THEORETICAL FOUNDATIONS OF MANAGEMENT OF INNOVATION PROCESSES IN AGRICULTURE IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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The state of the modern economy indicates the active implementation of innovations in the business processes of enterprises, the level of efficiency of which determines their success. Innovation activity is closely intertwined with the concept of "innovation process". On the one hand, the innovation process is the internal structure of innovation activity. On the other hand, the innovation process is a broader concept than the concept of innovation activity, since in its implementation innovation activity is the "red thread" and the process is achieved through this activity. Therefore, the study of the innovation process is given a special place when working on the conceptual apparatus in the field of innovation activity.

Sometimes scientists identify the concept of "innovation process" with the concept of "innovation cycle", "innovation lag" or "innovation phases". The only significant difference is usually in the number of stages identified by scientists who deal with this issue. Let us consider in more detail the definition of this definition in Table 1. Each author makes his own interpretation of this category, which is quite complex. The lack of unity of views and the presence of disagreements introduces significant contradictions in the interpretation of this concept and its understanding in society. Taking into account the above definitions, we can emphasize that we are most impressed by the definition given by Dorin Maier [3, p. 135]. It should be emphasized that having studied and analyzed the definitions of economists on the subject matter, we have proposed our own vision of this concept. In our opinion, the innovation process is a sequence of interrelated actions during which an innovation is transformed into a specific product, technology or service and is distributed among market participants.

In general, the innovation process is complex and multidimensional, and therefore requires a comprehensive approach based on both creativity and pragmatism. In the case of the creative approach, the birth of an idea is an impulse of the soul, while in the case of the pragmatic approach; the birth of an idea often grows out of the field of specific needs and very specific things.

In addition, the market plays an important role in the innovation process: with the creative approach, the creation of new products is driven by market needs, in which case it is passive, but with the pragmatic approach, new products are created in response to market needs and demands, in which case it is active. The synthesis of creative and pragmatic approaches should ensure maximum efficiency of the innovation process, but since this process is individual, the most rational option for implementing innovations should be chosen for each specific situation. The innovation process is cyclical and usually consists of several stages (Figure 1). This is one of the characteristic features of the innovation process. We believe that the innovation process begins with the search for new needs (existing or future). Only then does the search for innovations or the generation of ideas begin.

The innovation process in a business does not always cover all phases of the business. There are cases when a company uses third-party services. However, the final result still depends on the skilful management of this process, because in today's fierce competition and high speed of change, it is increasingly difficult for organisations to maintain their innovative, high-tech level alone, especially when it comes to digital business transformation. In this case, it is necessary to turn to competent experts, specialists in engineering and technological solutions, and possibly involve new participants to implement innovative ideas. This strategy of action is called co-invention, co-creation, collaboration, and is increasingly used in business.

Table 1. Definitions of the concept of "innovation process" by different authors.

Authors/source	Definition
Alexandra Ioanid, Denisa Iliescu [1, p. 2]	is a debut with a new plan or idea that will later be implemented with a new feature, and therefore differs from the process of simple creation, but becomes a dimension of business creation.
Borodina O. M., Uvarovskiy R. D. [2, p. 76]	takes place in any complex production and economic system, is a set of progressive, qualitatively new changes that continuously occur in time and space.
Dorin Maier [3, p. 135]	is the introduction of a production method or significant changes to specific machinery, equipment and/or software in order to reduce production and distribution costs, improve quality, produce or distribute new or improved products, increase efficiency or flexibility in production or supply activities, and reduce environmental risks.
Fabiana Matos da Silvaa, Edson Aparecida de Araujo Querido Oliveira, Marcela Barbosa de Moraes [4, p. 180]	is the dissemination of a project or new knowledge, which is a necessary procedure that all companies follow, especially to meet regulatory standards, but also through customer participation.
Miroslava Prváková [11, p. 160]	depends on the elements that characterise the 4th Industrial Revolution, such as digitisation, new technologies or flexibility.
Petrenko I. P., Yaroshenko S. S., Orel S.S. [13, p. 744]	is a set of successive, interconnected stages of innovation implementation from the inception of an idea to its commercialisation, which accompany the company's business activities and result in the creation of an innovative product.
Polozova T.V., Kryvtsun D.Y. [14, p. 111]	should be viewed as the process of transforming scientific knowledge into an innovation, its development and implementation, which is a set of successive stages of work from the origin of an idea and creation of an innovation to its development and production of the innovation itself. In other words, the innovation process is a system built in a certain way, within which innovation activities are carried out, and the result of the innovation process should be an innovation for practical use and dissemination.
Tate Mary, Bongiovanni Ivano, Kowalkiewicz Marek, Townson Peter [17, p. 191]	is a non-linear cycle of divergent and convergent activities that can repeat in unpredictable ways over time. It is a highly iterative process, and organisations may enter the process at different stages and return to previous points, but engaging in innovation follows a widely agreed life cycle

Source: compiled by the author according to [1, 2, 3, 4, 11, 13, 14, 17].

It should be noted that in order to manage innovation processes, it is necessary to identify the conditions that affect their effectiveness. One of these conditions is undoubtedly the successful implementation of all stages of the innovation process. In addition, it is necessary to ensure a clear connection between them, which requires the collection of operational and current information on the implementation of a particular phase of the innovation process. The quality of implementation of each stage of the innovation process depends on the ability to set a goal, on the correct choice of methods and means of achieving it, and on the professionalism of the direct performers.

The effectiveness of implementation directly affects the final result. However, in order to achieve the desired goal, there must also be a positive attitude towards the implementation of the innovation itself. The main task of the farm manager is to invent and create such conditions, because the effectiveness of the innovation depends on skilful management. Ultimately, the introduction of innovations in the production process should lead to a reduction in costs while achieving results. The effectiveness of an innovation depends on a number of conditions, which can be met by creating a new production process management system based on modern management

theory. Society develops through innovation. Therefore, this development requires adequate changes in the production sector. The transformations should include changes in the structure of the enterprise or farm, and, above all, should be focused on increasing profits.

