
Sustainable Municipal Management Model: The Smart Concept

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Abstract:

Purpose: The purpose of this article is to explore and evaluate the smart municipality model as a framework for sustainable municipal management. It aims to identify the key components and advantages of this model, particularly in improving local governance and the quality of life in rural areas. The focus is on the integration of advanced technologies such as the Internet of Things (IoT), big data, and Artificial Intelligence (AI), and how these technologies can enhance resource management, public engagement, and environmental sustainability.

Design/Methodology/Approach: This study employs a mixed-method approach that combines a comprehensive literature review, case study analysis, and in-depth interviews with municipal representatives. The research examines examples from Poland and other international contexts to understand how smart technologies are being utilized in municipal management. Through this methodology, the article seeks to evaluate both the benefits and challenges associated with implementing smart solutions in municipalities.

Findings: The study finds that the adoption of smart municipality initiatives can significantly enhance the sustainability of rural communities. Key benefits include more efficient resource management, reduction of environmental footprints, and increased community participation in local decision-making processes. Technologies such as IoT enabled smart waste management, air quality monitoring systems, and smart street lighting have proven effective in reducing resource consumption and improving public services. However, the research also highlights substantial barriers, including high implementation costs, public resistance to new technologies, and digital exclusion issues, particularly in less digitally literate populations.

Practical Implications: The practical implications of this research are significant for local government officials, urban planners, and policy makers. The findings underscore the importance of fostering public-private partnerships to secure the funding needed for smart initiatives. Additionally, the article emphasizes the need for targeted educational programs to increase digital literacy and raise awareness about the benefits of smart technologies. Municipalities must also focus on ensuring equitable access to digital solutions for all residents to avoid deepening social inequalities.

Originality/Value: This article makes a valuable contribution to the field of smart municipal governance by offering practical insights into the application of smart technologies in rural areas. It provides a detailed analysis of both the opportunities and challenges of

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implementing smart solutions and underscores the importance of public engagement, education, and infrastructure investment for successful adoption.

Keywords: *Smart municipality, sustainable development, public services, technology, community participation.*

JEL codes: *O10, Q01, R58.*

Paper type: *Research article.*

1. Introduction

With the rapid advances in technology and the growing interest in issues of practical implementation of sustainable development, the management concept of smart is becoming more and more developed. The smart city (smart city) and smart village (smart village) concepts are aimed at the economic and social development and sustainability of urban and rural areas. They are based on the use of modern technology, data, innovative solutions and community resources to improve the quality of life of the inhabitants, the efficiency of the space (city and village).

In this context, a sustainable municipal management model based on the Smart concept offers new opportunities for local communities. Using smart technologies such as the Internet of Things (IoT), big data and information management systems. Municipalities can better monitor and optimise resource consumption, infrastructure management and public service delivery.

This makes it possible not only to increase operational efficiency, but also to achieve sustainability goals such as reducing green-house gas emissions, improving air quality or increasing the share of renewable energy sources. The implementation of smart solutions also allows residents to be more actively involved in decision-making processes, which fosters stronger social ties and a better quality of life.

The purpose of the article is to identify and characterise a sustainable model of municipal management based on the Smart concept as a modern and effective approach to rural spatial management.

By identifying the key elements and advantages of this management model, challenges and directions for further implementation of the smart concept in municipal operations will be shaped. By analysing the benefits and future prospects, the article will provide a comprehensive understanding of the practical role, significance and potential of smart municipalities in the context of modern society

and the rural environment.

The concept of smart in spatial management refers to the use of modern technology, data and innovative solutions for the effective planning, design and management of spaces. This includes the integration of information, sensory and communication systems to improve different aspects of society, such as transport, infrastructure, energy, environment or public services.

The European Commission (Smart Villages, ENRD, 2021) proposes that Smart Villages can be understood as rural areas or communities that build on their strengths and capital, seek new solutions, and strengthen traditional and new stakeholder networks and services through digital and telecommunications technologies and innovation and better use of knowledge.

Thus, we can define a smart municipality as a local community that uses advanced ICT technologies such as the internet of things, artificial intelligence, data analytics and information systems to integrate different areas of social, economic and environmental life. The aim of smart municipalities is to improve the efficiency of the rural area, provide better public services and increase the quality of life of residents.

Kalinowski *et al.* (2021) in their detailed and practical study come to the conclusion that the concept of rural development proposed by the European Union - smart villages, is directed at villages that are 'declining' due to progressive depopulation, but not only to such villages. The beneficiaries of smart villages can be communities in different places, with different strengths and problems. These are villages that use digital technologies and innovations in their daily life, thus improving its quality, improving the standard of public services and making better use of resources (Kalinowski *et al.*, 2021, p. 129).

The basic elements of smart municipalities include:

1. *Technological infrastructure*: including communication networks, sensors based on the Internet of Things, monitoring systems and data analytics platforms.
2. *Public services*: smart municipalities offer innovative public services such as smart waste management, air quality monitoring, smart street lighting or data-driven public transport.
3. *Public participation*: an important aspect of smart municipalities is the active involvement of residents in the decision-making process and the design of solutions in line with their needs and expectations.
4. *Sustainability*: Smart municipalities aim to achieve sustainability by optimising energy consumption, reducing emissions, improving urban mobility and promoting the circular economy.

