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Smart City Concept and Sustainable Development

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Jacek Rudewicz[1]

Abstract:

Purpose: *The main purpose of the article is to demonstrate the relationships, opportunities, and threats that the implementation of the vision of the smart city can cause for its sustainable development in the subsystems of the city: economic, social, and natural.*
Design/Methodology/Approach: *The SWOT method was used to achieve the set goals, with the participation of experts and students of the spatial economy. The study was preceded by lectures and lectures for students. The article provides a synthetic analysis of publications comparing the Smart City concept and Sustainable Development.*
Findings: *As a result of the SWOT analysis, the subsystems of sustainable development that are important for urban development were identified, and then the most important strengths, weaknesses, opportunities, and threats were assigned to them. The findings suggest that smart cities have the potential to make significant contributions to sustainable development. However, there are also some potential challenges, such as the risk of increased inequality and the potential for technology to be used for surveillance.*
Practical Implications: *The results of the study and a brief literature review may be relevant for didactic purposes, debates about cities. It is possible that it will interest city leaders, as well as researchers who would like to expand, supplement, and reflect on the future of cities and the concept of a smart and sustainable city.*
Originality/Value: *The issue raised in the article is widely described in the literature, but mainly from the perspective of a literature review, semantic analysis of definitions, and the search for common grounds for the Smart City concept and the vision of a city developing in a sustainable way. They seem to be very optimistic. The SWOT analysis can make this issue more realistic.*

Keywords: *Sustainability, Smart City, Ubiquitous City, Sustainable Development, Urban Studies.*

JEL codes: *O18, Q01, Q56.*

Paper type: *Research article.*

[1]*Assistant Professor, University of Szczecin, Institute of Spatial Management and Socio-Economic Geography, jacek.rudewicz@usz.edu.pl;*

1. Introduction

Sustainable development and smart city are two concepts that have become increasingly popular in recent decades, sparking interest in various scientific, political, and business circles. The first concept focuses on the sustainable economic, social, and environmental development at both global and local levels (Rudewicz, 2020).

The second concept revolves around creating intelligent and innovative cities that provide their residents with high-quality living, high levels of public service efficiency, improved aspects of everyday life in cities. Both concepts seem to have much in common, but they also have their differences.

Smart city primarily focuses on using technology to improve the efficiency and quality of life in the city. Sustainable development, on the other hand, has a broader scope, longer time, and encompasses economic and environmental issues. Smart city approaches tend to be more tool-oriented, while sustainable development represents a broader, longer-term vision.

Some of the goals of sustainable development can be achieved through various means, including social solutions that technology can support, but not necessarily create. Therefore, the question arises as to whether the technologies associated with smart cities can also contribute to sustainable development or whether they might hinder it or disrupt it.

The problem is crucial because modern cities face various challenges, such as environmental pollution, climate change, and population growth. Smart cities can be a response to these challenges, but it is unclear how they can specifically contribute to sustainable development.

The purpose of this article is to compare the ideas of smart city and sustainable development and to explain their similarities and differences. The article also aims to explore how smart cities can contribute to sustainable development and whether it is possible to create a unified vision of Smart Sustainable Cities.

According to the definitions, a smart city is a city that uses information and communication technology (ICT) to improve the quality of life for its residents and more efficiently manage city operations.

Sustainable development, on the other hand, is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. From the perspective of time, these definitions require further clarification, as both the concept of smart city and sustainable development have evolved and expanded over time.

2. Literature Review

A literature review on the smart city concept, after several decades of its popularity, poses certain difficulties. Clear and precise definition of what this concept entails is not possible. One can speak of a certain "core definition," which revolves around the widespread application of technology in various aspects of urban functioning.

Many conceptual variations often arise by replacing the word "smart" with alternative adjectives, such as "intelligent" or "digital." The label "smart city" is a blurred concept and is used inconsistently. There is neither a template defining a smart city nor a universal definition. Many authors undertake semantic analysis, seeking the truth about the Smart City concept.

Authors who have devoted their meta-analyses of publications or sections of monographs to defining and conceptualizing smart cities (Albino *et al.,* 2015; Baraniewicz-Kotasińska, 2023; De Santis *et al.,* 2014; Ramaprasad *et al.,* 2017) have conducted their linguistic analyses on large samples of articles. Alongside overviews of general definitions, some authors have dedicated separate articles to examining the set of smart city definitions related to the idea of sustainable development (Toli and Murtagh, 2020; Havlicek *et al.,* 2013). In their review, they categorized these definitions, differentiating between academic (scientific), those formulated by industrial environments, and institutional definitions that include the term "sustainability."

