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THE CONCEPT OF SMART CITY DEVELOPMENT IN THE CONTEXT OF THE COVID-19 PANDEMIC ON THE EXAMPLE OF KRAKÓW AND BARCELONA – CITIES COMBINING TRADITION WITH MODERNITY

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(…) *But trample not the altars of the past!*
Although you shall much finer domes erect
Adam Asnyk, *To the young* (tłum. J. Zawadzki)

Summary

The concept of a smart city is still being developed despite the lack of a single universally accepted definition. It is implemented through different approaches in different cities around the world. The presented study concerns the improvement of this idea and the possibility of applying the solutions from Barcelona to the city of Kraków. This paper is based on the author's experience and observations during a trip to Catalonia and its capital – Barcelona – as well as a study of literature on the smart city. The author takes into account the specific topographical and environmental conditions of each city and the human-environment interactions that have shaped both cities over the centuries. The paper continues to focus on the challenges to smart cities following the COVID-19 pandemic. The pandemic has demonstrated the need to modify ICT (Information and Telecommunications Technologies) applications related to the functioning of the city. Preliminary conclusions drawn from the pandemic also indicate that further development of smart cities should be based not only on ICT applications in public services and public spaces, but also on guaranteeing individual spaces for citizens to live in long-term isolation. In addition, attention was drawn to the need to improve both direct and electronic communication, especially by telephone with the authorities of Kraków, to enable "co-governance" in areas where the voice of the city's residents can be very valuable.

Keywords

ICT • urban development • urban environment • smart city • COVID-19 pandemic

1. Introduction

The concept of a smart city has been evolving for several decades. From the outset, it refers to the application of highly developed IC technologies to solve complex urban prob-

lems for the improvement of the lives of citizens. However, there is no single universally accepted definition of the concept. The literature on the subject is relatively rich. Many researchers have tried to summarise its conceptual evolution and arrive at a convergence of various senses of this concept. A dozen definitions of a smart city were collected (Allam and Newman 2018). Three types of drivers have been identified (Yigitcanlar et al. 2018): community, technology, and policy; all related to desired outcomes, including productivity, sustainability, accessibility, well-being, and governance. Other researchers focused on specific areas of smart city deployment, such as mobile networks (Sacramento Gutierres et al. 2019), urban infrastructure (Roblek 2018), or particular cities (Hu 2019, Hunter et al. 2018, Madakam and Ramachandran 2015). The environment plays multiple roles in the implementation of each smart city project. It is a central factor of urban development that has been shaping the quality of city life for centuries. Anybody working on a smart city strategy should take into account the historical development and environmental conditions of a given city. Typically, the environment is also one of the priority objectives of any smart city project. The quality of the environment is one of the criteria by which the effectiveness of smart city projects is assessed. It is accompanied by other factors, such as competitiveness, entrepreneurship, innovation and talent in urban transformation concepts. In the EU documents, this concept is closely connected to the improvement of the environment, with particular emphasis on the reduction of CO_2 emissions and efficient energy management (European Commission 2020). In general, the smart city concept involves measures required to save urban resources. For example, the concept of "smart growth" has been developed to reduce the costs of uncontrolled urban sprawl. Other examples can be found in urban transport and e-government.

The role of modern ICTs in a smart city is crucial. However, this is not the only driver of urban development processes – the economic use of urban resources of all kinds is equally important. Many contextual changes have taken place in the urban public sector in recent years. The development of the information society, digital technologies and the knowledge economy have forced public administrations to transform how services are provided. The implementation of the concept of a smart city in city management has become essential for local authorities to make responsible decisions about the direction of urban development.

Six functional dimensions of a smart city were formulated: economy, mobility (in the traditional sense – transport, and in the modern sense – communication), environment, quality of life, social participation, and people (Urbnews 2017). In addition, numerous smart city rankings have been developed (Giffinger and Gudrun 2010).

The implementation of any smart city strategy occurs within a specific time and particular environmental conditions of a given city. Therefore, each city, which will take the example of the best smart city in implementing its own strategy, should modify existing solutions considering its local conditions.

Barcelona seems to be one of the most advanced cities in terms of digital transformation.

The Barcelona City Council provides key insights and conclusions on how to design smart city policies.

