

Innovative Solutions for Rural Transformation: Fostering Economic and Social Progress

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Abstract. The article presents the results of a study devoted to key aspects of the development of rural areas and the agricultural sector of the economy, which are innovative in nature and directly affect the country's food security in the context of modern challenges and threats. The purpose of the study comes down to the specification of the most important innovations (including digital ones), which are, in fact, necessary prerequisites for achieving local security in terms of, firstly, providing the population with affordable, high-quality and healthy food products, and secondly, the implementation of social and environmental challenges in rural regions. The tasks set to achieve the goal formulated in the work were solved through the use of research methods such as comparative analysis of existing theoretical research in this direction, assessment of the effectiveness of international and domestic practices, as well as relevant political initiatives, forecasting promising trends in the innovative development of the rural economy and rural areas taking into account the existing internal potential and external factors. Important scientific generalizations that have both theoretical and practical significance include the conclusions that (1) the dynamic development of the agricultural sector of the economy in the unfavorable circumstances of climate change and deteriorating geopolitical situation is possible through the active implementation of organizational and technological innovations (including digital) , (2) social innovation and digitalization are important for providing the rural population with essential social and ecosystem services, (3 all types of innovations (technological, social, organizational) are of high importance for the effective involvement of the rural population in the management of local development.

1 Introduction

The task of ensuring food security comes to the fore against the backdrop of threats of a biological, climatic and geopolitical nature, which have led to a transition in the approach to development from the concept of globalization to the paradigm of localization (taking territorial identity, economic independence, maximum local security as key components) [1, 2]. As noted in modern government documents, the Spatial Development Strategy,

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implemented in the Russian Federation since 2019, today requires certain adjustments aimed at ensuring that all Russian regions, firstly, identify centers of economic growth that allow them to effectively use the existing their potential, secondly, to stimulate the development of promising economic specializations to overcome existing inequality in the future, thirdly, to ensure the dynamic development of the agricultural sector of the economy, which is not only a guarantor of the country's food security, but also a condition for the functioning of some other sectors of the economy (mechanical engineering and other industries) [3, 4]. As for agricultural regions, which are the main suppliers of agricultural products and raw materials, the chances of their preservation and their competitiveness are not only strictly linked to the dynamics of development of the agricultural sector of the economy, which is key for them, but also to the social and environmental indicators of their condition (Figure 1). Due to the fact that the success of rural development (including the success of the functioning of the agricultural sector of the economy) and the well-being of the rural population largely depends on how innovative agriculture and other areas of the rural economy are, how widely innovation is used in providing villagers with social and ecosystem services, the structure of the study, the list of predetermined research stages, and then the presentation of the results obtained in this publication, are predetermined by the significance of innovation in various aspects of rural development, namely, (1) the possibility of innovative development of the agricultural sector of the economy, (2) application options innovations in the social sphere and the sphere of ecosystem services, (3) the potential of innovations in enhancing the participation of villagers in the management of local rural development.

**Sustainable economic
development**
Sustainable food growth
Balanced development of production
potential

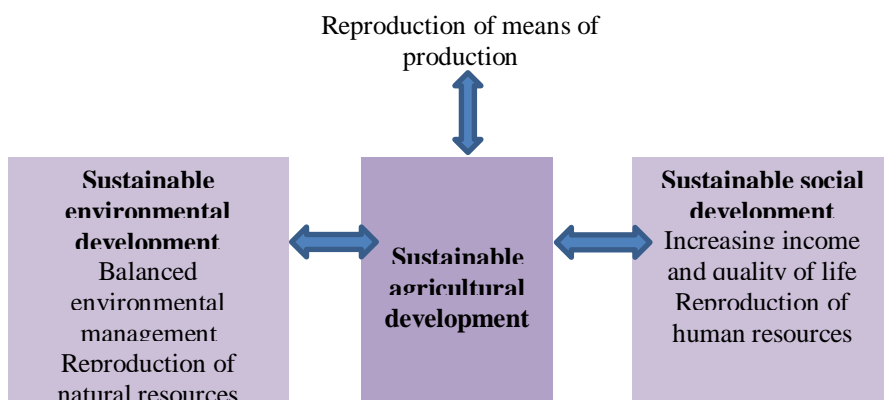


Fig. 1. Interrelation of components of sustainable development of agriculture

2 Materials and methods

The focus and structure of the study served as the basis for the selection of methods relevant to achieving the goal outlined in the work and the implementation of each of the specified stages of work. In the course of assessing the theoretical development of the issue, as well as in the process of specifying a suitable theoretical concept, the work of

