutions' importance for a smart city and attitudes and behaviours of Generation Z in the context of sustainability, the extent of ICT use by this generation and declarations and actual activities in terms of participation in smart city activities.

The research objective indicated the necessity of including specific thematic areas in the study, which in turn were described by means of items and indicators (variables) dedicated to them. The evaluation of smart mobility (SM) solutions' importance for a smart city was described by four indicators, sustainability (S) by two, ICT use (I) by three, as was participation (P).

To achieve the research goal, the authors formulated three research hypotheses. They are presented in a descriptive and graphic form (Figure 1) below. These were stated as follows:

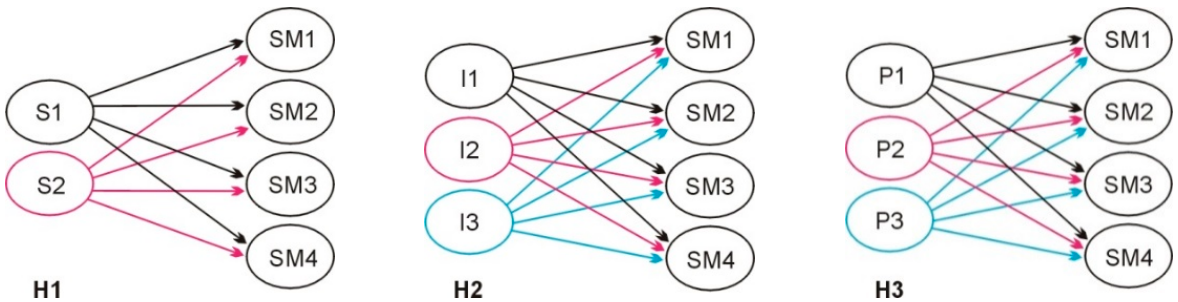

Figure 1. Graphic presentation of the hypotheses. Source: own elaboration.

Hypothesis 1. *The conscious approach of the representatives of Generation Z towards sustainability has an important and positive impact on their evaluation of smart mobility's importance for a smart city.*

Hypothesis 2. *The extent to which the representatives of Generation Z use ICT has a significant and positive impact on their evaluation of the importance of actions taken in the field of smart mobility for a smart city.*

Hypothesis 3. *The participation of the representatives of Generation Z in initiatives and activities in smart city has a significant and positive impact on their evaluation of the importance of activities undertaken in the field of smart mobility for a smart city.*

The diagnostic survey method and statistical data processing were applied to achieve the research objective. The authors developed a questionnaire consisting of 12 questions regarding the indicators chosen for analysis. The first two (S1 and S2—item Sustainability) aimed to identify Generation Z's attitudes and behaviours in the context of sustainability. The following three (I1, I2, I3—item ICT) referred to the frequency of using a smartphone for different purposes connected with mobility. In the following three questions of the questionnaire (P1, P2, P3—item Participation), the opinions of Generation Z members on their participation in proposing solutions and decision making concerning smart cities were investigated. The fourth part of the questionnaire covered indicators related to smart mobility (SM1, SM2, SM3, SM4—item Smart Mobility). A detailed description of items and all indicators is presented in Appendix A.

The last section of the questionnaire, with detailed information about respondents, contained questions referring to their gender, level and field of study, registration of residence, time spent every day using the various functions of the smartphone, voting in the last local or national election, and declaration of voting in the following local or national elections.

The authors designed the questionnaire based on the literature analysis mentioned above. A comprehensive list of literature sources is presented in Table 2.

Table 2. Literature sources for items.

Items	Sources
Sustainability	[151–156]
ICT	[130,157,158]
Participation	[54,55,61,70,76,158,159]
Smart Mobility	[74,81,82,152,153,157,158,160–165]

Source: own elaboration.

The survey questionnaire adopted a 5-point Likert scale, used to measure attitudes in the social sciences [166], based on ranking variables from 1 (definitely disagree or definitely unimportant) to 5 (definitely agree or definitely important) to items: S, P, SM, and a 6-point scale for the quasi-quantitative item ICT from 0 (never) to 5 (almost constantly).

