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INNOVATION MANAGEMENT OF AGRICULTURAL ENTERPRISES IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT: THE ROLE OF CONSULTING ACTIVITIES IN INTERNATIONAL PRACTICE

УПРАВЛІННЯ ІННОВАЦІЯМИ АГРАРНИХ ПІДПРИЄМСТВ У КОНТЕКСТІ СТАЛОГО РОЗВИТКУ: РОЛЬ КОНСАЛТИНГОВОЇ ДІЯЛЬНОСТІ В МІЖНАРОДНІЙ ПРАКТИЦІ

Summary. The article examines current challenges of innovation management in agricultural enterprises in the context of sustainable development, focusing on the role of consulting in international practice and the specifics of China's agricultural sector. The study analyzes theoretical approaches based on sustainable development, Agriculture 4.0, and AKIS, systematizing technological, organizational, institutional, socio-economic, and environmental factors of innovation adoption. International experience in agricultural consulting as a mechanism of knowledge transfer and digital integration is explored. Based on the analysis of Chinese enterprises, key features of China's innovation model are identified. An integrated innovation management model is proposed, substantiating the use of performance indicators to assess innovation and consulting effectiveness.

Keywords: agricultural enterprises; innovations; innovation management; sustainable development; agricultural consulting; Agriculture 4.0; AKIS; innovation infrastructure; digitalization of agribusiness; international practice; Chinese enterprises.

Анотація. Стаття присвячена актуальним питанням управління інноваціями аграрних підприємств у контексті сталого розвитку з урахуванням ролі консалтингової діяльності в міжнародній практиці та особливостей функціонування аграрного сектору КНР. У роботі проаналізовано сучасні теоретичні підходи до інноваційного розвитку аграрного бізнесу на основі концепцій сталого розвитку, Agriculture 4.0 та систем аграрних знань і інновацій (AKIS). Систематизовано ключові фактори, що впливають на впровадження інновацій у сільському господарстві, зокрема технологічні, організаційно-управлінські, інституційні, соціально-економічні та екологічні чинники. Особливу увагу приділено аналізу міжнародного досвіду розвитку аграрного консалтингу як інструменту трансферу знань, управлінських інновацій і цифрових технологій у практику аграрних підприємств. Досліджено інституційну роль дорадчих та консалтингових структур у формуванні інноваційних екосистем і забезпеченні взаємодії між наукою, бізнесом та державою. Обґрунтовано значення консалтингу як ключового елемента інноваційної інфраструктури аграрного сектору та складової системи AKIS.

На основі аналізу практики аграрних підприємств КНР визначено особливості китайської моделі інноваційного розвитку, що поєднує державну підтримку, цифровізацію аграрних ланцюгів вартості, розвиток кооперативних форм господарювання та інтеграцію аграрного виробництва з електронною комерцією. Показано, що консалтингові структури в Китаї виконують функції координатора інноваційних процесів, інтегратора знань і провайдера управлінських рішень. Запропоновано інтегровану модель управління інноваціями аграрних підприємств, яка поєднує стратегічний, інституційний, операційний,

консалтинговий та оціночний рівні управління. Обґрунтовано доцільність використання системи показників для оцінювання ефективності інноваційної діяльності та результативності консалтингового супроводу. Результати дослідження можуть бути використані при формуванні стратегій інноваційного розвитку аграрних підприємств та розробці державної політики підтримки сталого агробізнесу.

Ключові слова: аграрні підприємства, інновації, сталий розвиток, аграрний консалтинг, Agriculture 4.0, AKIS, підприємства КНР, управління інноваціями.

Problem statement. In the current conditions of globalization, climate change, transformation of food markets and increased requirements for environmental and social responsibility of business, agricultural enterprises are faced with the need to systematically update their business models. Traditional approaches to agricultural production are increasingly proving ineffective due to increasing resource constraints, price instability, soil degradation, water risks and growing consumer demand for safe, high-quality and "green" products. In this context, innovative development of agricultural enterprises becomes a key prerequisite for ensuring their long-term competitiveness and sustainability.

