Chapter 13
European Integration of Innovative Development of Ukraine's Economy as a Dominant Strategy for Ensuring Food Security

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ABSTRACT

This study explores the strategic directions for ensuring food security in the con-

DOI: 10.4018/979-8-3373-1355-9.ch013

text of Ukraine's innovative economic development and European integration. An important task is to introduce digital technologies and precision farming, use resource-saving technologies, and expand international cooperation. Integrating innovative approaches into the food security strategy will guarantee the domestic market's stability and strengthen Ukraine's export potential. The main obstacles to ensuring food security in Ukraine are identified, proposes indicators and normative values. It is proved that the European integration vector of innovative development of Ukraine's economy should include the main strategic directions of ensuring food security (innovative agricultural sector development, production diversification, infrastructure development, state support regulation, international cooperation). This strategy addresses immediate food security challenges and contributes to Ukraine's long-term economic sustainability, population welfare, and global competitiveness in agri-food.

1 INTRODUCTION

For Ukraine, an agrarian-oriented country active in the European integration process, food security is particularly important, as it affects its economic stability, social well-being, and international reputation. Food security is a key aspect of national security, which determines the ability of the state to provide the population with the necessary food in sufficient quantity, of appropriate quality, and at affordable prices. The study's relevance is due to Ukraine's current challenges as a country actively integrating into the European economic space. Food security is a key element of national security, as it ensures stable access to quality food for the population, stimulates the development of the agro-industrial complex, and promotes economic stability. In the European integration process, Ukraine must adapt its policies to EU standards, including introducing new approaches to agricultural production, adhering to the principles of sustainable development, ensuring high quality and safety of products, and optimizing logistics and export processes (Matyushenko et al., 2020; Matyushenko et al., 2021; Petrova, Ramazanov & Stemplewska, 2025).

Developing agricultural innovations is becoming a key prerequisite for increasing production efficiency, reducing costs, and minimizing environmental impact (Tireuov et al., 2018; Tireuov et al., 2019; Tireuov et al., 2020; Petrova, Nikolova & Pavlov, 2023; Seitzhanov et al., 2020). In this context, an important task is to introduce digital technologies, precision farming, and resource-saving technologies and expand cooperation with international partners (Homidov et al., 2024; Popova et al., 2023; Nikolova-Alexieva et al., 2022). Integrating innovative approaches into the food security strategy will guarantee the domestic market's stability and strengthen Ukraine's export potential, which is strategically important in global competition.

Ensuring Ukraine's food security in the context of its European integration course is driven by the importance of the food security strategy and the need to guarantee stable access to quality and safe food for the population, increase the competitiveness of the agricultural sector, and fulfill international obligations, including compliance with EU standards. Ukraine has significant agricultural potential that can be used not only for domestic supply but also to strengthen the country's position in international markets. However, this requires considering aspects such as adapting domestic legislation to European standards, improving the quality of food products, developing modern storage and transportation infrastructure, reducing dependence on imports of critical food products, and ensuring the stability of the domestic market. The food security strategy should also consider climate change, the need to introduce sustainable agricultural practices, the development of precision farming technologies, and support for small and medium-sized farms, which are the backbone of the agricultural economy in many European countries. Important factors are the development of logistics chains, the modernization of processing plants, and the strengthening of control over the quality and origin of food following the principles of traceability, which is a mandatory requirement of the EU. In addition, food security is a matter of national security, as a country's independence largely depends on its ability to meet the food needs of its citizens on its own. Geopolitical challenges, war, economic instability, and the risk of food crises require Ukraine to develop a comprehensive food security policy that includes state support for the agricultural sector, diversification of production, innovation stimulation, and foreign investment attraction. The successful implementation of such a strategy will contribute to economic growth and to Ukraine's integration into the European market, which will ensure the stability of the agricultural sector, increase farmers' incomes, and improve living standards.

The analysis of recent studies shows the depth of the problem of innovative development of Ukraine's economy in food security. For example, L. Bartkova and L. Veselovska (Bartkova & Veselovska, 2023) investigated whether consumers in the European Union are concerned about the quality of dual-quality products. The researchers investigated the impact on consumer behaviour, market reaction, and the effectiveness of product quality regulation measures. Fisunenko (Fisunenko, 2024) analysed the main trends in ensuring the sustainable development of Ukraine's green economy in the context of European integration (Fisunenko, 2024). The author examined the effectiveness of environmental strategies and their impact on the country's economic development. V.Hobela, S. Melnyk & M. Kurliak (Hobela et al., 2022) assessed the state and forecasted trends in Ukraine's food security against war. The researchers analysed the impact of military conflicts on food security and identified strategies for adapting to unstable conditions. T. Ivanova S. Marochko (Ivanova & Marochko, 2011) studied the issues of innovative economic development as a means

of ensuring food security in Ukraine in the context of the global financial crisis, where they identified the weak development of innovative infrastructure and the need to adapt the agricultural sector to crisis challenges. S. Javed et al. (Javed et al., 2022) described modern approaches to precision agriculture for managing food security in the face of climate change. Scientists have identified the low level of technological adoption on farms and the need for innovation to reduce climate risks. (Kotykova & Babych, 2021) assessed the sustainable use of agricultural land and found soil degradation, unsustainable land use, and a lack of stable government policy. Koval (Koval et al., 2014) assessed the resource potential of the agricultural sector of Ukraine and ways to implement it. The author identified insufficient resource use efficiency and low investment attractiveness of agriculture. (Kuchechuk, 2022) analysed global trends and challenges in food security, the impact of globalisation, climate change, and the growing demand for food with limited resources. The authors explored ways to strengthen food security in the EU in the context of sustainable development. The researchers examined the need to harmonise food security policies and environmental requirements. (Kvasha et al., 2024) analysed the state of food security in Ukraine in the current context. The researchers concluded that military operations, logistics disruptions, and the destruction of agricultural infrastructure are key factors disrupting Ukraine's food supply and security stability (Lagodiienko et al., 2022) assessed the impact of factors on Ukraine's food security, explored post-war trends, and ways to ensure them (Myskiv et al., 2024). Analysed the strategic priorities for developing Ukraine's agricultural exports under martial law, where they identified restrictions on foreign markets, currency market instability, and logistical difficulties as the main problematic issues (Nykonenko, 2022). Analysed the methodological support for the formation of food security in Ukraine and found some inaccuracies in defining an effective monitoring methodology and weak coordination between government agencies, proposed anti-crisis innovative management of agricultural enterprises as a dominant factor in economic recovery. The authors proved the need for new management models, adaptation to the challenges of wartime and post-war (Shatska et al., 2024). Thus, the food security strategy in the context of the European integration vector of innovative development of Ukraine's economy is complex, as it involves solving social, economic, environmental, and technological problems. Its implementation is key to the country's sustainable development, improving the population's welfare, and strengthening Ukraine's international position as a reliable partner in ensuring global food stability.

2 MATERIALS AND METHODS

The research requires using a set of scientific methods to obtain in-depth analytical results and develop effective methodological recommendations. The primary methodological approach is a systems analysis, which allows for assessing food security as a multidimensional phenomenon, considering economic, social, environmental, and political aspects. Empirical methods, such as collecting and analyzing statistical data, are essential for studying the dynamics of agricultural production, the level of food consumption by the population, and the state of foreign trade in food products. Economic and mathematical modeling methods help predict the impact of various factors on the level of food security in the context of European integration. Optimization models can be used to develop effective strategies for using land, financial, and labor resources in the agricultural sector of Ukraine. SWOT analysis methods help assess the strengths and weaknesses of Ukraine's food security and identify opportunities and threats arising from European integration processes. Comparative analysis allows us to study the European Union's experience in food security and assess the possibility of implementing best practices in Ukraine. In addition, expert evaluation methods help analyze experts' opinions on the main challenges and strategic priorities in this area. The institutional approach allows studying the legal and organizational mechanisms for ensuring food security, particularly those related to harmonizing Ukrainian legislation with EU legislation. The innovative approach involves the study of modern technologies that can contribute to increasing the efficiency of agricultural production, including the introduction of digital technologies, precision farming, and biotechnology. Together, all these methods create a comprehensive methodological approach for analyzing and formulating food security strategies in the context of Ukraine's innovative development and European integration.

