



Innovative Technologies for Bionic Transformation of Rural Areas

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Abstract: *This article elaborates on the current trends in rural areas in the EU related to smart rural development. It presents different models of smart villages that can increase the attractiveness of rural areas and create favorable conditions for local businesses and entrepreneurship.*

Special attention is given to bionic transformation as a new and emerging potential of rural regions to create new jobs, stabilize rural populations and strengthen the economic resilience of non-urban areas. Several examples – European successful case studies are presented.

Conclusions lead to the innovation of the smart village approach through bionic transformation, the development of a common strategic framework to support the implementation of different models based on rural areas' specifics and a common platform for the cooperation and exchange of ideas and solutions with different stakeholders.

1. EU RURAL DEVELOPMENT POLICY

Rural areas make up 83% of the territory of the European Union, where 30% of the European population lives, and this share has been decreasing for the past fifty years. These sub-areas are extremely important for the future development of the EU, as they ensure food production, renewable energy sources, climate neutrality, preservation of biodiversity, etc. Therefore, the quality of life of almost one-third of the people in the EU depends on the quality and level of rural development, which further determines the conditions for the development of rural entrepreneurship. In this respect, regardless of the country, most rural areas within Europe are still suffering from a variety of problems related to the low level of entrepreneurship and digitalization, the outflow of mostly young residents and the ageing population. Since its establishment, the European Union (EU) has been actively implementing rural development policies aimed at promoting economic, social and environmental well-being in rural areas. The primary instrument used by the EU for rural development is the Common Agricultural Policy (CAP)⁴, which has undergone several reforms over the years. Today, the core objectives of CAP are as follows:

- Improving agricultural productivity: The EU supports farmers through financial assistance, research and innovation programs and measures to promote modernization and technological progress in agriculture.
- Ensuring a decent life for farmers: The CAP provides direct income support to farmers, helping to stabilize their incomes and maintain their competitiveness.

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⁴ The strategic regulation that governs the CAP is Regulation (EU) 2021/2115 of the European Parliament and Council of December 2, 2021 on establishing rules on support for strategic plans drawn up by member states within the framework of the Common Agricultural Policy (strategic plans within the CAP) and which are financed from the European Agricultural Guarantee Fund (EAGF) and the European Agricultural Fund for Rural Development (EAFRD) ([European Union, 2021](#))

- **Balancing territorial development:** The EU recognizes the importance of maintaining balanced territorial development throughout the region. It aims to reduce disparities between rural and urban areas by supporting investments in rural infrastructure, services and other local initiatives.
- **Increasing competitiveness:** The EU seeks to make European agriculture more competitive in the global market by supporting market-oriented agricultural activities and encouraging value-added processing.
- **Promoting sustainable management of natural resources:** The CAP integrates environmental care by supporting environmentally sound practices such as organic farming, agro-forestry and sustainable land management.
- **Fostering innovation and job creation:** The EU promotes research, development and innovation in rural areas to foster economic diversification and create employment opportunities beyond traditional agricultural activities.
- **Fostering cooperation and networking:** The EU encourages rural communities to work together through various cooperation initiatives, such as LEADER (Liaison Entre Actions de Développement de l'Économie Rurale) groups, which support bottom-up local development strategies.

The EU's 2021-2027 Multiannual Financial Framework was adopted on 17 December 2020. The CAP MFF is EUR 1.21 trillion with an additional EUR 808 billion from the next-generation EU Recovery and Resilience Facility. The total amount for the common agricultural policy is EUR 386.6 billion divided between the two funds (often referred to as the “two pillars” of the CAP) ([European Commission, n.d.](#)):

The European Agricultural Guarantee Fund (EAGF) as the “first pillar” has an allocation of EUR 291.1 billion. An amount of EUR 270 billion will be provided for income support schemes and the rest will be earmarked to support agricultural markets. The European Agricultural Fund for Rural Development (EAFRD) as the “second pillar” of the CAP has a total allocation of EUR 95.5 billion. This includes EUR 8.1 billion from the EU Recovery and Resilience Facility to help address the challenges posed by the COVID-19 pandemic.

