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SUSTAINABLE RURAL DEVELOPMENT IN THE CONTEXT OF DIGITAL TRANSFORMATION: THEORETICAL AND METHODOLOGICAL ASPECTS

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В статье на основе сравнительного анализа зарубежных моделей исследуются теоретические и методические основы устойчивого развития сельских территорий в условиях цифровой трансформации. Обоснованы институциональный, системный, территориальный и цифровой подходы, что позволило определить механизмы их реализации, преимущества, ограничения и условия применения. Установлено, что устойчивое развитие сельских территорий обеспечивается посредством интеграции эффективного государственного управления, развития институциональной среды, цифровых инноваций, участия заинтересованных сторон и территориального планирования. На основе результатов сравнительного анализа определены наиболее перспективные направления, которые могут быть адаптированы к условиям развития сельского хозяйства и сельских территорий Ливана.

Ключевые слова: устойчивое развитие, сельские территории, цифровая трансформация, институциональный подход, сравнительный анализ, сельское управление, территориальное развитие.

This article explores the theoretical and methodological foundations of sustainable rural development in the context of digital transformation through a comparative analysis of international models. Institutional, systemic, territorial, and digital approaches are substantiated, allowing us to identify their implementation mechanisms, advantages, limitations, and application conditions. It is established that sustainable rural development is achieved through the integration of effective public administration, institutional development, digital innovation, stakeholder participation, and territorial planning. Based on the results of the comparative analysis, the most promising areas are identified that can be adapted to the conditions of agricultural and rural development in Lebanon.

Keywords: sustainable development, rural areas, digital transformation, institutional approach, comparative analysis, rural governance, territorial development.

Introduction

Sustainable rural development has evolved from an agricultural concept into a multidimensional development paradigm that integrates economic growth, social inclusion, environmental sustainability, institutional effectiveness, and technological innovation. Rural territories are now recognized not only as areas of agricultural production but also as strategic spaces that contribute to food security, environmental protection, regional competitiveness, and balanced socioeconomic development [1, 2]. Consequently, sustainable rural development has become a priority within international policy agendas, particularly following the adoption of the Sustainable Development Goals (SDGs), which emphasize the interdependence of economic, social, and environmental objectives [1, 3].

The rapid development of digital technologies has further transformed approaches to rural development. Broadband infrastructure, precision agriculture, geographic information systems, cloud computing, digital public services, and data-driven decision-making have expanded opportunities to improve agricultural productivity, strengthen governance, and increase the resilience of rural communities [4, 5]. However, international research consistently demonstrates that digital transformation contributes to sustainable development only when supported by effective institutions, coherent public policies, and sufficient human and organizational capacities [4, 6].

D.C. North, E. Ostrom, C. Ray, C. Folke, R. Biggs, A.V. Norström, B. Reyers, J. Rockström, B. Walker, S. Barrett, S. Polasky, I. Scoones highlight that sustainable rural development cannot be achieved through isolated sectoral policies. Institutional, territorial, and resilience approaches emphasize that long-term development depends on effective governance, stakeholder participation, adaptive capacity, and coordinated territorial planning rather than technological innovation alone [7-12].

Belarusian scholars (V.G. Gusakov, N.V. Kireyenka, A.P. Shpak) similarly argue that digital transformation should be regarded as an institutional instrument support-

ing innovation, competitiveness, and balanced territorial development [13-15]. These theoretical considerations are particularly relevant for Lebanon, where rural areas continue to experience fragmented governance, inadequate digital infrastructure, limited investment capacity, and increasing socioeconomic disparities despite their significant agricultural and regional development potential [16-18]. Under such conditions, successful rural development requires not the direct transfer of foreign models but the careful adaptation of international experience to Lebanon's institutional and socioeconomic context.

Against this background, the present study aims to analyze the theoretical and methodological foundations of sustainable rural development in the context of digital transformation through a comparative assessment of international development models and to identify institutional and policy approaches that can be adapted to strengthen sustainable rural development in Lebanon.

Materials and methods

The research is based on comparative analysis, systematic literature review, synthesis, scientific generalization, and classification. Its scientific novelty lies in proposing an integrated analytical framework that combines institutional coordination, territorial governance, resilience, digital transformation, and stakeholder participation to support sustainable rural development in institutionally fragile countries.

Main Part

Evolution of the Concept of Sustainable Rural Development

The concept of sustainable rural development has undergone significant transformation over the past decades, reflecting changes in development theory, environmental governance, and technological innovation (Figure). Over time, this production-oriented perspective proved insufficient, as many rural regions continued to experience poverty, demographic decline, environmental degradation, and weak institutional capacity despite improvements in agricultural productivity. Consequently, sustainable rural development evolved into a multidimensional concept integrating economic growth, environmental protection, social inclusion, institutional effectiveness, and technological innovation [2, 3].