3 RESULTS

Ensuring food security is one of the fundamental elements of national security and the sustainable development of any country. For Ukraine, an essential player in the global agri-food market, the food security issue is particularly relevant in the context of European integration processes and the introduction of innovative approaches to the economy (Bondarchuk et al., 2023; Fisunenko, 2024; Hobela, Melnyk & Kurliak, 2022; Ivanova et al., 2021).

Ensuring food security requires research into such aspects as: the socio-economic impact of food policy on vulnerable groups in the current context, food security policy has an economic and a deeply social dimension. Marginalised and vulnerable

groups of the population, such as internally displaced persons, people with disabilities, large families, pensioners, and rural residents, who often lack access to quality food and stable sources of income, require special attention. The main instruments of targeted support for these groups are food subsidies, social cards, and local food initiatives; geopolitical aspects of Ukraine's agricultural policy in the context of war and regional instability - the current state of Ukraine's food security is inextricably linked to the geopolitical situation - Russia's full-scale war against Ukraine has led to the destruction of infrastructure, mining of agricultural land, reduction of export potential, and blockade of ports. These factors have national and global significance, as the decline in Ukrainian grain exports has an impact on food crises in the Middle East and Africa. In light of Ukraine's European integration course, agricultural policy is gaining strategic importance not only for domestic food security but also for the country's foreign policy positions. The stability of the agricultural sector directly affects Ukraine's image as a reliable food supplier on a global scale. This became especially evident during the full-scale war, when the issue of grain exports and other agricultural products turned into a geopolitical lever of influence - an example of this is the implementation of the 'grain initiative' with the participation of the UN and Turkey. Strengthening the institutional capacity of the agricultural sector, digitalisation of logistics, quality, and environmental guarantees for products are all factors that strengthen international confidence in Ukraine as a partner. Within the framework of cooperation with the EU, agricultural security is seen not only as a domestic policy but also as an element of the single European market, which requires compliance with standards, harmonisation of the regulatory framework, and openness to integration formats.

In addition, strengthening the agricultural sector will allow Ukraine to form new geo-economic alliances with countries in the Middle East, Africa, and Asia interested in stable food supplies. In this context, agrarian diplomacy is becoming an essential part of foreign policy, and cooperation with international financial organisations and funds helps strengthen supply chains' resilience and expand access to new markets. The role of international organisations (WTO, FAO, EBRD, UN) in supporting the food security strategy - FAO (provides analytical support, humanitarian assistance, and technical expertise in war-affected regions); WTO regulates the rules of international agricultural trade, which is key to the issue of access to Ukrainian agricultural products. Large-scale agricultural production often leads to soil degradation, water pollution, and biodiversity loss. Innovative approaches that combine economic efficiency with environmental responsibility are critical in the context of the transformation of Ukraine's agricultural sector caused by the challenges of war, climate change, and the requirements of European integration.

1. Precision farming uses satellite technologies, drones, IoT (Internet of Things), sensors, and artificial intelligence algorithms to monitor soil conditions, moisture, crop development, etc. Its application allows for reducing the cost of fertilisers, water, and fuel; optimise yields; and minimise the anthropogenic impact on the environment. The potential for precision farming in Ukraine is high, especially at large agricultural enterprises. Government support for small and medium-sized producers is needed through subsidies, educational programmes, and concessional lending to promote it.
2. Organic production - organic farming excludes chemical fertilisers and pesticides, instead involving crop rotation, biological plant protection, and improving soil fertility using natural methods. Its advantages include safe products with high added value, growing demand in the European market, and export potential. However, it requires a transition period and certification, so a clear state policy to support such producers and alignment with EU requirements is needed.
3. Regenerative agriculture is an approach to preserve and restore natural resources - soils, biodiversity, and aquatic ecosystems. Key practices include: minimal tillage, cover crops, livestock integration, and composting. This model allows for increased CO_2 sequestration, which aligns with the EU's climate goals.
4. Agroecology - the agroecological approach considers ecosystem linkages in agricultural production, integrating scientific knowledge with traditional practices. Its key values are localisation of production, social justice, and environmental adaptability. Agroecology not only supports the sustainability of the agricultural system but also contributes to the development of rural communities.

It is also necessary to consider the EU's European Green Deal policy as a benchmark for Ukraine. The European Green Deal is a sustainable development strategy that aims to achieve climate neutrality by 2050. Within its framework, the Farm to Fork sub-strategy is key for the agricultural sector, which envisages: reducing the use of pesticides by 50%; reducing the use of fertilisers by 20%; increasing the share of organic farming to 25%; and promoting short supply chains. For Ukraine, adaptation to the Green Deal is not only a challenge but also an opportunity: reorientation of agricultural exports to high-value, environmentally friendly products; attraction of funding from European funds (e.g., LIFE, Horizon Europe, European Climate Pact); technological modernisation of production through digitalisation and innovation. However, it is essential to consider national peculiarities: a large share of the extensive output, low levels of state support for small farmers, and the effects of the war on infrastructure. Therefore, a phased approach to integrating Green Deal principles, including flexibility, financial instruments, and adaptive policies, is needed.

Examples of EU countries in this context are worth highlighting: Poland, which has transformed the farming sector through EU investments, the development of cooperatives, and support for small producers. Lithuania has implemented product quality control systems and integrated digital solutions. Romania has focused on developing its agricultural insurance system and adopting sustainable development policies. These examples should be used to formulate recommendations for Ukraine to improve its agricultural policy, attract investment, digitalise agriculture, increase its export potential, and adapt to EU standards.

The European integration vector of development envisages the adaptation of the Ukrainian agricultural sector to European food quality and safety standards, which, in turn, requires institutional changes, the introduction of the latest technologies, and the formation of an effective food security monitoring system. The innovative development of Ukraine's economy creates conditions for introducing innovative agriculture technologies, improved resource management, and increased production efficiency, which helps to ensure the stability of the domestic market and the competitiveness of Ukrainian products in foreign markets.

Ensuring Ukraine's food security in the context of the European integration vector of economic development is a complex multifactorial process that includes economic, social, environmental, and political aspects. The prerequisites for food security include a developed agro-industrial complex, stable functioning of the domestic food market, effective state regulation, and integration into the European Union's common market. One of the key factors in ensuring food security is the development of agriculture, which involves introducing modern technologies, modernization of production facilities, increasing the efficiency of agricultural production, and adaptation to EU standards. Access to European markets for Ukrainian producers is also essential, as it requires harmonization of national legislation with EU requirements, an adaptation of sanitary and phytosanitary standards, and improvement of food quality and safety. Government policy ensures food security by supporting farmers, promoting exports, attracting investment in the agricultural sector, and developing infrastructure. One of the key aspects is the rational use of land resources, the introduction of environmentally friendly technologies, and an effective system of state control over product quality. The social aspect of food security involves ensuring access to quality food for all population segments, reducing poverty, and ensuring a stable income level. Developing food logistics, transport infrastructure, and distribution systems that reduce product losses and increase availability is essential. European integration requires compliance with food safety standards and an increase in the competitiveness of the Ukrainian agricultural sector, which requires reforms in governance, support for small and medium-sized farms, and increased cooperation between producers. Deeper integration into European economic processes also implies diversification of agricultural production, transi-

tion to sustainable agricultural development, rational use of natural resources, and implementation of effective food security mechanisms. Ensuring Ukraine's food security in the context of European integration requires a comprehensive approach, including modernization of the agricultural sector, improvement of the legislative framework, adaptation to EU standards, social policy to ensure food accessibility and development of infrastructure for the efficient functioning of the food market. State support and legal regulation of food security in Ukraine are among the key elements in the context of the European integration vector of the country's economic development. In the context of globalization and modern challenges such as climate change, economic instability, military conflicts, and pandemics, food security is becoming one of the key components of state stability. European integration processes also require adapting the national regulatory framework to the EU standards. One of the first steps towards ensuring food security is the legislative definition of this concept. Food security is defined as a state in which all population segments have access to sufficient, safe, and nutritious food that meets their physiological needs. Legislative acts regulating this area create the basis for forming a national food policy that must meet the standards and requirements set by the EU. The key documents that define the legal framework for food security in Ukraine are the Law of Ukraine 'On Food Safety and Quality,' 'On State Support of Agriculture', and other regulations related to the protection of public health, environmental protection, and development of the agricultural sector. However, it is also important that as part of its European integration, Ukraine is obliged to adapt its regulatory framework to EU standards, particularly in product certification, food quality, and environmental safety standards.