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domestic and foreign scientists was subject to analysis [10, 12, 7], whose research focus is innovations in various aspects of rural life. Particular attention is paid to scientific research on the problems of innovative development of agriculture, namely, regenerative, climatesaving, organic agriculture, both relevant practices taking place in various countries of the world, including the Russian Federation, and theories that are gaining popularity. Considering that in order to develop rural areas, preserve the rural population, improve the environment, and solve demographic problems in modern circumstances, it is important to introduce all kinds of innovations, the use of review and analytical tools was advisable for studying the relevant experience, both available in the Russian Federation and abroad. Techniques of factor analysis and forecasting methods were used in the work to identify promising options for using innovations in the context of existing challenges and threats of a biological, climatic and geopolitical nature.

3 Results and discussions

Agrarian regions occupy a significant share of the total territory of the Russian Federation, make a significant contribution to ensuring the country's food security, preserving rural areas, their special mentality and culture, and therefore the development of the innovative potential of rural areas (along with cities and urban areas) is considered an important state priority. problem [5]. As the research results demonstrate, the potential of rural innovation is, as a rule, high and is based on the reserves of natural resources (land, water and others)

available in rural areas, specific (including tacit) knowledge and skills, unique mechanisms (established in rural space) cooperation (networks). As a result, rural areas have a critical role to play in harnessing local potential and mitigating the impacts of climate change, while leveraging technological, social and organizational innovation to overcome weather- and climate-sensitive industries, weaker infrastructure and limited social services, remoteness of territories from urban centers and, as a consequence, from educational, medical and other modern social facilities. Innovation is applied not only in economic, social and environmental activities, but also in the processes of realizing the role that rural residents and rural communities play in rural space, trying to make it “smart”, sustainable and attractive for living, working and relaxing.

First of all, we should dwell on new models of the functioning of agriculture (as well as forestry and fisheries), defined in modern literature by such definitions as “regenerative”, “climate-saving”, “organic”, which, of course, are not synonymous, but cover some similar characteristics. The general concept of new agricultural models is based on the fact that, on the one hand, citizens want to have access to “healthy” and high-quality food products at a reasonable price, to live in environmentally friendly conditions, on the other hand, agricultural producers strive for decent incomes and acceptable working conditions. Achieving such a balance, including when the climate is changing, is only possible in an innovative way, and taking into account the interests of current and future generations of residents of rural areas. The existing literature on this issue confirms the limitations of traditional agricultural models in meeting modern social and political demands associated with sustainable development of agriculture and rural areas [6]. In addition, modern research reveals the obvious potential of the industry to adapt to new challenges and risks associated with biological, climatic and geopolitical threats [7].

Based on the analysis undertaken, which involves an assessment of existing (international and domestic) agricultural practices, it is possible to identify some of them that have investment potential (for example, regenerative and organic). In accordance with the criteria for sustainable development and its goals outlined by the UN General Assembly in 2015, they can operate with economic returns equal to (or even better than) traditional agriculture, while simultaneously demonstrating their positive impact on the environment

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and climate. Essentially, such systems are climate-smart, with less negative impact on the climate and environment than many known agri-food systems. Moreover, they provide many positive environmental externalities in the form of healthier soils, industry decarbonization, increased biodiversity, and other positive ecosystem impacts. Being dependent on the natural environment, agriculture involves close interaction between the primary production sector and the management of the natural habitat, and therefore regenerative agriculture, combining the desire for dynamic development of the industry with the desire to preserve the environment and climate, becomes worthy of study and broadcast.

Emerging from the growing recognition of, and working to reduce, the negative climate impacts associated with conventional food production, regenerative agriculture is known to have the potential to have important environmental and social impacts that are essential to the long-term sustainability of existing food systems. Today, amid intense research, compelling evidence has emerged in scientific publications for the positive social and

environmental impacts that can be achieved through regenerative agriculture [8, 9]. Equally important is the economic justification for the transition of agricultural activity from the traditional model (which “places” farmers and other agricultural producers between high input costs and unstable product prices, neither of which they can control) to a regenerative one (which gives the farmer more economic opportunities and control) [10]. In this regard, evidence that regenerative agriculture can provide high financial returns, even given the inherent risks for farmers and the investors who support it, is noteworthy. The source of income in this case is, firstly, such advantages of using modern technologies as increased productivity (yield) and reduced costs, secondly, favorable dynamics of product prices due to an increase in its public assessment (cost), thirdly, additional government payments made to farmers for meeting environmental (and other) requirements and consistent operating results.