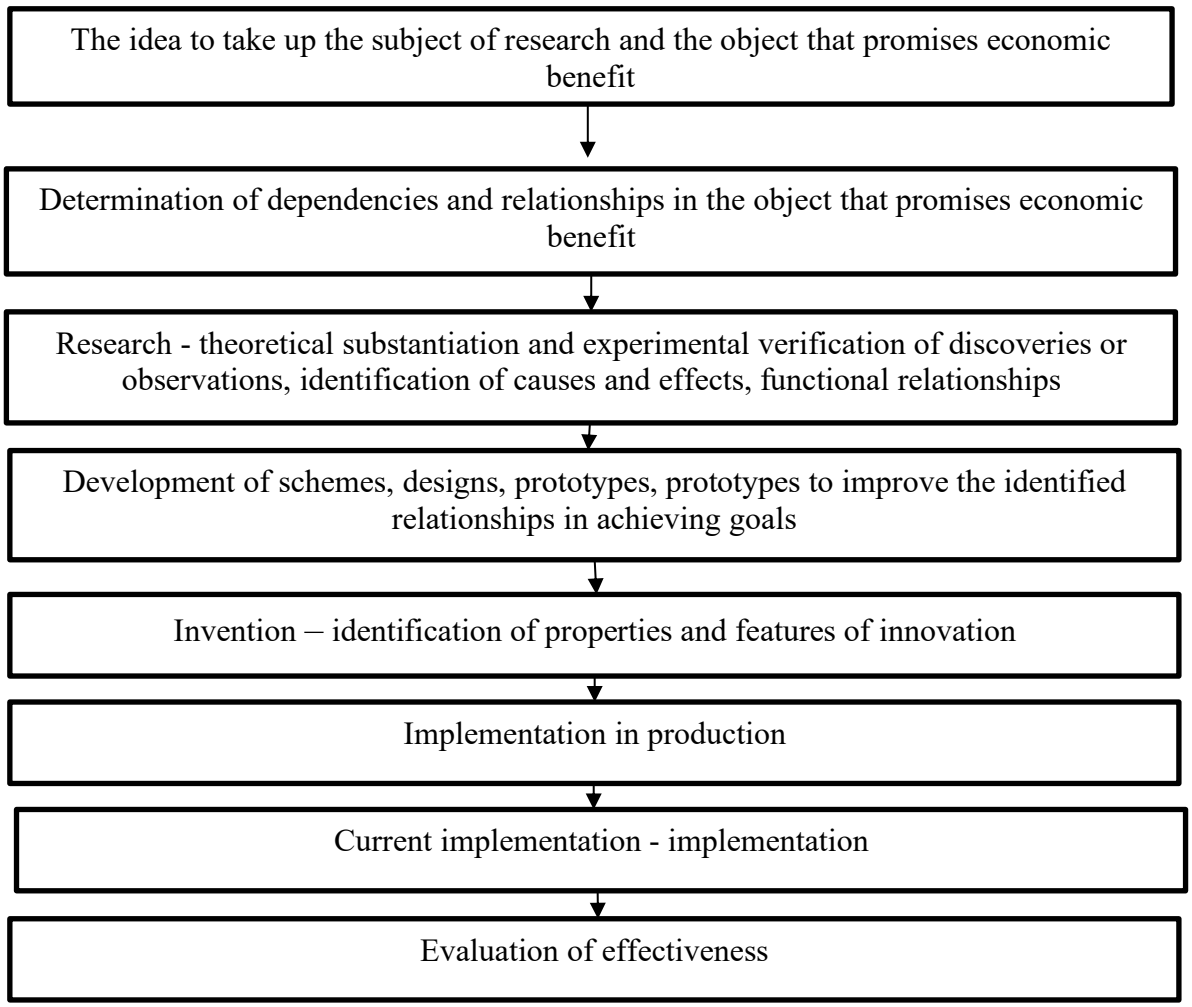

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Figure 1. Stages of the innovation process at the level of a business entity
Source: improved by the author on the basis of [5, p. 18].

We fully support the view that "an important factor in the innovation process is the computerisation of the innovation management system" [16, p. 16], and that "the most important factor at all stages of innovation management is the support and commitment of the company's manager. The company should regularly measure the results of innovations and communicate them to all employees" [16, p. 16].

An effective combination of internal and external incentives can become a particularly significant motivation for active innovation, which will increase the interest of business structures in implementing innovations. Therefore, identifying the real factors that can impede or facilitate innovation activity is an important area in the study of innovation processes (Table 2).

Table 2. Main factors influencing the implementation of the innovation process.

Group of factors	Factors hindering innovation activity	Factors that promote innovation
1	2	3
Financial and economic	Insufficient financing of scientific research, which leads to a significant limitation of innovation development opportunities; outdated methods of assessing the effectiveness of design solutions based on minimising one-time capital expenditures, which hinder the introduction of new materials and technologies; a shortage of specialists in the commercialisation of scientific and technical developments and management of intellectual property; underdevelopment of effective financial mechanisms for reducing innovation risks (venture capital financing, risk insurance, etc.).	Availability of a reserve of financial resources and provision with own financial resources; stable financial position of enterprises; availability of the necessary innovation infrastructure; state support for innovation programmes; attraction of venture capital to finance innovation projects; improvement of the system of sales of inventories; search for reserves to reduce costs of innovation activities
Production and technological	Weakness of the material and scientific and technical base, lack of reserve capacities; dominance of current production interests; lack of information on new technologies; irrational use of own production capacities; use of outdated equipment.	Availability of a reserve of material and technical resources, advanced technologies, necessary economic, scientific and technical infrastructure; replacement or repair of worn-out equipment; use of advanced equipment and production technology; growth of production capacities; growth of the level of technological processes; use of advanced methods of organising production, labour and management; improvement of working conditions.
Political	Political situation in the country, instability; politically determined low capacity of the Ukrainian market for many innovative products of the world community; lack of reliable and effective mechanisms of interaction between the state and the business sector of the regional economy; imperfection of the regulatory framework for innovation and innovation infrastructure; insufficient number of tax benefits and subsidies to stimulate innovation activity of enterprises in the region	Legislation and tax policy encouraging innovation; government creating favourable economic conditions for investment in innovation; state and regional innovation policy; government support for innovation programmes; tax breaks and subsidies to stimulate innovation
Legal	Restrictions in antitrust, tax, depreciation, patent and licensing legislation.	Legislative measures (especially incentives) that encourage innovation, state support for innovation.

Table 2. Continuation.

1	2	3
Environmental	Environmental barrier based on psychology and theories about global environmental change; restrictions on the use of new technologies and research due to attacks by anti-globalisation and green activists.	Use of different types of eco-innovation.
Social, psychological, cultural	Resistance to change, which can lead to such consequences as a change in the status of employees, the need to find a new job, the reorganisation of a new job, the reorganisation of established ways of doing things, the violation of behavioural patterns and established traditions, fear of uncertainty, and fear of punishment for failure.	Moral encouragement of participants in the innovation process, public recognition, provision of opportunities for self-realisation, and liberation of creative labour. Normal psychological climate in the labour collective. Readiness to make an innovative breakthrough
Organisational and managerial	Established organisational structure, excessive centralisation, authoritarian management style, prevalence of vertical information flows, departmental isolation, complexity of inter-industry and inter-organisational interactions, and rigidity in planning, market orientation, and focus on short-term profitability of participants.	Flexibility of organisational structure, democratic management style, prevalence of horizontal information flows, self-planning, assumption of adjustments, decentralisation, autonomy, formation of targeted working groups.

Source: modified by the author on the basis of [19, p. 78], [21, p. 192-193].

Overcoming the problems listed in the Table 2 will undoubtedly boost innovation, but digitalisation is a significant driver, as it acts as a tool for increasing the innovativeness of knowledge, as a tool for adapting and processing knowledge to be used as a resource for innovation, in other words, digitalisation acts as a "conduit" between a person and a material asset.

The state should take the lead in matters related to innovation, as all innovation processes are expensive and involve a fairly high percentage of risk. Not all entrepreneurs are ready for this, but it is almost certain that the situation will change under favourable innovation conditions. That is why the state should take on the role of a soft regulator and provide incentives through economic benefits.

Considering and taking into account all factors, individually or in combination, allows for a more complete development of an organisation's innovation strategy. Without continuous innovation and strategy revision, including changes in important factors, an organisation's effective operation in the modern competitive field will be constantly under the influence of various threats to economic security.

The peculiarities of the innovation process require the involvement of a large number of participants of various forms of ownership and types of activity, determines the specifics of its financing and the need to build complex and diverse communication flows and relationships. At the same time, these features create difficulties in the development and promotion of innovations and put barriers in the way of innovation.

We present the processes of formation of innovation utility by stages of the innovation process in Figure 2.

However, investment in innovation in our country remains low, although most companies understand the importance of developing this area for all enterprises. In order for Ukraine to move to an advanced innovative path of development, it is necessary to create conditions under which: any enterprise that develops new technologies could take out a cheap long-term loan; research teams that create new technologies could receive financial support for the implementation of their projects and the

introduction of the results obtained into production; scientists working in the main areas of the formation of a new technological mode and universities that train specialists in the relevant profile would receive the necessary funding to implement the new technologies.

Thus, systemic state policy measures are needed to influence the remaining scientific and technological potential, to timely restructure our economy on an advanced technological basis, to fully increase its competitiveness and to radically change the attitude of society towards innovation. Another important problem is the low demand for innovations, especially in agriculture, as it is more profitable for companies to buy off-the-shelf equipment abroad than to engage in their own innovation activities. Neither the private nor the public sector shows the necessary interest in implementing innovations, so production is falling due to the aging of technologies, processes and equipment. Thus, we get a stagnant economy due to the unwillingness of managers to engage in innovative activities.