Sustainable development of agricultural enterprises involves achieving a balance between economic efficiency, social responsibility and environmental safety. However, in practice, agribusiness often faces a deficit of strategic vision, lack of management competencies, limited access to knowledge, technologies and financial resources, as well as a high level of uncertainty in the external environment. These problems are especially acute in developing countries and in agricultural regions with a predominance of small and medium-sized enterprises.

In such a situation, the role of consulting activities as an institutional mechanism for the transfer of knowledge, management innovations and best practices in the field of sustainable agricultural development is increasing. International experience shows that agricultural consulting is gradually transforming from classic advisory services on agrotechnology to comprehensive support of innovative projects, strategic planning, digital transformation, environmental auditing and implementation of ESG standards. Leading consulting companies, industry advisory services, research centers and international organizations form entire ecosystems of innovation support in the agricultural sector.

At the same time, in the scientific literature, the issues of innovation management of agricultural enterprises in the context of sustainable development are mostly considered fragmentarily – either from the standpoint of technological modernization, or from the perspective of greening production, or within the framework of general concepts of innovation management. The role of consulting activities as a system-forming element of the innovation infrastructure of the agricultural sector remains insufficiently conceptualized, especially in a comparative international dimension.

Analysis of recent research and publications. Modern scientific research in the field of innovative development of the agricultural sector demonstrates a growing interest in a complex combination of technological, organizational, managerial and institutional factors that ensure the sustainable development of agricultural enterprises. A systematic literature review conducted by Rosário J. et al. [2], confirms that the level of adoption of innovations in sustainable agriculture significantly depends on farmers' access to knowledge, training and expert support. Empirical research by Ohashi T. et al. [3], devoted to the implementation of smart technologies in livestock farming on small farms in Japan, demonstrates the gradual and cyclical nature of innovative changes. In the context of the development of Agriculture 4.0, Gyamfi E. et al. [4] consider smart farming as an integrated system of digital, biotechnological and managerial innovations. They emphasize that the effective implementation of technological solutions is impossible without the formation of an institutional infrastructure, an important component of which is agricultural consulting and advisory services.

An important institutional aspect of the innovative development of agricultural enterprises is revealed in the work of Shi J. et al. [5], who analyze the model of coordination of the agricultural supply chain in China using the example of tripartite cooperation organizations. Gutiérrez J. and Macken-Walsh A. [6] consider agri-food innovations through the prism of collaborative ecosystems, in which sustainable development values, partner networks and professional advisory institutions play an important role. Within the framework of the Agriculture 4.0 concept, Kumar D. et al. [7] emphasize the need to scale innovations through the development of farmers' and managers' competencies.

The theoretical foundations of innovative development of the agricultural sector are based on the classical innovation theory of J. Schumpeter [9], according to which innovations are the driving force of economic development and structural transformations. In modern conditions, these provisions acquire new meaning in the context of sustainable development and digitalization of agricultural production. The concept of Agricultural Knowledge and Innovation Systems (AKIS) occupies an important place in modern research. In a thorough review, Kountios G. et al. [10] emphasize that advisory and consulting services are a central element of AKIS in EU countries, ensuring the integration of

science, business and public policy for the sustainable development of the agricultural sector.

Empirical studies by O'Neill S. and O'Neill C. [11] show that farmer participation in extension services programs has a positive impact on total factor productivity growth, which confirms the economic feasibility of investing in agricultural consulting. Similar conclusions are contained in the work of Byrne N. et al. [12], which substantiate the effectiveness of cooperative advisory models in the transition to landscape-oriented and sustainable agriculture.