Each of the EU Member States adopts its program or programs at the national level that are consistent with the common agricultural policy and its objectives. However, in the next programming period, a joint effort is to develop smart villages and bionic transformation of economic activities related to rural development.

2. RURAL DEVELOPMENT THROUGH SMART VILLAGES

The idea of a “smart village” generally implies ensuring a high quality of life for the population through a culture of lifelong learning and acceptance of innovations while preserving cultural tradition and heritage ([Maja et al., 2020, p. 152021](#)). A smart village is defined as a village where development breakthroughs are integrated with information technology systems and innovation for the benefit of local communities ([Adamowicz, 2021, p.20](#)). This concept was introduced in 2015 by the international community through development assistance initiatives in Asia and Africa addressing issues such as energy availability, education, access to health care and water and food security. Today, smart villages are a globally recognized concept of rural development - sophisticated ecosystems involving different stakeholders, similar to smart cities. Their main goal is to raise the standard of living of rural communities, and promote development and sustainability ([Maja et al., 2020, p. 152030](#)).

Unlike well-defined definitions, the notion of a smart village depends on the context, adapting to the specific conditions and social challenges of each community. However, all smart villages share the characteristics of using technology, fostering entrepreneurship and prioritizing sustainable development, stimulating economic growth and innovation. The goal of smart villages is to improve well-being by adopting community-driven technologies and solutions that are tailored to the specific requirements and circumstances of the communities they serve (Calzada, 2023, p. 6).

The smart village concept assumes that the continuous development of technology can open up new opportunities to generate income and provide services in rural areas (Dubois & Sielker, 2022., p. 1776). This idea must be combined with other efforts under a well-thought-out and socially acceptable rural development program to significantly raise living standards in rural regions. In addition to traditional investments in infrastructure, this includes business sector development, investment in human capital, civil society development, access to public e-services, environmental protection through circular economy practices, and innovative information and communication technology (ICT). In smart villages, the implementation of locally defined smart specializations in areas such as tourism, culture, promotion of local products, including agricultural and food products, is also expected (Adamowicz, 2021, p. 9).

The development of the community into a smart village depends on a complex process of digital transformation and good governance in the local community (Satola & Milewska, 2022, p. 6) The introduction of digital technology in local government ensures the improvement of the accessibility and quality of public services, the encouragement of transparent decision-making and the active involvement of residents in the discussion and decision-making on the most important local issues. In doing so, the key challenges in this process are the limited awareness and competencies of local government and stakeholders, the need for change in organizational culture, technological and financial barriers and the imperative to create cooperation relationships among all stakeholders.

Smart village as a concept in European rural policies has come to life in the last ten years as a holistic approach to community development with an emphasis on integrating digital technologies into the process of providing services such as artificial intelligence, the Internet of Things, robotics and blockchain technology. One of the cornerstones of smart village development in the EU is fostering a creative rural economy. This implies the development of better employment opportunities, though, for example, the development of tourism, the preservation of cultural heritage and food production as the backbone of a new entrepreneurial atmosphere among the local population. Improving the spatial aspects of rural areas includes the preservation and accessibility of green areas and parks in villages and the preservation of the quality of agricultural land. The socio-cultural component of the development of smart villages in the EU includes the growth of highly educated inhabitants in villages and encouraging them to stay in the village. Instead of migration of rural population to urban centers, the strengthening of economic and social development of urban and rural areas is encouraged. In doing so, improving the information and communication infrastructure within the village ensures seamless connectivity and access to modern services serve (Wojcik et al., 2021, p. 4).

3. KEY ASPECTS OF TRANSFORMING RURAL COMMUNITIES INTO SMART VILLAGES

For a rural community to become a smart village, the digital transformation of local government is key. This process involves the use of digital technologies and platforms to improve public services, thus ensuring the acceleration of decision-making by encouraging the involvement

of the community in the reflection and planning of local development and increasing the transparency of work. Digital transformation changes the type, scope and ways of providing public services from the exclusive implementation of individual services to the planning and directing the desired development. In addition to their growth through the digital transformation process, local governments also provide access to information and communication technology skills and cybersecurity for all citizens.