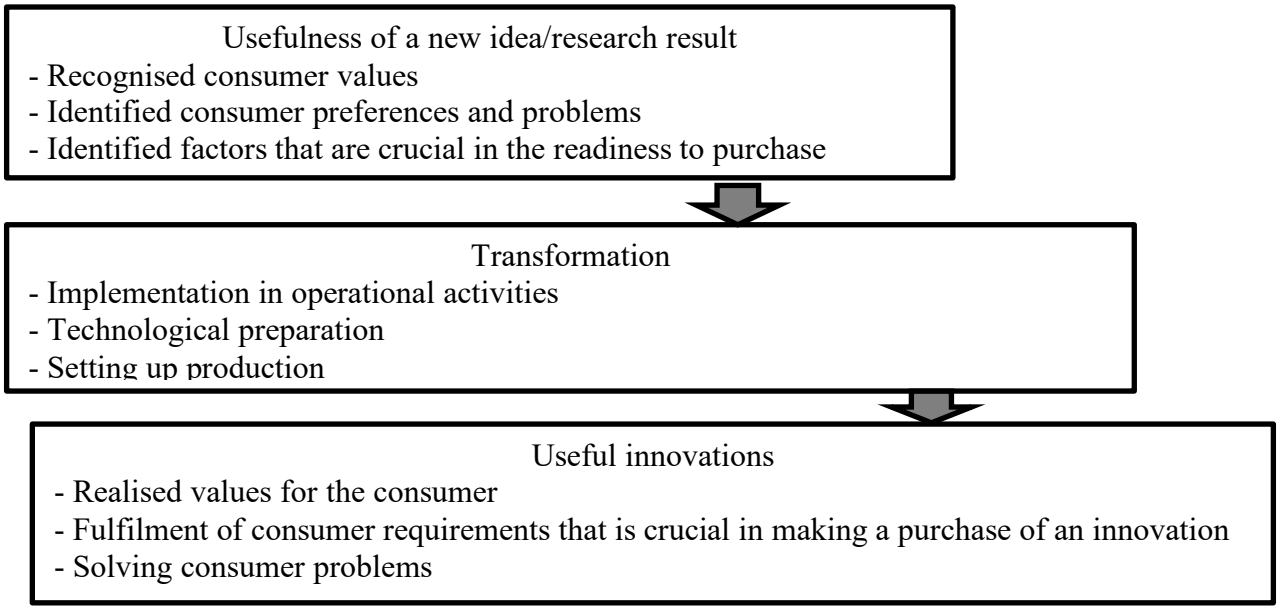

Figure 2. Processes of formation of innovation utility by stages of the innovation process.

Source: [10, p. 5].

Based on the above, it can be argued that innovations in society have a significant impact on the economy. The role of innovation in society cannot be overestimated. Innovations perform economic and social functions, cover all aspects of society, touch upon personal issues, bring positive effects and force society to change its way of life.

Agriculture is subject to the same economic processes and laws as other sectors of the economy. However, the agro-industrial complex has specific features that significantly affect not only the efficiency of its operations, but also the course of the production process itself.

The organisational and economic essence of innovation processes is related to the goals and objectives of their development, which consist in the constant organisational, economic, technical and technological renewal of agricultural production aimed at its improvement, taking into account the achievements of technology, science and international experience. The ultimate goal of these processes is to create an innovative agrarian economy, in which the achievements of science and best practices will be adopted on a proactive basis.

Innovative formations in agriculture have fundamental differences in the nature of financing and the economic basis of their operation. There are significant differences in the main purpose of such entities' activities – from a technical and technological idea to its scientific implementation, realisation (implementation) and provision of information and advisory services. There is also a significant difference in the scale of operation – from the international and national level to the level of a particular agricultural enterprise.

Innovation processes in the agro-industrial complex are characterised by a wide range of regional, sectoral, functional, technological and organisational features. The conditions and factors that influence the innovative development of the agro-industrial complex are divided into negative (hindering innovative development) and positive (contributing to the acceleration of innovative processes).

In a general sense, the innovation process is perceived as a set of successive actions taken to prepare and apply new technical, organisational, managerial, economic, marketing and other solutions. Thus, the innovation process is a chain of successive transformations of an idea into an innovation. It should be noted that innovation processes in agriculture are distinguished by a number of features and specific trends. The main feature of innovation processes in agriculture is the specificity of the organisation of agricultural production itself.

Innovations in Ukrainian agriculture can be divided into several groups. First, there are innovations related to the wear and tear or severe obsolescence of agricultural machinery. Although these investments may seem to lack an innovative component, this is not the case for a large part of the country's farms. Therefore, the introduction of machinery that is widely used in Western countries in our country can, in fact, be considered a "regional" innovation. Secondly, the introduction of elite plant varieties and highly productive breeds into production will be an innovation. Thirdly, innovation can be in the use of scientific developments to stimulate production, i.e. new fertilisers and additives in various areas of agriculture. Fourth, innovation can affect the management system of an enterprise – from new approaches to management to the introduction of electronic control and production management systems. Fifth, innovations may relate to the infrastructure of the agro-industrial complex, which is a macroeconomic decision that requires attention and support from the state. These may include measures to assess soil conditions and provide recommendations to farmers, advice on how to implement certain innovations in production, and information on various developments and opportunities. Or it could be programmes for the lease of high-performance agricultural machinery by small and medium-sized enterprises from the state. The gradual and balanced application of all these types of innovations in practice can have a positive effect on the agricultural sector.

One of the distinctive features of agriculture is that the leading resources for agricultural production are considered to be the nonman-made products of nature – plants, animals, territory, climate, weather. These resources develop according to biological laws.

The production process in agriculture involves the use of living organisms and depends mainly on their physiological characteristics. For example, failure to comply with the timing and duration of work (too early sowing, delayed harvesting, etc.) may result in the loss of some products and reduced profits. In addition, the length of the production cycle means that producers cannot respond quickly to changing market conditions.

Agriculture is characterised by seasonality of production, which is due to the mismatch between the period of work and the period of production. Seasonality significantly affects the use of resource potential, the organisation of the production process and the efficiency of the industry.

Significant is dependence on weather conditions, which cannot be sufficiently smoothed out by either a high level of agricultural technology or advanced technologies. As a result, it is difficult to reliably predict the level of agricultural income. It should be noted that deteriorating weather conditions lead to lower crop yields, which in turn is reflected in lower production volumes, higher production costs, and loss of profit by agricultural enterprises.

The level of adoption of advanced technologies in agriculture remains low. There is also a lag in infrastructure development.

Another factor affecting efficiency in agriculture is the low quality and insufficient quantity of inputs, including seed and fertilisers, which make yields more dependent on weather conditions. Production losses are also caused by defects and physical and moral obsolescence of machinery. The high cost and lack of financial capacity prevent farms from modernising their machinery and tractor fleet and reducing the impact of this factor.

Therefore, since the natural process of reproduction of plants and animals is a substantial and determining factor in the reproduction of human life, there is a need to adjust (adapt) all organisational, managerial, socio-economic, technical and production, innovation, and market processes in this sector

of the economy to the needs and patterns. When managing innovations, it is necessary to take into account not only financial laws, but also the laws of nature.

However, it should be emphasised that breeding cannot make up for the lack of fertilisers, varieties cannot fill the gaps in agricultural technology, and breeding cannot replace feed. In addition, unlike other industries, the production process in agriculture is not prone to shortening the timeframe. Different types of agricultural products have different production periods. Effective innovation can mitigate the impact of natural and climatic factors, but only to a certain extent. Therefore, when developing innovative solutions, their interconnection with biological processes should be taken into account. Thus, natural factors have a significant impact on the innovation activities of agricultural enterprises. The innovation activity of an individual agricultural enterprise is also influenced by the technological level of the agricultural sector (the speed of technological change in the sector, access to existing innovative developments, the interconnection of enterprises in the exchange of technologies, etc.) Very often, the interaction of enterprises with scientific institutions is not elaborated.

In addition to sectoral factors, innovation activity in agriculture is also influenced by the innovation potential of the region. Thus, the ability of enterprises to carry out innovative activities is influenced by the state of the regional system of training scientific and engineering personnel, the system of attracting investments to the region, regional support for innovative projects, the investment climate of the region, the development of the system of interaction between enterprises and scientific and educational institutions of the region, the presence of clusters of innovative development, agro-technological parks, and the demographic situation. The specifics of the agricultural sector also include the need for state support for the industry, which helps to overcome the unprofitability of agriculture and allows enterprises to operate in the face of losses caused by natural factors.