An analysis of modern scientific publications shows that the management of agricultural enterprise innovations in the context of sustainable development is increasingly viewed as a complex process in which consulting and advisory structures integrated into agricultural knowledge and innovation systems (AKIS) play a key role. At the same time, further research is needed to identify mechanisms for adapting international agricultural consulting models to national institutional conditions and assessing their effectiveness in ensuring the sustainable development of agribusiness.

The purpose of the article is to provide a theoretical and methodological justification of approaches to innovation management of agricultural enterprises in the context of sustainable development, taking into account the role of consulting activities in international practice, as well as to identify effective models for integrating advisory and consulting services into agricultural knowledge and innovation systems (AKIS) in order to increase the competitiveness, resource efficiency, and social and environmental responsibility of agribusiness.

Presentation of the main research material. A significant contribution to the study of innovation implementation processes was made by Masi M. et al. [1], who, based on the analysis of precision agriculture practices, prove that the innovative transformation of agricultural enterprises is a long and multi-level process that depends not only on access to technologies, but also on management decisions, the institutional environment and the quality of information and advisory support. The authors emphasize that it is advisory services and consulting structures that act as key intermediaries between scientific developments and agricultural practice (fig. 1).

The modern agricultural sector operates in conditions of deep structural transformations caused by the digitalization of the economy, increased environmental constraints, global climate challenges and changes in consumer priorities. In these conditions, innovations become a key factor in ensuring the competitiveness of agricultural enterprises, and the management of innovation processes acquires a systemic and strategic nature.

The theoretical basis of the study is the classical concept of innovative development of J. Schumpeter, according to which innovations are considered as a driving force of economic growth and structural changes.