Ensuring food security is one of the most important components of any country's economic policy, especially in the context of Ukraine's European integration vector. This issue includes not only guaranteeing an adequate amount of food for the population but also the stability of food markets, an effective system of state control over food quality and safety, and the development of agriculture. As part of the European Union, Ukraine strives to integrate its policies into European standards, which also applies to food security. The legislative framework of Ukraine and the EU in food security consists of several regulations defining the rules for producing, circulating, and consuming food products. The Ukrainian legal framework includes:

1. The Law of Ukraine 'On Food Security' (2002) defines the basic principles and mechanisms for ensuring food security in the country. The law sets out the main directions of food security policy, including guaranteeing a sufficient amount of food and improving product quality and safety.

2. The Law of Ukraine 'On Food Safety and Quality' (2012) regulates food safety standards and the obligations of producers, importers, and sellers to ensure product quality and safety.
3. Food Safety Code of Ukraine - describes the food safety management system and the interaction of various authorities in Ukraine to ensure an adequate level of food safety at all stages of the food supply chain.
4. National Standards and Technical Regulations - Ukraine develops and implements national standards that meet international requirements, particularly Codex Alimentarius standards.
5. The Strategy for Sustainable Development of Ukraine until 2030 provides for priorities in agricultural policy, including food security.

The following regulations and directives are included in the EU legislative framework:

1. Regulation (EC) No 178/2002 of the European Parliament and the Council - establishes general principles and legal requirements for food and feed safety, including labeling rules and food traceability systems.
2. Directive 2000/13/EC of the European Parliament and the Council - concerns the labeling and advertising of food products to provide complete and accurate information to consumers.
3. Regulation (EU) 2017/625 of the European Parliament and the Council sets out the requirements for official control and monitoring of food and feed safety within the EU.
4. Codex Alimentarius is an international standard with which the EU harmonizes its national food safety regulations and is also the basis for food safety policy in the EU.
5. EU Farm to Fork Strategy - defines ways to achieve sustainable development of food security and the food system within the EU, considering environmental, economic, and social factors (Kvasha et al., 2024; Lagodiienko et al., 2022; Myskiv et al., 2024).

The European Union has a comprehensive and detailed system of food security legislation based on numerous directives, regulations, and decisions. A comparative table of the legislative framework of Ukraine and the EU in the field of food security is presented in Table 1.

Table 1. Legislative framework of Ukraine and the EU in the field of food security

Aspect	Ukraine	EU.
Main legislative acts	Law of Ukraine 'On Food Security', Law 'On Food Safety and Quality'	Regulation (EC) No 178/2002, Regulation (EU) 2017/625, Farm to Fork Strategy
Basic principles	Ensuring sufficient quantity, quality, and safety of food products	Food safety, labeling, environmental friendliness, sustainable development
Monitoring and control	National control bodies, state inspections	Official control by a single body, the European Monitoring
Environmental and sustainable development	Sustainable Development Strategy of Ukraine until 2030	Farm to Fork strategy for sustainable development of the agricultural system
International cooperation	Alignment with international Codex Alimentarius standards	Close cooperation with Codex Alimentarius, international standards
Labeling and consumer information	Defining national food labeling standards	Directive 2000/13/EC - mandatory labeling and advertising of products
The role of the state	The state is the main regulator and controller of food safety	Joint European control, each country has its own national control bodies

(Javed et al., 2022; Kotyková& Babych, 2021; Kotykova et al., 2022; Kushniruk et al., 2021)

As Ukraine seeks to integrate into the EU, it should adapt its food security legislation to European standards. The implementation of modern norms, such as those contained in the Farm to Fork Strategy or Regulation (EC) No 178/2002, will allow Ukraine to ensure a high level of food security, strengthen food control, and adapt agriculture to the requirements of sustainable development, which is important for the European integration process. State support for food security is implemented through various mechanisms, among which the most important are farmers' subsidies, public food procurement for strategic reserves, and program measures to ensure food stability. One key aspect is supporting small and medium-sized farms, which are essential participants in the country's food market. An important component of this support is promoting organic agriculture development that meets EU environmental and food safety requirements. The state's institutional capacity is exceptional in ensuring food security and effective governance. Establishing and maintaining a stable system of food stocks that can be used in crises is an important part of government policy. At the same time, developing agricultural infrastructure, including logistics, storage, and processing of agricultural products, is necessary. Given the European integration of Ukraine's economy, the country must comply with EU requirements and standards for food security, including implementing sustainable development principles, high product quality standards, and environmental requirements. One example is the adaptation of Ukrainian legislation to EU standards on genetically modified organisms, pesticides and fertilizers, and food safety. Ukraine's integration into the European economic and legal system involves the gradual implementation of EU standards in agricultural policy, which includes not only ensuring food secu-

rity but also developing the agricultural economy based on innovative technologies that will help to increase production efficiency and ensure the sustainability of the country's food systems. Thus, in the context of European integration, the state should develop a comprehensive approach to food security, combining support for domestic producers with the implementation of European requirements and standards. In this case, Ukraine will be able not only to ensure the stability of the domestic food market but also to strengthen its position in the international arena in agriculture and food security (Fisunenko, 2024; Hobela, Melnyk & Kurliak, 2022; Ivanova et al., 2021; Ivanova& Marochko, 2011; Javed et al., 2022; Kotyková& Babych, 2021; Kotykova et al., 2022; Kushniruk et al., 2021).

The principles of state regulation of food security in the context of the European integration vector of Ukraine's economic development are determined by several strategic approaches aimed at integration into European economic and legal structures. European safety and sustainable development standards are based on ensuring citizens' stable access to safe, high-quality, and affordable food. In this context, the state regulation of food security in Ukraine is based on the following basic principles (Table 2).

Table 2. Basic principles of state regulation of food security in Ukraine in the context of the European integration vector of innovative development of the Ukrainian economy

Principle	Description
The principle of integration with European legislation	One of the key aspects of Ukraine's European integration policy is the adaptation of national legislation to EU standards in food security. This includes adopting regulations that meet EU requirements, such as food safety laws, veterinary regulations, and phytosanitary standards. Regulation should ensure that Ukrainian producers and suppliers meet the requirements of the European market and harmonize product quality control.
The principle of transparency and accountability	In the process of state regulation, it is important to ensure transparency in decisions on the production, storage, transportation, and sale of food products. The openness of procedures and accountability of the authorities reduce corruption risks and promote trust in the state control system. The EU actively uses digital tools and databases to track food quality, and Ukraine should develop similar mechanisms.
The principle of sustainable development	The European integration process emphasizes the need to implement the principles of sustainable development in food security. This means ensuring food's economic affordability and agricultural production's environmental sustainability, compliance with environmental safety standards, and support for rural communities and small farms through appropriate subsidies and incentives. The principle of sustainability also implies the efficient use of natural resources, such as water and land, considering the need to adapt to climate change.