Table 1. Advantages and Challenges

Advantages	Challenges
<ul style="list-style-type: none"> • Improving public services by using digital technologies • Increase in local government skills in working with digital technologies • Increase in knowledge of local population in the use of digital technologies • Remaining highly educated population in local communities • Involvement of local people in development decisions • Development of new economic activities (tourism) • Preservation of spatial units • Using modern technologies such as artificial intelligence, the Internet of Things, robots and blockchain 	<ul style="list-style-type: none"> • Low level of awareness and competence among residents • Building physical infrastructures for digital transformation of local communities • Transforming organizational culture in local government • Overcoming technological barriers • Overcoming financial obstacles • Establishing effective cooperation between all local stakeholders • Connecting with urban areas

Source: Own research

One of the key challenges in the digital transformation of rural communities in smart villages is related to the inclusion of the local population in development decision-making processes. Furthermore, there is often a low level of awareness and competence among residents regarding the use of information technologies, which indicates the necessary transformation of work and organizational culture, overcoming technological and financial obstacles and establishing effective cooperation with other stakeholders, so that an increasing number of people with higher education will lead to digital transformation (Anabestani & Kalateh Meymari, 2020, p.145).

The process of transforming rural communities into smart villages is visible under the following smartness dimensions:

- Smart People – the activities implemented focus on education (organization of training on computer skills, graphic design, regular science and sports festivals), sports (organization of sports competitions), joint spending of time and integration of the local society.
- Smart Economy – the activities support starting and running a business and testing new ideas for products and activities. Some examples are the development of a Social Entrepreneurship Incubator and activities for the older generation to combat digital exclusion to abolish surtax, communal contributions, consumption taxes, taxi license fees and utility fees for hotels and camps.
- Smart Environment – the activities support the circular economy, recycling, promote awareness of environmental protection and the use of renewable energy.
- Smart Governance – the activities supporting innovative solutions for accessing information and communication with the local population via digital tools. People can access e-referendum to take part in local decisions and they can evaluate employees of municipal administration online. Also, the local population can submit their ideas (even unrealistic ones) and choose directions of development and implementation of plans.

- Smart Living – the activities support access to modern premises, communal infrastructure, health and social welfare services, schools and libraries, as well as multiple associations and institutions (sports, culture, veterans, pensioners associations).
- Smart Mobility - the activities support free local public transport and free transport connections with surrounding urban areas. Also, the road infrastructure and parking lots have been improved.
- Smart People – the activities support decision-making via e-referendum, the unemployed can engage in motivation and learning educational workshops, e-access to services, and the Internet. All activities will support young residents to return and settle in the village.

To realize the digital transformation of smart villages in its entirety, all these aspects should be included. In this way, the integrated concept of a smart village is realized, which implies a commitment to technology integration, community involvement, sustainable development, effective communication and economic empowerment (Kagungan & Rosalia, 2022, p. 174).

4. EXAMPLES OF GOOD PRACTICE: FROM URBAN INSPIRATION TO RURAL ACTION

In 2023, a survey of the European smart village concept was conducted through activities within the Interreg Central Europe project (CE100085) MTAV “Smart Village Transition, a model for more competitive and attractive villages in Central Europe / More than a Village”. Five smart villages were analyzed: Babina Greda (2021) (Croatia), Sveta Nedelja (n.d.) (Croatia), Pomurje Region (Slovenia), Mniszek village (n.d.) (Poland) and Pottery Village (n.d.) (Poland). Common characteristics of these local communities are development challenges faced by a small number of residents, an aging population, the departure of young educated people to cities, poor transport connections and insufficient communal infrastructure. The smart transformation process responds to some of these challenges in order to increase the quality of life of people in rural areas. The key development steps of these rural communities are visible through the developed smart strategic development plans in which they have focused on the smart approach to development. Also, the digitalization of local government was implemented and all relevant stakeholders were actively involved in the creation of smart villages through the bottom-up development approach.

The specificities of individual approaches in the formation of smart local communities are related to the emphasis on the digital transformation components. Thus, some smart villages have a strong connection with the academic community on their way to digitization, some villages have opted for the digitization of local supply chains for selling local products (e.g. farmers to pay mobile applications), or for building modern living facilities with modern technologies as in urban areas.