A renewed village preserves what is most valuable but is also not afraid of the

challenges of new times, a new model of development in which the local authority and its subordinate public institutions cooperate with other actors on the local scene. These are the inhabitants and their associations (formalised and informal) acting not so much as recipients of support, but as co-creators of various types of projects (Zajda, 2023).

The implementation of the smart municipality concept requires a carefully planned strategy and the coordination of activities at different administrative levels. A key aspect is the integration of modern technologies with traditional management methods. An example is the use of intelligent energy management systems that monitor energy consumption in public and private buildings and then optimise its distribution, resulting in savings and a reduction in CO₂ emissions.

Educating residents about the benefits of smart municipalities is essential to achieving the full potential of these solutions. Information campaigns and training programmes help to raise awareness of the available technologies and their practical application in everyday life. In addition, promoting environmental basics and the responsible use of resources contributes to the sustainable development of the municipality.

One of the foundations for the successful implementation of smart municipalities is cooperation between the public and private sectors. Public-private partnerships enable the pooling of resources and competences of different entities, which speeds up the process of implementing modern technological solutions. An example of this can be joint projects in the field of transport infrastructure construction, where private companies provide modern technologies, and the municipality provides administrative and logistical support.

For a smart municipality to function effectively, it is essential to ensure equal access to technology for all residents, regardless of their age, social status or location. Digital exclusion programmes, such as free computer and smartphone training and high-speed internet access, are key to creating an inclusive community that embraces the benefits of modern technology.

The future of smart municipalities is not only about adapting the latest technologies, but also about developing modern governance models and strengthening social ties. As technologies such as artificial intelligence, big data and blockchain become more widespread, the opportunities for the development of smart villages will expand. It is important that local authorities remain open to innovation and continue to work with residents and external partners to create more sustainable and integrated communities.

The implementation of the smart municipality concept has the potential not only to improve the efficiency of public services and the convenience of residents, but, most significantly, also to contribute to the achievement of sustainable development goals.

In this article, we will analyse how smart municipalities can contribute to sustainable development (emission reduction and environmental protection; efficient use of resources; social inclusion and resident participation) and what challenges may arise in this process.

One of the key aspects of achieving sustainability when implementing smart municipalities is reducing greenhouse gas emissions and protecting the environment. Through smart management of energy, transport and waste, smart municipalities can reduce their carbon footprint and minimise their environmental impact. For example, smart street lighting systems reduce energy consumption and smart transport systems reduce traffic jams and emissions.

The implementation of the smart municipality concept contributes to a more efficient use of resources by promoting the circular economy and minimising waste. By analysing data and monitoring resources, production processes, waste management and the use of natural resources can be optimised. For example, intelligent water management systems can minimise water waste by detecting leaks and optimising consumption.

Sustainable smart-community development requires active community involvement and resident participation. The implementation of smart solutions should take into account the needs and expectations of the local community and ensure equal access to technology for all social groups. Social inclusion can be achieved by organising community consultations, building partnerships and promoting education and awareness of the benefits of smart development.

2. Literature Review

In recent years, the growing interest in sustainability issues and the use of smart technologies in municipal management has become increasingly apparent. Sustainability is a key element of spatial and social planning, while smart solutions offer new opportunities to improve efficiency and quality of life for residents. An analysis of existing research on this topic will provide a better understanding of the challenges, benefits and best practices associated with the implementation of these concepts in the context of urban and rural municipalities.

Research on the smart village concept in different countries around the world focuses on different aspects of this local development model, from its definition and characteristics to the assessment of benefits and challenges, and the analysis of specific implementation cases. Key areas of research include the efficiency of public services, public participation, sustainability or technological and financial aspects.

The analysis of specific smart village implementation cases identifies differences between countries and provides practical conclusions on the effectiveness of solutions.

The study by Adesipo *et al.* (2020) analysed trends in climate-smart agriculture in different areas, globally and in Europe. The study used a literature analysis method, interviews with experts, case studies and data collection through sensors and IoT technologies. Mathematical modelling allowed predicting the impact of the implementation of these technologies in different scenarios.

The results show that smart technologies, such as sensors, IoT and blockchain, significantly improve the efficiency of agricultural production and reduce losses. Drones make it possible to monitor large areas, and climate technologies help to better manage natural resources and reduce greenhouse gas emissions. The introduction of these technologies has helped to increase incomes and improve the quality of life for rural residents.

Aziiza and Susanto (2020) conducted a study in Banyuwangi Regency, Indonesia, focusing on the development of a smart village model. The study included initial interviews with key informants, a literature review and an analysis of local regulations. A smart village model was developed, divided into six main dimensions: governance, technology, resources, rural services, daily life and tourism. The model aims to improve the quality of life of villagers through the use of technology and is flexible, allowing for adaptation to the specific needs of each village in Banyuwangi Regency.

The study by Zhang and Zhang (2020) focused on planning strategies and practices related to smart villages in China, adopting a general systems theory approach. Data from government reports, national statistics and academic literature were analysed, as well as empirical data from pilot smart village projects in various provinces in China. Local authorities and villagers were also interviewed.

The results indicate that the implementation of smart villages has significantly contributed to improving rural sustainability, improving agricultural production management, agricultural product safety and access to health and education services. However, challenges were identified related to the lack of uniform planning and regional differences in the level of technology implementation, highlighting the need for further investment and government support in digital education for villagers.