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Table 2. Continued

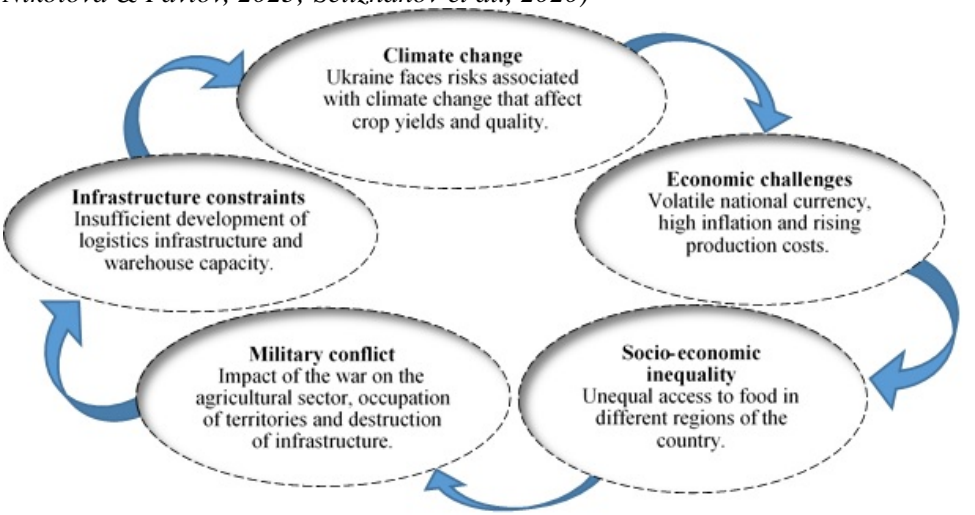
Principle	Description
The principle of innovation and technological development	In the context of European integration, Ukraine should actively introduce the latest technologies into food production, particularly in the field of agro-technology and food processing. It is important to support the development of research institutions and the introduction of innovative methods in agriculture, which will increase productivity and production quality in line with EU requirements.
Principle of inclusiveness and social justice	Ensuring food security should not be limited to economic indicators alone. It is important that all segments of the population, including socially vulnerable groups, have access to quality food. The principle of social justice is to support those segments of the population that may face difficulties accessing food due to economic or other factors. This may include social programmes, assistance to vulnerable groups, and food subsidies.
Principles of safety and quality control	In European integration, food security implies strict control over food quality and safety. This includes regular inspections for compliance with EU standards, accreditation of laboratories, monitoring of food products at all stages of production and sale, and a practical certification system. Particular attention should be paid to controlling potential risks, such as pesticide contamination or other hazardous substances.
Principle of support for small and medium-sized producers	In the context of European integration, it is important to ensure a level playing field for small and medium-sized farms. Support for such producers through financing programmes and access to new markets and technologies is essential for developing a competitive agricultural sector. It also helps to diversify food supplies and reduce dependence on large corporations, which can harm food security.

(Bondarchuk et al., 2023; Fisunenko, 2024; Hobela, Melnyk & Kurliak, 2022; Ivanova et al., 2021; Ivanova & Marochko, 2011; Javed et al., 2022)

Thus, ensuring food security in the context of the European integration vector of Ukraine's economic development requires a comprehensive approach that combines economic, social, environmental, and technological components. Important aspects include adaptation to European standards, support for innovation, sustainable development, and social justice, which contribute to achieving sustainable food security for Ukrainian citizens.

It is essential to highlight the importance of identifying optimal strategic approaches to harmonizing national legislation with EU norms, ensuring food security for the population, and minimizing the risks of dependence on food imports. It also contributes to a better understanding of the impact of external economic factors, such as climate change, global food crises, and geopolitical challenges, on the food sector in Ukraine. In recent years, these factors have severely challenged Ukraine's food security (Fig. 1) (Ivanova & Marochko, 2011; Javed et al., 2022; Kotyková & Babych, 2021; Kotykova et al., 2022; Kushniruk et al., 2021; Kvasha et al., 2024).

Figure 1. Challenges to food security in Ukraine (Petrova, Ramazanov, Stemplewska, 2025; Tireuov et al., 2018; Tireuov et al., 2029; Tireuov et al., 2020; Petrova, Nikolova & Pavlov, 2023; Seitzhanov et al., 2020)



To overcome all these obstacles, Ukraine should move towards European integration, providing great opportunities and benefits. Let us consider some of them in more detail.

1. Access to European markets is one of the key factors of Ukraine's integration into the European Union, which opens significant prospects for developing the national economy. The European Union is one of the largest consumer markets in the world, and the entry of Ukrainian goods and services into this market helps to expand export opportunities, increase competitiveness, and attract investment. At the same time, access to European markets requires compliance with strict standards and requirements in quality, product safety, environmental friendliness, and consumer protection. The free trade area between Ukraine and the EU, which operates under the Association Agreement, has become an essential tool for trade facilitation, reducing tariffs and duties, and eliminating technical barriers. However, to take full advantage of this format, Ukrainian producers need to introduce modern technologies and improve the standardization and certification of products following the requirements of European legislation. This is especially true for the agricultural sector, machine building, chemical, and food industries, which are priority sectors for export to the EU. Access to European markets also helps to increase confidence in Ukrainian products on the global stage. Meeting high EU standards automatically opens the door to other

markets, as European certification is considered one of the most respected in the world. This allows Ukraine to gain a foothold in the EU market and actively develop exports to other countries, using European markets as a springboard for further growth (Fisunenko, 2024; Ivanova & Marochko, 2011; Kotykova et al., 2022; Myskiv et al., 2024).

2. The introduction of European standards is one of the key areas of transforming Ukraine's economy as part of its European integration course. This process covers many areas, including agriculture, the food industry, the environment, energy, and industrial production. The main goal of adapting to European standards is to ensure high product quality and consumer safety, reduce environmental impact, and increase the competitiveness of the Ukrainian economy in international markets. One of the most critical components of implementing European standards is harmonizing national legislation with EU regulations. In the agricultural sector, this involves the introduction of food safety standards, such as the Hazard Analysis and Critical Control Point (HACCP) system, which is mandatory for food producers in the EU. Compliance with these requirements opens access to the European market and increases consumer confidence in Ukrainian products domestically and abroad. European standards also stimulate the transition to sustainable development, which involves the rational use of natural resources, introducing environmentally friendly technologies, and reducing harmful emissions. This is particularly relevant for Ukraine, which has significant agricultural potential but faces the challenges of soil degradation, water pollution, and the impact of climate change. Introducing modern agriculture and livestock farming technologies, such as precision farming, new-generation irrigation systems, and using renewable energy sources, contributes to environmental safety and economic efficiency (Ivanova et al., 2021; Kotyková & Babych, 2021; Lagodiienko et al., 2022; Stryzhak et al., 2020).
3. Innovations and technologies play a key role in the implementation of Ukraine's European integration vector, as they are the basis for modernizing the economy, increasing competitiveness, and achieving the high standards required by the European Union. As a country with strong scientific and technological potential, Ukraine has a unique opportunity to become a leader in implementing innovations in various sectors, such as agriculture, energy, information technology, transport, and industry. In the context of European integration, one of the main tasks is to adapt the national economy to EU standards, which requires modern technologies, digitalization of processes, and infrastructure development. The agricultural sector's innovative development, an essential driver of Ukraine's economy, plays a special role. Precision farming technologies, automation of production processes, using drones to monitor crops, and introducing new-generation irrigation systems can significantly improve production efficiency,

reduce losses, and ensure that products meet European quality standards. This, in turn, opens new export opportunities for Ukrainian producers and facilitates their integration into the EU's single market. Thus, introducing innovations and modern technologies is not only a prerequisite for Ukraine's integration into the EU but also a powerful tool for accelerating economic growth, improving the population's welfare, and strengthening the country's position internationally. Innovative development in the context of European integration opens new prospects for Ukraine, allowing it to move confidently towards a knowledge-based, technology-led, and sustainable economy of the future Bondarchuk et al., 2023; Hobela, Melnyk & Kurliak, 2022; Javed et al., 2022; Kushniruk et al., 2021).