Bearing in mind the environmental differences between cities, this paper focuses on the possibility of applying smart city solutions adopted in Barcelona, which is a city renowned for its achievements in implementing smart city strategy (Madakam and Ramachandran 2015, Ferrer 2017), to Kraków – a city that has formulated its smart city objectives in its strategy for 2030.

2. Barcelona – European model of smart city

With over three million inhabitants, Barcelona is the second largest city in Spain. It is the capital of the autonomous region of Catalonia. The City Council launched a strategy in 2011 to use information technologies to improve city governance (Ferrer 2017). Successful implementation of the strategy has been widely recognised in the world. In 2014, the European Commission awarded Barcelona the "iCapital" award "for introducing the use of new technologies to bring the city closer to citizens" (EC 2014). Furthermore, Barcelona was listed in several rankings among the most advanced in Europe and worldwide in regard to smart city solutions (Johnson 2018; Eden Strategy Institute 2019; Joss et al. 2019). Barcelona's achievements in implementing the smart city concept encourage the authorities of other cities to follow its example. However, the solutions successfully functioning in Barcelona will not necessarily be equally effective in another city's environment. Therefore, we need to take a closer look at the history of urban development of both Barcelona and Kraków.

Barcelona's origins as an urban settlement date back to the 1st century BC, when the Romans founded their colony here. Its urban development took place in a fixed topographical framework on the coastal plain between the Mediterranean coast in the east and the Montjuïc and Tibidabo hills in the west. Two small rivers Besòs and Llobregat initially flanked the city from the south and north (Casellas 2009). In the Middle Ages, the city turned into a Mediterranean metropolis. The city walls, built in the 13th century, covered an area several times larger than the Roman core. In the 15th century, the medieval urban area surrounded by a wall was expanded again to about 190 ha (Casellas 2009).

The city walls were demolished in 1854, and the expansion of the urban area to about 1,600 ha was based on the famous Cerdy plan. The great international events were consecutive milestones in Barcelona's urban history. These were the Universal Exhibitions in 1888 and 1929, and the Olympic Games in 1992 (Garcia-Ramon 2000). Over the centuries of development, the inhabitants have shaped Barcelona's environment – this is especially true of the hydrological network (as in the case of Kraków). The 12 parallel streams flowing from the Collserola range to the sea have been channelled to prevent the risk of flash floods. In addition, underground water reservoirs have been built in the city in recent years (Barrera et al. 2005).

Many concepts employing information technologies in Barcelona are potentially worth relocating to other cities as well. One of them is the CITY OS platform – a tool for processing and analysing urban information that allows simulation and prediction of problems that may occur in the city. It performs analyses, simulations and forecasts based on the collected information. Data in the platform can be transferred horizon-

tally between individual applications, as well as vertically between various urban monitoring and crisis management centres.

Telematics-based procedures have been implemented for faster customer service. The Open Data application deserves special attention. It enables public data to be opened and shared in digital and standard formats. In this way, residents can reprocess this data. The app encourages private companies that complement the public sector to create new free or paid services. The concept of Open Data is an essential component of open government and is impartial to the idea of "government as a platform" (Sobczak 2014).

In addition, a package of projects related to the smart mobility concept was implemented to reduce traffic congestion and the negative impact of traffic on the environment. Electric and hybrid vehicles have been introduced to urban transport. A similar measure was taken in Kraków. Most city buses and a significant number of taxis in Barcelona are electrically powered. This mode of transport is energy-efficient and reduces air emissions. It is worth knowing that there are more than 300 charging points at various locations around the city where it is possible to charge batteries for free, and this number is constantly growing. Already in 2013 there were 294 public electric vehicles, about 500 hybrid taxis, 130 electric motorcycles and 400 private electric vehicles, and their number is growing as well. Although the European Union would like to prohibit the sale of cars with internal combustion engines after 2035, since the climate and the environment are at stakes, everyone knows too well the obvious disadvantages of electric cars, such as charging batteries (long charging time, relatively low vehicle range, high load on the power grid). This disadvantage can be eliminated by hydrogen cells, which in turn raise problems with the appropriate infrastructure related to the production and storage of hydrogen.