Malik *et al.* (2022) conducted a study in the state of Uttarakhand, India, focusing on the impact of digitalisation on rural communities. The study involved the collection of quantitative data through questionnaires and qualitative data through indepth interviews. The focus was on internet accessibility, digital literacy and the economic impact of implementing smart IoT technologies.

The results showed that digitalisation has contributed to a significant increase in internet use and improved digital skills, especially among younger residents. IoT technologies increased agricultural productivity, and residents gained better access to online education and health services. The implementation of new technologies has

also brought economic benefits, creating new employment opportunities related to digital services. However, older residents faced difficulties in adapting to the new technologies.

Research on smart villages and agricultural technologies shows that these innovations can make a significant contribution to sustainable rural development, improving the efficiency of agricultural production, increasing incomes and the quality of life of rural residents.

Despite the positive results, there are also challenges, such as the lack of uniform planning, regional differences in the level of technology implementation and the adaptation difficulties of residents. The findings of this research suggest the need for further investment and support in digital education and access to smart technologies for farmers and rural residents.

Poland is also an object of interest in research into the activities of municipalities, however, the dynamics and scope of this research are somewhat different compared to more advanced countries. An analysis of research in Poland to date reveals both some similarities and differences compared to global trends. Some studies focus on emphasising the role of information and communication technologies in improving the efficiency of public services and the quality of life of residents, while others also take into account aspects of sustainable development and public participation.

An important entry point in the implementation of sustainable local development policies and smart by urban and rural areas is the level of development of their infrastructure. The spatial development status of municipalities was examined in the work of Feltynowski (2022) through the prism of infrastructure in spatial planning.

A critical view of village renewal issues was displayed in a study by Wójcik and Jeziorska-Biel (2023), grouped into research on local development, the selective nature of programmes and building a sense of place. In the work of Zajda (2023), it was reasoned that social innovation would contribute to the goal of village renewal, which is to involve residents in the process of solving social problems.

In Poland, the development of smart communities is still in its infancy, but more and more local governments are taking steps to introduce innovative technologies into their cities and municipalities. Research on the state of smart-municipality development in Poland often focuses on assessing technical and organisational readiness, identifying needs and funding opportunities.

A study by Mróz *at al.* (2023) analysed the scale of spatial distribution of EU cohesion policy funds in rural areas in Poland. According to this study, municipalities located in urban functional areas of voivodeship capitals are characterised by a higher level of outlays under cohesion policy funds than municipalities located in the rest of the country. It was noted that the most funds

were allocated in rural areas for investment in transport and technical infrastructure, and the least for environmental protection and digitalisation measures.

Research on initiatives and pilot projects in Poland focuses on the analysis of specific activities undertaken by local governments, government institutions and the private sector. Examples of projects include smart waste management systems, air quality monitoring, or platforms for public participation (Kalinowski *et al.*, 2021).

The analysis of previous research on the implementation of the smart concept in the local area both in the world and in Poland reveals a growing interest in this topic and the variety of activities undertaken and areas studied. Although Poland still faces challenges in the development of the smart village concept, there is great potential to use innovative technologies to improve the quality of life of residents and the efficiency of public services.

3. Methodology

The study uses the results of research carried out by analysing secondary sources, including specialist journals, interviews, publications of professional and public organisations. The method used was an indepth case study analysis of purposefully selected municipalities, which are examples of good practice in the implementation of the smart concept in recent years. In the course of the research, face-to-face interviews were conducted with managers of municipalities.

The main hypotheses that guide this research are:

Hypothesis 1: The implementation of advanced technologies will improve resource management efficiency in rural communities.

Hypothesis 2: Active participation of residents in decision-making will contribute to the sustainable development of smart municipalities.

Hypothesis 3: High costs of technology implementation are a primary barrier to the realization of the smart municipality concept.

The first stage of the study will be to analyse the literature on the concept of smart in rural areas and local sustainable development. For this purpose, academic publications, reports and press articles on this issue will be analysed. The analysis of the literature on the subject will allow for the definition of the concept of smart municipalities and their key elements, also for a precise discussion of the foundations and assumptions of this development model.

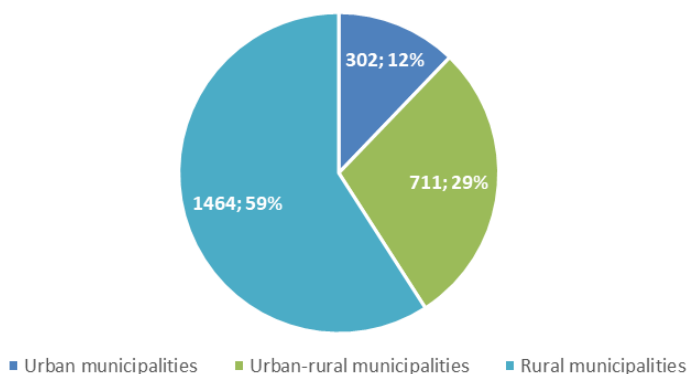
The next step will be to analyse practices related to the implementation of smart-municipal projects. We will analyse success cases and challenges encountered when implementing smart solutions in different socio-economic and geographical contexts. We will draw on project reports, case studies and economic and social analyses to understand the practical aspects of smart municipalities.

