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ANALYSIS OF APPROACHES TO INNOVATION ACTIVITY MANAGEMENT AT MODERN ENTERPRISES

Abstract. *This article is devoted to a comparative analysis of methodological approaches to managing innovation activities in agricultural enterprises in the context of global technological transformation – a phenomenon referred to in the scientific literature as "Agriculture 4.0". The study's relevance stems from increased competition in global food markets, the need to ensure food security, and the special role of innovation in the long-term competitiveness of the agricultural sector, including during the current conflict in Ukraine.*

The article systematizes five basic methodological approaches to managing innovation activities: resource-based, market-based, strategic, systemic, and project-based. For each approach, the essence, key tools, advantages, and limitations are identified. It has been established that the resource-based approach predominates in the practice of domestic agribusinesses, whilst global experience indicates that the strategic and systemic approaches are more effective.

The study examined five key areas of technological innovation in the agricultural sector: precision farming, digitalization and the Internet of Things, biotechnological innovations, renewable energy and resource conservation, and agri-logistics and digital sales channels. For each area, the quantitative effects of implementation are presented, and the potential for application in the Ukrainian context is assessed.

International experience in managing agricultural innovations is summarised using examples from the Netherlands (the 'tetraspiral' model and the Food Valley cluster), Israel (public-private partnerships and AgriFood accelerators), and Brazil (state-led technology transfer via EMBRAPA). Recommendations have been formulated for adapting foreign models to Ukrainian realities. A system of indicators for assessing the effectiveness of an agricultural enterprise's innovation activities has been proposed, covering input, output, efficiency, potential, and market indicators.

Keywords: *innovations, innovation management, innovation development, agricultural enterprise, methodological approaches, Agriculture 4.0, precision farming, renewable energy, digitalization, AgriTech.*

АНАЛІЗ ПІДХОДІВ ДО УПРАВЛІННЯ ІННОВАЦІЙНОЮ ДІЯЛЬНІСТЮ СУЧАСНИХ ПІДПРИЄМСТВ

Анотація. *У статті систематизовано 5 базових методичних підходів до управління інноваційною діяльністю: ресурсний, ринковий, стратегічний, системний і проєктний. Для кожного підходу визначено сутність, ключові інструменти, переваги та обмеження. Встановлено, що у практиці*



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вітчизняних аграрних підприємств переважає ресурсний підхід, тоді як світовий досвід свідчить про вищу результативність стратегічного та системного підходів. Досліджено п'ять ключових напрямів технологічних інновацій в аграрному секторі: точне землеробство, цифровізація та Інтернет речей, біотехнологічні інновації, відновлювана енергетика та ресурсозбереження, агрологістика й цифрові канали збуту. Для кожного напрямку наведено кількісні ефекти від впровадження та оцінено потенціал їх застосування в умовах України. Узагальнено міжнародний досвід управління аграрними інноваціями на прикладі Нідерландів (модель «тетраспіралі» та кластер Food Valley), Ізраїлю (державно-приватне партнерство та AgriFood-акселератори) та Бразилії (державний трансфер технологій через EMBRAPA). Сформульовано рекомендації щодо адаптації зарубіжних моделей до українських реалій. Запропоновано систему показників оцінки ефективності інноваційної діяльності аграрного підприємства, що охоплює витратні, результативні, ефективні, потенційні та ринкові індикатори.

Ключові слова: інновації, управління інноваційною діяльністю, інноваційний розвиток, аграрне підприємство, методичні підходи, Agriculture 4.0, точне землеробство, відновлювана енергія, цифровізація, AgriTech.

Formulation of the problem . The global agribusiness sector is undergoing a technological revolution known as "Agriculture 4.0" (or "AgriTech"). This process is characterized by the widespread adoption of digital technologies, automation, artificial intelligence, and biotechnology in agricultural enterprises' production processes.

Amid growing competition in global food markets and the need to ensure food security, innovation is becoming a key driver of the agricultural sector's competitiveness. For Ukrainian enterprises operating under wartime conditions while maintaining significant export potential, technological modernization is particularly relevant.

Understanding methodological approaches to managing innovation activities and analyzing leading practices for their implementation are prerequisites for developing effective measures at the level of a specific enterprise. This is precisely the objective of this article.

Analysis of recent research and publications. An analysis of the literature shows that several complementary approaches have emerged for managing innovation activities in modern enterprises, differing in their focus and tools. The strategic approach views innovation management as a component of the enterprise's overall strategy. A. V. Grynyov justifies the formulation of an innovation development strategy based on continuous renewal [2], whilst a systematic presentation of the functions and tools of innovation management is provided in the work of N. V. Krasnokutskaya [4]. This is further developed by R. Kaplan and D. Norton's concept of the strategy-oriented organization, which transforms strategic intentions into measurable performance indicators [9].