Barcelona has a smart parking system with about 500 wireless sensors in parking bays, which provide real-time information on parking spaces. This information is displayed on screens in the city centre, as well as is available on mobile phones and the Internet (Madakam and Ramachandran 2015). This solution should be copied in Kraków. Furthermore, urban bus transport has been reorganised, a new network of orthogonal bus routes has been implemented, and smart interactive bus shelters – equipped with touchscreens, providing timetables and information on waiting time – have been installed. These screens are powered by solar panels (Misja Smart City Transform-Nation 2015).

A system of smart traffic lights based on analysis of flow, density and speed in the entire street network supports traffic management in busy parts of the city (EU Smart Cities Information System 2020). An intelligent traffic light management system enables emergency vehicles to find the fastest route to the scene of the accident (Pod Group 2019).

The reversible lane system (experimentally introduced in some parts of the city) is also noteworthy. It allows, with appropriate control and signalling, to increase the capacity of a multi-lane route during peak hours by blocking an underused lane in the opposite direction of traffic.

Another measure implemented in Barcelona is an intelligent waste management system. Waste bins are fitted with sensors to monitor waste levels. This information is

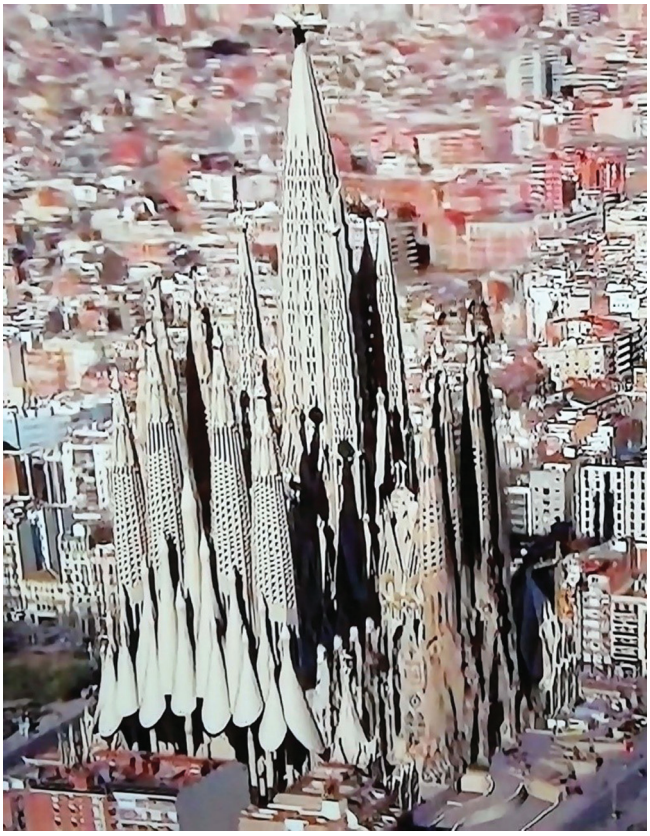
delivered wirelessly to the town hall team, which plans the route of the rubbish trucks. Truck drivers are kept informed of the optimal route. In this way, the cost of the waste management service can be reduced (Boulos and Al-Shorbaji 2014).

Recreational areas have also been integrated – an intelligent water management system includes automatic irrigation and automatic fountain control. The project was introduced in city parks. The use of water from the municipal water supply is automatically optimised thanks to sensors installed in the grass. This system calculates the amount of water entering the ground according to the needs of plants, taking into account data on precipitation, evaporation, infiltration, and runoff. Irrigation is switched off automatically in case of rain. Similarly, if there is wind, the water stream in fountains is regulated so as not to spill outside the irrigated area. Barcelona has also developed a smart lighting system that provides energy-efficient control over its 1155 street lamps (Madakam and Ramachandran 2015).

Taking care of ergonomics, combined with fanciful, spectacular architectural solutions, is already a tradition in Barcelona. The famous bench, created in Park Güell by an outstanding Catalan architect – Antoni Gaudí – is only one example. When designing it, he had his worker sit down in the formation phase so the imprint of his body was reproduced precisely in the bench's shape, fitting perfectly with the human body (Fig. 1).