A major milestone in this evolution was the publication of the Brundtland Report (Our Common Future, 1987), which defined sustainable development as development that meets present needs without compromising the ability of future generations to meet their own needs. This definition established the conceptual foundation for balancing economic, environmental, and social objectives within development policy. Although widely accepted, the concept has also been criticized for its broad formulation and the limited guidance it provides regarding practical institutional implementation [1, 2].

Subsequent theoretical developments expanded this perspective. Ecological economics emphasized that economic development must remain within environmental limits, while the concept of planetary boundaries demonstrated the importance of preserving ecosystem resilience for long-term sustainability. These ideas are particularly relevant for rural territories, where agricultural productivity depends directly on the sustainable management of natural resources [19, 20].

At the same time, systems theory introduced a holistic understanding of rural territories as interconnected socio-economic, environmental, institutional, and technological systems. According to this approach, improvements in one area, such as agricultural productivity or digital infrastructure, influence employment, education, environmental quality, public services, and regional competitiveness. Although systems thinking provides an integrated analytical framework, its practical implementation requires effective institutional coordination [21, 22].

The institutional perspective further strengthened the theoretical foundations of sustainable rural development. North demonstrated that effective institutions create stable conditions for long-term development, while Ostrom em-

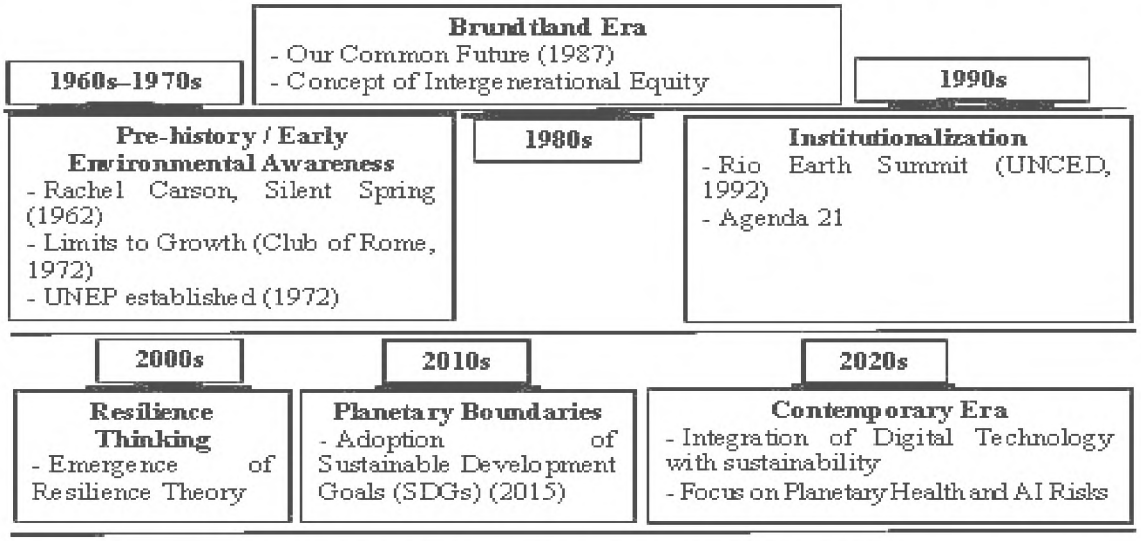


Figure. Evolution of the concept of sustainable rural development

phasized participatory governance and the collective management of common resources. These contributions underline that technological progress alone cannot ensure sustainable development without transparent institutions, coherent public policies, and effective governance mechanisms [7, 8].

The most recent stage in the evolution of the concept is associated with digital transformation. Technologies such as precision agriculture, geographic information systems, artificial intelligence, digital platforms, and electronic public services have expanded opportunities to improve agricultural productivity, public administration, and rural competitiveness. Nevertheless, international experience consistently demonstrates that digital transformation should be regarded as an instrument supporting sustainable development rather than an objective in itself, as its effectiveness depends on institutional quality, governance capacity, digital infrastructure, and human capital [4-6].

This institutional interpretation is also reflected in the Belarusian scientific school. N.V. Kireyenka argues that digital transformation contributes to sustainable rural development only when integrated into long-term territorial planning, innovation policy, and effective public administration [14, 23]. Similarly, V.G. Gusakov emphasizes the importance of coordinated state policies and institutional modernization [13], while A.P. Shpak highlights the role of innovation systems and knowledge transfer in strengthening rural competitiveness [15].