They evaluated whether sustainability holds a primary, secondary, or tertiary position. They also observed the orientation of definitions towards the pillars of sustainable development: socially, economically, and environmentally oriented. In summary, the idea of sustainable development is present in views on smart cities. Among dozens of definitions and descriptions, it can be found in several or inferred indirectly.

Taking a closer look at the issues of defining a smart city, one can observe that some fall into technocentric categories. In the content of these definitions and the views of their authors, terms related to technology, ICT (Information and Communication Technologies), digital infrastructure, public services, data assets generated by people and things (IoT - Internet of Things), and open Application Programming Interfaces (APIs) dominate. These definitions date back to the early 21st century, with a focus on the tool aspects of technology.

It aims to facilitate management, lead to greater efficiency, resource savings, and cost reduction (Barrionuevo *et al.,* 2012; Cretu, 2012; Stawasz and Sikora-Fernandez, 2015). Technocentric definitions also reference pollution reduction, increased social integration, and sustainable development through technology.

A socio-economic framework for defining smart cities results in an approach where authors emphasize, above all, a high quality of life, investments in human and social capital, the development of transportation and communication infrastructure, citizen involvement in city management processes, and their greater decision-making power.

This approach emphasizes the greater competitiveness of cities, the resolution of public issues, as well as the integration and greater sustainability of the city's development areas. They do not place a clear emphasis on technology, but it does appear in their perspective (Caragliu *et al.,* 2011; Papa *et al.,* 2013; Szczech-Pietkiewicz, 2015; Thuzar, 2011; Anjam *et al.,* 2020).

Alongside approaches linking social issues with economic ones, humanistic-social perspectives also emerge in smart city definitions. In these definitions, the emphasis is placed on relationships and connections between residents, city officials, and other entities participating in the city management process. These approaches focus on ecological humanism, creativity, and the talent of residents, education, and awareness of the need for intelligent spatial management, and the creation of smart communities (Garg *et al.,* 2017; Giffinger *et al.,* 2007; Hollands, 2008; Kourtit *et al.,* 2012).

Smart city is also defined through criticism, a kind of critical and polemical definitions. From the perspective of the purpose of this work, it is worthwhile to examine them. Criticisms against the concept include so-called gadgetry and an unconventional approach to conventional matters (Barber, 2014).

A myth unrelated to urbanization (Krivý, 2016). The possibility of surveillance, citizen control, techno-political social order (Greenfield, 2013; Sadowski and Pasquale, 2015), technocratic utopia (Czapnik, 2019). The critical perspective often focuses on classifying smart city concepts as a kind of utopia and points out that technologies and devices are resource-intensive.

An important critical argument against smart cities, which has not been noticed in the literature, is the inequality in access to technology on a global scale. Some countries and cities with lower technical culture may be excluded from implementing this concept, and inequality may also arise within a given city-agglomeration due to lower digital competencies of older people or migrants.

The critical and polemic typology of Smart City by Cohen (Cohen, 2015) is highly valued. In this typology, Smart City transitions from a typically technocratic and dehumanized orientation, through centrally managed top-down approaches, to Smart City 3.0, where residents, with the help of technology, build inclusive and sustainable cities.

As noted by Ballas (2013), the concept of a smart city is used in urban planning. It is treated as an ideological dimension, according to which being a smarter city entails strategic planning directions. Governments and public agencies at all levels adopt the concept of intelligence to distinguish their policies and programs aimed at sustainable development, economic growth, and better quality of life for citizens, economic growth, quality of life, and happiness.

The concept of a smart city is also linked with the vision of a sustainable city by Korean researchers (Jang and Suh, 2010), going a step further and formulating the concept of a Ubiquitous city (U-City). It is a concept that combines high technology saturation and ubiquitous information systems to create a smart city capable of addressing the challenges associated with rapid urban development and ensuring sustainable development.

In such a city, as in the past, technology engagement is expected to contribute to the construction of eco-cities. Through "green socio-technical solutions" aimed at reducing environmental impact and ushering cities into the low-carbon era. Technologies such as smart grids and information systems will be capable of directing and monitoring a modern ecological city, from infrastructure (energy distribution, waste collection, integrated transport systems, etc.) to public life (provision of public services, information management, etc.).