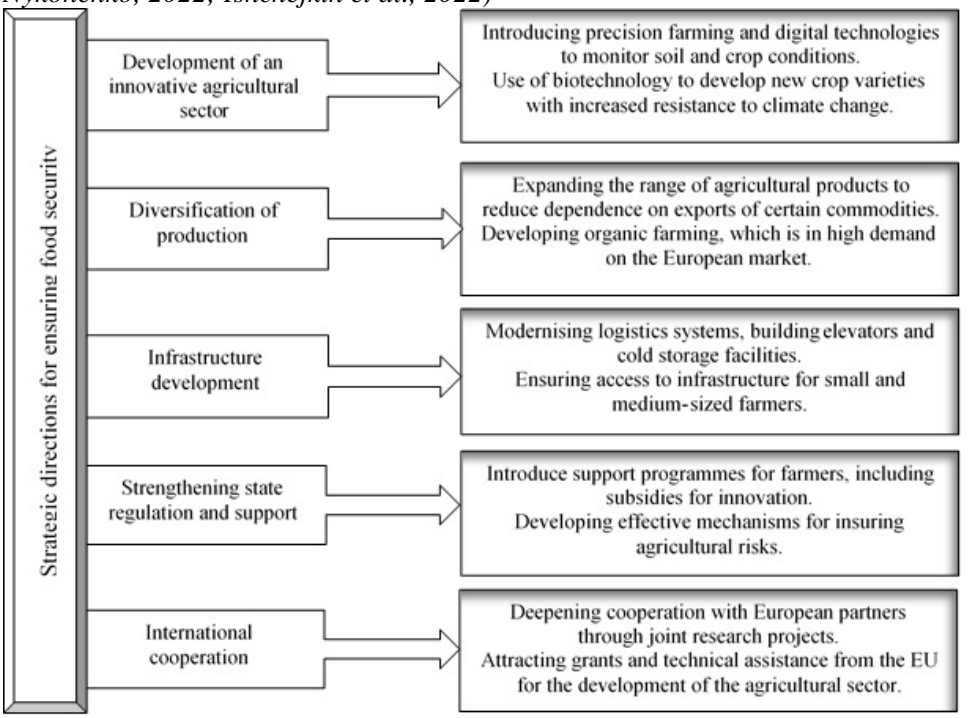
4. Attracting European investors to develop Ukraine's agricultural sector and infrastructure is an important strategic direction that contributes to strengthening the economy, increasing the agricultural sector's competitiveness, and integrating the country into the European economic space. Ukraine has significant agrarian potential due to its fertile soils, favorable climate, and geographical location, which makes it attractive to foreign investors. European investment can play a key role in modernizing the agricultural sector by helping to introduce the latest technologies, increase productivity and product quality, and reduce environmental impact (Kvasha et al., 2024; Nykonenko, 2022; Olshanska et al., 2024; Kazbekova et al., 2024; Stryzhak et al., 2020; Belgibayeva et al, 2024; Kussainova et al., 2024).

One of the key aspects of cooperation with European investors is the development of infrastructure that ensures efficient logistics, storage, and transportation of products. Ukraine needs a large-scale modernization of its warehousing facilities, logistics centers, and railway and port facilities, which will reduce product losses and optimize export flows. European investors can offer financial support, expertise, modern technological solutions, and best management practices in this context. In addition, the attraction of European capital contributes to the development of the processing industry, an essential element of added value in the agricultural sector. The creation of modern agricultural processing companies will increase employment in rural areas and expand the range of quality products for domestic and foreign markets. At the same time, European investments will help adapt production to EU standards, a prerequisite for exporting products to European countries. Thus, the involvement of European investors in the development of Ukraine's agricultural sector and infrastructure opens new opportunities for modernizing the industry, enhancing its competitive advantages, and strengthening its position in international markets. This process will contribute to the economy's sustainable development and will also be an essential step towards Ukraine's integration into the European community. In this way, the European integration vector of innovative development

of Ukraine's economy should include the main strategic directions of food security (Fig. 2). Consider and analyze the strategic directions of food security in detail.

1. Developing an innovative agricultural sector is key to ensuring Ukraine's food security and integration into the European economic area. One of the most critical areas of this development is the introduction of precision agriculture and digital technologies for monitoring soil and crop conditions. The use of modern technologies, such as GPS navigation, drones, and sensors for measuring soil moisture and composition, allows farmers to obtain detailed information about the condition of each field. This helps optimize the use of resources such as fertilizers, water, and crop protection products, reducing costs and increasing yields. For example, analyzing data from satellites and drones allows us to identify problem areas quickly, respond to them, and reduce the risk of crop loss, using biotechnology to develop new crop varieties with increased resistance to climate change. The use of genetic engineering and breeding techniques allows for the development of crop varieties that require less water, are resistant to pests, and have a shorter ripening period. This helps stabilize yields in the face of climate change but also helps reduce the use of chemical plant protection products, which positively impacts the environment. Precision agriculture and biotechnology synergy create unique opportunities for transforming Ukraine's agricultural sector, ensuring its efficiency, environmental friendliness, and competitiveness in international markets. An innovative approach to agriculture allows us to solve urgent problems and lay the foundation for the sustainable development of the agricultural sector, which is strategically important for the country's economy and the well-being of its population (Kushniruk et al., 2021; Lagodiienko et al., 2022; Ishchejkin et al., 2022; Lutkovska et al., 2024; Kazbekova et al., 2024; Stryzhak et al., 2020).

Figure 2. Strategic directions for ensuring food security in Ukraine (Kushniruk et al., 2021; Kvasha et al., 2024; Lagodiienko et al., 2022; Myskiv et al., 2024; Nykonenko, 2022; Ishchejkin et al., 2022)



2. Diversification of production is one of the most important ways to ensure the stability of Ukraine's agricultural sector, especially in the context of integration into the European economic area. Expanding the range of agricultural products helps to reduce dependence on exports of certain commodities, such as grain crops or sunflower oil, which currently account for a significant share of Ukraine's exports. This approach helps to reduce the risks associated with fluctuations in global prices for certain commodities. It helps to strengthen Ukraine's position in international markets by offering a wider range of products. European consumers increasingly prefer environmentally friendly and certified products that meet organic production standards. Ukraine has significant potential for developing this segment due to its fertile soils, favorable climatic conditions, and large areas that have not yet been intensively used for industrial agriculture. Expanding organic production will increase export revenues and improve the country's environmental situation, contributing to the sustainable development of rural areas (Fisunenko, 2024; Hobela, Melnyk & Kurliak, 2022; Ivanova et

al., 2021; Ivanova & Marochko, 2011; Javed et al., 2022; Kotyková& Babych, 2021; Kotykova et al., 2022; Kushniruk et al., 2021).

3. Infrastructure development includes the modernization of logistics systems, which involves improving the transport, warehousing, and transportation networks to ensure a timely and efficient supply of agricultural products to domestic and foreign markets. This includes building and upgrading roads and railways, and developing multimodal transport hubs to reduce the time and cost of transporting products. Particular attention should be paid to developing port infrastructure and cargo handling capabilities in seaports, which is important for agricultural exports. An integral part of modern logistics is the development of storage facilities, such as elevators and cold storage. The construction of modern elevators will allow the harvest to be stored in the best possible conditions, reducing the risk of losses due to deterioration in grain quality. At the same time, cold storage facilities will ensure proper storage of vegetables, fruits, and other perishable goods. Thus, comprehensive modernization of logistics systems, construction of modern elevators and cold storage facilities, as well as access to these resources for small and medium-sized farmers, are key factors that will help to improve the efficiency of the agricultural sector, reduce costs and losses in the production and storage of agricultural products, and strengthen Ukraine's food security in general.
4. Strengthening state regulation and support. One of the priority areas is the introduction of support programs for farmers, including subsidies for introducing innovative technologies in agricultural production. Such programs will encourage small and medium-sized producers to modernize their farms, introduce precision agriculture, use modern agricultural technologies, and comply with environmental standards. Thanks to financial support, farmers can purchase the latest equipment, introduce digital technologies for monitoring land and crops, and use natural resources more efficiently, which will help increase their productivity and competitiveness. An equally important aspect is the development of effective agricultural risk insurance mechanisms. The agricultural sector is one of the most vulnerable sectors of the economy due to its dependence on natural and climatic conditions, which can significantly affect the yields and financial stability of farms. An effective insurance system will minimize the impact of natural disasters such as droughts, floods, or hail and provide financial support for the resumption of production. Introducing such mechanisms requires active government involvement in co-financing insurance premiums, creating state guarantee funds, and encouraging private insurance companies to cooperate with agricultural producers. These measures will help strengthen the financial stability of farmers, increase their trust in government support, and create favorable conditions for long-term planning and development. At the same time,

implementing such initiatives requires a thorough analysis of farmers' needs, the development of transparent mechanisms for distributing public resources, and effective control over their use to avoid corruption risks. Thus, strengthening state regulation and support will be essential to ensure the sustainability and innovation of Ukraine's agricultural sector Myskiv et al., 2024; Nykonenko, 2022; Ishchejkin et al., 2022; Olshanska et al., 2024; Lutkovska et al., 2024).