The findings of the research indicate that all five smart villages analyzed have a common understanding of the need, process and implementation of digital transition. They all agree that the development of a Smart Village Strategy is an initial step that helps in identifying challenges and setting goals, enabling the allocation of resources needed to implement the right actions. In order to create and implement an effective smart village strategy, it is necessary to analyze the advantages of the area and create a resource base, as well as to describe the needs and set an end vision to be progressively achieved. It is important to stipulate in the Strategy the importance of innovation, the importance of community engagement and cooperation in the process of strategic planning. It emphasizes the importance of embracing new technologies to enhance the efficiency of the environment, create competitiveness and promote sustainable practices.

The success of the Smart Village strategy planning process as well as implementation largely depends on the active involvement and cooperation between stakeholders, including local authorities, educational institutions, and experts, and the readiness of a community to support and embrace innovations and adapt to changes. Involving and informing all local stakeholders about the possibilities and plans for smart village development in order to improve living conditions ensures a broad view of the development needs of the entire community. Involvement of local government as well as NGOs is very important, as they activate, monitor progress, encourage and support in critical situations, fatigue, or lack of spectacular successes (especially at the beginning). Active involvement and cooperation between stakeholders including local authorities, educational institutions, experts but also the villagers themselves guarantees the success of the implementation of the smart village strategy.

5. CONCLUSION AND RECOMMENDATIONS

The idea of “smart villages” is a framework for transforming rural development by providing creative responses to the specific problems that rural regions face. Inadequate transport infrastructure, limited access to digital services and negative demographic trends such as ageing population and migration to urban centers are just some of the problems that rural communities often face. These difficulties can be an obstacle to economic development and general quality of life, but they also act as incentives for creativity. Through innovative solutions, digitization, and community involvement, smart communities can be a framework to address some of these challenges. Through the implementation of the concept of smart villages, it seeks to improve the quality of life of the rural population, increase the provision of public services and promote economic growth and development with an emphasis on the use of digital technologies and digital solutions.

For the past ten years, the European Union has also committed to reducing the digital gap and improving access to networks and digitization of rural areas by encouraging projects and investments aimed at creating smart rural communities. This includes the thoughtful use of digital technology to improve public service delivery, speed up decision-making processes, increase transparency and actively involve local citizens in local government. The importance of this strategy has been underlined by the recent acceleration of digitization caused by the COVID-19 pandemic and is expected to play a significant role in the development of smart villages in the future.

Public services in rural areas cover a wide range of tasks, including local infrastructure maintenance, health care and education. The transition from conventional service delivery to new methods, such as co-production and co-creation, active citizen involvement in service delivery, are led by smart villages. With this transition, public services will become not only more efficient but also better adapted to the unique demands and ambitions of rural areas.

The path to achieving the full potential of smart villages faces many obstacles such as low involvement and awareness of the rural population, financial constraints for innovative initiatives, limited communication of infrastructure and ageing population. However, these difficulties have developed into opportunities for teamwork and new approaches to communication and the involvement of the local population in planning their development and pointing out good practices and ensuring the exchange of experience and knowledge on the digital transformation of rural areas.

The future of rural development is smart local communities. Smart villages are a development framework to improve the quality of life and foster sustainable development in rural communities by emphasizing digital transformation, the provision of new public services and the active participation of local people in planning the future development of the community. Therefore, further research in this area is needed to assess the benefits and effectiveness of smart village initiatives to date, to develop new concepts and test their adaptability to different rural contexts, and to discover more effective methods and best practices for providing public services in rural areas. In doing so, one of the priorities is to explore the possibilities of coordinating development between rural and urban areas, which should be a priority in thinking about future smart villages. This cooperation can result in improved infrastructure, economic development and joint solutions to societal challenges. Improved cooperation between urban and rural communities can also solve the accumulated problems of overcrowded urban areas, combat localism and encourage interurban cooperation. Smart villages can also, through this cooperation, develop adaptive governance structures to address specific problems caused by urbanization to adapt to the changing landscape of urban regions.

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