The analysis of the reliability of the scale performed on the basis of Cronbach's alpha values allows to consider all sets of responses S, I, P, SM as consistent. The highest level of reliability, classified as very high, was determined for SM (0.881) and the lowest for P (0.724), classified as high. The S and I sets also have very high levels of reliability (0.830 and 0.871, respectively).

Dependency analysis was performed using Pearson's chi-square independence test. To determine the strength of the relationship, the following were used: symmetric measures: Cramer's V, and contingency coefficient. The normalisation of the data, giving them a quantitative character, made it possible to apply the Pearson correlation coefficient and then to examine the directionality of the analysed relationships based on the results of simple and multiple linear regression. The use of mixed analytical methods in the study, indicated as the most effective in social research [167], produced consistent and comprehensive results rejecting uncertain results.

The statistical analysis was performed using the IBM SPSS Statistics Ver. 27.

3.3. Demographic Profile of the Respondents

The questionnaire was tested by a pilot study. All identified problems were eliminated and the revised research tool was addressed to representatives of Generation Z, that is, students attending higher education institutions located in Lublin. The number of

respondents was 484 and met the minimum sample size criterion for a general population of 65,000 students, with an assumed error of 5%. The respondents represented various fields of study: management (26.4%), economics (28.9%), and computer science (26.7%), all of which were closely related to smart city management, and others not closely related to the topics covered (pedagogy, psychology, mechatronics, manufacturing engineering, biomedical engineering, construction, mathematics and medicine—18.0%). A total of 100% of them were full-time students.

It is important to note that the respondents included not only residents of Lublin, but also people commuting to and moving around the city by different means of transport. All respondents were over 18 years old, so according to the electoral law in Poland they were entitled to vote in local and national elections. A detailed description of the research sample is presented in Table 3.

Table 3. Sample structure.

Group	Number of Respondents	Percentage
Total		
-	484	100.0
Gender		
Women	253	52.3
Men	231	47.7
Level of study		
First degree studies (BA)	273	56.4
Second degree studies (MA)	202	41.7
5-year Masters course	9	1.9
Registration of residence (number of inhabitants)		
Lublin	122	25.2
Rural area	194	40.1
Urban area, up to 15,000	55	11.4
Urban area, up to 150,000	95	19.6
Urban area, up to 300,000	16	3.3
Urban area, over 300,000 (other than Lublin)	2	0.4
Amount of time spent using the smartphone each day		
I don't use a smartphone every day	6	1.2
Less than 2 h	51	10.5
More than 2 but less than 4 h	158	32.6
More than 4 but less than 6 h	150	31.1
More than 6 but less than 8 h	74	15.3
8 h and more	45	9.3
Voting in the previous elections		
Yes	346	71.5
No	98	20.2
I don't remember	40	8.3
Declared willingness to vote in the next elections		
Yes	362	74.8
No	34	7.0
I don't know	88	18.2

Source: own elaboration.

The survey was conducted in March and April 2022 using the computer-assisted web-interviewing (CAWI) method, which is one of the methods in quantitative research in social sciences [168].

4. Results

The analysis of the obtained research results demonstrates the presence of a statistically significant relationship for most of the items adopted and the indicators describing them. It can be seen that, in terms of the impact on Smart Mobility, Sustainability has the highest score and Participation has the lowest (based on symmetric measures and Pearson correlation coefficients). The following Results section will describe the detailed results obtained in the study. Only statistically significant relationships (with the exception of Pearson Correlation in the Participation area) are included.

4.1. Sustainability

The analysis of the research results shows that, at the level of single variables, it is possible to indicate the presence of Sustainability effects on Smart Mobility. The chi-square test returns values indicating statistically significant relationships between all pairs of variables S1, S2 and SM1, SM2, SM3, SM4 (Table 4). It should be noted that the strongest relationship was observed for S1 and SM1 (0.275) and the weakest for S2 and SM3 (0.107).