The investment-resource approach focuses on the financial support of innovations: A. A. Peresada views the management of the investment process as a holistic system, without which the implementation of innovative projects is impossible [5].

The digital (technological) approach interprets innovation management through the prism of digital transformation. O. E. Gudz argues that the emergence of the digital economy is changing the value orientations and management models of enterprises [3]. In practical terms, this is illustrated by research into Big Data technologies [15], the potential of blockchain for supply chain transparency [8], and McKinsey's analytical forecast regarding the impact of digital solutions [12].

The sustainable development approach adds environmental and social dimensions to the assessment of innovations. L. O. Voloshchuk links the innovative development of enterprises to Ukraine's sustainable development goals [1], which are supported by L. Lipper's concept of 'climate-smart' production [11], A. Karp's research on the role of biotechnology [10], and the FAO report on renewable energy [13].

The applied (benchmarking) approach synthesizes international experience – the Dutch case of H. Bremmers and S. W. F. Omta [6], the Brazilian EMBRAPA model [7], Israeli AgriTech as an innovation under resource constraints [14], and the assessment of Ukraine's potential in the World Bank report [16]. Thus, the sources thoroughly explore individual approaches but apply them in isolation. This highlights the need for an integrated approach that combines strategic, investment, and digital tools, considering the requirements of sustainable development for Ukrainian enterprises.

The purpose of the article. is to conduct a comparative analysis of methodological approaches to managing innovation activities in agricultural enterprises and to summarize leading international experience in their practical implementation, with the aim of identifying promising directions for the technological modernization of domestic agricultural production.

The main material presentation. The scientific and practical literature identifies several basic

methodological approaches to developing a system of innovative activities for agricultural enterprises, each with its own logic and corresponding set of tools (Table 1).

Table 1

A comparative analysis of methodological approaches to fostering innovation in agricultural enterprises

Approach	Essence	Key tools	Advantages	Weaknesses
Resource-based	Innovations are developed based on the company's existing resource potential	SWOT analysis, SNW analysis, resource base analysis	Realism, consideration of constraints	Reactive approach, limited vision
Market-based	Focus on unmet market demand and market opportunities	Market research, competitor analysis	Market orientation	Failure to capitalise on internal capabilities
Strategic	Innovation is viewed as a tool for achieving strategic goals	Roadmaps, scenario planning, BSC	Focus	Complexity of implementation
Systemic	Innovation activities as a subsystem of the overall enterprise management system	Process-based approach, systems analysis	Comprehensiveness	High implementation complexity
Project-based	Innovation is implemented in the form of individual projects with defined resources and timelines	Project management (PMBOK), Agile, Scrum	Manageability, measurability	Fragmented approach

Source: developed by the author

The resource-based approach is the most common among domestic agricultural enterprises, a pattern attributable to limited financial resources and limited access to investment capital. At the same time, leading international experience demonstrates the advantages of strategic and systemic approaches, which ensure a synergistic effect from the implementation of innovations.

Modern innovations in the agricultural sector span a wide range of areas within an enterprise's production activities. A review of leading practices allows us to identify the following key areas:

1. Precision farming. This is a technology for managing agricultural land based on the collection and analysis of data on soil conditions, crops, and weather. The technology involves GPS navigation during tillage and sowing, satellite monitoring of crops (NDVI analysis), differentiated application of fertilizers and plant protection products based on soil fertility maps, and UAVs (drones) for aerial photography and spraying [11]. According to the McKinsey Global Institute, the implementation of precision farming technologies enables a 15–20% reduction in fertilizer costs, a 20–25% reduction in the use of plant protection products, and a 5–15% increase in crop yields [12].

2. Digitalization and the Internet of Things in agricultural production. Modern agricultural enterprises are actively implementing telemetry systems for agricultural machinery, smart sensors for monitoring the microclimate in storage facilities and livestock complexes, automated irrigation control systems, and digital agribusiness management platforms (ERP for the agri-food sector, Farm Management Software) [15].

3. Biotechnological innovations. This area includes: the use of new varieties and hybrids with improved resistance and yield, the application of microbiological fertilizers and biopesticides, technologies for regulating the soil microbiome (including composting and vermiculture), as well as precision fermentation to produce feed additives [10].

4. Renewable energy and resource conservation. Solar panels are being introduced for agricultural production, along with biogas plants based on livestock waste and drip and subsurface irrigation systems, which reduce water consumption by 30–50% [13].