The final stage of the study will be to conduct interviews with experts, local community representatives and municipal development staff. The interviews will provide an understanding of diverse perspectives, an assessment of the state of the art, identification of key issues and opportunities for the development of the smart concept in municipalities. Interview questions will include experiences of implementing smart village solutions, assessment of benefits and challenges, and future perspectives on this development model.

4. Research Results and Discussion

Since 1999, a threetier structure of local government has been in force in the Republic of Poland, consisting of: municipal government, district (powiat) government and Voivodeship government. According to data from the Polish Ministry of Interior and Administration, Poland is currently (as of 01.01.2024) divided into 16 voivodeships, 314 counties and 2,477 communes (238 urban, including 66 cities with district rights, 711 urban-rural and 1,464 rural) (Figure 1).

Figure 1. Structure by type of municipalities in Poland, 2024



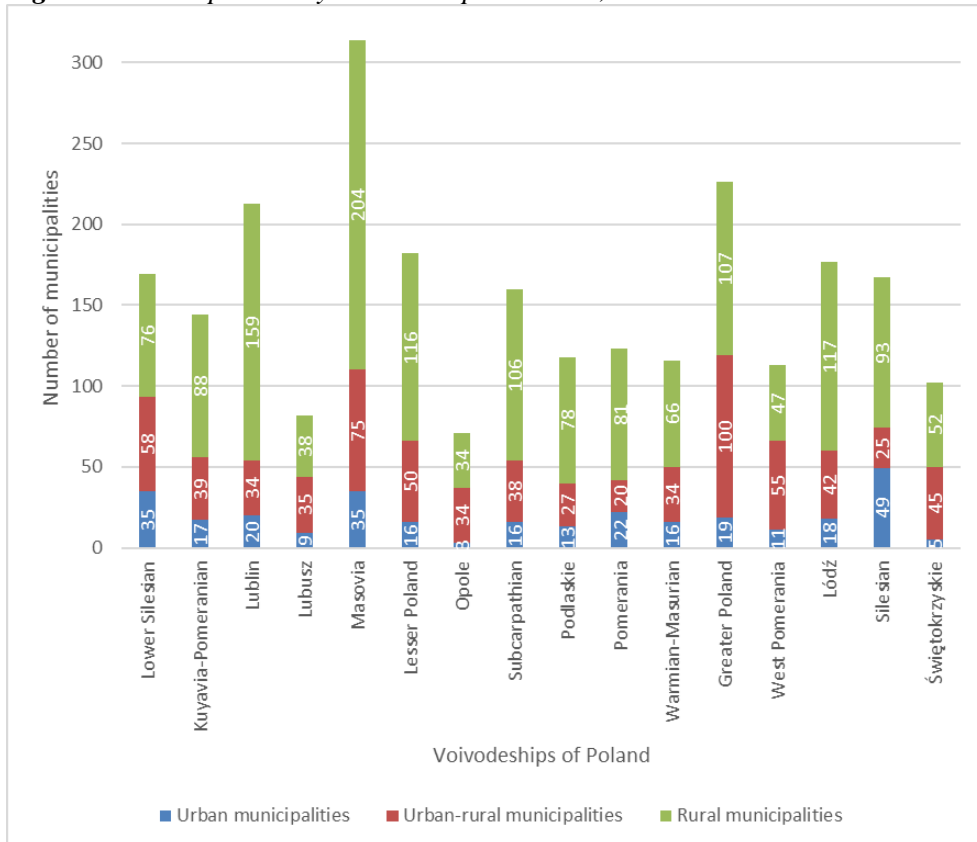
Source: Own calculations based on JST database of Ministry of Interior and Administration of Poland (2024). <https://www.gov.pl/web/mswia/baza-jst>

Figures 2-3 illustrate that the largest number of rural municipalities is found in the Masovian Voivodeship, with 204 units, making it the region with the highest total number of municipalities. The Greater Poland Voivodeship has a notable 27.1% of urban-rural municipalities, while the West Pomeranian Voivodeship boasts 42.7%.

Urban municipalities, including cities with powiat rights, are most prevalent in the Silesian Voivodeship, which has a considerable number despite their overall smaller share compared to rural municipalities in most voivodeships. The analysis reveals significant regional variations in Poland's administrative structure, with a dominance of rural municipalities overall. Additionally, more urbanized areas, such as Silesia, exhibit a greater proportion of urban municipalities, while less urbanized provinces like Lublin and Mazovia show a clear predominance of rural municipalities.

The Opole Voivodeship displays the most balanced distribution between urban-rural and rural municipalities.

Figure 2. Municipalities by voivodeship in Poland, 2024



Source: Own calculations based on JST database of Ministry of Interior and Administration of Poland (2024). <https://www.gov.pl/web/mswia/baza-jst>