Table 4. Sustainability vs. Smart Mobility—chi-square tests results.

Variable	Chi-Square Tests			Symmetric Measures	
	Value	df	*p* *	Cramer's V	Contingency Coefficient
S1 × SM1	395.817	20	<0.001	0.143	0.275
S2 × SM1	214.582	20	<0.001	0.096	0.189
S1 × SM2	272.826	20	<0.001	0.063	0.126
S2 × SM2	308.182	20	<0.001	0.062	0.122
S1 × SM3	530.464	20	<0.001	0.083	0.163
S2 × SM3	269.517	20	<0.001	0.054	0.107
S1 × SM4	545.908	20	<0.001	0.090	0.177
S2 × SM4	372.865	20	<0.001	0.068	0.134

* Asymptotic significance (two-sided). The effect is significant for $p < 0.05$.

The correlations indicated by the chi-square test are confirmed by the values of Pearson correlation coefficient (Table 5). The existing relationships, all of which are statistically significant, indicate an unclear and moderate strength of the relationship.

Table 5. Sustainability vs. Smart Mobility—Pearson correlation results.

Variable Coefficient (*p*)	SM1	SM2	SM3	SM4
S1	0.339 ** (0.000)	0.274 ** (0.000)	0.297 ** (0.000)	0.294 ** (0.000)
S2	0.278 ** (0.000)	0.218 ** (0.000)	0.205 ** (0.000)	0.261 ** (0.000)

** Correlation is significant at the 0.01 level (2-tailed).

The influence of S1 and S2 on Smart Mobility is confirmed by the results of linear regression (Table 6). Besides the singular impact on Smart Mobility of the indicators included in the Sustainability item, the results show that there is a joint impact of S1 and S2 on SM1 and SM4, respectively. The multiple regression results did not confirm the existence of a joint impact of S1 and S2 on SM2 and SM3. The fact that there is a joint impact of the indicators included in the Sustainability Item on the single indicators SM1–SM4 should be regarded as an extension of the acceptable aggregation of data giving rise to the construction of a fully aggregated causal model. These results should be treated as a confirmation of the correctness of the selection of explanatory variables with respect to the explained variable and the strengthening of the overall assessment of the S → SM impact.

Table 6. Sustainability vs. Smart Mobility—linear regression results.

Variable	Unstandardised Coefficients	Test t		ANOVA	
		t	*p* *	F	*p* *
S1 → SM1	0.319	7.922	<0.001	62.766	<0.001
S2 → SM1	0.297	6.362	<0.001	40.479	<0.001
S1 → SM2	0.171	6.265	<0.001	39.256	<0.001
S2 → SM2	0.155	4.910	<0.001	24.110	<0.001
S1 → SM3	0.198	6.827	<0.001	46.611	<0.001
S2 → SM3	0.156	4.607	<0.001	21.223	<0.001
S1 → SM4	0.250	6.753	<0.001	45.599	<0.001
S2 → SM4	0.253	5.932	<0.001	35.190	<0.001
S1, S2 → SM1	0.251 0.145	5.295 2.686	<0.001 0.007	35.395	<0.001
S1, S2 → SM4	0.184 0.141	4.227 2.833	<0.001 0.005	27.145	<0.001

* Acceptable level: $p < 0.05$. Only statistically significant relations are shown in the Table.

The results obtained in the relationship and regression analysis indicate that all Sustainability variables have a statistically significant impact on all Smart Mobility variables. Overall, attitudes towards sustainability (S1) have a stronger influence on Smart Mobility compared to behaviours in the context of sustainability (S2). As for the impact on single variables referring to smart mobility, (S1) has the strongest impact on ecological solutions in public transport (SM1) (0.319). Next in order were, respectively: road traffic (SM4) (0.250), alternatives to public means of transport and city's adaptation to their needs (SM3) (0.198), and amenities for passengers and residents (SM2) (0.198). Behaviours in the context of sustainability (S2) have a slightly smaller impact on the single indicators of Smart Mobility, and the order of the strength of impact coincides with the order of the impact of S1 on SM.