Photo: I. Pisiewicz

Fig. 1. The famous perfectly shaped bench, 110 m long, created by A. Gaudi and located in Park Guell, is covered in colourful mosaics



Source: own elaboration according to TV Planete+ HD

Fig. 2. Sagrada Famiglia, the symbol of Barcelona – this is what it will look like when it is completed in 2026 on the anniversary of Antonio Gaudí's death

3. Kraków as a potential repetition of Barcelona

Kraków is a typical inland city located in southern Poland on the Vistula River, which for centuries, before the invention of railways, was the country's main communication route. Archaeological research has confirmed that the development of the city of Kraków began with a small settlement built on a hill among wetlands. The formal urban status of Kraków dates back to the mid-13th century.

Long-term changes to Kraków's environment have undoubtedly had a significant impact not only on the relief and hydrological network, but also on its climate in terms of humidity and airflow.

Changes in the relief of Kraków, which continued since the Middle Ages, had a significant impact on the residents' lives. The pursuit of a safe and relatively comfortable place to live was the main reason for these changes.

Apart from a few hills, the area of Kraków is almost flat with shallow river valleys. For centuries, the inhabitants of Kraków used watercourses for transport, defence, and as a source of energy. For this reason, they had to fight floods. Therefore, they built embankments and modified riverbeds according to their own needs.

Two opposing tendencies shaped the oldest phase of settlement in the area of the present city of Kraków. The first was the development of settlements at higher elevations (around 215 m above sea level) on the northern outskirts of today's city. This development proceeded without respecting the natural defensive conditions. The second was the development of settlements on the floodplain of the Vistula (approx. 205 m above sea level) due to the suitable natural defensive conditions.

The oldest spatial layout of Kraków formed on the north-south axis. Defensive conditions determined that the urban area was limited to the area of the mouth of the Vistula and its two tributaries: Rudawa and Prądnik. In general, the hydrological network of the city was expanded and compacted until the 19th century, when the moats lost their military significance, the steam engine replaced the water mill, and the railway provided better communication routes than the Vistula River. Many ponds, moats, wetlands and mills disappeared, and the area was drained.

As a result of these anthropogenic changes, the water areas in Kraków decreased from 116.20 ha (13.6%) before the foundation of the city (13th century) to 44.86 ha (5.2%) today. Taking into account the two ponds, which existed only temporarily, the area of water bodies decreased from 132.90 ha (15.5%) to 44.86 ha (5.2%). In addition, about 100 ha (11.7% of the city's area) of wetlands were drained (Jankowicz 1993).

The urban environment underwent further changes in the 20th century when heavy industry developed and large multi-family housing projects were built, leading to significant growth of the urban area, as shown in Figure 3.

Currently, these post-communist estates, which still have a significant share in urban resources, require a more attractive arrangement of open space between the blocks, instead of further densification. This is also necessary to improve the urban climate and ventilation, especially as the density of housing projects reduces the number of "ventilation chimneys" and reduces the supply of fresh air to the city. Due to the current urban layout of the city, resulting from sustained pressure on the environment, the problem of air quality is particularly acute. It is a huge call for the city authorities, who still continue to pour concrete over Kraków (XI World Urban Forum – Katowice, June 2022). This entails the need to introduce and effectively enforce a legal structure, ordering investors to build infrastructure related to the project area and immediately adjacent (pavements, car parks, small green areas, etc.). There are many roads without pavement in Kraków's districts, such as Azory or Tonie, which needs to change, because a smart city must first and foremost fulfil the role of a city that is safe and friendly for its residents.

According to the IESE report "Cities in motion Index 2017" (IESE Business School 2017), only two Polish cities were among the hundred best smart cities in the world: Warsaw in 54th place and Wrocław – 95th. At the top of this list are New York, London, and Paris. It is assumed that the smart city uses advanced technologies to improve the quality of life in all aspects. Kraków with its 800 000 residents (the data as of 2018,

currently due to Ukrainian arrivals this number is well over one million) was not mentioned in this report.