5. Agri-logistics and digital sales channels. Innovative solutions in this area include implementing food traceability systems (using blockchain technology to verify origin), developing direct sales channels (e-commerce in agribusiness), and automating grain storage facilities and silos [8].

Summary table of current innovative practices in the agricultural sector.

To systematize current innovation practices in agricultural enterprises and assess their applicability in Ukrainian enterprises, a summary table (Table 2) has been compiled.

Table 2

Contemporary innovative practices in the agricultural sector and their characteristics

Area of focus	Technology/tools	Country	Effect	Potential for adoption in Ukraine
Precision farming	GPS navigation, UAVs, NDVI monitoring	United States, EU	+5–15% yield, -20% fertilizer	High – technology is available

Continued from Table 2

Digitalization	IoT sensors, Farm ERP	Netherlands, Israel	-15% operating costs	Medium – infrastructure is required
Biotechnology	Hybrid seeds, biological products	Brazil, United States	+10–25% yield	High – active market
Renewable energy	Solar panels, biogas	Denmark, Austria	-30–40% energy costs	Medium – capital-intensive
Automation in livestock farming	Milking robots, feeding systems	Netherlands	+20% productivity	Low/medium – high cost
Agri-e-commerce	Digital trading platforms	China, EU	Reduction in intermediaries	Growing – Agroxy, UkrAgroConsult
Blockchain	Product traceability	EU	+15–20% price premium	Low – in the early stages
Artificial intelligence	Yield and disease forecasting	United States, Israel	Reduction in losses by 30%	Growing

Source: developed by the author

An analysis of international experience helps identify the most effective approaches to stimulating innovation in the agricultural sector.

The Netherlands is regarded as one of the world's leading centers for agricultural innovation. Despite its limited agricultural land area, the country ranks among the world's leading exporters of food products. The Dutch model is based on the 'tetraspiral' concept, which involves active cooperation between the state, research institutions, business, and society. Wageningen University and the Food Valley innovation cluster play a key role in this process [6]. Among the key technological solutions currently used in the country, it is worth highlighting greenhouse complexes with controlled microclimates, water recycling systems, vertical farming, and digital logistics and supply chain management systems.

Israel is an example of effective agricultural innovation development under conditions of limited natural resources. The country's significant contribution is linked to the development of drip irrigation technologies, particularly the work of Netafim, as well as to water management systems and the breeding of drought-resistant crops. The Israeli model of innovative development is based on public-private partnership mechanisms and the operation of specialized AgriFood accelerators [14].

Brazil provides an effective example of how innovative solutions can be adapted to the conditions of a developing economy. EMBRAPA plays a central role in shaping agricultural innovation policy, ensuring the development and transfer of modern technologies for agricultural production. Every year, the organization implements numerous innovative solutions adapted to tropical and subtropical climates [7].

Despite the challenging conditions of the war, Ukraine retains significant potential for agricultural innovation. According to the Ministry of Agrarian Policy and Food of Ukraine, until 2022, the AgriTech market in Ukraine experienced stable growth, and leading agrarian companies, including Kernel, MHP, Astarta, and Mriya Group, were actively implementing digital and biotechnological solutions [4].

At the same time, research by the FAO and the World Bank indicates several significant barriers to the innovative development of Ukraine's agricultural enterprises. The main problems identified include a lack of financial resources, a shortage of qualified specialists in innovative technologies, limited infrastructure development, and limited access to market information and modern technological knowledge [16].

A synthesis of scientific approaches and international practical experience enables the formulation of an algorithm for building an innovative activity system for an agricultural enterprise, encompassing a sequence of interrelated stages, as shown in Fig. 1.