The analysis of the obtained research results confirms that the conscious approach of Generation Z to sustainability has a significant and positive impact on their evaluation of importance of actions taken in the field of smart mobility for a smart city. The first Hypothesis (H1) can, therefore, be confirmed.

4.2. ICT

Similarly to Sustainability, in the ICT item, all indicators show a statistically significant relationship with Smart Mobility (Table 7). However, it should be noted that these relationships are vague and moderate.

Table 7. ICT vs. Smart Mobility—Pearson correlation results.

Variable Coefficient (*p*)	SM1	SM2	SM3	SM4
I1	0.208 ** (0.000)	0.243 ** (0.000)	0.218 ** (0.000)	0.182 ** (0.000)
I2	0.195 ** (0.000)	0.186 ** (0.000)	0.165 ** (0.000)	0.246 ** (0.000)
I3	0.229 ** (0.000)	0.215 ** (0.000)	0.313 ** (0.000)	0.232 ** (0.000)

** Correlation is significant at the 0.01 level (two-tailed).

This relationship is confirmed by the linear regression analysis, the results of which demonstrate that all indicators of the ICT item have a statistically significant impact on all the single indicators of Smart Mobility (Table 8). In addition to the single relationship of single ICT variables with Smart Mobility, the results show that there is a joint impact of independent variables in eight cases. A joint causal effect of the three indicators I1, I2, I3 did not occur. There were also no joint effect relationships for SM3. The joint I → SM relationships,

as in Sustainability, indicate the validity of the selection of explanatory variables in relation to the explanatory variable in terms of the identified single statistical relationships.

Table 8. Sustainability vs. Smart Mobility—linear regression results.

Variable	Unstandardized Coefficients	Test t		ANOVA	
		t	p *	F	p *
I1 → SM1	0.227	4.658	<0.001	21.697	<0.001
I2 → SM1	0.157	4.360	<0.001	19.008	<0.001
I3 → SM1	0.181	5.155	<0.001	26.575	<0.001
I1 → SM2	0.176	5.503	<0.001	17.210	<0.001
I2 → SM2	0.100	4.149	<0.001	19.008	<0.001
I3 → SM2	0.113	4.827	<0.001	23.298	<0.001
I1 → SM3	0.169	4.909	<0.001	24.101	<0.001
I2 → SM3	0.095	3.664	<0.001	13.427	<0.001
I3 → SM3	0.176	7.242	<0.001	52.443	<0.001
I1 → SM4	0.180	4.069	<0.001	31.295	<0.001
I2 → SM4	0.180	5.571	<0.001	31.033	<0.001
I3 → SM4	0.166	5.237	<0.001	27.431	<0.001
I1, I3 → SM1	0.140	2.566	0.011	16.733	<0.001
	0.133	3.362	<0.001		
I1, I2 → SM1	0.168	3.192	0.002	14.779	<0.001
	0.107	2.751	0.006		
I2, I3 → SM1	0.088	2.132	0.033	15.659	<0.001
	0.139	3.447	0.006		
I1, I3 → SM2	0.132	3.663	<0.001	18.659	<0.001
	0.068	2.584	0.010		
I1, I2 → SM2	0.146	4.184	<0.001	17.651	<0.001
	0.056	2.186	0.029		
I2, I3 → SM2	0.056	2.066	0.039	13.863	<0.001
	0.085	3.192	0.002		
I2, I3 → SM4	0.127	3.448	<0.001	19.971	<0.001
	0.105	2.904	0.004		
I1, I2 → SM4	0.099	2.073	0.039	17.770	<0.001
	0.151	4.288	<0.001		

* Acceptable level: $p < 0.05$. Only statistically significant relations are shown in the Table.