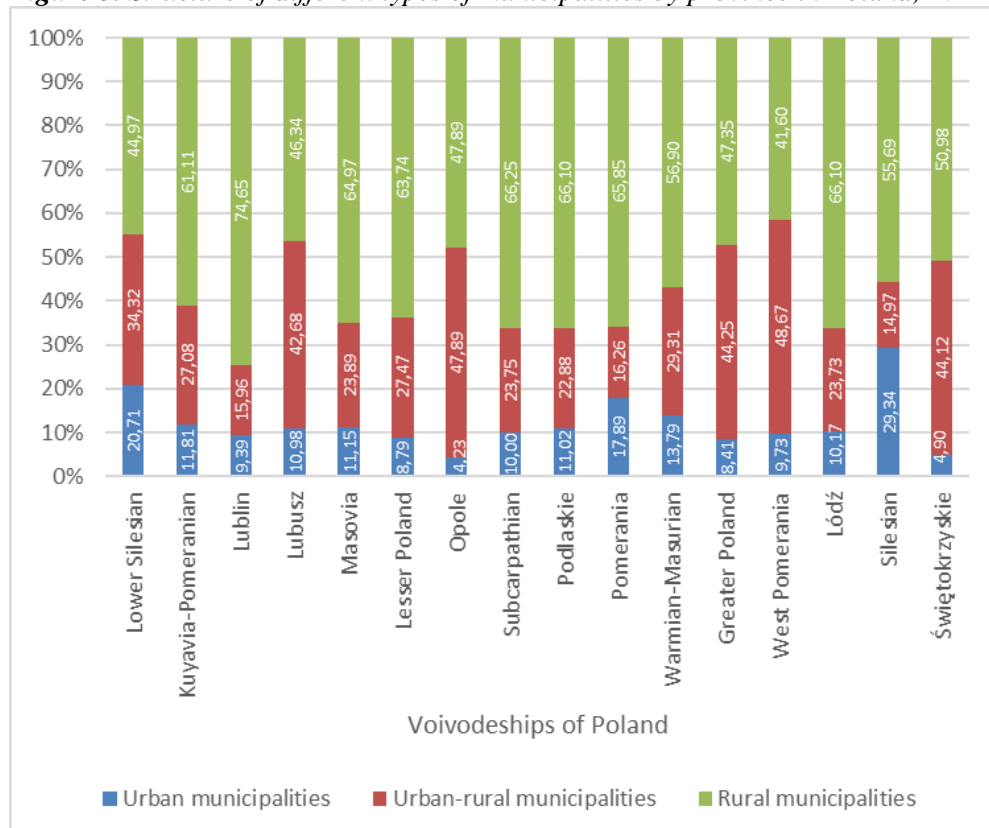
The concept of a smart village, or smart village and municipality, is becoming increasingly popular in Poland. An analysis of the challenges related to the development of smart municipalities in Poland includes, among others, issues of financing, social education, or the need to strengthen the technological infrastructure. Development perspectives point to the need for cooperation between the public, private and social sectors, as well as the potential for the development of smart municipalities in smaller towns and rural areas.

We will mention some examples of the use of distinct elements of the Smart concept:

A pilot smart village as part of the Smart Village Poland project as an initiative of the Ministry of Development. Villages were selected to test various technologies and

solutions to improve the quality of life of rural residents. For example, solutions from smart energy systems, waste management or e-government were used.

Figure 3. Structure of different types of municipalities by province in Poland, 2024



Source: Own calculations based on JST database of Ministry of Interior and Administration of Poland (2024). <https://www.gov.pl/web/mswia/baza-jst>

The municipality of Lisków in the Wielkopolskie Voivodeship modernised the public space and road connections around the Community Cultural Centre, including the installation of 16 innovative hybrid wind-solar streetlights. The project has improved transport in the municipality, improved access for the disabled and elderly and increased safety for all residents after dark. The energy-efficient streetlights have also improved the municipality's cash flow, meaning that more funds are available for local development activities (ENRD, 2022a).

Use of modern technology on farms. More and more farms in Poland are using intelligent solutions, such as soil moisture sensors, crop monitoring systems or automation of agricultural processes. This makes it possible to optimise production processes and increase efficiency. In Tomaszyn, Olsztynek municipality in the Warmian-Masurian Voivodeship, an Agricultural Production Cooperative was

established under the Smart Rural 21 programme. The Ostoja Nature Cooperative is the ‘agricultural ecosystem of tomorrow’, a closed loop ecological farm that uses waste as fuel and enables year-round food production, ensuring higher yields with minimal environmental impact (Weisbrod, 2023, pp. 6-8).

Another example is the ‘Angel Gardens’ project, which helps to create small organic family farms and support them in the production of organic vegetables, fruits, herbs and flowers. It includes education through practical workshops as well as online guidance, conducting it on a national scale. New methods of organic farming have been implemented, such as ‘energy-efficient raised borders’. Communication tools are in place to quickly scale and implement the Angel Gardens idea nationwide (ENRD, 2021).

Development of digital infrastructure. As part of programmes funded by both EU and national funds, many villages in Poland are being provided with access to high-speed internet and digital infrastructure. This is a key element in the development of smart villages, enabling residents to use modern technologies in their daily lives.

There are numerous examples of the implementation, dissemination and practical use of various Smart City / Municipality mobile applications, such as the Environmental and Public Safety Monitoring System in the Municipality of Boguchwała in the Subcarpathian Voivodeship, the Nakielska Mobile Application in the Municipality of Nakło nad Notecią in the Kuyavian-Pomeranian Voivodeship, the Rawicz Mobile Application in the Municipality of Rawicz in the Greater Poland Voivodeship, the My Local News mobile application of the Municipality of Wólka in the Lublin Voivodeship and many others.

A good practice for linking education and innovation in villages is Płońsk in the Mazovian Voivodeship, where a company has been set up to reach the smallest villages with an offer of innovative activities for young people to explore innovative ways of gaining knowledge and learning about modern technologies (robotics, 3D printing, electronics), usually only available in cities. The project has created 12 mobile robotics learning stations for children and six stations for mnemonic training with seniors (ENRD, 2022b).