It is important to note that the economic, social and environmental objectives of regenerative agriculture cannot be addressed in isolation, through isolated technical innovations alone. Instead, a more comprehensive approach is needed that links food production and consumption, agricultural producers and consumers. New agricultural models have certain features, but, as a rule, are aimed at a number of results relevant for sustainable development: 1) improvement of soil condition (leads to increased productivity, especially on degraded lands); 2) introducing crop diversification strategies and increasing crop diversity; 3) the use of complex crop rotations (instead of the simple ones inherent in traditional farming methods); 4) limited use (or exclusion) of synthetic fertilizers, as well as herbicides, fungicides and insecticides to control weeds and pests; 5) careful use of hormones and antibiotics when treating animals; 6) development of modern agroforestry methods.

Regarding the features of organic farming, emphasis should also be placed on (1) eliminating the use of synthetic fertilizers, most agrochemicals and genetically modified seeds, (2) moving to more diverse crop rotations, (3) growing cover crops between commercial ones, (4) using biological fertilizers such like compost or manure [11]. As elsewhere in the world, domestic organic producers strive to maintain (or create) biologically active soils for nutrient cycling and pest and disease control, often rely on mechanical methods for weed control (e.g., cultivation), include keeping livestock into their crop rotations to increase land fertility. As a result, organic agriculture, although still a niche activity, is actively supported by the government and stimulated by consumers who place high value on organic (certified) food [12]. Producers of such products, in turn, receive a significant price premium, varying from country to country and from crop to crop, depending on the dynamics of supply and demand.

To conclude the question regarding innovative value chains in modern models of

multifunctional agriculture, it should be emphasized that they can only be implemented on the basis of modern digital solutions. The range of digital opportunities in agriculture is expanding every year and includes a variety of technologies [13]. Digital platforms for managing agricultural production have been developing most actively in recent years, making it possible to make operational decisions based on data on the state of factors influencing production (in crop production, primarily on the state of soils and other factors affecting plant growth), weather, presence of pests and diseases. An example is such of them as “CloverFarmer”, “Agrosignal”, “Agropoisk”, used to manage field work and other agricultural technological processes based on daily observations, their analysis, decisions made using artificial intelligence. In fact, most digital technologies make it possible: 1) in crop production - to monitor and manage plant development processes, influencing yields and reducing production costs;

2) in animal husbandry - control the nutrition, living conditions, health and behavior of animals; 3) in the industry as a whole - to manage production processes, carry them out with greater accuracy and productivity. Digital tools include (1) sensors and other components of automation of agricultural processes (including the Internet of things), (2) robotics, (3) cloud platforms for data collection and analytics (including predictive analytics), (4) artificial intelligence and machine learning tools, (5) unmanned vehicles [14].

In 2023, the Russian Ministry of Agriculture published a rating of regions in terms of the digital development of their agro-industrial complex (18 indicators of digital transformation were used) [15]. The Republic of Tatarstan took first place, the next three – regions such as Kostroma, Oryol and Tomsk, fifth place – the Chuvash Republic. In many others, positive trends in the digitalization of rural space were noted (an increase in the number of specialists, improvements in information security, the development of digital infrastructure, the creation of an “Agricultural Center for Digitalization”, etc.). Large agricultural farms in many domestic regions are actively using the capabilities of artificial intelligence, the advantages of modern monitoring systems, data analysis, and neural networks. At the same time, despite the significant potential of the agro-industrial complex in the field of digitalization, the Ministry of Agriculture notes serious difficulties associated with the lack of financial resources for the introduction of digital technologies not in individual farms, but in the majority of them (according to Rosstat, costs for information and communication technologies in the section “Agriculture, hunting and forestry” amounted to 4 billion rubles in 2015 or 0.34% of similar investments in all sectors of the economy, in 2017 – 0.85 billion rubles or 0.2%). [16]. In addition, a significant problem in promoting digitalization is the shortage of specialized specialists in this field, the low level of development of digital infrastructure in rural areas remote from cities, and some immaturity of formal institutions (legal regulation) in the field of digitalization [16].