In the ITU-T report (Smart sustainable cities: An analysis of definitions Focus Group on Smart Sustainable Cities, 2014), 116 definitions were analyzed using 50 keywords. The following attributes consistently appear across the literature in terms of describing a smart sustainable city: Sustainability – This is related to city infrastructure and governance, energy and climate change, pollution, and waste, and social, economics and health.

Quality of life – Is a recurrent theme. One of the aims of SSC would be to improve QoL in terms of emotional as well as financial well-being.

Urban aspects – This includes multiple aspects and indicators including technology and infrastructure, sustainability, governance, and economics.

Intelligence or smartness – A “smart” city exhibits implicit or explicit ambition to improve economic, social, and environmental standards. Commonly quoted aspects of smartness include smart economy, smart people, smart governance, smart mobility, smart living, and smart environment.

Another approach to explaining the smart city concept is to divide the city and its system into subsystems or areas, which are considered separately by giving them the term smart. It becomes apparent in this way that the smart city concept is multidisciplinary, complex, multidimensional. Giffinger *et al.* (2007) identified four components of a smart city: industry, education, participation, and technical

infrastructure. This list has since been expanded in a recent project conducted by the Centre of Regional Science at the Vienna University of Technology which has identified six main components (Giffinger *et al.*, 2007; Lombardi *et al.*, 2012).

Smart Economy − competitiveness, innovation, productivity, entrepreneurship, labour market flexibility, investment. Smart Mobility - sustainable transport systems, both local, inter-urban and international. Smart Environment − attractiveness of natural assets, environmental protection and management of natural resources, degree of environmental pollution.

Environmental awareness. Smart People − level of citizen education, creativity, quality of social interaction, openness to the outside world, social and cultural diversity, participation in public life. Smart Living − culture, lifelong learning, living conditions and living comfort, personal security, health, social integration. Smart Governance − administrative functioning, transparency of governance, policies and perspectives, socialisation of development.

3. Methodology

The method employed to achieve the article's objective involves a modification of the expert panel and SWOT analysis. This was carried out through discussions among academic professionals (six individuals with doctoral degrees) and a small group of spatial economy students from the Institute of Spatial Economy and Social and Economic Geography.

Throughout the debate and brainstorming sessions, a list of subsystems related to sustainable development within the three pillars—economy, society, and the natural environment (Tables 1, 2, 3) − was generated. The three main areas of sustainability, referred to as pillars (economy, society, and the natural environment), were further divided into subsystems. These categories delineate the processes and stakeholders involved in sustainable development, and they were then compared with the Smart City approach.

4. Research Results and Discussion

The results of the SWOT analysis are presented in the three tables below. This is a scaled down version of the main results.

Table 1. *Subsystems of the sustainable city and the Smart City concept.*
Economic development SWOT

1.	**Economic Growth:**
S	Sustainable and inclusive growth, driven by innovative technologies and eco-friendly practices.
W	Potential dependence on large technology corporations.
O	Creation of new jobs, development of sectors related to modern technologies and

	sharing economy. Business environment improvements and networking.
T	Potential issues with cybersecurity and resilience to disruptions.
2.	**Personal Income:**
S	Increase in residents' income, time savings, lower costs. Multiplicative effect.
W	Bearing the costs of new technologies, the risk of social inequality.
O	New job opportunities, potential for the development of high-value-added and efficient sectors.
T	Potential social inequalities, the need for restructuring in traditional sectors.
3.	**Employment:**
S	Creation of new jobs through innovative projects.
W	Need for new qualifications. Technological unemployment.
O	Development of sectors related to modern technologies, opportunities for new skills.
T	Possibility of job loss in low-skilled sectors.
4.	**Economic Activation:**
S	Development of local service sector businesses.
W	High costs for small businesses, competition with large corporations.
O	Investments in modern technologies, development of startups.
T	Tendency towards capital accumulation in large corporations.
5	**Competitiveness and Attractiveness for Investors and Capital:**
S	Innovative business environment, access to modern technologies.
W	Dependence on large corporations, competition with other cities.
O	Attraction of investments through modern solutions, development of high-tech sectors.
T	Ryzyko utraty inwestorów na rzecz konkurencyjnych miast.
6.	**Efficiency of Urban Processes:**
S	Improvement of the efficiency of urban resource management, minimization of operating costs. Optimization of urban system processes and metabolism.
W	High implementation costs, ongoing maintenance, and process improvement costs.
O	Improvement of public transportation, sustainable urban practices.
T	Potential issues with cybersecurity, resistance from residents.
7.	**Households:**
S	Improvement of the efficiency of urban resource management, minimization of operating costs. Optimization of urban system processes and metabolism.
W	High implementation costs, ongoing maintenance, and process improvement costs.
O	Improvement of public transportation, sustainable urban practices.
T	Potential issues with cybersecurity, resistance from residents.
8.	**Economic Entities:**
S	Growth of sectors related to modern technologies.
W	Necessity to adapt traditional sectors, competition with corporations.
O	Support for innovation, development of high-value-added sectors.
T	Risk of traditional business failure, competition with global companies.
9.	**City Management:**
S	Effective city management through technological solutions, e-governance. Data-driven decision systems.
W	High implementation costs, resistance among city staff.
O	Introduction of data analysis tools, improvement of the delivery of municipal services.