Initiatives by local leaders. Many villages in Poland are developing thanks to the involvement of local community leaders. One example is the municipality of Skołyszyn in the Subcarpathian Voivodeship, where the inhabitants, together with the local government, implement projects on renewable energy sources or waste recycling (Gmina and Skołyszyn, 2020).

Another example is the municipality of Gostycyn in the Kuyavian-Pomeranian Voivodeship. As part of this project, a group of local actors began to create and develop a thematic village based on its industrial past, shaped by the presence of underground lignite mines.

The project activities included a number of investments, such as the creation of an underground ecomuseum, the reconstruction of elements of an adit mine, the development of a nature trail and the establishment of a pottery house. As a result, the small Polish village has become a tourist destination (ENRD, 2015).

Use of renewable energy. In some villages, projects using renewable energy are being developed, such as the installation of photovoltaic panels on residential roofs and wind farms. This makes it possible to reduce dependence on traditional energy sources and to reduce CO₂ emissions.

As an example, we can mention ongoing projects to use renewable energy infrastructure and implement intelligent energy management systems in the Municipality of Wierzbica in the Lublin Voivodeship, the Municipality of Zduny in the Łódź Voivodeship, the Municipality of Żukowo in the Pomeranian Voivodeship and many others.

These examples are diverse in terms of space, socio-economic structure, population, nature of the smart initiative identified. At the same time, they show that the smart village concept is present and developing in Poland, bringing benefits to both rural residents and the local community as a whole.

As part of the research on the implementation of the Smart Village concept in Polish municipalities, a series of interviews was organised with representatives of selected municipalities conducted from January to September 2024. The research comprised open-ended questions relating to the barriers encountered in the implementation of the concept in practice and to the smart solutions introduced, relevant from a local point of view.

The interviews aimed to gather information on experiences, benefits, challenges and future perspectives related to the implementation of smart solutions in municipal management. The interviews were conducted using a semi structured method, which allowed for flexible adaptation of the questions to the specifics of each municipality and freedom to explore interesting themes. The interviewees were employees of the municipal administration responsible for the implementation of municipal development solutions.

Based on interviews with experts involved in municipal development strategy, the differences in needs and approaches to innovation in municipalities are analysed, as well as the importance of flexible and dynamic strategic planning that enables adaptation to changing conditions and community needs. Key citations from the interviews:

‘In order to receive funding from the European Union, every project, even the smallest, must be written into the development strategy beforehand. This can lead to a situation where certain community needs are not taken into account in time. The

need for precise strategic and operational planning, as well as accurate foresight of the community's activities in the short and medium term, is crucial' (interview, institution 1).

'Innovation and smart solutions for each municipality are radically different. For one municipality, a pavement or an illuminated space is already an innovation and a pressing need. For another, it's smart transport management systems, smart apps and energy-saving measures. It all depends on the foundations and previous development of the community' (interview, institution 2).

'Pilot projects are already enshrined or are yet to be incorporated into the strategy. It is worth emphasising that each of these projects requires careful preparation, justification and adaptation to the specific needs of the community. This means that strategic planning needs to be flexible and take into account the possibility of changes as projects are developed and implemented. In addition, it is important to ensure that the various initiatives work together to achieve maximum efficiency and synergy from the changes implemented. In this way, the strategy becomes not just a document, but a living process that is constantly evolving and improving' (interview, institution 3).

According to the analysis of the data received during the interviews:

1) the practical benefits from implementing the separate tools of the Smart concept include:

- the implementation of smart street lighting management systems, which has reduced energy consumption and improved the safety of residents;
- the introduction of an e-government system, which has simplified administrative procedures and increased the transparency of the municipality's activities;
- the creation of local community centres, which has increased social involvement and integration of residents;
- the implementation of an air quality monitoring system, which has allowed a rapid response to pollution.
- the development of intelligent transport systems, which improved the mobility of residents and reduced traffic jams;
- the implementation of intelligent waste management systems, which increased recycling efficiency and reduced waste.

2) some of the barriers encountered in the implementation of the concept include:

- high investment costs and lack of sufficient financial resources for further development;
- resistance of residents to use new technologies and low awareness of their benefits;
- limited funds for maintenance and development of community or integration centres;
- problems integrating new systems and applications with existing infrastructure;
- high maintenance costs of the transport management system;
- lack of awareness among residents about the benefits of recycling and other

elements of the smart concept.

3) to prospects:

- planning the development of e-services for residents and further investment in technology infrastructure;
- developing educational programmes for residents to increase acceptance and skills in using the proposed technologies;
- seeking public-private partnerships to secure funding for the future;
- expanding the monitoring system with additional sensors and working with environmental organisations;
- introducing more efficient transport solutions, such as car- and bike-sharing;
- educational campaigns to raise environmental awareness among residents.

Interviews conducted with representatives of municipalities showed that the implementation of the Smart Village concept brings significant benefits, such as improving the quality of life of residents, increasing the efficiency of public services and promoting sustainable development.

However, municipalities also face numerous challenges, including high investment costs, public resistance and problems integrating new technologies into existing infrastructure. In order to successfully implement the smart concept, it is necessary to raise additional funds, develop educational programmes and cooperate with the private sector.