Turning to the social aspects of innovative development of rural areas, we should start with the fact that in recent decades in rural areas of the Russian Federation, as in many developed countries of the world, there has been an outflow of population, as young people flock to cities in order to access wider options in obtaining education, employment, and creating more favorable conditions for their life, work and leisure [17]. For now, the reality is that those who decide to stay in rural areas often have to deal with fewer economic opportunities, lower incomes, the quality of social services that does not meet modern demands, and imperfect (compared to the city) digital (and other) infrastructure [18]. A certain contribution to the strengthening of existing inequality was made by the

consequences of the coronavirus infection (COVID-19) that broke out throughout the world, demonstrating the vulnerability of many localities to extreme circumstances, as well as the importance of their self-sufficiency with all necessary goods and services [19]. Rural areas have faced serious difficulties in recent years, including limited conditions for remote

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work, home schooling of children, provision of medical services, including due to the backwardness of digital infrastructure and the so-called “digital divide” in general. Although it is important to note that it was precisely in the circumstances of the coronavirus crisis that incentives appeared in rural regions to retain young people within their borders, to attract the necessary specialists and other workers to the villages, to return townspeople and their families to the rural space (in search of more living space, good ecology, beautiful landscapes).

In such conditions, social innovation takes on a new dimension and becomes vital for creating a favorable social environment in rural areas, adapting to climate change, and expanding economic opportunities for villagers. Considering that many domestic rural areas are remote from cities and urban settlements, differ from them by a weaker economy, transport, infrastructure, and difficult living conditions, they are the ones who need (especially in the context of the noted climatic and demographic changes) those social innovations that can revive rural areas, to resist “failures of markets and the state.” Against the background of the COVID-19 pandemic, new social initiatives manifested themselves in the fact that rural communities, introducing various forms of mutual assistance and cooperation, took responsibility for providing the most necessary services in the field of healthcare, education, training, social care, protection from natural anomalies and disasters. In addition, many agricultural enterprises operating in rural areas include in their functionality the performance of a number of social and environmental functions, without which the life of villagers would be extremely difficult. Starting from the fact that social innovation is by definition a response to social challenges that cannot be overcome by traditional market mechanisms or existing government institutions, in rural areas it covers real-world practices that include topics such as local development, child care and elderly people, health care and distance learning, mobility and energy, local social networks and local government (and others). Empirical data on the driving factors, processes and results of the impact of social innovations on rural development make it possible to identify among them those that are based on organizational innovations (supply of all kinds of services through cooperatives and other forms of cooperation and integration, diversification of the activities of large agricultural organizations and farms in the direction interests of local communities), and those based on digital technologies [20]. While focusing on the latter, it is worth highlighting some extremely important social and digital initiatives that improve service delivery in rural areas. These innovations can be financed by district administrations, rural communities, and private entrepreneurs who, within the framework of federal, regional and municipal programs for the development and implementation of the “smart village” concept, have a significant impact on the quality of life in rural areas.

The existing practices in domestic rural areas to create “smart villages” demonstrate that rural areas and communities, relying on their strengths and local assets, new opportunities for creating added value, digital information and communication technologies to attract rural development specialists, generate social and digital innovations worthy of emulation in many neighboring areas and regions. Having studied many examples of such innovations, it is important to note that what they have in common (united under the term “smart village”) is (1) a focus on the immediate interests of rural residents, (2) the desire to balance

the goals of equity and efficiency, (3) the use of digital technologies only when , when they are truly relevant to better serve rural communities, (4) spreading beyond a certain locality and taking into account its connections with neighboring villages, rural and urban areas, large cities, (5) building on their basis new forms of cooperation and alliances, (6) formation of an individual digital space, taking into account the lack of a single model and ready-made solutions,

(7) achieving a multiplier effect from the mobilization of unique natural, human and other local resources for the development of rural areas [21].

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Against the backdrop of today's challenges, the emergence of multi-service centers in rural areas that provide a wide range of basic services for rural residents, on the one hand, supporting the entrepreneurial spirit and developing new business ideas, on the other, deserves attention. As shown by specific examples examined during the study, the combination of social and digital innovations, which underlies the functioning of multiservice centers, collaboration centers (coworking), digital platforms, helps to increase social activity and limit the outflow of young people from rural areas, creating networks to attract professionals and improving the digital skills of local entrepreneurs, attracting investment and generating initiatives for new projects. It is important that the experience gained during the development of these practices can be used today to promote tourism business within rural areas (its importance for rural development has recently been emphasized by the government and the President of the Russian Federation), national crafts, multimodal transport mobility and other important areas activities.