The results obtained in the relationship and regression analysis demonstrate that all ICT indicators have a statistically significant impact on all the Smart Mobility indicators. In this case, its force is slightly lower than in the case of Sustainability. The strongest influence on Smart Mobility is observed in the frequency of using a smartphone for smart mobility purposes (I1), followed, respectively, by the frequency of using a smartphone for other purposes (entertainment, education, shopping, etc.) (I3) and the frequency of using a smartphone for real-time information (I2). The order of the impact of ICT on the single indicators of Smart Mobility coincides with the order of impact of Sustainability.

The analysis of the obtained research results allows to confirm that the extent of the ICT use by the representatives of Generation Z has a significant and positive impact on their evaluation of the importance of actions taken in the field of smart mobility for a smart city. The second Hypothesis (H2) can, therefore, be confirmed.

4.3. Participation

Participation is another area whose relationship to smart mobility was the basis for the formulation of the research hypothesis. The fact that there are statistically significant relationships between Participation and Smart Mobility is confirmed by the chi-square test (Table 9).

Table 9. Participation vs. Smart Mobility—chi-square tests results.

Variable	Chi-Square Tests			Symmetric Measures	
	Value	df	*p* *	Cramer's V	Contingency Coefficient
P1 × SM1	177.119	20	<0.001	0.151	0.290
P2 × SM1	123.944	20	<0.001	0.127	0.245
P3 × SM1	63.641	20	<0.001	0.091	0.178
P1 × SM2	504.519	20	<0.001	0.136	0.263
P2 × SM2	420.095	20	<0.001	0.124	0.242
P3 × SM2	128.133	20	<0.001	0.069	0.136
P1 × SM3	329.066	20	<0.001	0.103	0.202
P2 × SM3	284.373	20	<0.001	0.096	0.188
P3 × SM3	107.247	20	<0.001	0.059	0.117
P1 × SM4	171.062	20	<0.001	0.086	0.169
P2 × SM4	146.845	20	<0.001	0.080	0.157
P3 × SM4	102.431	20	<0.001	0.066	0.132

* Asymptotic Significance (2-sided). The effect is significant for $p < 0.05$.

However, the correlation analysis did not confirm all of the chi-square test results (Table 10). Pearson correlation coefficients indicate that Participation is the characteristic least related to Smart Mobility. For characteristic P3, the relationship with SM2 and SM3 was not confirmed, and for the other two indicators (P1 and P2), the relationship is very unclear.

Table 10. Participation vs. Smart Mobility—Pearson correlation results.

Variable Coefficient (*p*)	SM1	SM2	SM3	SM4
P1	0.310 ** (0.000)	0.427 ** (0.000)	0.312 ** (0.000)	0.261 ** (0.000)
P2	0.198 ** (0.000)	0.342 ** (0.000)	0.249 ** (0.000)	0.175 ** (0.000)
P3	0.094 * (0.039)	0.057 (0.211)	0.086 (0.060)	0.123 ** (0.007)

** Correlation is significant at the 0.01 level (two-tailed). * Correlation is significant at the 0.05 level (two-tailed).

The lack of real impact of P3 on Smart Mobility is also confirmed by the linear regression results (Table 11). Furthermore, the acceptability of the two models of SM1(P3) and SM4(P3) should be associated with the very low impact of P3 on Smart Mobility. In the case of Participation, there were no joint relationships including at least two variables.

Table 11. Participation vs. Smart Mobility—linear regression results.

Variable	Unstandardised Coefficients	Test t		ANOVA	
		t	*p* *	F	*p* *
P1 → SM1	0.302	70.154	<0.001	510.179	<0.001
P2 → SM1	0.176	40.445	<0.001	190.754	<0.001
P3 → SM1	0.067	20.068	0.039	40.275	0.039
P1 → SM2	0.276	100.368	<0.001	1070.501	<0.001
P2 → SM2	0.201	70.982	<0.001	630.707	<0.001
P1 → SM3	0.216	70.222	<0.001	520.154	<0.001
P2 → SM3	0.157	50.639	<0.001	310.800	<0.001
P1 → SM4	0.231	50.932	<0.001	350.190	<0.001
P2 → SM4	0.140	30.896	<0.001	150.176	<0.001
P3 → SM4	0.080	20.731	0.007	70.458	0.007

* Acceptable level: $p < 0.05$. Only statistically significant relations are shown in the Table.