The conclusions from the interviews and the literature analysis provide valuable insights for the further development of the Smart Village concept in Poland, emphasising the importance of the synergy between technology, community and sustainable development.

Sustainability is a key aspect in the implementation of smart municipalities, which includes emission reduction, resource efficiency, social inclusion and solving the challenges of the process. The implementation of smart solutions should take into account the needs of modern society, strike a balance between economics, the environment and society, and promote innovation for sustainable local development.

Despite the numerous benefits, the development of smart municipalities also involves certain challenges. These include data security, accessibility for all social groups, implementation costs and the need to constantly adapt to technological changes.

A considerable number of diverse issues have been investigated in the literature, related to the details of implementing the distinct tools of the smart concept in Poland. In this context, a study by Budziewicz-Guźlecka and Drożdż (2022) identified a number of energy challenges of a smart village. These include the lack of awareness of the environmental impact of energy, the low level of public knowledge about new energy solutions and the lack of public trust in modern energy

solutions in rural areas. An important challenge is highlighted by Feltynowski (2022), who draws attention to the possibility of cooperation between municipalities in the provision of infrastructure services, which can lead to more efficient management of these resources, as well as allow for the reduction of administrative service costs.

Wójcik and Jeziorska-Biel (2023) assert that the benefits include capturing the sense and motivation for action, finding a sense of influence and agency, returning to the idea of social action, building on resources, developing strategies to alleviate the social problems that afflict them, making the space a friendly and functional place.

Among a number of problems, the researchers include inefficient bureaucratic mechanisms, the facade of projects, the short-sightedness of local plans and strategies, the template nature of implemented solutions, the lack of a comprehensive (nationwide) programme of village renewal and many other ineffective or even negative actions that distort the actual idea of programme implementation.

Due to the digitalisation of urban spaces and rural spaces, Kos et al. (2022) point out that cybermobility will allow for a more efficient realisation of the needs of the human of the future, for the elimination of the basic transport challenges of the modern world, will contribute to the reduction of external costs of the operation of transport systems, will accelerate the implementation of various economic processes, and will eliminate competence gaps in the labour market.

Nevertheless, the emergence of new challenges has been identified, which we have not dealt with on a massive scale so far. These will be related, among other things, to changes in the way in which needs are met and the challenges of new land use (Kos et al., 2022).

Addressing these issues requires cooperation between the public, private sector and civil society and a partnership and inclusive approach. It is also important to strictly comply with data protection legislation and ensure transparency in the collection and use of data in smart projects.

Based on an analysis of aspects of the implementation of the smart municipality concept, the article attempts to systematise the advantages, challenges and prospects for sustainable development of the Polish countryside (Table 1).

Table 1. Implementation of the smart municipality concept: advantages, challenges, developments

| Advantages (benefits) | Challenges | Development directions |
|---|---|--|
| Efficiency of public services: As a result of the use of technology, smart municipalities can provide | Data security: Where data is collected, processed and shared on a large scale, there is a risk of | Education and public participation: It is important to promote public awareness of the |

| | | |
|--|---|---|
| <p>more efficient and tailored public services to residents, leading to increased public satisfaction.</p> | <p>data privacy and security breaches. Attacks by hackers can lead to the theft of personal data, interruption of services or manipulation of information. It is therefore important to ensure that adequate safeguards are in place, as well as systems to monitor and respond to potential threats.</p> | <p>benefits of the smart municipalities concept and to encourage residents to actively participate in the process of planning and implementing space solutions.</p> |
| <p>Sustainable development: The smart-municipality model promotes sustainable development through reduced resource consumption, reduced emissions, and better management of urban infrastructure.</p> | <p>Implementation costs: The introduction of smart municipality infrastructure and systems involves high investment costs, both in the initial implementation phase and in the longer term associated with maintenance and updating. Some municipalities may find it difficult to raise sufficient funding for this purpose, which may delay or limit the implementation of the relevant tools.</p> | <p>Sustainable mobility: The development of intelligent transport systems and the promotion of alternative means of transport can help reduce traffic congestion, air pollution and improve the quality of life in cities.</p> |
| <p>Innovation: Smart municipalities are becoming places for testing and implementing new technologies, which attracts investments, talents, requires creative decisions and approaches to their implementation and promotes economic development.</p> | <p>Need to continually adapt to technological changes: Technologies are evolving rapidly, meaning spaces need to continually update their solutions to keep up with technological advances and maintain their efficiency. The need to constantly adapt to new technologies can be a challenge for both infrastructure and management, and also requires significant financial outlays. Lack of continuous development can lead to systems becoming outdated and spaces losing their competitiveness.</p> | <p>Innovative financing model: Searching for new models for financing projects implementing elements of the smart municipalities concept, such as public-private partnerships or EU funds, to help cover costs and increase scalability.</p> |
| <p>Improving the Quality of Life: Thanks to improvements in the areas of transport, safety,</p> | <p>Accessibility for all social groups: When implementing smart technologies in municipalities,</p> | <p>Development of digital infrastructure: Providing access to fast and reliable</p> |

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| health care and education, the concept of smart municipalities contributes to improving the quality of life of residents. | there is a risk that some social groups may be left out or excluded from using new services and solutions. It is important to ensure that innovations are accessible to all residents, regardless of their social status, age or technical skills. Lack of equal access can deepen social inequalities. | communication networks is crucial for the development of smart municipalities, especially in rural areas. |
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Source: Author's own work.