5. International cooperation plays a vital role in ensuring Ukraine's food security and the integration of its agricultural sector into the European economic area. Deepening cooperation with European partners through joint research projects allows the adaptation of national policy to modern standards and technologies and the active implementation of innovative solutions in agriculture. The participation of Ukrainian research institutions, universities, and agricultural enterprises in such projects facilitates the exchange of knowledge, the development of new technologies, and the implementation of practices based on the principles of sustainable development. This creates conditions for modernizing production processes, increasing resource efficiency, and ensuring high-quality agricultural products. An essential tool to support the agricultural sector is to attract grants and technical assistance from the European Union. The EU offers numerous funding programs to develop agriculture, introduce environmentally friendly technologies, adapt to climate change, and support small and medium-sized farms. Taking advantage of these opportunities allows Ukrainian agricultural producers to gain access to advanced technologies, increase their competitiveness, and expand their access to European markets. In addition to financial support, the EU's technical assistance includes consulting, training, and the organization of educational programs and training. This helps to improve the level of personnel qualifications, implement EU standards in production and quality control, and improve the management system of the agricultural sector. Interaction with European partners also opens opportunities for building long-term business relationships based on common interests and trust. Thus, international cooperation and attracting European resources are strategically important areas for developing the Ukrainian agricultural sector. They create the basis for its integration into the global economy, ensure the sustainability of the country's food system, and contribute to the welfare of the population.

Several key factors influence food security strategies in the context of the European integration vector of Ukraine's economic development. First and foremost, integration into European structures requires compliance with international standards and regulations on food quality, safety, and transportation. This includes the introduction of modern quality management standards, food safety control systems, and increased openness and transparency in food policy. Another important aspect is to increase

the competitiveness of Ukrainian agricultural producers in the European market. This is possible through the modernization of the agricultural sector, in particular through investments in technology, the development of agricultural cooperatives, and support for small and medium-sized farms. The third factor is building an institutional framework for effective food security management. This includes improving legislation, strengthening the institutional capacity of state control bodies, and raising the level of education and public awareness of consumer rights and food safety. In addition, it is essential to develop infrastructure, including a logistics network that will ensure efficient transportation and storage of products that meet international standards. This will help reduce product losses during transportation and storage and ensure a stable supply to the market. All these factors together determine the direction of food security strategies in the context of Ukraine's European integration, contributing to improving the quality and safety of food products and stimulating sustainable economic development. Let us consider them in more detail. Strategies to ensure Ukraine's food security in the context of the European integration vector of economic development are shaped by a set of external and internal factors that determine opportunities and challenges for the agricultural sector, the food industry, and state policy in the field of food security. (Table 3).

Table 3. Key factors influencing food security strategies

Factor	System of factors
Institutional and legal factors	Implementation of European food safety standards (in particular, the Hazard Analysis and Critical Control Points (HACCP) principles). Harmonization of agricultural legislation, including mechanisms to control product quality and safety, and compliance with EU sanitary and phytosanitary (SPS) standards are essential for exporting products to the EU. Implementing environmental standards in production will reduce the negative impact of the agricultural sector on the environment.
Economic and financial factors	State support for farms, particularly small and medium-sized enterprises. Access to finance for production modernization (soft loans, government subsidies, international grants). The impact of external economic conditions, such as trade restrictions, changes in customs tariffs, and currency fluctuations. Diversification of sales markets will reduce dependence on one region and minimize risks to food security.
Agricultural and technological factors	Use innovative methods in agriculture, such as precision farming, biotechnology, and irrigation systems. Development of agricultural science and research institutions that improve crop varieties and production technologies. Improving the efficiency of logistics and transport infrastructure to maintain product quality during transport. Use digital technologies to monitor soil conditions, forecast yields, and optimize resource consumption.
Environmental and climatic factors	Climate change affects crop yields. Soil degradation and the need to implement measures to restore fertility. Reducing the use of pesticides and fertilizers to meet European requirements for sustainable agriculture. Improving the efficiency of water use and combating droughts.

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Table 3. Continued

Factor	System of factors
Social and demographic factors	Fighting poverty and raising incomes affect the purchasing power of citizens. Ensuring equal access to food in urban and rural areas. Educating the population about healthy eating and reducing food losses. Ensuring social protection of vulnerable groups, including pensioners and low-income families.
Geopolitical and security factors	Destabilization of production processes in agriculture is due to armed conflict. The destruction of infrastructure makes it difficult to transport and export products. Threats to food sovereignty due to the occupation of certain territories. The importance of developing the domestic market and strengthening food stocks to ensure stability in times of crisis.

(Nykonenko, 2022; Ishchejkin et al., 2022; Olshanska et al., 2024; Lutkovska et al., 2024)

Thus, ensuring Ukraine's food security in European integration depends on economic reforms, legislative harmonization, technological modernization, environmental sustainability, and social policy. Successful implementation of these strategies will ensure stable food production, expand export opportunities, and improve the population's quality of life. The principles of implementing the strategy for ensuring Ukraine's food security in the context of the European integration vector of economic development (Table 4) are based on a comprehensive approach to the formation of an effective agricultural policy, harmonization of legislation with EU norms, and introduction of modern technologies in agriculture and food production. The primary principle is to comply with the EU standards for food quality and safety, which includes the adaptation of the regulatory framework, improvement of the control system over the production and circulation of agricultural products, and implementation of approaches that meet the requirements of HACCP (Hazard Analysis and Critical Control Points). An important principle is to develop a sustainable agricultural economy by supporting environmentally friendly farming practices, promoting organic production, and rational use of land and water resources in line with European environmental practices. Another key aspect is the diversification of production and reduction of import dependence, which involves developing the domestic market, stimulating local production, and creating conditions for exporting Ukrainian agricultural goods to EU markets. In addition, the principle of food accessibility is essential, as it aims to provide the population with quality and affordable food, in particular through mechanisms of state support for socially vulnerable categories of citizens and stimulating the development of small and medium-sized farms. The principle of digitalization and innovative development of the agro-industrial complex envisages the introduction of modern technologies in agriculture, automation of production processes, and development of an electronic accounting system to improve the agricultural sector's efficiency. In addition, the principle of partnership and integration into international food markets focuses on expanding trade cooperation with EU countries, attracting foreign investment and

technological exchange, which will help increase domestic agricultural product competitiveness. An important role is also played by the principle of scientific and technical support, which involves the development of agricultural science, support for research projects, and the introduction of innovations that will contribute to the efficient use of resources and increase agricultural productivity. Thus, the implementation of Ukraine's food security strategy in the context of European integration is based on a systematic approach that includes legal harmonization, economic diversification, innovative development, environmental responsibility, and social accessibility, which together ensure the sustainable development of the food sector and strengthen Ukraine's position in international agricultural trade (Nykonenko, 2022; Ishchejkin et al., 2022; Olshanska et al., 2024; Lutkovska et al., 2024).

Implementing the strategy for ensuring the food security of Ukraine in the context of the European integration vector of economic development is based on a comprehensive approach that covers legislative, economic, environmental, technological, and social aspects. In the context of integration into the European Union, the main task is to harmonize Ukraine's agricultural policy with EU requirements, which involves the introduction of high standards of food quality and safety, modernization of production facilities, support for sustainable development of the agricultural sector and strengthening the position of Ukrainian producers in European markets.