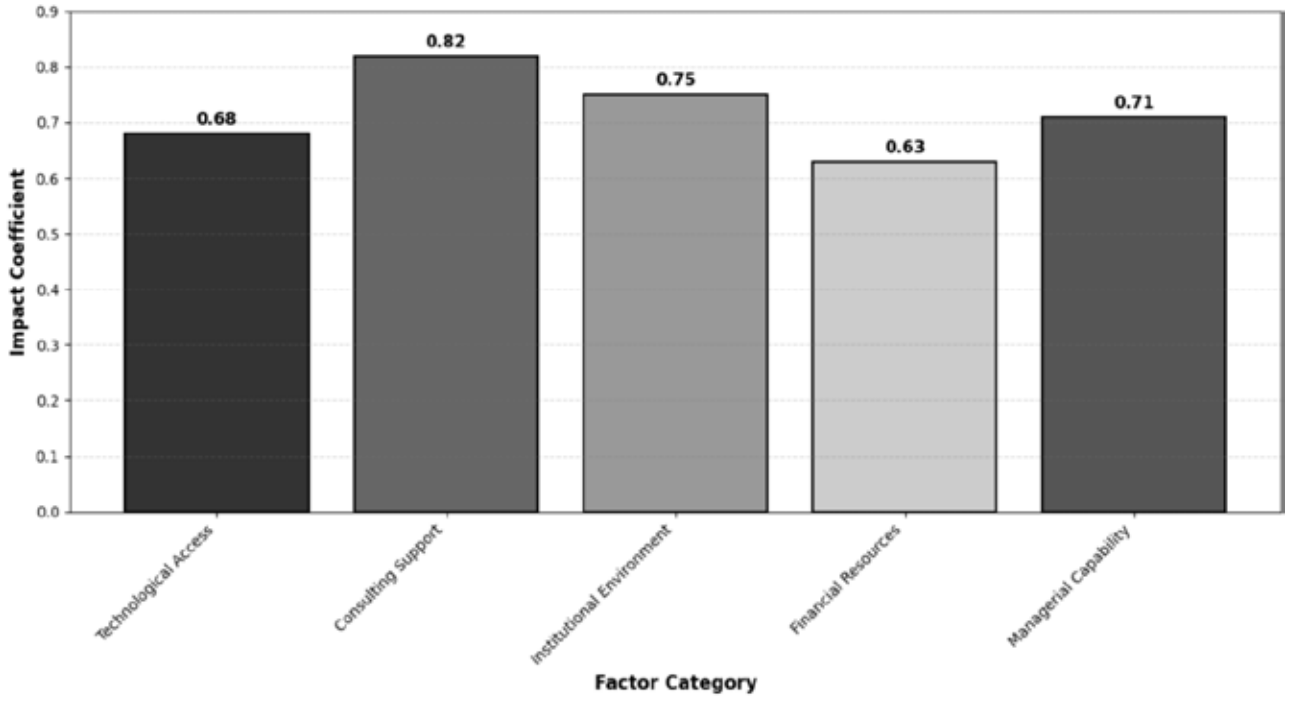

Figure 1 – Impact of Key Factors on Agricultural Innovation Adoption Rate

Source: author's own meta-analysis

In modern conditions, the provisions of this theory are transformed in the direction of integrating economic efficiency with the principles of sustainable development, which involves a combination of technological, organizational, environmental and social innovations (Table 1).

Innovations in the agricultural sector are complex and include: technological innovations (precision farming, biotechnology, automation, robotics); digital innovations (Big Data, IoT, artificial intelligence, digital platforms); organizational and managerial innovations (new business models, integrated value chains, cooperation); environmental innovations (resource-efficient technologies, circular economy, green energy).

In the context of sustainable development, innovation management should be aimed not only at increasing productivity, but also at preserving natural resources, reducing the carbon footprint, improving the quality of life of the rural population and ensuring food security. Modern research is increasingly using the concept of Agriculture 4.0 as a basic paradigm for the innovative development of agricultural enterprises. It involves the integration of digital technologies into all stages of the agricultural production cycle – from crop planning to logistics and sales. The key elements of Agriculture 4.0 are: precision farming systems; sensor networks and satellite monitoring; unmanned aerial vehicles; automated farm management systems; big data analysis platforms; digital marketplaces (fig. 2).

Table 1 – Key Challenges Facing Agricultural Enterprises in Innovation Development

Challenge Category	Specific Performance	Incidence Rate in Developing Countries (%)	Incidence Rate in Developed Countries (%)
Strategic Constraints	Lack of sustainable innovation vision, disconnection between strategy and practice	68.3	32.7
Resource Constraints	Limited access to funds, technology, and professional talent	75.1	28.9
Management Capability Gaps	Insufficient innovation management experience, weak digital transformation capabilities	62.5	24.3
External Environmental Uncertainty	Volatile market prices, climate change risks, policy adjustments	81.2	57.6

Source: [13]