The results obtained in the relationship and regression analysis indicate that not all Participation indicators have a statistically significant impact on single indicators of Smart Mobility. Local authorities' actions aimed at involving citizens in proposing solutions and participating in decision making (P1) is the indicator that has the strongest impact on Smart Mobility. This was followed by opportunities to submit ideas and participate in decision making (P2). For previous activity in proposing solutions and participating in decision making (P3), the impact on Smart Mobility cannot be considered statistically significant. The order of the impact of Participation on the single indicators of Smart Mobility does not coincide with the order of impact determined for the Sustainability and ICT indicators. Participation has the strongest impact on ecological solutions in public transport (SM1), followed by amenities for passengers and residents (SM2), road traffic (SM4), and alternative to public means of transport and city's adaptation to their needs (SM3).

Based on the statistical analysis of the results, the hypothesis (H3), that the participation of representatives of Generation Z in smart city initiatives and activities has a significant and positive impact on their evaluation of the importance of smart mobility activities, cannot be fully confirmed. This hypothesis can only be partially confirmed for P1 and P2.

5. Discussion

The study allowed for the identification of relations between the indicated areas defining the characteristics of the representatives of Generation Z, such as: the approach towards sustainability, the extent of ICT use and participation in the evaluation of smart mobility's importance for a smart city. The research objective has, therefore, been achieved.

All the surveyed characteristics of the members of Generation Z were related to their evaluation of the importance of smart mobility described by four indicators: ecological solutions in public transport, amenities for passengers and residents, alternatives to public means of transport and city's adaptation to their needs, and road traffic. The study confirmed that there is a significant and positive impact of the approach towards sustainability and the use of ICT on all the above indicators of smart mobility. In the case of participation, this impact was only partially confirmed.

The first of the characteristics describing the representatives of Generation Z concerned their approach towards sustainability. This area was described using two indicators: attitudes towards sustainability and behaviours in the context of sustainability. The study showed a positive and significant effect of both indicators on all indicators of smart mobility.

A relatively strong influence appeared for the first of the indicators concerning approach towards sustainability which means that, according to the results, young people's attitudes have a stronger influence on their evaluation of smart mobility than their declared behaviours in this respect. The impact was strongest in the Smart Mobility indicator regarding ecological solutions in public transport. A lower impact was shown for the second indicator concerning the conscious approach towards sustainability, which refers to the pro-environmental behaviour declared by the respondents. In this case, the Smart Mobility indicator related to public transport also had the strongest impact. Among the indicators proposed in the survey, it seems that public transport is, in the eyes of the respondents, the most strongly related to issues of urban sustainability.

The results clearly indicate the importance of a conscious approach towards sustainability as a characteristic of Generation Z, which confirms previous studies identified in the analysis of the literature on the subject [12,14,107,140,151,152]. At the same time, they also confirm the relationships described in the literature between sustainability and the implementation of smart mobility solutions in cities [29,74,85,90,161,165,169]. It is also worth noting that the identified impact gap in the case of pro-environmental attitudes and behaviours can be attributed to the occurrence of the attitude–behaviour gap phenomenon, quite widely described in the literature, mainly in the context of theories of reasoned action and planned behaviour [170–172]. As the conclusions of the literature analysis indicate, such discrepancies can, under certain conditions, be reduced by means of appropriate educational projects, which can be an important indication for action by local authorities, but also by other organisations promoting pro-environmental attitudes [173,174].

In conclusion, it can be said that the surveyed representatives of Generation Z had a positive approach towards sustainability. They also rated smart mobility solutions relatively highly, which confirms the conclusions of the literature analysis [175]. The existence of a significant and positive impact of sustainability-based behaviours on the evaluation of smart mobility solutions' importance for a smart city was also confirmed.