T	Risk of cyber-attacks, the need for education for city staff.

Source: *Own study.*

General SWOT analysis for the Smart City model in the context of the development of a sustainable social pillar.

Table 2. *Subsystems of the sustainable city towards the Smart City concept. Social development SWOT*

1.	**Personal Safety:**
S	Urban monitoring, alarm/scurity systems, technologies improving residents' safety. Transportation safety.
W	High implementation costs, potential privacy violations.
O	Improvements in monitoring and data analysis, collaboration with local communities to enhance safety.
T	Risk of misuse of monitoring systems, residents' resistance related to privacy.
2.	**Education and Upbringing:**
S	Implementation of modern educational technologies, access to e-learning, programs supporting skill development.
W	Necessity for investment in educational infrastructure, potential digital exclusion.
O	Development of online teaching programs, investments in technical education and digital skills.
T	Unequal access to education, potential dependence on technology.
3.	**Health:**
S	Implementation of technologies supporting healthcare, telemedicine, monitoring residents' health.
W	Necessity for integration of healthcare systems, patient privacy protection.
O	Improvement of healthcare accessibility, development of remote diagnostics, innovative treatment methods.
T	Risk of privacy loss of medical data, resistance among medical staff.
4.	**Living Conditions:**
S	Improvement of living conditions through smart building management, efficient energy consumption.
W	High energy costs for residents, the need for the modernization of existing buildings.
O	Development of ecological housing solutions, efficient resource management.
T	Risk of social exclusion, the need for residents' education in new technologies.
5.	**Public Transport:**
S	Improvements in public transport through monitoring and data analysis, development of intelligent transport systems.
W	High costs of upgrading transport infrastructure, resistance among users.
O	Development of data-based public transport, collaboration with the private sector on modern solutions.
T	Potential cybersecurity issues in transportation, resistance to changes in infrastructure.
6.	**Culture:**
S	Introduction of technologies supporting cultural heritage, promotion of art and culture.
W	High costs of maintaining cultural institutions, the need for equal access to culture.

O	Development of virtual forms of culture, accessibility of culture for all.
T	Risk of losing authenticity in culture, potential inequalities in access to culture. AI as a creator.
7.	**Social Capital:**
S	Support for local communities, platforms supporting civic participation.
W	Potential issues with citizen data security.
O	Increased interaction and information for residents through technology.
T	Escape of communities into the virtual world.

Source: *Own study.*

General SWOT analysis for the Smart City model in the context of sustainable development in the environmental pillar.

Table 3. *Subsystems of a sustainable city in the context of the Smart City concept. Natural environment SWOT*

1.	**Climate Change in Cities:**
S	Implementation of emission reduction strategies, development of low-impact public transportation, educating residents about climate change.
W	High adaptation costs, resistance from residents to behavior change.
O	Investments in renewable energy sources, development of energy management systems.
T	Increased risk of natural disasters, need for global cooperation.
2.	**Pollution:**
S	Monitoring and control of emissions, community education on the consequences of pollution.
W	High implementation costs of monitoring systems, the need to change existing industrial processes.
O	Elimination of emissions from vehicles and emissions from own sources such as furnaces, fireplaces.
T	New emission threats, increase in energy consumption and indirect emissions from certain technologies.
3.	**Waste:**
S	Waste recycling and segregation systems, educating residents on this topic.
W	High costs of recycling infrastructure, resistance from residents to new segregation practices.
O	Investments in waste reduction technologies, promotion of a circular economy.
T	Increase in the number of electronic waste and batteries difficult to recycle.
4.	**Tereny zieleni**
T	Increase in electronic waste, the need for waste storage and recycling of batteries.
S	Development and maintenance of city parks, promotion of afforestation and community gardens.
W	Pressure on urban space, the need for investment in the maintenance of green areas.
O	Revitalization of urban areas, creation of new green spaces.
T	Loss of green areas to urbanization, the need for protection against climate change.
5.	**Biodiversity:**
S	Protection of natural areas, programs for the protection of endangered species.
W	Conflicts between development needs and environmental protection, lack of