Lack of funds is not the only obstacle to the implementation of the concept of a smart city in Kraków. Equally important is the failure to implement community participation arrangements in urban governance. Delegating the decisions to citizens and their groups is still not popular among local authorities. Few people attend public consultations, which take place during City Hall office hours. Sometimes the authorities do not want to hear the voice of the residents and use the additional privileges granted to them (judges, MPs...). The participatory budget alone, implemented in many Polish cities, is not enough to make city co-management rational. Moreover, the concept of open data, which provides citizens with access to public data in different digital formats and encourages the creation of new services, is still not being used. Reducing energy consumption and CO_2 emissions is a major challenge for local authorities. Winter air pollution exceeds acceptable levels in Kraków and other large Polish cities, even though there has recently been some increased investment in the development of environmental solutions, including thermal modernisation of buildings and photovoltaics.

However, the city authorities expressed their ambitions to make the city smart in the Kraków Development Strategy entitled "This is where I want to live. Kraków 2030". The City Council of Kraków adopted this strategy in February 2018 (Gmina Kraków 2018).

Being a smart city is listed in the strategy among the city's main aspirations – these are divided into six areas: smart people, smart economy, smart mobility, smart environment, smart management, and smart life.

Smart people mean here that highly qualified and creative inhabitants of Kraków will initiate, with the support of IC technologies, changes in the city aimed at continuous improvement of the quality of life.

Smart economy includes the development of creative industries generated in business spheres based on modern services, technologies, and the R&D sector (research and development).

The concept of smart mobility includes an integrated transport system that uses IC technologies and an efficient network of high-speed connections between all possible points in the city.

Smart environment refers to energy consumption, adaptation to climate change, reduction of emissions, and sustainable resource management.

Smart governance in strategy has attributes such as competence, public participation in decision-making, transparency of activities and high quality and availability of public services. Also expressed is the need for an integrated city management system that allows the participation of all city users.

Smart living means that the city guarantees that its inhabitants have a friendly place to live. This, in turn, is characterised by high-quality education, health care, care for the elderly, modern technical and social infrastructure, security, as well as attractive cultural activities, leisure activities, and care for the natural environment, including urban green areas.

Further chapters of the strategy contain lists of implemented and planned strategic programmes and strategic projects. The term "smart" is repeatedly used to express the aspirations of the city. In addition, many programmes and projects that do not directly relate to smart city projects follow the six principles described above. Particular emphasis is placed on transport issues, such as the completion of the construction of ring roads and the High-Speed Agglomeration Railway; the expansion of the tramway network, the construction of a new runway at Kraków-Balice International Airport; and the construction of new interchanges integrating various modes of transport; in addition, the Park & Ride System; the integration of tickets for urban transport; the extension of the network of bicycle paths and pedestrian traffic to selected streets in the centre. All these projects will contribute to smart mobility in Kraków.

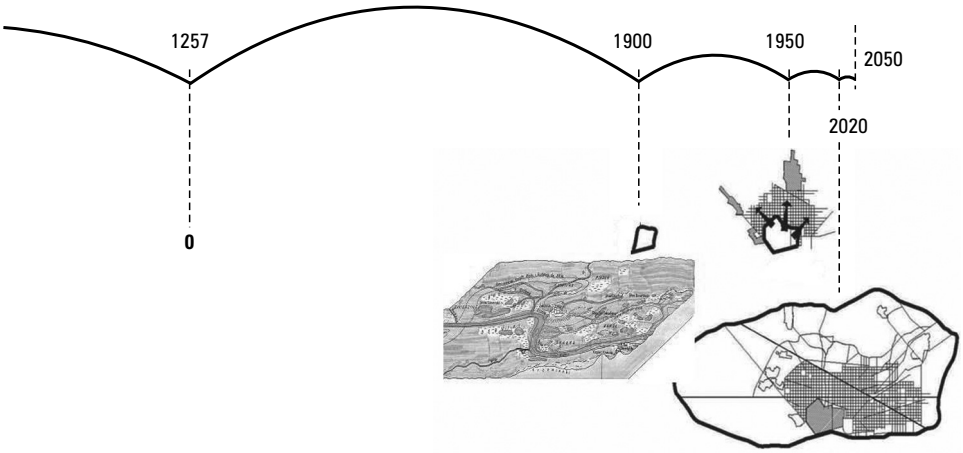
In terms of environmental protection, strategic projects focus on air quality. This means further efforts to reduce low emissions. The list of projects includes the replacement of solid fuel heating systems with gas systems; expanding the central heating network in the historic city centre and Kazimierz district, and improving the energy efficiency of public buildings. The planned revitalisation of existing green areas and the creation of new green areas (including pocket parks) are listed in the chapter devoted to public space. It is assumed that the percentage of people living at a distance of 300 m from recreational green areas will increase from 75% in 2017 to 86% in 2030.