Main Methodological Approaches to Sustainable Rural Development

The systems approach views rural territories as interconnected socio-economic and environmental systems in which changes in one component affect the others, supporting integrated planning but requiring strong institutional coordination and reliable data [10, 24].

The institutional approach emphasizes the importance of governance quality, formal institutions, and regulatory frameworks in shaping development outcomes. D.C. North and E. Ostrom demonstrate that sustainable rural development depends on effective institutions, stakeholder cooperation, and coherent public policies rather than technological progress alone [7, 8].

The territorial approach recognizes that rural territories differ in their resources, institutional capacity, and development potential, requiring place-based policies adapted to local conditions while maintaining national coordination [9].

The Sustainable Livelihoods Approach focuses on strengthening household assets and improving resilience, whereas the resilience approach highlights the capacity of rural communities to adapt to environmental, economic, and social shocks [12].

The digital transformation approach considers digital technologies, including precision agriculture, digital platforms, artificial intelligence, and electronic public services are considered as important drivers of sustainable rural development. However, international experience demonstrates that their effectiveness depends on institutional quality, governance capacity, digital infrastructure, and human capital [4-6, 25].

The results of the methodological comparison are summarized in Table 1, which presents the analytical focus, principal contribution, and main limitation of each approach.

For Lebanon, none of these approaches is sufficient individually. Sustainable rural development therefore requires an integrated analytical framework combining systems thinking, institutional coordination, territorial governance, resilience, and digital transformation while considering national socioeconomic conditions.

Comparative Analysis of International Models of Sustainable Rural Development in the Context of Digital Transformation

International experience demonstrates that sustainable rural development cannot be explained through a single universal model. This study compares three development models representing different governance traditions and levels of institutional capacity: the European institutional model, the state-coordinated modernization model represented by Belarus and selected East Asian countries, and the developing and fragile-country model [13, 14].

The European institutional model represents one of the most comprehensive approaches to sustainable rural development through the Common Agricultural Policy (CAP), the European Green Deal, the Long-Term Vision

Table 1. Comparative Characteristics of the Main Methodological Approaches

Approach	Main focus	Main contribution	Main limitation
Systems	Interaction among economic, social, environmental and institutional processes	Reveals feedbacks and supports integrated planning	Complex to operationalize
Institutional	Rules, organizations and governance capacity	Explains implementation quality and incentives	Reform is gradual and politically demanding
Territorial	Place-specific resources and needs	Supports locally adapted and participatory policies	Local capacity may be uneven
Sustainable livelihoods	Household assets, vulnerability and well-being	Connects policy outcomes to people's living conditions	May understate macro-level constraints
Resilience	Adaptation to shocks and long-term continuity	Strengthens preparedness, diversification and learning	Can become vague without measurable instruments
Digital transformation	Connectivity, data, platforms and digital services	Improves information, access and efficiency	May deepen digital and territorial inequalities

Source: developed by the author on the basis [4; 7, 8; 10; 12; 14; 25].

for Rural Areas, and the Smart Villages initiative [26, 27].

Its principal strength lies in multilevel governance, long-term strategic planning, stakeholder participation, and the integration of digital technologies within broader territorial development policies. Broadband infrastructure, precision agriculture, digital public services, and innovation platforms contribute to both agricultural competitiveness and environmental sustainability. However, this model depends on strong institutions, advanced administrative capacity, and substantial financial resources, limiting its direct applicability to developing countries. Nevertheless, its principles of integrated territorial planning, participatory governance, and digital public administration provide valuable guidance for Lebanon [4, 26, 27].

Within the Belarusian scientific school, N.V. Kireyenka emphasizes that digital transformation should function as an institutional instrument supporting governance, innovation, and territorial competitiveness [23], while V.G. Gusakov highlights the role of coordinated public policy and institutional modernization [13]. A.P. Shpak further stresses the importance of innovation systems and knowledge transfer in strengthening rural competitiveness [015]. Similarly, China's Digital Village Strategy and South Korea's long-term investment in digital infrastructure illustrate how coordinated national policies can accelerate rural modernization. Although this model provides strong strategic coordination and effective resource mobilization, excessive centralization may reduce local flexibility and stakeholder participation [28]. For Lebanon, its principal lesson lies in strengthening institutional coordination rather than replicating centralized governance structures.

The developing and fragile-country model, observed in countries such as Jordan, Egypt, Tunisia, Rwanda, and several Sub-Saharan African states, demonstrates that meaningful progress can be achieved despite financial and institutional constraints [29]. Digital technologies have improved agricultural extension, climate information systems, mobile banking, and digital entrepreneurship through partnerships involving governments, international organizations, civil society, and local communities. The flexibility of this model allows relatively low-cost digital solutions to generate local improvements. However, donor dependence, fragmented implementation, and weak institutional coordination frequently limit long-term sustainability. These challenges closely resemble the current Lebanese context, where numerous successful donor-supported initiatives have remained isolated because they were not integrated into a coherent national rural development strategy [16, 17].