Kalinowski *et al.* (2019) indicate that local authorities, leaders and residents want to change their living conditions. They do not want to wait passively for help but face the challenges of contemporary local development themselves. They are looking for solutions that can serve this purpose. They create associations, foundations and join various organizations to be able to apply for funds - larger and smaller (Kalinowski *et al.*, 2021, p. 129).

Research on the benefits of implementing the smart municipality concept emphasizes improving the efficiency of public services, increasing social involvement and achieving sustainable development. However, the analysis of challenges indicates the need to cope with problems related to privacy and data security, insufficient technological infrastructure and high implementation costs.

Despite the numerous benefits, implementing sustainable development in smart municipalities also faces challenges. One of the main challenges is balancing economic, social and environmental efficiency. In addition, there are opposite concerns related to data privacy, excessive dependence on technology and the possibility of digital inequality.

The development prospects of the smart municipality concept include the development of new technologies, such as artificial intelligence, the Internet of Things, and even blockchain, which can further increase the efficiency of spatial management. In addition, it is important to continue research on the effectiveness and impact of smart municipalities on the environment, society, and economy.

The findings of this article highlight the significant potential of smart municipality initiatives in enhancing sustainable development and improving the quality of life for residents. The analysis demonstrates that the integration of modern technologies, such as IoT and big data, can lead to more efficient resource management and foster greater community participation in decision-making processes.

However, while these results are promising, they warrant a critical examination. The statistical analysis and case studies presented indicate that while smart solutions can

streamline public services, the actual implementation often faces substantial challenges. These challenges include high initial costs, technological integration issues, and varying levels of digital literacy among residents. The article emphasizes that without addressing these barriers, the full benefits of smart municipalities may not be realized.

Moreover, the findings align with the work of other researchers in the field. For instance, Kalinowski *et al.* (2021) also underscore the importance of public participation and the need for tailored technological solutions that cater to the specific needs of different communities.

Similarly, studies by Adesipo *et al.* (2020) emphasize the role of smart technologies in agricultural efficiency, reflecting a broader trend in the literature regarding the transformative potential of digital solutions in rural settings.

Furthermore, the challenges identified in this study echo concerns raised by Budziewicz-Guźlecka and Drożdż (2022), who point out that the lack of public awareness and resistance to change can hinder the adoption of innovative solutions. Thus, the present study not only contributes to the existing body of knowledge but also reinforces the notion that successful implementation of smart solutions requires a holistic approach, encompassing technological, social, and educational dimensions.

In conclusion, while the article provides valuable insights into the benefits and challenges of smart municipalities, it also highlights the necessity for ongoing research and collaboration among various stakeholders to overcome the barriers to implementation. Future studies should focus on longitudinal analyses to assess the long-term impacts of these initiatives on rural communities and explore strategies for enhancing public engagement and reducing digital exclusion.

5. Conclusions, Proposals, Recommendations

Smart municipalities are the future of local development, integrating innovative technologies with the principles of sustainable development. Through the effective use of information and communication technologies, municipalities can contribute to improving the quality of life of residents, the efficiency of public services and environmental protection.

However, to achieve the full potential, it is necessary to constantly adapt to technological changes, engage the local community and search for innovative financial solutions.

The implementation of modern technologies is crucial for the effective management of rural spaces. Smart municipalities, using technologies such as IoT, artificial intelligence or blockchain, can significantly improve the efficiency of management processes, the quality of public services and the quality of life of residents. These

technologies enable better monitoring and optimisation of resources, which contributes to sustainable development.

To achieve the full potential of smart municipalities, it is crucial to increase awareness and educate residents about available technologies and their benefits. Information campaigns, training programs and workshops can help residents better understand and use modern technologies in their daily lives. Only through active community involvement can lasting effects and full integration of technologies be achieved.

Effective implementation of the smart municipalities concept requires cooperation between the public and private sectors. These partnerships allow for combining resources and competences, which speeds up the process of implementing technology. Examples of joint projects, such as the construction of communication infrastructure or waste management, show that cooperation can bring tangible benefits to both parties and the entire local community.

One of the main challenges is to ensure equal access to technology for all residents, regardless of their age, social status or place of residence. Programs to combat digital exclusion, such as free training or access to fast internet, are essential to create an inclusive community using modern technologies. This is the only way to prevent the marginalization of certain social groups.

The implementation of the smart municipalities concept should always take into account the principles of sustainable development. Optimizing energy consumption, reducing CO₂ emissions, managing natural resources and promoting a circular economy are key elements of this process. Intelligent management systems, such as air quality monitoring or waste management systems, contribute to environmental protection and improving the quality of life of residents.

Analysis of specific cases of implementation of the smart municipalities concept, both in Poland and abroad, provides valuable conclusions and inspiration for other municipalities. Projects such as the installation of photovoltaic panels, intelligent street lighting systems or the development of digital infrastructure show that smart municipalities can bring real benefits.

It is important for local authorities and communities to actively share their experiences and learn from each other. The future of smart municipalities is associated not only with the adaptation of the latest technologies, but also with the development of modern management models and strengthening social ties.

Technologies such as artificial intelligence, big data and blockchain open up new opportunities for the development of smart villages. Local authorities should remain open to innovation and continue to cooperate with residents and external partners to create more sustainable and integrated communities.

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