	coordinated conservation efforts.
O	Reconstruction of natural habitats, education about the importance of biodiversity.
T	Threats to local ecosystems, loss of biodiversity.
6.	**Spatial Planning:**
S	Development of spatial plans considering sustainable development, economization, and socialization of the planning process.
W	Resistance from local communities to changes in spatial plans, difficulties in coordinating actions between sectors.
O	Development of intelligent planning systems, citizen participation.
T	Risk of major planning errors resulting from a technocratic approach and the neglect of the human factor.

Source: *Own study.*

In summary, the strengths of the Smart City concept for Sustainable Development revolve around increased urban efficiency, leading to enhanced energy efficiency, reduced greenhouse gas emissions, and energy savings. Positive effects extend locally and externally, with intelligent transportation management improving traffic flow and reducing congestion, contributing to emission reduction and shorter travel times.

Waste management based on monitoring technologies allows for efficient recycling, promoting a circular economy. Smart City technologies enhance access to public services, safety, and residents' quality of life, fostering community awareness and civic participation.

Weaknesses of the Smart City concept include cybersecurity risks associated with system attacks, potentially leading to privacy loss and service destabilization. Mitigating the risk of data loss becomes crucial, and addressing privacy challenges from monitoring and data collection systems requires strict regulations and societal education. Digital exclusion may result from uneven access to technology, necessitating equal access assurance and educational programs.

High implementation costs may be a barrier for smaller cities, requiring funding sources and adjustments to budgets. Infrastructure-related issues, especially with older infrastructure, may necessitate costly upgrades, requiring investments and minimizing disruptions during modernization. While the Smart City concept brings benefits, addressing challenges is crucial in the implementation process.

During SWOT analysis, the opportunities of the Smart City concept for sustainable development align with its strengths but unfold over an extended timeframe. This means that experts and individuals interested in the city still express hopes and concerns regarding the Sustainable Smart City.

Significant expectations revolve around citizen participation and resident attitudes, emphasizing previously unnoticed technological possibilities that enhance

transparency and community engagement. The aim is to improve the quality of life by leveraging technology to create more friendly and efficient urban spaces.

However, threats to the relationship between Smart City and sustainable development include projected future risks related to privacy and excessive control. Digital exclusion may result from a lack of access to advanced technologies, leading to inequalities. Issues of cybersecurity and urban resilience are also highlighted.

Technology introduces new threats, including intentional disruptions or complications in the city's information systems, posing risks to its functioning. The E-pollution phenomenon, driven by large amounts of data and network-connected devices, can increase energy consumption. Furthermore, the introduction of automation and artificial intelligence may result in job losses in certain sectors, negatively impacting the community.

5. Conclusions, Proposals, Recommendations

To optimize the intelligent city model for sustainable economic development, cities should invest in smart urban solutions aligned with economic goals, ensure equitable implementation, and collaborate with businesses through public-private partnerships. Developing supportive policies is also crucial.

However, potential weaknesses include the need to carefully assess the costs and benefits of Smart City solutions, as overinvestment and unnecessary complexity are possible. Additionally, cybersecurity measures must be implemented to protect against threats, such as the misuse of residents' data, as seen in China's Social Credit System. Future considerations involve the emergence of AI-based solutions replacing the service sector, necessitating investment in programs addressing technological unemployment and discussions about universal basic income.

An area for future research into the smart city concept and sustainable urban development is the attitude of citizens towards the encroachment of technology into their everyday lives and urban spaces. A social backlash is emerging here, a resistance criticising the dehumanisation of space.

The control of authorities and corporations on the one hand and the lack of social control over data and its use on the other. A new player and topic for the scientific world in the concept of smart cities and sustainable development is becoming artificial intelligence.

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