Thus, due to the special biological, natural, historical and socio-demographic nature of agriculture, innovation processes in the agro-industrial complex manifest themselves in a specific way, which determines the originality of approaches and methods of managing innovation processes, combining different types of innovations, and strengthening the role of the state in stimulating innovation.

The introduction of innovations into production processes is necessary both to ensure competitive advantages and to grow the national economy as a whole. The consistent development of science and technology has a significant impact on economic relations. The agro-industrial complex has a significant innovation potential, so timely implementation of innovations in this sector is a key to sustainable development.

Innovation activity in agriculture is not uniform. This is due to the different economic and financial situation of agricultural sectors and their different innovation potential. It follows that the process of innovation development is not linear and depends on various circumstances.

The low innovation level of the modern agro-industrial complex is due to a number of factors, a full analysis of which requires much more in-depth study, but even with a superficial look at the problem, there is no doubt that with the current level of funding for research in the agricultural sector, it is impossible to expect qualitative changes in the implementation of innovations in agricultural production.

Given that agricultural production in small-scale conditions have significant specifics that significantly affect all stages of the innovation process: from the production of R&D, transfer of innovation, its implementation and ending with the commercialisation of innovation and obtaining economic benefits.

Innovative processes in agriculture have a number of peculiarities due to the specifics of the industry (Figure 3).

In today's economy, innovations are found in almost all segments of agriculture. Science, knowledge-intensive technologies and active innovation activities allow for the vigorous implementation of scientific developments in practice and contribute to the growth of agricultural production. Therefore, the overall goal for the state, agricultural enterprises, and research organisations should be to create conditions under which all new technologies and developments are actively used in agricultural production and increase its competitiveness.

The following areas of innovative technologies are typical for agriculture:

- soil cultivation technologies;
- technologies for harvesting and preserving products;
- technologies for raising and keeping livestock;
- technologies for the production of agricultural machinery and equipment.
- technologies for soil drainage and irrigation.
- technologies for transporting and selling products.

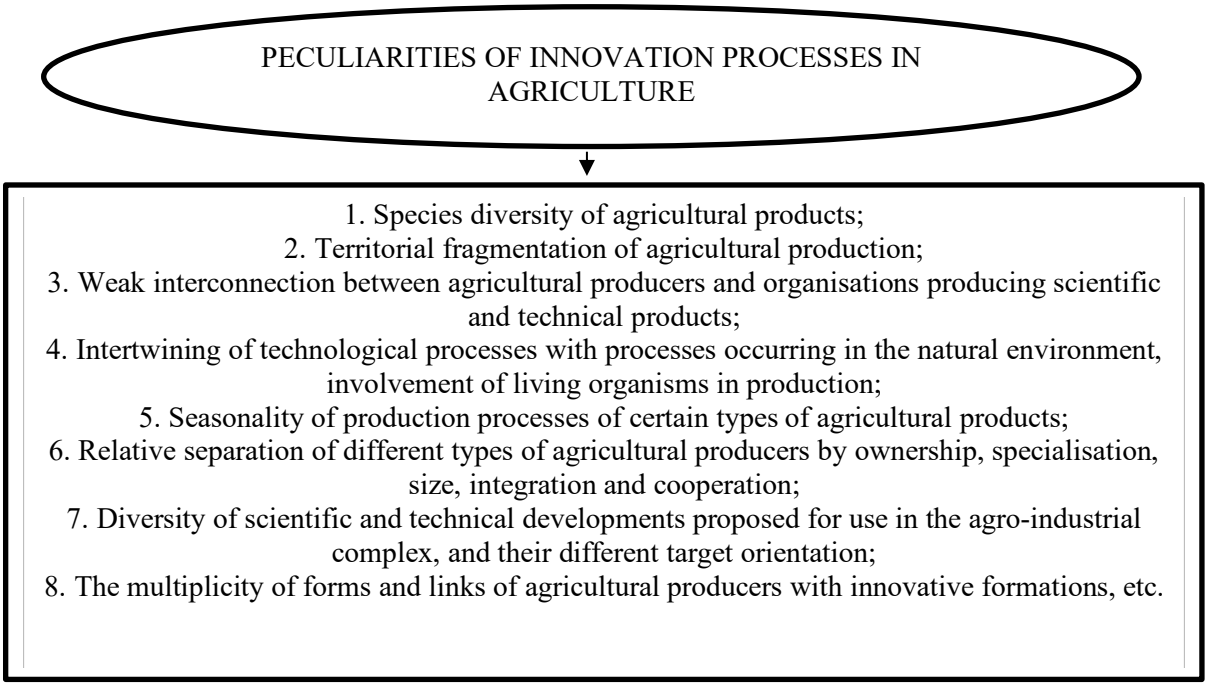

Figure 3. Features of innovation processes in agriculture.

Source: compiled by the author.

The specificity of the agricultural sector is that the development of innovative technologies in the industry is slower. The most common innovations that are actively implemented in practice in developed countries are presented in Table 3.

Table 3. Agricultural technologies.

Parameters	Crop production	Animal husbandry
Possibilities of use	Precision surveillance systems; global navigation satellite system; satellite technology; land cover maps; computer vision for planting analysis; automatic irrigation systems.	Machine vision for livestock accounting; facial recognition systems for livestock; animal rationing; veterinary services; optimisation of the agricultural machinery fleet.
Problems of application	Significant investment needs; requires a large amount of research and development; requires highly skilled personnel.	High cost of updating and modernising products; need to import modern technological means of keeping, feeding and caring for animals.

Source: compiled by the author.

The use of modern information and digital technologies facilitates operational monitoring of production processes in agriculture. This allows technologies to be adapted to the needs of the agricultural sector.

One of the most promising technologies being actively implemented in agriculture is a geographic information system (GIS) used to monitor the use of agricultural land, as the long-term use of extensive farming methods on agricultural land has led to a catastrophic decline in soil fertility, and therefore digital mapping products are increasingly being used by young and rapidly developing farms.

Geoinformation technologies are used to create thematic maps on the farm's territory, such as a map of soils (soil differences), agrochemical maps based on the results of agrochemical surveys of land plots. Using sets of thematic maps created for a given region, such as a series of agroclimatic, climatic, phenological, phytophenological, biological conditions, a wide range of analytical actions are carried out to create a number of synthetic maps designed to solve the tasks of the agricultural producer: general assessment of agroclimatic conditions of the territory, determination of the possibility of growing crops, structure of sown areas, pre-sowing soil treatment, sowing and sowing rates, doses of mineral and organic fertilisers.

Geographic information systems allow you to create convenient and flexible databases that store both spatial and semantic information and allow you to monitor crops and farming results, which allows you to make more accurate forecasts in the future. But GIS does not limit the range of its functionalities to this point. Suppose that the technology for growing and producing agricultural products is established and operates under the farmer's control, but there is a problem with processing, storage and marketing of products, and here GIS comes to the rescue. The same applies to firms that supply mineral fertilisers, pesticides, agricultural machinery, spare parts, fuels and lubricants, and other goods and services required for farming.

It should be noted that in rural areas, the level of computer users is still incomparably lower than in cities, but the introduction of geographic information technologies, even at the district level by farmers' associations or individual firms, is already yielding positive results in the use of GIS in agribusiness. Having briefly reviewed the main tasks that GIS can solve in agriculture, it should be noted that this is only a small part of the possibilities of this technology, which, due to its very flexible structure, strong mathematical platform and powerful analytical capabilities, will find many more applications in this very important time.

The agricultural market offers both foreign and Ukrainian developments. For crop production, digital products can be categorised into several areas (Table 4).

Table 4. Digital technologies for agricultural production.