Another examined characteristic of the representatives of Generation Z concerned the extent to which they use ICT, which was described by means of three indicators: frequency of using a smartphone for smart mobility purposes, frequency of using a smartphone for real-time information, and frequency of using a smartphone for other purposes (entertainment, education, shopping, etc.). The study concluded that there is a significant and positive influence between the extent to which the respondents use ICT and their evaluation of smart mobility's importance.

This impact is statistically significant, but its strength is weaker than for the area on approach to sustainability. The indicator referring to using a smartphone for smart mobility purposes had the strongest impact on all Smart Mobility indicators. This may suggest young people's interest in adopting solutions dedicated to this kind of applications. Such survey results confirm, in this respect, the conclusions from the literature analysis in the context of young people's acceptance of similar solutions [157,176].

In conclusion, on the basis of the study, it is possible to confirm the wide range of ICT use by representatives of Generation Z, which is consistent with previous research results in the literature [12,13,15,99,120,132,177]. Moreover, their interest in using ICT to support smart mobility solutions in smart cities can be pointed out, which also confirms the results of previous studies on ICT relationships to the smart mobility-related areas of sustainable smart cities [17,157,158].

The research results presented in this paper indicate that participation is not as clearly a statistically significant area influencing smart mobility as sustainability and ICT. The two indicators analysed in this respect, that is, local authorities' actions aimed at involving citizens in proposing solutions and participating in decision making and opportunities to submit ideas and participate in decision making, significantly influence the respondents' evaluation of smart mobility. It is worth noting that these factors are strongly reliant on initiatives on the part of the city authorities, taking steps to involve citizens in the projects created. This research result seems to be quite obvious, as "top-down" citizen involvement

initiatives, representing the smart city approach of generation 2.0, are described in many theoretical and empirical publications [54,70,71,73,76,79].

Differently, the results relate to the indicator regarding previous activity in proposing solutions and participating in decision making and its impact on the evaluation of smart mobility. In this case, the test results did not confirm a significant statistical relationship. Based on an analysis of the literature on citizen participation in smart city development, Thomas et al. concluded that city dwellers often remain on the margins of issues and not involved in municipal management [55]. According to these authors, there is an apparent gap in this respect between the theory described in the academic literature and the actual involvement of citizens in city affairs.

According to Alderette, knowledge of smart city concepts, including smart mobility, can be a major factor in explaining the active or passive behaviour of citizens [78]. It seems, therefore, that, in this case, the city authorities' strategy of educating and raising awareness can be an effective tool for involving citizens in smart initiatives and projects. Vicente and Novo point to another factor that could have an impact on increasing citizen participation. This is, according to them, the level of trust the residents have in the city government. However, the analyses conducted by these authors did not confirm the relationship that trust can be an important factor explaining citizen participation, or lack thereof [178].

A study carried out in the Spanish city of Malaga confirms that the positive attitude of citizens towards the introduction of urban improvements related to quality of life and smart mobility is not directly related to their real need to participate in these activities [73]. Although a report of the Directorate General for Internal Policies of the European Parliament indicates that Spain is one of the countries with the highest number of smart mobility initiatives [83], survey results indicate that more than half of the inhabitants of Malaga are not even familiar with the concept and essence of smart city. The authors of the study therefore ask, "If the majority of inhabitants of a city in which many actions related to the smart city have been carried out do not even know what it consists of, does that demonstrate a distance from the concept and an evident lack of participation?" [73] (p. 7). In addition, reports published by the European Commission indicate that smart city projects develop citizen participation in a very limited way, with little citizen engagement [46].

The results of the research confirm that the extent of the participation of young people is most strongly related to one of the indicators of Smart Mobility, that is ecological solutions in public transport. This provides support for the conclusion that public transport is, in the eyes of the respondents, significantly related to issues of sustainable urban development, and it is in this area with which the young generation sees the need to engage most [179].