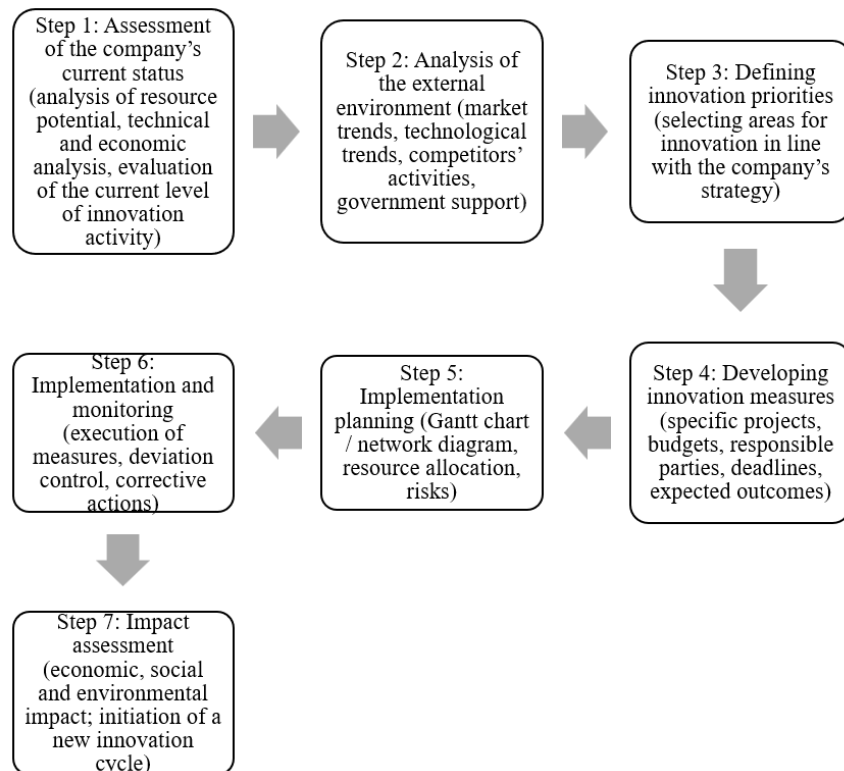


Fig. 1. Algorithm for developing an innovation management system for an agricultural enterprise

Source: compiled by the author based on [2; 9; 3; 5]

This algorithm reflects the cyclical nature of the innovation process and ensures the systematic organization of an enterprise's innovation activities, from problem diagnosis to the evaluation of results achieved. A system of relevant indicators is required to monitor the implementation of innovation measures and assess their effectiveness (Table 3).

Table 3

A system of performance indicators for assessing the effectiveness of an agricultural enterprise's innovation activities

Group of indicators	Indicator
Input	Share of innovation expenditure in revenue
	R&D expenditure per employee
Output	Share of innovative products
	Number of innovations implemented
Efficiency	Profitability of innovation projects
	Payback period for innovation investments
Potential	Number of patents and know-how
	Fixed asset renewal ratio
Market	Market share growth
	Increase in product competitiveness

Source: compiled by the author based on [1;2]

Thus, the concepts of "innovation" and "innovative activity" are multidimensional categories that are interpreted differently across academic schools. The author's definition of an agricultural enterprise's innovative activity is a purposeful, systematically organized set of measures aimed at creating, implementing, and commercializing new or significantly improved products, technologies, and organizational solutions in agricultural production, thereby increasing competitiveness and operational efficiency. Classifying innovations by content (technological, product, organizational, marketing, environmental) and degree of novelty (radical, incremental) enables the development of differentiated strategies for various types of agricultural enterprises, depending on their resource potential and market position. An analysis of the best global practices in innovation

within the agricultural sector indicates broad opportunities for their adaptation and implementation at domestic enterprises, provided there is adequate financial and human resource support.

Conclusions. To sum up, the innovative activities of an agricultural enterprise constitute a focused, systematically organized set of measures aimed at creating, implementing, and commercializing new or significantly improved products, technologies, and organizational solutions, thereby enhancing competitiveness and operational efficiency. The multifaceted nature of this concept necessitates a clear choice of methodological approach for its management, depending on the enterprise's size, resource potential, and strategic objectives.

A comparative analysis of five methodological approaches – resource-based, market-based, strategic, systems-based, and project-based – has shown that the strategic and systems-based approaches are the most effective in the long term. They ensure a synergistic effect from implementing innovations and align innovation activities with the enterprise's overall development goals. In contrast, the resource-based approach, which is widespread in domestic practice, despite its realism, limits the scope for innovative thinking and is predominantly reactive.

An analysis of the technological trends within "Agriculture 4.0" has shown that precision farming technologies and biotechnological innovations offer the greatest potential for application in Ukrainian enterprises, as they are the most accessible given existing infrastructure and an active domestic market. The implementation of digital solutions and renewable energy is promising but requires appropriate infrastructure and financial support.

A review of the experiences of the Netherlands, Israel, and Brazil indicates that effective management of innovation in the agricultural sector is impossible without active state involvement – in the form of grant funding, preferential lending, the development of advisory services, and the promotion of scientific and industrial cooperation. The Brazilian model of state technology transfer and the Israeli model of AgriFood accelerators are the most suitable for adaptation in Ukraine.

Prospects for further research include the empirical verification of the proposed approaches using data from specific agricultural enterprises and the development of sectoral benchmarks for key indicators of innovation activity in the context of Ukraine's post-war recovery.

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