The direction of using IT technologies	IT technologies proposed for use
1	2
GIS technologies and electronic field mapping with applications for portable gadgets	Farm Works Site (Pro), SST Summit, SMS Desktop Software (Advanced and Basic), JD Reports MAP, Agrarian Office, Agro-Net NG, FarmView Record Keeper, Farm Truck Mate, SST Stratus and others.
GPS systems for parallel driving	Outback, Raven, Trimble, GreenStar, TeeJet, Leica.
Field measurement and soil sampling	Agronaut (can be used for parallel driving of equipment) Farm Works Mobile, SST Stratus, SMS Mobile, AGRO-GPS Mobilbox, etc.; AgroUrban, Site, Farm Works Site Pro, SSToolbox, LandView Mapper, etc;
Universal mapping applications	Map-2011, MapInfo ArcView

Table 4. Continuation.

1	2
Agricultural production management. Accounting software	Accounting support: 1C: Enterprise 8 (Management of an agricultural enterprise, Accounting of an agricultural enterprise, etc.) Economic software: Planning in crop and livestock production, Budget planning of agricultural enterprises, software tool "Feasibility studies in crop production" (TEO-Agro), Farm Funds, Panorama-Agro, AgroHolding IAS and software "AT Agrar-Office" of the German company Land-Data Eurosoft, etc.
UAVs in agriculture	DroneUA PD1900, ITEC SKIF NDVI, Katana-Agro (Matrix UAV), DroneePLANE (Dronee), Leleka-100 (DeViRo), Flying Tractor (IT KIT), UAS6-50 (Aeroservice), AeroDrone (DR-60), etc. Unmanned Aerial System (Kray Technologies) and 3 models of UAVs of the Flirt series: Arrow, Cetus and Iron. MegaDrone has created the SkyHunter MD-1 drone, and also has two hexacopter models in its portfolio – MD-Smart and MD-Lite, as well as the VTOL Hawk aircraft.

Source: compiled by the author.

The use of robots and autonomous vehicles can reduce labour costs and increase the efficiency of agricultural production.

It is also worth considering the role of space technologies in agriculture, which are satellite navigation systems that allow controlling a large area, preventing or minimising losses from adverse weather events.

Innovations in agriculture result in the following: increased yields, financial cost savings due to the optimal use of seeds and fertilisers; improved agrochemical properties of the soil, and much more. Innovative technologies have been successfully used abroad for several decades, and in recent years, domestic agricultural producers have begun to adopt them.

However, the innovative development of domestic agriculture faces a number of challenges, including:

- low level of technological modernisation of agriculture and the existence of imbalances in it;
- low effective demand of domestic producers for innovative products;
- weak mechanism of research and development activities and lack of incentives for agricultural producers to adopt innovations;
- orientation of leading agricultural enterprises to purchase scientific and technical solutions and technologies abroad;
- lack of a well-developed concept of development and stimulation of innovation in the agro-industrial complex;
- underdeveloped domestic infrastructure;
- implementation of innovations is of a spotty nature and is aimed at modernising the material and technical base, which does not contribute to increasing the efficiency of agricultural production in general.

The following areas should be prioritised for the development of innovation processes in the agricultural sector:

- re-equipment of agricultural organisations;
- development of organic production;
- development of information and infrastructure support for innovation in the agro-industrial complex;
- development of innovation policy and strategy at both the federal and regional levels to promote advanced technological modes;

- restoration of soil fertility, prevention of all types of soil degradation, development of adaptive technologies for agroecosystems and agrolandscapes, etc.

However, a number of problems impede the pace of agricultural development and innovation, which will be discussed in more detail. Thus, the main problems that impede the effective development of the agricultural sector include:

1) limited domestic demand;

2) relatively low competitiveness of most agricultural products;

3) underutilisation of agricultural potential due to inefficient structure of the agricultural sector (uneven distribution of land resources between large agricultural producers and small agribusinesses; underutilisation of human potential);

4) lack of affordable lending for small and medium-sized agribusinesses;

5) high share of the shadow sector in the agricultural sector;

6) a decline in human resources due to the outflow of people from rural areas, especially highly skilled professionals;

7) low labour productivity in agriculture.

All of the above problems largely impede the introduction of innovations in agricultural production, but they need to be levelled so that they do not become a block to further development of the agricultural sector. The innovation process in the agricultural sector is characterised by a number of features (Figure 4).

The innovation process in the agricultural sector is characterised by a number of peculiarities. Any innovation in agriculture depends on the climatic conditions of the regions, and this applies to both the costs of the innovation process and the timing of its implementation, which makes investments in innovation projects in the agricultural sector more risky than in other sectors of the economy. However, the lengthy process of developing and implementing an innovation makes it possible to use the human resources of both research institutions and agricultural enterprises more efficiently.

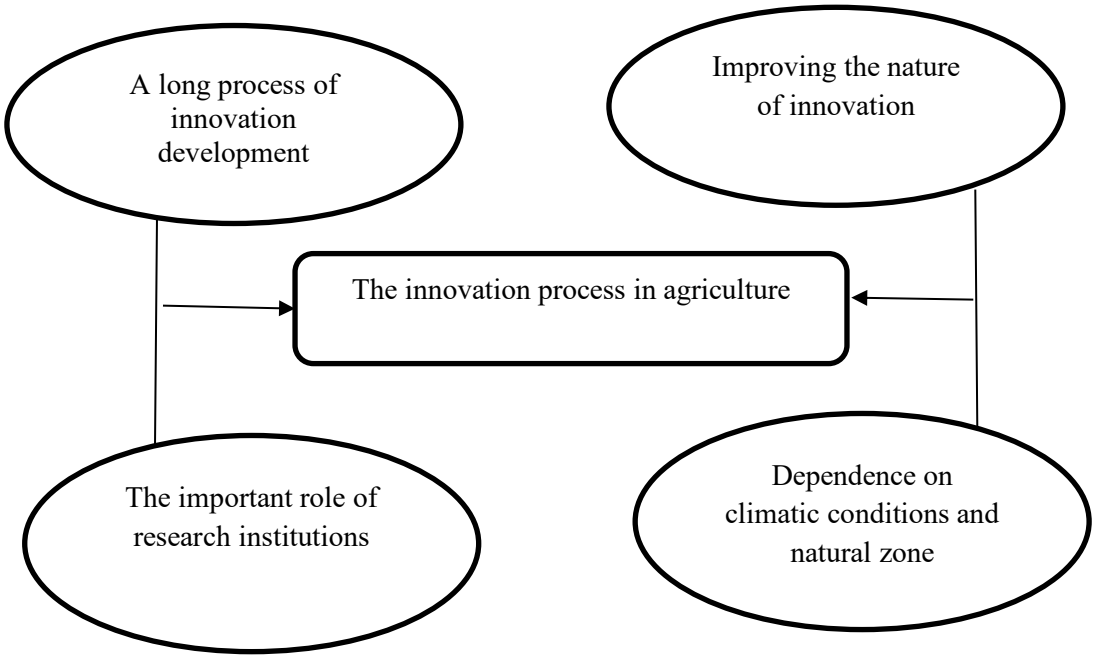

Figure 4. Specifics of the innovation process in agricultural production
Source: compiled by the author.

In the context of limited resources, scientific and technological progress and, in particular, innovation processes are priority areas for the development of the agro-industrial complex and increasing its efficiency, as they allow for continuous improvement, renewal and development of production based on the achievements of science, technology and engineering. The entire set of innovations in the agro-industrial complex can be grouped into 4 groups (Table 5).

Table 5. Classification of types of innovation in the agro-industrial complex.

Selection and genetic	Production and technological	Organisational and managerial	Economic and environmental
New varieties and hybrids of agricultural plants	Use of new equipment. Modern industrial technologies in livestock and crop production	Development of cooperation and formation of integrated structures in the agro-industrial complex	Formation of a system of personnel for scientific and technical support of the agro-industrial complex
New breeds, types of animals and poultry crosses	Science-based farming and livestock systems. New fertilisers and their systems. New plant protection products	New forms of maintenance and provision of resources for the agro-industrial complex	Improving working conditions, addressing health, education and cultural issues of rural workers
Development of plants and animals resistant to diseases, pests and adverse environmental factors	Biologisation and ecologisation of agriculture. New resource-saving technologies for food production and storage aimed at increasing the consumer value of food.	Marketing of innovations. Creation of innovation and advisory systems in the field of scientific, technical and innovation activities. Concepts and methods of decision-making. Forms and mechanisms of innovative development.	Improving the quality of the environment. Ensuring favourable environmental conditions for living, working and recreation.