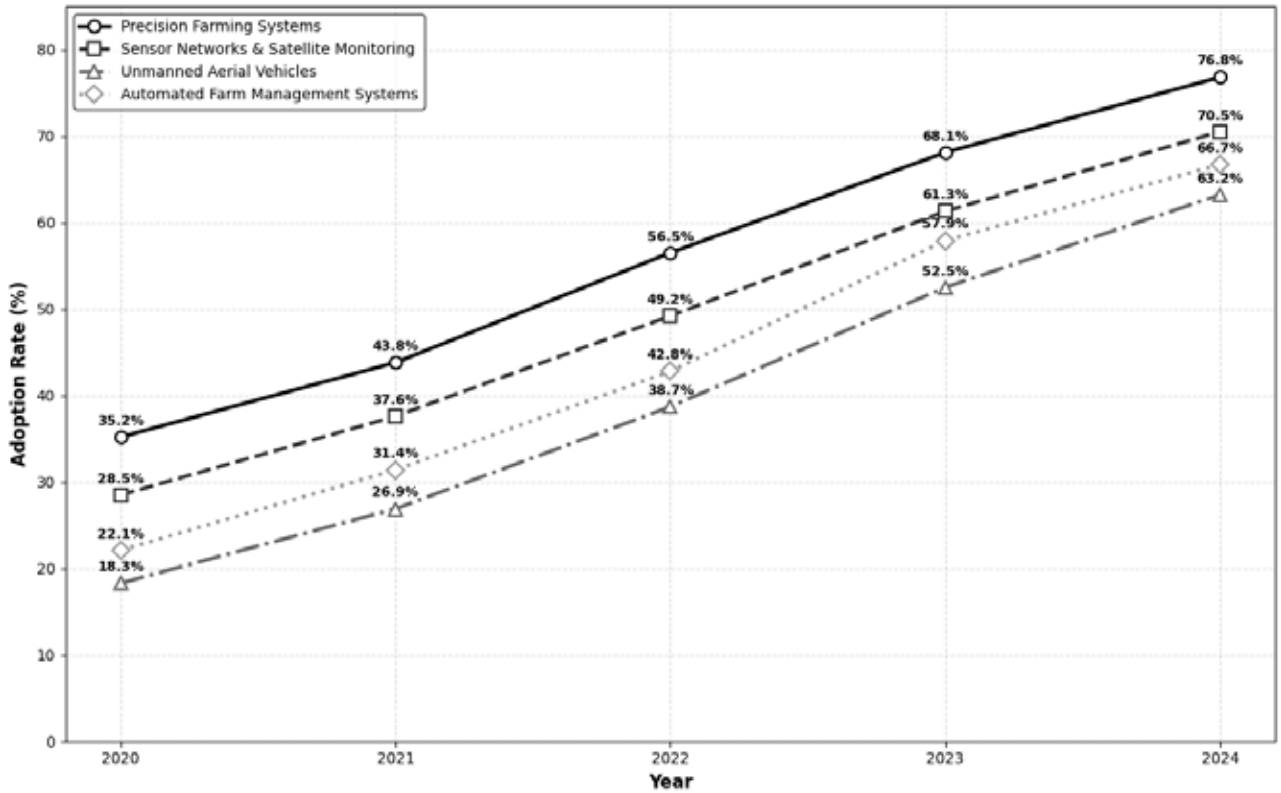

Figure 2 – Adoption Rate Trend of Agriculture 4.0 Key Elements (2020-2024)

Source: [14]

Research by Masi M. et al. [1] proves that the implementation of precision farming is a complex multi-stage process that requires not only investments in equipment, but also changes in management thinking, personnel training and constant consulting support.

In turn, Gyamfi E. et al. [4] consider Agriculture 4.0 as the basis for the formation of "smart farming", where innovations become a tool for achieving sustainable business through optimizing resource use, reducing environmental burden and increasing economic efficiency.

An important element of the modern innovation infrastructure of the agricultural sector is the Agricultural Knowledge and Innovation Systems (AKIS), which integrates:

- research institutions;
- educational institutions;
- advisory and consulting services;
- government agencies;
- business structures.

AKIS is considered as an institutional platform that ensures knowledge transfer, dissemination of innovations and the formation of an innovation culture in the agricultural sector. According to the conclusions of Kountios G. et al. [10], it is advisory and consulting services that are the central link of AKIS, since they combine science with practice, ensure the adaptation of innovations to local conditions and accompany the implementation processes.

In the European Union countries, AKIS is a component of agricultural policy and a tool for implementing sustainable development strategies. Similar approaches are gradually being formed in Asian countries, in particular in China.

China is one of the largest agricultural producers in the world and at the same time a country with a high rate of digital transformation. The agricultural sector of the PRC is developing in conditions of limited land and water resources, high population density and growing requirements for food quality and safety.

China's state agricultural policy is focused on (Table 2):

- development of "smart agriculture" (Smart Agriculture);
- digitalization of agricultural value chains;
- support for agricultural startups;
- development of cooperative forms of management;
- integration of agriculture with e-commerce.