Several ongoing and planned projects are particularly related to the use of ICT. These are: development of the existing Municipal Spatial Information System; promotion of the system of open access to public information (open data); organisation of an information platform for entrepreneurs; creation of a new Municipal Information System; development of the municipal CCTV system; organisation of the Security and Monitoring Centre in Kraków; development of the System of Electronic Public Services in the Kraków City Hall; extension of the Public Information Bulletin of the Kraków City Hall; modern electronic services and ICT applications, for example in public transport large interactive maps showing the actual position of the vehicle have been installed at several tram or bus stops in the city. In addition, these maps display information about obstacles along the route (Ulaan 2020). Information about the actual arrival of the tram or bus is available on smartphones. (Gmina Kraków 2019). Unfortunately, these predicted journey times are not always in line with an actual situation (traffic jams). On top of that, the passenger has to pay for the journey time – longer and more expensive than the timetable – thus this needs to be changed. Also, the purchase of transport tickets needs to be improved by the possibility of using both cash and a card in the means of transport not merely as an alternative.

Also, it is practically cost-free to improve the efficiency of car movement in Kraków, extending the time of yellow light (approx. 0.5s) between the red and green in the traffic lights as currently, it is switched off or it is too short (the driver's reaction time and the vehicle's preparation for starting is longer – according to the author's observation). Similarly, the creation of a so-called green line, informing of the recommended speed between junctions, or information on the duration of red and green lights – in the author's opinion – would be beneficial.

In addition, due to the pavement's often immediate vicinity to the road – in connection with the controversial provision on absolute priority for pedestrians at crossings – it would be advisable to introduce an intelligent system to signal pedestrians' intentions to cross the road, e.g. using proximity sensors or a weight-activated signal when a person is directly (but sufficiently) in front of the crossing.

Attention should also be paid to the quality of road surface (e.g. the composition of the asphalt mixture) and its profiling, which in many cases can lead to an accident, for example as a result of slipping or uncontrolled track changes.



Source: Author's study

Fig. 3. Diagram of the development of Kraków over the centuries

4. Rules of technology transfer from Barcelona to Kraków after the COVID-19 pandemic

Introducing smart city solutions in Kraków that are comparable to with those already existing in Barcelona advanced relatively smoothly until the beginning of spring 2020. As in the case of Barcelona, smart mobility was a priority area in Kraków. Smart public transport devices installed in Kraków both in vehicles and at bus stops provide passengers with a similar type of information as in Barcelona. According to the author, it is reasonable to implement in Kraków similar smart traffic light systems. However, not all solutions successfully implemented in Barcelona should be automatically copied to Kraków.

The significant environmental and cultural differences between these cities mean that smart city priorities are also different. Compared to Barcelona, Kraków has a more humid climate with relatively even precipitation throughout the year. The tradition of urban parks in Kraków dates back to the first quarter of the 19th century and has continued quite successfully. In 2018, the city of Kraków authorities created 18 new pocket parks (Labuz 2019). Therefore, it is not so urgent for Kraków to implement a smart

water management system for public greenery, similar to the one in Barcelona. On the other hand, the climate in Kraków is cooler, and the heating season is much longer than in Barcelona. Therefore, the city authorities need to tackle low emissions of air pollutants in order to achieve smart environment goals.