Source: compiled by the author.

In today's fiercely competitive environment, economic growth and increased competitiveness of agricultural enterprises require the introduction of innovative processes into production. However, this process is hampered by the following problems: reduction of state support for the agro-industrial complex and funding of scientific and technical programmes; lack of innovation infrastructure and state innovation policy and strategy; low profitability of agricultural enterprises; lack of effective interaction between science and business; low level of training of personnel of agricultural organisations.

In general, there are currently three main areas of innovation in agricultural enterprises (Figure 5).

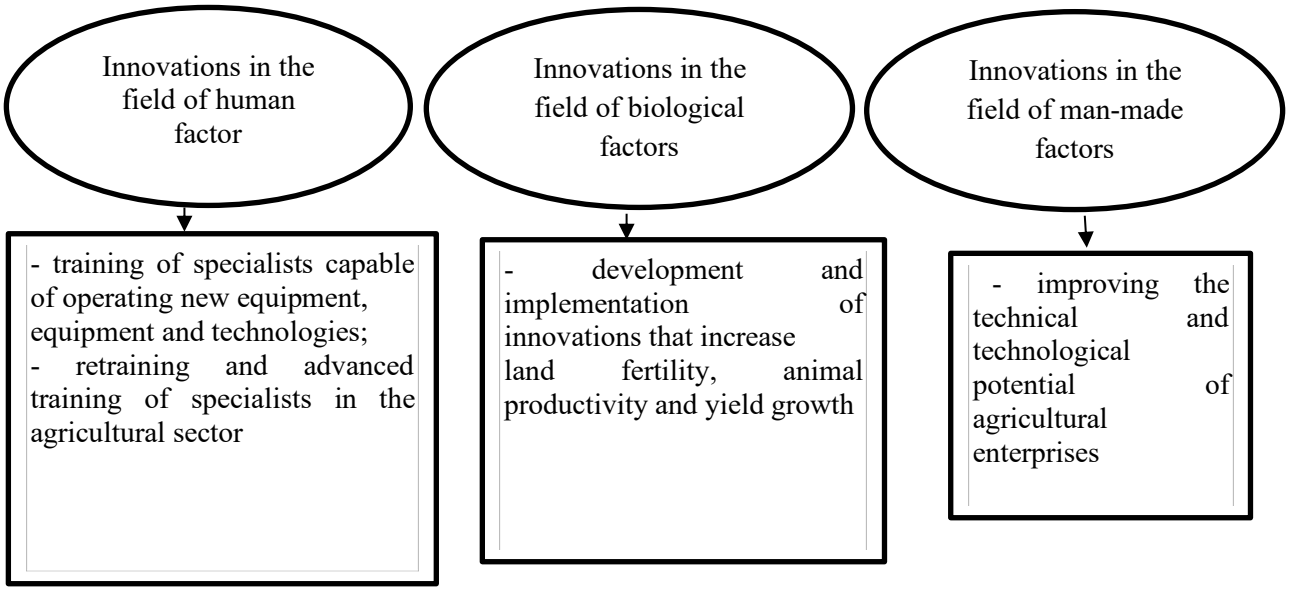

Figure 5. Areas of innovation in agriculture.

Source: compiled by the author.

In our opinion, the following innovations can be considered the most potentially effective today and can be implemented in various areas of agriculture in the short and medium term.

1) safe genetic engineering of seed material;
2) zero-runoff hydrosystem fisheries;
3) tray-condenser irrigation systems;
4) "sea" potatoes;
5) computerised cattle management;
6) bioinsecticides and pollinators;
7) cocoon-sleeve granaries;
8) precision seeding technologies;
9) smart greenhouses;
10) Craft Scanner sensors to control the depth of tillage;
11) aeroponic farms (growing plants without soil)
12) use of drones;
13) precision farming systems
14) use of cloud technologies;
15) digitalisation of accounting (collection, transmission, analysis and processing of data)
16) modernisation of machinery, etc.

Digital technological changes have a significant impact on the economic development of agricultural enterprises. The introduction of modern digital technologies into the practical activities of agricultural producers is the main driving force behind progress in the agricultural sector. A new model of economic growth of agricultural enterprises based on the information and digital type of development implies a change in the overall paradigm of production process management.

Digital technologies have a significant impact on the development of innovation processes in agriculture in general and crop production in particular. The introduction of modern digital tools into the production activities of farmers is a driving force for progress in the agricultural sector. The priorities of the digital component of innovative development are the intellectualisation of all areas of activity, environmental friendliness, use of modern technologies, digital assistants, upgrading the technical and technological base, etc. The established digital environment will help to improve the efficiency of agricultural production, namely: reducing the cost of purchasing seed, fertilisers and fuels, fully adapting the equipment used to natural and climatic conditions through the use of advanced technologies, as well as the qualitative development of the management decision-making system.

In general, new technologies open up opportunities for their non-standard application. For example, unmanned aerial vehicles have appeared on the market and have been used as a new entertainment. Let's consider the possibilities of using unmanned aerial vehicles in the agricultural sector.

The use of drones in agriculture saves time on some types of work and increases the efficiency of certain processes:

1) Helping farmers collect data on the condition of crops. Even in cloudy weather, drones take pictures of fields and provide more accurate data than satellites. This is reflected in new crop patterns, yields and, consequently, profitability;

2) Checking soil conditions for nitrogen and other substances, as well as creating three-dimensional soil analysis maps. The map can be conveniently used as a planting scheme;

3) Planting seeds. Unmanned aerial vehicles are equipped with special devices for planting seeds. The aircraft hovers above the ground and shoots a seed capsule into the soil;

4) Watering and fertilising the soil. The aircraft scan the area, descend to the required height above the ground and gradually spray fertiliser. The drones are programmed to detect dry areas of land, which they then water. Since the drone can lift a weight of just over 200 kg, watering is only carried out on a spot basis. With this understanding, it is possible to fix a crop problem before it becomes more serious. The drone can see the weeds in the field down to the bush and distinguish their types.

Then the data on their total number is entered into the database, and subsequently into the tractor's "brain". The sprayer applies the chemicals in a single spot. The consumption of expensive drugs and even fertilisers is reduced by 5-35%.

5) Notification of the appearance of bacteria. Multispectral cameras are mounted on the equipment, with the help of which the drone creates maps.

6) Counting livestock. Flying is overhead, the drone counts and inventories livestock. Each animal has its own thermal signature, which can be captured and taken into account by a thermal camera. This thermal sensor can identify livestock with abnormal body temperature, which is a strong indicator of disease or ill health. In addition to counting, the drone can also conduct regular inspections of the pasture fence to detect damage. For example, if a fence is broken, the drone will report it.

Although many practitioners are still very wary of the technology's potential for precision farming, the developers say that drones will soon be indispensable. And the point is not even that digital technology is now at every turn. From an economic point of view, drones can save a lot of money, despite the fact that the costs are high. Nevertheless, IT specialists promise to bring about a technological revolution in agriculture in the shortest possible time.

In the agricultural sector, unlike other sectors of the economy, the introduction and expansion of innovations and innovative technologies is slower, and this requires special attention and substantial support from the state. Market adoption of innovations is constrained by factors such as low solvency of farms; lack of long-term investment in innovative agricultural technologies; and lack of reliable and complete information on new scientific developments in agriculture.

Of course, it is the introduction of innovative processes in the agricultural sector and related industries that can ensure the competitiveness of the domestic agro-industrial complex. To do this, the following conditions must be met.

1. The entire production process must be built in accordance with the requirements, guidelines and regulatory parameters.

2. Technical and technological re-equipment of production along the entire chain of product promotion - from raw materials to sales of finished products.

3. Systematic updating of the range of final products, improvement of quality and consumer properties of finished food, taking into account changes in market demand.