Table 4. Main principles of implementation of the food security strategy of Ukraine in the context of European integration

Key principles	Characteristics
Harmonisation of legislation with EU standards	The basis is to bring national legislation in line with European regulations on food safety, veterinary and phytosanitary control, standardization, product labeling, and environmental standards. This includes the implementation of such acts as Regulation (EC) No 178/2002 (general principles and requirements for food legislation), Regulation (EC) No 852/2004 (food hygiene), and others. It is also essential to introduce the principles of traceability of products 'from farm to table', which guarantees control at all stages of production.
Improving food quality and safety standards	Improvements to the food quality control system include the mandatory application of HACCP (Hazard Analysis and Critical Control Points) standards, which minimize the risk of food incidents and improve product safety. Sanitary and phytosanitary standards are also being adapted to European requirements, facilitating the export of Ukrainian agricultural products to EU markets.
Development of a sustainable agricultural economy and environmentally friendly agriculture	Food security in the context of European integration is inextricably linked to preserving natural resources and introducing environmentally friendly farming practices. In this context, the priorities are reducing the use of chemical fertilizers and pesticides; supporting organic production and certification of products according to European standards (EU No. 848/2018); rational use of water resources and prevention of soil degradation; development of agro-ecological practices that help reduce greenhouse gas emissions and adapt agriculture to climate change.
Diversification of production and reduction of import dependence	Ukraine has enormous agricultural potential, but much of its production is focused on the export of raw materials, in particular grains and oilseeds. At the same time, the domestic market mainly depends on processed food imports. Therefore, it is essential to create incentives for the development of the food industry, increase the level of processing of agricultural products, expand the range of domestic food products, and improve their competitiveness.
Development of small and medium-sized farming	The European agricultural sector model is based on supporting small and medium-sized farms that ensure food security and employment in rural areas. For Ukraine, it is important to implement state support programs for farmers, provide financial grants and soft loans, and promote the cooperative movement, increasing the agricultural sector's sustainability and ensuring product availability for the population.
Food accessibility and social protection of the population	Ensuring access to quality and safe food for all segments of the population is a key aspect of food security. This requires the introduction of mechanisms to regulate prices for basic foodstuff, the creation of strategic food reserves, the development of social programs to support the poor, and the introduction of a targeted assistance system.
Innovations and digitalization of the agricultural sector	Modern technologies, such as precision farming, automated crop monitoring systems, biotechnology, and artificial intelligence to predict yields and manage production processes, will help improve the agricultural sector's efficiency. It is also important to develop digital platforms to ensure the transparency of agribusiness, electronic markets for products, and the introduction of blockchain technologies to track the origin of products.

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Table 4. Continued

Key principles	Characteristics
Expansion of trade cooperation with the EU and international integration	Another important area is the development of exports of Ukrainian food products, expanding the geography of supplies, removing technical barriers to trade, and Ukraine's active participation in international organizations such as the World Trade Organisation (WTO) and the Food and Agriculture Organisation (FAO).
Development of science and education in the agricultural sector	To ensure food security, it is necessary to support the development of agricultural science, conduct research in breeding, genetics, and biotechnology, develop innovative farming methods, and train specialists in the latest technologies. It is also important to create centers of agricultural competence and innovation clusters.

(Nykonenko, 2022; Ishchejkin et al., 2022; Olshanska et al., 2024; Lutkovska et al., 2024; Kvasha et al., 2024; Lagodiienko et al., 2022)

Thus, the implementation of Ukraine's food security strategy in the context of European integration is based on a multifaceted approach that includes legislative reforms, environmental initiatives, technological innovations, social programs, and international cooperation. Implementation of European standards, development of farming, increase in the level of product processing, expansion of trade opportunities, and support for scientific research will contribute to strengthening food security and the sustainable development of Ukraine's economy.

No effectively implemented strategy can exist without evaluating its effectiveness. Assessing the effectiveness of the food security strategy in the context of the European integration vector of Ukraine's economic development requires a systematic approach and the use of key performance indicators (KPIs). These indicators include food self-sufficiency, the share of agricultural exports to the EU, introducing innovative technologies in the agricultural sector, and reducing product losses due to logistical problems. We propose evaluation formulas for each of these indicators that allow for a quantitative analysis of the strategy's effectiveness.

The level of food self-sufficiency (LFS) determines the ability of a country to provide its population with the necessary food. It is one of the key indicators of food security. It describes the relationship between the volume of domestic production of basic foodstuffs and the level of consumption by the population. A high level of LFS indicates the country's independence from food imports, the stability of the agricultural sector, and reduced risks associated with external factors such as international trade sanctions, changes in the global environment, or geopolitical crises. If the LFS exceeds 100%, it means that the country produces more than it consumes and can export the surplus. If the value is less than 100%, the country is forced to cover the deficit through imports. The level of food self-sufficiency depends on a set of economic, social, and natural and climatic factors:

agricultural production - depends on agricultural policy, investment in technology, fertilizer use, climatic conditions, and agricultural productivity;
consumption by the population - influenced by demographic changes, income levels, pricing policy, and cultural food traditions;
export-import balance - if a country is focused on food exports, this can reduce domestic supply and lower the level of LFS;
government regulation policy - subsidies to farmers, tariff regulation of imports and exports, control over food prices;
the efficiency of logistics and infrastructure - affects the level of product losses during transportation and storage.

For Ukraine, one of the world's largest food exporters (cereals, sunflower oil, poultry meat), the level of self-sufficiency in certain categories of products exceeds 100%. However, some segments (e.g., fish, fruit, and certain types of meat products) are in short supply and dependent on imports. European integration implies harmonization of the food security system in line with EU standards, which includes strengthening quality control, improving the environmental sustainability of agricultural production, and creating conditions for diversification of production to ensure high self-sufficiency in all key product groups. Thus, a high level of LFS contributes to the country's economic stability, minimizes dependence on foreign markets, and provides the population with affordable and high-quality food. The following formula calculates it:

$$LFS = \frac{P_{prod}}{P_{cons}} \times 100\% \quad (1)$$

P_{prod} – is the volume of food production in the country (tons, liters, etc.);

P_{cons} – total food consumption in the country.

A level of self-sufficiency above 100% indicates the possibility of exporting products, while a level below 100% indicates dependence on imports.

Share of agricultural exports to the EU (SAE-EU) - allows us to assess the success of integrating Ukrainian producers into the European market. The higher the share of agricultural exports to the EU, the more successfully Ukrainian producers adapt to the requirements of the European market, which indicates: harmonisation of quality standards - compliance of Ukrainian products with EU sanitary and phytosanitary requirements; Competitiveness of the agricultural sector - ability of Ukrainian producers to work effectively in the conditions of fierce competition in the European market; Growth of trust of European partners - increase in the Factors affecting the SAE-EU level: regulatory changes - adaptation of Ukrainian legislation to EU norms (Association Agreement, Free Trade Area); sanitary and phytosanitary requirements - compliance of products with European food safety standards; competitive advantages - low production costs, fertile soils, high agricultural productivity; logistics and infrastructure - availability of transport corridors, ports, customs points

for export; political and economic stability - impact of military risks, sanctions, and EU economic policy. In recent years, the share of agricultural exports to the EU has been growing due to the Deep and Comprehensive Free Trade Area (DCFTA) between Ukraine and the EU; the expansion of duty-free quotas for certain types of products (honey, cereals, poultry, fruits, vegetables); and the development of export-oriented food processing industries. Thus, SAE-EU is a key indicator for assessing Ukraine's economic integration into the European market, reflecting the level of adaptation of Ukrainian producers to EU standards, their competitiveness, and the dependence of the agricultural sector on European exports. Calculation formula:

$$SAE - EU = \frac{E_{EU}}{E_{total}} \times 100\% \quad (2)$$

де E_{EU} – is the volume of agricultural exports to the EU countries (in monetary or physical terms);

E_{total} – total exports of agricultural products.

The growth of this indicator indicates the success of adaptation to EU requirements and the increased competitiveness of Ukrainian products.