Finally, social and digital innovation is being used in Russian villages to deliver critical public and private health and social care services, while being driven by the interests and needs of rural communities and leveraging the power of new technologies. The tasks in the field of digitalization of the healthcare sector in many rural areas of the Russian Federation are: 1) creating conditions for equal access to specialized medical care for rural residents, including through the transformation of the IT infrastructure of medical organizations; 2) introduction of platform solutions into the healthcare system at the regional and federal levels to improve the efficiency of its functioning in rural areas; 3) improvement of digital tools for diagnosing and treating diseases of rural residents, taking into account the problem of remoteness of medical centers from rural towns and villages [22]. In the field of social care, the use of digital capabilities and modern technologies in the provision of social, medical, psychological assistance and other areas of care for people with disabilities, the elderly and children is important. The relevance of rapid digital transformations in various social segments has increased during the COVID-19 pandemic and continues today, when its consequences are being overcome, as well as when rural areas are faced with modern climate and geopolitical challenges.

The final point in outlining the most important conditions for innovative rural development concerns organizational innovations used to actively involve the rural population and rural communities in managing their own life activities in terms of organizing common space, using existing local potential, developing the rural economy, preserving the environment and rural landscapes. Today, taking into account some forced localization of regional development against the backdrop of climatic anomalies (hazardous phenomena associated with floods, fires, landslides are increasing in some areas) and unprecedented foreign economic sanctions (disruption of production and logistics chains, difficulties with conducting certain types of agricultural activities), tasks related to the development of new models for ensuring their economic (and other) security come to the fore in the development of rural areas. In world practice, in this regard, quite often they

support schemes for the participation of rural communities in making the most important decisions regarding which areas of rural development are the most important at a certain moment, which of them deserve state support, how local opportunities can be used to implement the initiated event communities [23]. In European countries, such models are called LEADER (Liaison Entre Actions De Développement De L'économie Rurale) and CLLD (Community-Led Local Development), and projects initiated using their concept in many other countries are implemented with some peculiarities, but no less successfully. In domestic conditions, they are closely related to the support of national (local) traditions, the creation of unique rural industries, and the provision of essential social and ecosystem services. Digital technologies (for example, digital platforms) are also actively used in the procedures for interaction between rural leaders, entrepreneurs, investors, representatives of , 03012 (2024) *RGELN2024* local administrations and other levels of government that play a key role in successful rural development.

4 Conclusions

In the new environmental conditions, the Russian agro-industrial industry is faced not only with new difficulties, but also with new opportunities, which (together) stimulate agricultural producers to introduce all kinds of innovations, including the latest digital solutions. Digital technology components, specialized platforms, and other digital resources are used in the agricultural sector to increase labor productivity, improve production efficiency, and achieve high results in crop production, livestock farming, and processing. Digital capabilities are being leveraged in rural economies to optimize the use of natural resources, reduce production losses and waste, reduce the environmental impact of agricultural production, and improve the quality and safety of products (by monitoring soil conditions, plant growth and animal husbandry, and the use of pesticides and fertilizers). Digital solutions can significantly reduce the risks within the agricultural industry and rural areas by promptly providing agricultural producers with weather forecasts, data on the spread of plant or animal diseases, and information on the latest agricultural methods, technologies and practices.

In the social and environmental spheres, the introduction of innovations (including digital ones) is important for achieving sustainable development of rural areas, promoting convergence trends in the living conditions of rural and urban residents, and providing villagers with quality services. The events and circumstances of recent years, starting with the COVID-19 pandemic, have stimulated a significant modernization of the tools and mechanisms for carrying out medical, educational, and other social activities in rural areas. As a result, innovations cover both market and government spheres, satisfying the needs of residents, ensuring the availability of services even in extreme economic, climatic and geopolitical conditions. Thanks to significant financial investments from the state and approaches to financing innovation, in many rural areas it is possible to significantly improve the well-being of rural residents, advance in solving the problems of sustainable social and economic development, provide better care for children, the elderly, and people with disabilities, and provide a more complete range of services for unlocking creative potential, learning, strengthening physical and mental health. As a result, social innovations, which are such both in their goals and in the means used, bring obvious benefits to rural communities and society as a whole, expanding their options in ensuring successful rural development and achieving food security in the country. Organizational innovations that make it possible to generate practices of joint activity, mutual assistance and cooperation within rural localities are no less important than technological and social innovations.

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