4. Ensuring the availability of agricultural products and finished food at affordable prices to different categories of consumers.

5. Agricultural production of all forms, types and directions should have a clear and unchanging export orientation, taking into account all the most important criteria and indicators of marketing and competitiveness that are generally recognised in the world.

It should be noted that all stages of the innovation process in the agro-industrial complex should be supported in the development of innovation processes. This process includes interaction and simultaneous strengthening of technological, economic and socio-economic changes to achieve a synergistic effect. To implement an innovation development strategy, legal, economic and managerial parameters must be taken into account. Agribusinesses should work in close cooperation with scientific institutions; receive advisory information on possible changes in the concept of their production to a more promising and innovative one.

Despite all the above problems, the Ukrainian agricultural sector has a high potential for development and prospects for innovation. One of the key advantages of Ukraine's agricultural sector is access to the most important resources that support agricultural production.

Creating something new always starts with brainstorming. The company is always on a constant systematic search for innovations that can meet a specific need of society. At the same time, every business must have a well-developed management mechanism that ensures that every idea is thought through and implemented; otherwise the management will have to abandon it. This process is illustrated in Figure 6, which shows all the possible stages of an idea before it is fully transformed into an innovative project on a farm.

Ideas can come from a variety of sources. These include: consumers, wholesalers, suppliers, competitors, manufacturers, marketers, technologists, specialised innovation organisations, etc.

Sometimes competitors' activities can give rise to a new idea. New products on the market often become the starting point for finding a competitive innovation. It should be noted that sometimes innovations are copied. Sometimes an idea or development is plagiarised. This is dishonourable, but it is a real practice of market behaviour of agricultural enterprises. Another important problem is the low demand for innovations, especially in agriculture, because it is more profitable for enterprises to buy ready-made equipment abroad than to engage in their own innovation activities. Neither the private nor the public sector shows the necessary interest in implementing innovative processes, so production is falling due to the aging of technologies and equipment. This results in economic stagnation due to the unwillingness of managers to engage in innovative activities.

Innovative entities in agriculture are fundamentally different. They differ both in the form of financing and in the basis of their economic function. The differences are noteworthy. The purpose of such an entity ranges from a technical and technological idea to its scientific implementation, implementation and provision of information and advisory services. There is a big difference in the scale of activity - from international and national to the level of a particular agricultural enterprise.

Innovations in agriculture in Ukraine can be divided into several groups. First, there are innovations related to the wear and tear or severe obsolescence of agricultural machinery. Although these investments may seem to lack an innovative component, this is the situation in a large part of the country's agricultural enterprises.

Therefore, the introduction of machinery that is widely used in Western countries in our country can, in fact, be considered a "regional" innovation. Secondly, the introduction of elite plant varieties and highly productive breeds into production will be an innovation. Thirdly, innovation can be in the use of scientific developments to stimulate production, i.e. new fertilisers and additives in various areas of agriculture. Fourth, innovation can affect the management system of an enterprise – from new approaches to management to the introduction of electronic control and production management systems. Fifth, innovations may relate to the infrastructure of the agro-industrial complex, which is a macroeconomic decision that requires attention and support from the state. This may include measures to assess soil conditions and provide recommendations to farmers, advice on how to implement certain innovations in production, and information on various developments and opportunities. This could include programmes to lease high-performance agricultural machinery from the state. The gradual and balanced application of all these types of innovations in practice can have a positive effect in the agricultural sector.

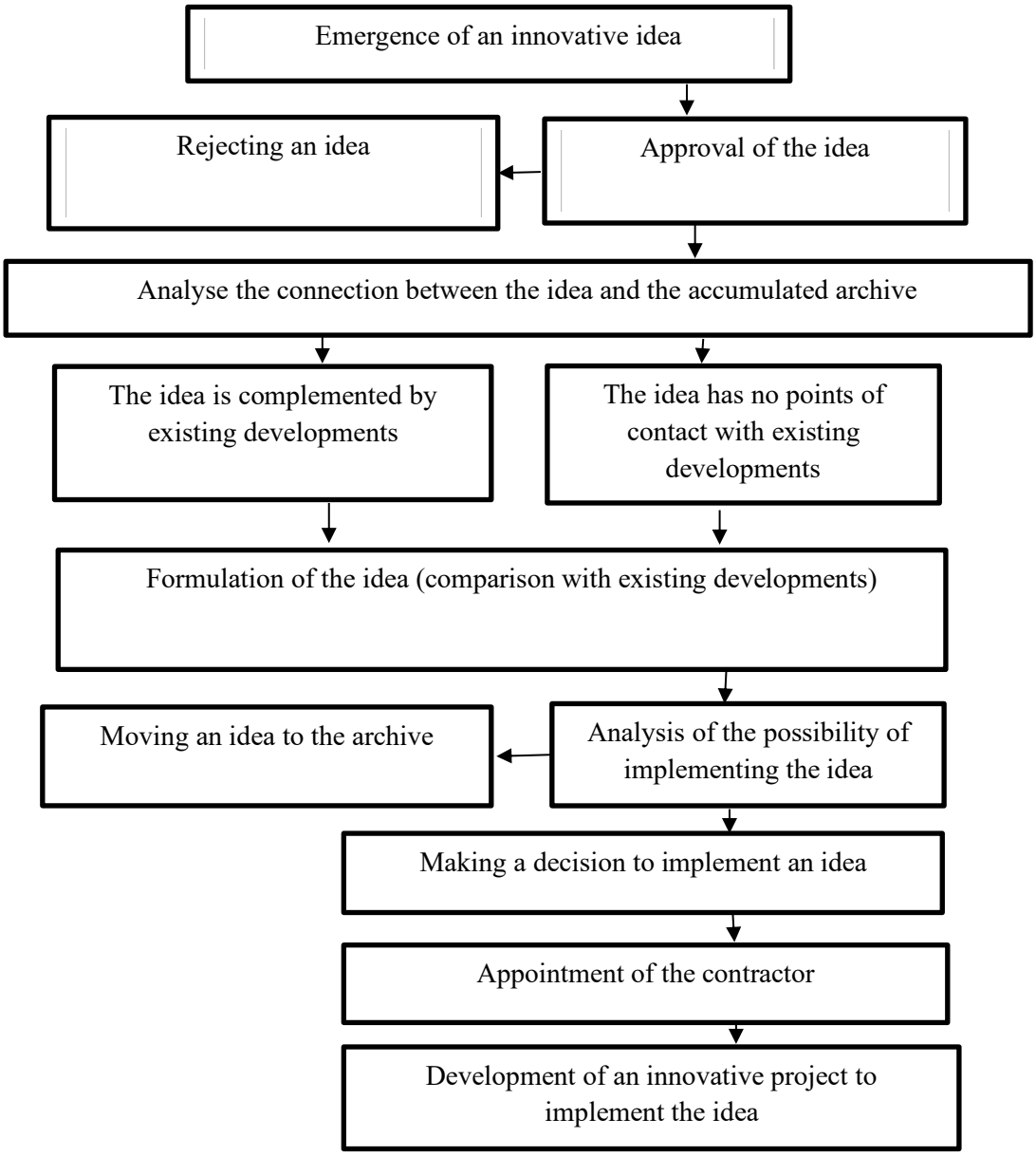

Figure 6. Schematic of the process of passing an innovative idea in a farm.

Source: compiled by the author.

Sometimes a company faces its own technical and technological problems and begins to solve them. Ideas arise, which then result in discoveries or inventions, and sometimes cause a real revolution in the industry. Following the emergence of ideas at the R&D stage, the most promising ones are selected. It is here that the foundation of a future innovation project is laid. The main task here is to ensure that the future innovation project is relevant and can be integrated into the overall development strategy of the agricultural enterprise. In addition, the idea must meet social, environmental, cultural and other standards.