The outbreak of the COVID-19 pandemic at the beginning of 2020 brought an unprecedented change in the lives of people around the world. We are still living in the shadow of the pandemic in both Spain and Poland, hence the need to reduce personal contact among people during the pandemic confirmed the importance of ICT and the Internet of Things (IoT) for city functioning. Many people who previously avoided using smartphones or laptops were forced to do so in order to do their shopping, contact the local administration, work from home or meet other everyday needs. At the same time, the pandemic revealed the limitations of these technologies and showed that not every problem can be solved by using IC technologies. The pandemic has shed new light on the possibilities offered by ICT. Some good solutions developed for the normal situation have lost their relevance in a long period of limited use of public space and restricted mobility. For the same reason, new needs have emerged. In Kraków, for example, the only possibility to purchase a seasonal public transport ticket during the pandemic was through the Internet. At the same time, it was necessary to half the maximum number of passengers allowed on trams and buses. In such a situation, it has become more important to know how many seats are available in a vehicle than to be able to track the movement of a vehicle on a smartphone or screen.

ICTs during the pandemic were very helpful in testing and tracking contacts of infected people in order to find those who need to go through quarantine. Such an approach, based on mass tests and tracking, applied in South Korea and Germany, allowed to limit the number of casualties of the pandemic (Caduff 2020). In quarantine itself, just as important as the quality of individual living spaces, which cannot be replaced by any ICT solution, is the ability to contact the outside world online or by telephone.

The pandemic also brought about a significant change in the role of urban green areas. Public parks have been closed in Kraków for a long time. Thus, even the smallest individual gardens or plots became necessary for the city's quality of living. This situation is now back to normal.

Another challenge for smart city solutions in relation to the pandemic is all kinds of public interactive information devices. Regardless of the information displayed, they require touching the buttons. Most of them are switched off since the pandemic, and operate automatically. This should be taken into account in the further development of smart public transport stops, user-activated traffic lights and other interactive devices freely available in public urban spaces.

5. Conclusions

The development of ICT enables a fast and unlimited transfer of data and access to databases, It also makes it possible to create an efficient and easily programmable infrastructure. All of these factors, together with a developed sensor network, are resulting

in increasingly computerised cell-to-cell connections. This in turn demands changes in city management due to the need for advanced technologies. The main benefits are the improvement of services provided to city users and the saving of money, time and energy in the functioning of the city.

At this year's 11th World Urban Forum, held in Katowice in June, special attention was paid to the continuous process of covering the cities with concrete, which is a pressing issue also for Kraków and its local authorities.

Smart city solutions developed and deployed in one city can be relocated to another city to solve common problems. This applies mainly to traffic management, public transport, or waste management. At the same time, each city develops in special natural, economic, social, and cultural conditions. This in turn leads to different problems and different needs. Consequently, each city may have different priorities in the use of ICT. Pandemics, including COVID 19, are a natural phenomenon that happened before and can be expected to return as new pathogens will appear in the future (Caduff 2020). It is too early to fully assess the effectiveness of measures taken in different countries to contain the spread of the disease – staying at home was the most common measure recommended to urban residents during the pandemic. In terms of quality of living, the importance of individual living spaces should be emphasised. As to urban planning, this calls for an appropriate balance between public and individual spaces. The latter includes not only publicly accessible but also individual greenery (private garden or allotment). In this context, the idea of public parks, which seemed smart due to their availability, needs to be revised. In terms of ICT applications, the long isolation at home is stimulating online shopping and public and commercial online services.

The pandemic is a great challenge for all smart city solutions in public urban transport. Changing the content of information available on smartphones or displayed on screens at stops is not a problem. The dilemma is to reconcile the need for social distance with the efficient use of public transport. Temporary solutions included the isolation of the driver's cabin and the imposition of passenger limits in a vehicle, much lower than its physical capacity. This may be enough, as long as people's mobility is significantly restricted. In the longer term, more advanced technical measures are needed, for example, the use of anti-virus covers on seats, free disinfectant fluids at every stop, modifications to vehicle design, and even the replacement of trams and buses with innovative autonomous electric vehicles, which, however, requires modifications to routes.

Touching buttons and screens is a particularly important problem in smart city solutions during pandemics. Until now, all interactive devices, such as ticket machines, automatic timetable information, or some light signals installed in public spaces usually required the user to press a button or touch a screen to make a selection. Such devices cannot provide full safety during and after pandemics, even if they are frequently disinfected or covered with antivirus material. The optimal solution is to replace them with remotely controlled devices. The user would then operate the device via an individual remote control or a smartphone after downloading the appropriate app.

No matter what final solutions are developed, a smart city will need to be "touchless" and epidemically safe now and in the future.

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