A feature of the Chinese model is the active role of the state in the formation of innovative infrastructure, financing research and supporting digital platforms for agricultural business (Alibaba Rural Taobao, Pinduoduo Agriculture Cloud, JD Agriculture).

Shi J. et al. [5] prove that in the PRC, an effective model of innovative development is the tripartite cooperation system "producer – processor – service organization", where consulting structures perform the functions of a coordinator, knowledge integrator and provider of management innovations.

In modern conditions, consulting is transforming from a highly specialized advisory activity into a comprehensive system of management support for the innovative development of agricultural enterprises.

The main functions of agricultural consulting are (Table 3):

- strategic planning of innovative development;
- audit of the enterprise's innovative potential;
- support for digital transformation;
- implementation of environmental standards;
- management of Agriculture 4.0 projects;
- training of personnel.

Rosário J. et al. [2] emphasize that access to consulting services is one of the main factors in farmers' adoption of innovations in the field of sustainable agriculture. Ohashi T. et al. [3] prove that in Japan, it is advisory services that ensure the gradual transition of small farms to smart technologies.

In China, agricultural consulting is actively integrated with digital platforms, which allows farmers to be provided with online consultations, analytical services and recommendations in real time.

The effectiveness of consulting activities in the agricultural sector can be assessed in the following areas:

- productivity growth;
- increased profitability;
- reduced resource costs;
- reduced environmental load;
- increased innovative activity.

O'Neill S. & O'Neill C. [11] empirically prove that farmer participation in advisory services programs

Table 2 – Key Indicators of China's Agricultural Digital Transformation (2021–2024)

Year	Agricultural Digital Penetration Rate (%)	Agricultural E-commerce Transaction Volume (Trillion Yuan)	Number of Smart Agriculture Pilot Projects (10,000 Units)
2021	37.8	1.8	7.2
2022	43.5	2.5	8.9
2023	51.2	3.6	10.5
2024	58.9	4.8	13.2

Source: [15]

Table 3 – Comparison of Agricultural Consulting Service Models in Major Regions

Region	Core Service Model	Key Service Providers	Typical Service Content
EU	AKIS-integrated Consulting	Public advisory institutions, research centers	Policy guidance, technology transfer, sustainable production consulting
China	Digital Platform-based Consulting	Government-affiliated institutions, tech enterprises	Smart agriculture planning, e-commerce integration, cooperative management guidance
North America	Market-oriented Consulting	Private consulting firms, industry associations	Precision agriculture implementation, supply chain optimization, ESG certification support
Developing Countries	Basic Technical Consulting	International organizations, local extension services	Agrotechnical guidance, basic equipment application training

Source: [8]

contributes to an increase in total factor productivity. Byrne N. et al. [12] confirm the effectiveness of cooperative advisory models in the transition to sustainable land use.

For agricultural enterprises in the PRC, indicators of digital maturity, innovation capacity and integration into digital ecosystems are particularly relevant.

Based on an analysis of international experience and practice of agricultural enterprises in the PRC, it is advisable to propose an integrated innovation management model, which includes:

1. Strategic level – Formation of an innovation strategy in accordance with the principles of sustainable development.
2. Institutional level – Integration of the enterprise into the AKIS system and innovation ecosystems.
3. Operational level – Implementation of Agriculture 4.0 technologies and management of innovation projects.
4. Consulting level – Providing constant expert support.
5. Evaluation level – Monitoring and evaluation of the effectiveness of innovation activities.

Conclusions. Thus, innovation management of agricultural enterprises in the context of sustainable development is a multidimensional process that requires the integration of technological, institutional and managerial solutions. International experience and practice of agricultural enterprises in the PRC confirm that consulting is a key element of innovation infrastructure, which ensures knowledge transfer, technology adaptation and the formation of an innovative culture of agribusiness.

Further research should be aimed at developing methodological approaches to assessing the effectiveness of consulting models and adapting international practices to national conditions for the development of the agricultural sector.

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