The situation in the agricultural sector remains unfavourable, which also affects the state of the scientific and technological sphere. In today's globalised world, Ukraine's technological level of agricultural production is lagging behind the world's leading countries. "An analysis of five international rankings that assess the innovation of economies around the world shows that the effectiveness of Ukraine's innovation activities in 2019-2020 decreased by all indices. The reason for this unfavourable situation lie in the reduction in spending on research and development as a percentage of GDP, which

affected the quality of human capital" [15, p. 75]. It is not without reason that states pay great attention to supporting innovative business and is in many cases the initiator and engine of innovation processes.

B. V. Khakhula, having conducted a study, notes that "traditionally, new or improved technologies of agricultural production are in the first place among innovations. The second and third places are occupied by new varieties and hybrids of crops, as well as new crosses of poultry, lines and breeds of animals. Then – deep processing of products and introduction of new machinery, mechanisms and equipment" [7, p. 82]. Zapirchenko L. D., Ryabovolyk T. F. argues in their study that "agricultural enterprises transfer innovations into everyday work at a slow pace" [20, p. 82]. We cannot but agree with the opinion of these scientists, because in 2019, according to the results of the assessment of the Innovation Index of Ukrainian companies by Mind [9], only one agricultural enterprise overcame the barrier of 75 points and received the status of innovative. This is the Agroprosperis group of companies, which, according to the rating of the top 100 latifundists of Ukraine in 2022 presented on Latifundist.com, ranks 4th and cultivates 300 thousand hectares [18]. To compete with other companies, agriholding managers must effectively manage innovation processes. Managers are forced to make decisions that can affect the efficiency and productivity of their companies. Only one out of five large agricultural holdings has been granted the status of an innovative one. The others fall short of it. There is an axiom that in order to run a successful business, you need to introduce innovations into production and be able to manage the innovation process at the enterprise. We would like to emphasise that in a rather conservative agricultural market, the future of large agricultural holdings lies in creating processes for product preservation, logistics and supply for small farmers. When working on the land, they are more effective because they can respond to situations locally and are less dependent on bureaucratic processes. That is why some agriholdings work with farmers through a supply chain that provides the farmer with everything he needs: seeds, pesticides, fertilisers, loans, elevator services, railway wagon services and farmers' export contracts.

Two mistakes are commonly made in the process of selecting innovative ideas. Namely, you can either settle on a project that turns out to be ineffective or give up on a really promising idea. To minimise this risk, you need to consider as many ideas as possible. This way, the risk of failure is significantly reduced. It should be noted that in order to achieve the innovation objectives of an agricultural enterprise, a thorough non-functional analysis should be carried out during the selection of ideas, the results should be jointly verified and the idea should be evaluated. Two types of decisions are possible here: rejection of the idea or further consideration. After a brief formulation of the idea, the possibility of its implementation is analysed, and a decision is made either to move the idea to the archive or to implement it. An idea may be placed in the archive in the following cases: lack of financial resources and inability to borrow them, lack of fixed assets, significant shortage of personnel or low qualifications, high level of risk unacceptable for an agricultural enterprise, etc.

If a decision is made to implement the idea, an executor is appointed and an innovative project is developed. In our opinion, the most potentially effective innovations today are those that can be implemented in various areas of agriculture in the short and medium term, namely safe genetic engineering of seed material; zero-runoff hydrosystem fisheries; tray-condenser irrigation systems; "sea" potatoes; computerised management of cattle; bioinsecticides and pollinators; cocoon-sleeve grain storage; precision seeding technologies; "smart" greenhouses; Craft Scanner sensors to control the depth of tillage; aeroponic farms (growing plants without soil); use of drones; precision farming systems; use of cloud technologies; digitalisation of accounting (collection, transmission, analysis and processing of data); modernisation of machinery, etc. Digital technological changes have a significant impact on the economic development of agricultural enterprises.

It is worth noting that today there is already agricultural machinery with fuel level sensors, cruise control, autopilot, remote monitoring systems, autopilot systems and artificial vision technology. Digital IT companies and investors are making intensive financial investments in the agricultural sector. The level of adoption of advanced digital technologies in agricultural enterprises is still low. Over the past two decades, various companies have been introducing software for agricultural producers. There is a big gap between the technologies presented at conferences and symposia and what is actually implemented and used in the agricultural sector. The industry's transition to digitalisation of business

processes will take time: peasant farms that operate in the old-fashioned way are competitive due to cheap labour. In this regard, it is necessary to ensure an acceptable level of Internet and IT penetration in Ukrainian villages, as required for the integration of the agricultural sector in today's competitive environment. New innovative technologies are a challenge not only for agricultural producers, but also for Ukrainian start-ups that develop innovations. Jindra Peterkova, Katarzyna Černá, and Pawel Makurova conducted an interesting study on the implementation of innovations at Czech and Polish enterprises. They found that the implementation of innovations is significantly influenced by "management as the initiator of innovation in 56% of cases, rather than the owner" [6, p. 4]. The same trend is observed in Ukraine.

The introduction of modern digital technologies in the practical activities of agricultural producers is the main driver of progress in the agricultural sector, where, unlike other sectors of the economy, the introduction and dissemination of innovations and innovative technologies is slower, which requires special attention and significant state support. The introduction of innovations by agricultural enterprises (including farms) is limited by the following factors: low solvency, lack of long-term investments in innovative agricultural technologies, lack of reliable and comprehensive information about new scientific developments. Thus, under current conditions, only 4.8% of the total number of agricultural enterprises developed and implemented technological innovations, due to a reduction in investment programmes, including those for innovation, and the structural restructuring of agriculture. The state innovation policy in the agricultural sector is not properly implemented, and producers are forced to solve the issue of practical application of innovations on their own [12, p. 1900-1901].

The management process is most often positively promoted by making appropriate decisions to maximise the use of available innovation resources and to create an infrastructure to support innovation processes. Implementation of any innovative project, including the agro-industrial complex, requires the expenditure of certain resources, the cost and efficiency of which must be assessed. The project-based approach to investment activity in the agricultural sector is based on the principle of cash flow assessment. Its peculiarity is its predictive and long-term nature, which necessitates taking into account time and risk factors. The main thing is that the result of any innovative project is profit (income). All project participants should benefit from its implementation. Thus, by using and implementing innovative developments, farms will reduce costs, increase production and profits; conquer markets, which will contribute to the economic efficiency and development of the national economy [8, p. 48].

If we talk about sustainable development of agrarian enterprises, it can be ensured under the following conditions:

- limitation of economic growth, material production and consumption to the ability of ecological systems to recover;
- humanisation, introduction of a certain system of principled approaches to the issues of social activity, transformation of the social subsystem of enterprise management within the framework of human orientation, preservation of stability of social and cultural subsystems.

As for the significance of the concept of sustainable development, the study of the problems of sustainable development of agrarian enterprises will help to level the impact of challenges associated with the processes of globalisation and industrialisation of the industry, overcome its crisis state and ensure the growth of production efficiency and environmental protection. In modern conditions, sustainable development of the agrarian sector of the economy can take place only in conditions of proportional and harmonious development of interrelated components: economic, social and environmental. It is interesting to assess the trends of such interaction: as a result of recent changes in the economic and political sphere, the positive dynamics, which was previously inherent in the general integral indicator of sustainable development of the agricultural sector of the national economy, begins to level out, and the potential for sustainable development of the industry under study is only half realised. Restraining factors in the economic sphere are: reduction in the volume of investment and the number of economic entities in the sector, which resulted in a decrease in gross agricultural output; in the social sphere – a high level of unemployment among the rural population and the resulting low level of income and unfavourable social and living conditions; in the environmental sphere – insufficient financing of environmental programmes and reduction of measures to restore the productivity of

agricultural land; and in the environmental sphere – insufficient funding of environmental programmes and reduction of measures to restore the productivity of agricultural land. The assessment of the degree of balance between the three components that determine the sustainable development of the agricultural sector has revealed the insufficient development of the social component, which hinders the development of human capital, the most important factor of production in any sphere. Building up social assets of agrarian enterprises is closely connected with changes in the social subsystem of management. The social subsystem of enterprise management includes a set of its employees with professional training and certain practical experience. The efficiency and competitiveness of any subject depends to a large extent on the fixation, demographic composition of the personnel, its ability to adapt to changes in the process of realisation of the system's goals.

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