In conclusion, despite the growing expectations of active citizens to increase their participation in the development of smart mobility, it seems that the representatives of Generation Z are not really interested in this. Their declarations of willingness to get involved in various opinion-forming activities and decision making processes do not, in reality, transform them into active co-creators of smart mobility solutions. As a consequence, the large group of young but passive beneficiaries of smart mobility solutions causes cities to fail to meet the smart city requirements of generation 3.0 [70,71]. Solving this problem can therefore be an important educational, organisational and technological challenge for city authorities, pointing the way to future activities in the field of active participation of people representing Generation Z.

6. Conclusions and Limitations

The main research objective of the authors was to identify the relationship between the evaluation of smart mobility solutions' importance for a smart city, attitudes and behaviours of Generation Z in the context of sustainability, their use of ICT as well as declarations and actual participation in activities in smart cities.

The analysis of the literature on the subject allowed the authors of the article to identify key items referring to these areas. Sustainability, information and communication technologies, and participation were statistically analysed in order to identify their impact

on the four main indicators of smart mobility in a smart city, that is, ecological solutions in public transport, amenities for passengers and residents, alternatives to public means of transport and city's adaptation to their needs, and road traffic.

In today's world, sustainability takes on particular importance. Awareness of this problem should be significant, especially among young people, who in the future will decide, as employees and employers, to take pro-environmental actions.

The use of state-of-the-art technologies is significantly increasing in modern cities. One of the key challenges today is the implementation of smart mobility, related to the implementation of ICT-based solutions. The representatives of Generation Z, who are constantly using the latest technologies, recognise their great potential for the development of smart mobility in cities.

Even though young people openly declare their willingness to co-create solutions and to join the decision making processes of city's authorities, Generation Z representatives are not really interested in active participation in supporting the development of a smart city. This indicates that the declarations of young people from Generation Z are not really being translated into action.

Summing up the above considerations, the obtained results allowed to fill the identified research gap concerning the perception of the representatives of Generation Z regarding information and communication technologies, the approach towards sustainability and citizen participation in the context of smart mobility in sustainable smart cities. It is worth emphasising that the wide range of the adopted research model and the conducted analyses allow for the identification of new research areas and the continuation of the considerations undertaken in this article in the future. At the same time, the results obtained can be recommended to the managing authorities of smart cities as guidelines for the search for innovative solutions to improve the quality of life of inhabitants based on the principle of sustainable development.

The results of this study should be read in light of certain limitations. First, although quite numerous, the study sample cannot be considered fully representative of the entire population of Generation Z. Additionally, the research sample consisted of students of universities located only in one city. Although Lublin is known as a smart city, it would be worth carrying out similar studies in other smart cities in Poland and other countries.

One of the limitations refers to the ICT item. In order to make it more transparent, the assumption was adopted that the young people usually access the ICT solutions using their smartphones, as they account the majority of the mobile device market in the world [119].

Another major limitation is the young age of the respondents and the phase of the life cycle in which the representatives of Generation Z find themselves, as their preferences regarding pro-ecological activities and expected values may change over time. Nevertheless, conducting similar research with breakdowns according to the respondents' field of study and preferred means of transport in the city could also bring interesting results.

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Appendix A

Table A1. Items and indicators of items used in the research.

Items	Indicator Symbol	Indicators of Items (Variables)
S Sustainability	S1	Attitudes towards sustainability
	S2	Behaviours in the context of sustainability
ICT Information and Communications Technology	I1	Frequency of using a smartphone for smart mobility purposes
	I2	Frequency of using a smartphone for real-time information
	I3	Frequency of using a smartphone for other purposes (entertainment, education, shopping, etc.)
P Participation	P1	Local authorities' actions aimed at involving citizens in proposing solutions and participating in decision making
	P2	Opportunities to submit ideas and participate in decision making
	P3	Previous activity in proposing solutions and participating in decision making
SM Smart Mobility	SM1	Ecological solutions in public transport
	SM2	Amenities for passengers and residents
	SM3	Alternative to public means of transport and city's adaptation to their needs
	SM4	Road traffic

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