The comparative characteristics of the selected international models and their applicability to Lebanon are summarized in Table 2.

The comparative analysis demonstrates that each model offers valuable lessons while reflecting specific historical, institutional, and socioeconomic conditions. The European model highlights integrated territorial governance, stakeholder participation, and environmental sustainability but requires institutional capacities that currently exceed those available in Lebanon. The Belarusian and East Asian experiences emphasize the importance of strategic planning, institutional coordination, and innovation systems, whereas developing-country experiences illustrate the potential of flexible, context-specific digital solutions despite limited resources.

For Lebanon, none of these models can be transferred directly. Instead, the most appropriate approach is a hybrid model combining the European emphasis on territorial governance and stakeholder participation, the Belarusian focus on institutional coordination and long-term strategic planning, and the flexibility demonstrated by developing countries in implementing affordable digital solutions. Such a model should prioritize strengthening institutional coordination, expanding digital infrastructure, developing human capital, encouraging public-private partnerships, and establishing effective monitoring mechanisms before large-scale technological expansion.

Overall, the comparative analysis confirms that digital transformation alone cannot ensure sustainable rural development. Sustainable outcomes emerge only when technological innovation is supported by effective governance, institutional capacity, coherent public policies, and active stakeholder participation. These findings provide the conceptual basis for adapting international expe-

Table 2. Comparison of International Rural Development Models

Model	Governance	Digitalization	Advantages	Weaknesses	Applicability to Lebanon
European institutional	Multilevel, regulated and territorially programmed	Broadband, smart villages, digital services, innovation platforms	Long-term financing, participation, monitoring and territorial adaptation	High administrative and financial requirements	Useful for territorial planning, local partnerships and monitoring
State-coordinated modernization	Strong national coordination and strategic programmes	Smart agriculture, national platforms, data systems and infrastructure	Rapid mobilization, policy continuity and investment scale	Risk of excessive centralization and limited local flexibility	Relevant for strategic coordination and clear institutional responsibility
Developing/fragile-country	Mixed public, donor, NGO and local delivery	Mobile tools, pilot platforms, digital finance and advisory services	Flexible, targeted and responsive to vulnerable groups	Fragmentation, donor dependence and weak scalability	Reflects current conditions but requires stronger national integration

Source. Developed by the author on the basis [4, 5; 13; 16; 25; 27].

rience to Lebanon's institutional and socioeconomic realities while avoiding the direct replication of foreign development models.

Conclusion

This study demonstrates that sustainable rural development has evolved into a multidimensional concept integrating economic, social, environmental, institutional, and technological dimensions. The analysis confirms that sustainable rural development cannot be achieved through agricultural or technological measures alone but requires effective governance, territorial planning, stakeholder participation, and institutional capacity.

The comparative assessment shows that no single methodological approach or international model is universally applicable. Each provides valuable insights while reflecting specific institutional and socioeconomic conditions. Consequently, sustainable rural development is best understood through an integrated framework combining institutional coordination, territorial governance, resilience, and digital transformation.

The analysis further indicates that international experience should be adapted rather than replicated. The European model contributes principles of territorial governance and stakeholder participation, the Belarusian and East Asian experiences emphasize strategic coordination and innovation, while developing-country models demonstrate the value of flexible digital solutions under resource constraints.

For Lebanon, the findings suggest that strengthening institutions should precede large-scale digital modernization. A hybrid model combining institutional coordination, territorial participation, and context-specific digital solutions offers the most appropriate direction for sustainable rural development.

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ПОСТУПИЛА В РЕДАКЦИЮ 16.07. 2026

Электрогидравлический обкаточно-тормозной стенд

Предназначен *для холодной и горячей обкатки двигателей внутреннего сгорания (ДВС) и создания тормозной нагрузки при обкатке коробок переменных передач и ведущих мостов.*





Основные технические данные

Мощность электрического двигателя для холодной обкатки, кВт	11
Тип тормозного устройства	гидравлический
Мощность торможения, кВт	100
Диапазон регулирования частоты вращения вала электродвигателя, об/мин	500 - 3000
Диапазон частоты вращения гидравлического тормоза (при г/о), об/мин	1200 - 2900
Диапазон измерения частоты вращения, об/мин	
- магнитоиндукционным тахометром	до 3000
- электронным тахометром	до 9999
Диапазон измерения давления масла, Мпа	0 - 40
Диапазон измерения температуры масла, °С	0 -150
Масса стенда, кг	200
Занимаемая площадь, $м^2$, не более	1,5