Implementing innovative technologies in the agricultural sector (IT) - the share of enterprises that have implemented innovations in the total number of agricultural enterprises. The introduction of innovative technologies in the agricultural sector (IT) is one of the key factors in increasing agricultural productivity, resource efficiency, and food security. This indicator reflects the level of technological development of the agricultural sector and its ability to adapt to modern challenges, particularly in the context of European integration. The share of enterprises that have implemented innovations in the total number of agricultural enterprises can be used to assess the level of implementation of innovative technologies.

Criteria for taking into account innovative technologies:

digital technologies - the use of precision farming systems, agrodrones, satellite monitoring, farm management systems, and yield forecasting;
biotechnology - the use of genetically improved crops and animals, biological plant protection products, and microbial fertilizers;
energy-saving technologies - introduction of water-saving technologies (drip irrigation), alternative energy sources (biogas plants, solar panels);
smart farms - automated systems for feeding, milking, and monitoring animal health;
organic production - transition to environmentally friendly farming methods without using chemicals.

The data for calculating this indicator can come from official statistics (State Statistics Service, Ministry of Agrarian Policy and Food of Ukraine), surveys and reports of enterprises, and research by think tanks and international organizations.

The analysis of the share of enterprises that implement innovations allows for assessing the level of technological modernization of the agricultural sector, identifying regional imbalances in implementing innovations, developing state programs to support innovation, and evaluating the effectiveness of investments and international technical assistance. The share of enterprises implementing innovative technologies is an essential indicator of the competitiveness of Ukraine's agricultural sector. Its increase will contribute to efficient resource use, productivity, adaptation to climate change, and compliance with European standards.

This indicator is calculated using the following formula:

$$IT = \frac{N_{innov}}{N_{total}} \times 100\% \quad (3)$$

де N_{innov} – is the number of agricultural enterprises that have implemented innovative technologies;

N_{total} – total number of agricultural enterprises.

A high value of this indicator indicates the progressive development of the sector and its readiness for a competitive environment.

Reduced Product Loss due to Logistics Issues (RPL) is measured as the ratio of product losses due to logistics issues to the total product volume, which is presented as a coefficient. RPL (Reduced Product Loss due to Logistics Issues) is an essential indicator of the efficiency of the logistics system in the agricultural sector and the food industry. It allows us to estimate the share of lost products due to logistical difficulties concerning the total production volume. Factors affecting RPL. The following logistics factors affect the value of this indicator: insufficient development of transport infrastructure - poor condition of roads, insufficient number of freight movements, lack of appropriate transport; problems with product storage - lack or low quality of warehouses, refrigeration equipment, non-compliance with storage conditions; suboptimal transport routes - long or complex routes that lead to spoilage of products during transportation; delays at borders and customs - especially relevant for the export of perishable products; lack of digitalization of logistics processes - insufficient use of GPS monitoring systems, automated logistics management systems, analytical forecasting tools; climatic and seasonal factors - adverse weather conditions that complicate transportation; low level of coordination between participants in the logistics chain - ineffective interaction between manufacturers, transport companies, warehouse operators and retailers.

Ways to reduce RPL - Reducing product losses due to logistical problems is possible through the following measures: modernization of transport infrastructure - repair and construction of roads, development of rail and water transport; introduction of modern logistics technologies - GPS trackers, intelligent supply management systems, automated warehouses; improvement of storage conditions - construction of cold storage facilities, improvement of perishable goods transportation conditions; optimization of logistics routes - reduction of transportation time, expansion

of RPL is a key indicator in determining the efficiency of logistics processes in the food sector. The lower the RPL value, the more efficient the logistics system is, which means fewer product losses, higher profits, and more stable food security. Reducing losses due to logistical problems contributes to the competitiveness of Ukrainian agricultural products on the European market, which is important in the context of European integration. RPL calculation formula - the result is expressed as a coefficient (from 0 to 1) or as a percentage (by multiplying by 100%).

$$RPL = \frac{L_{\log}}{P_{prod}} \times 100\% \quad (4)$$

L_{log} – is the volume of product losses due to logistical problems;

P_{prod} – is the volume of products produced.

A decrease in this indicator indicates improved logistics processes and higher supply efficiency.

Table 5 describes the indicators and normative values to consider when assessing this strategy's effectiveness.

Table 5. Indicators and their normative values in assessing the effectiveness of the implementation of the food security strategy in the context of the European integration vector of Ukraine's economic development

Indicator	Description	Normative value
Level of food self-sufficiency (LFS)	Reflects the country's ability to meet its own food needs.	≥ 100% (high level of security). A value of <100% indicates dependence on imports.
Share of agricultural exports to the EU (SAE-EU)	Measures the share of agricultural exports to the EU in total exports.	30-50% or more, depending on the trade structure. A higher figure demonstrates successful integration into the EU market.
Implementation of innovative technologies (IT)	The share of enterprises implementing innovations in the total number of agricultural enterprises.	≥ 40%. A high value indicates the progressive development of the industry.
Reduction of product losses due to logistical problems (RPL)	This reflects the number of product losses due to inefficient logistics in total production.	≤ 5-10%. A value above this threshold indicates the need to improve logistics processes.

[proposed by the authors]

The integrated use of these indicators will allow for a comprehensive assessment of strategy implementation, identification of weaknesses, and adjustment of approaches to achieve the goals. Quantitative analysis based on formulas combined with qualitative analysis will ensure objectivity and accuracy in management decision-making.

To improve food security in Ukraine in the context of the European integration vector of economic development, it is worth delving into several key aspects, including infrastructure development, legislation adaptation, production efficiency improvement, and integration of Ukraine into European economic systems.

1. Modernisation of the agricultural sector. Ukraine should actively introduce innovative technologies in agriculture. This may include using modern methods of growing crops, such as precision farming, drones to monitor soil and crop conditions, and biotechnology to improve plant varieties and animal breeds. Moving to automated production management systems is also essential, as it will significantly reduce costs and increase the agricultural sector's efficiency. This will require public investment, facilitating access to the latest technologies, and education and training for farmers.
2. Harmonisation of standards and regulations. The European Union sets very strict requirements for food safety and quality. Ukraine needs to adapt its legislation to EU standards to export to European markets without additional barriers. This includes the introduction of quality standards such as HACCP (Hazard Analysis and Critical Control Point of Production and Processing), organic certification, environmental regulations, and labeling requirements.
3. Development of storage and transport infrastructure. Ukraine has a significant problem with its agricultural storage infrastructure. Many harvests are lost due to the lack of modern storage and cold storage facilities, negatively affecting the country's food security. Improving the infrastructure includes modernizing grain storage facilities, building new facilities for storing vegetables and fruits, and improving logistics to ensure that products are transported quickly to consumers. This will allow for more storage and reduce seasonal price fluctuations, which is important for stable supply in the domestic market.
4. Strategy for the development of organic production. The European market for organic products is becoming increasingly important and promising. Ukraine has significant potential for developing organic agriculture due to its fertile soils and large agricultural areas. Creating favorable conditions for organic producers is about improving food security and preserving biodiversity and the environment. This requires comprehensive changes in government policy, including subsidies for farmers, support for organic certification, and promotion of Ukrainian organic products on the European market.
5. Improving the efficiency of land management. Ukraine must effectively manage its land resources to ensure sustainable food production. Implementing comprehensive measures to restore degraded land, combat erosion, and preserve soil fertility is necessary. An important part is to create a resilient ecosystem that can sustain productivity over the long term while considering climate change.

6. Financing and support for farms. Supporting small and medium-sized farmers should be one of the main areas of food security. An essential element is access to credit on favorable terms, support for crop insurance, and subsidies for machinery and fertilizers. In addition, encouraging farmers' cooperatives will help to bring small producers together to achieve economies of scale and reduce costs.
7. Expanding export opportunities and integration into European markets. Access to EU markets is an essential aspect of the European integration process. Thanks to free trade agreements with the European Union, Ukraine can export its agricultural products to the EU without significant customs restrictions. However, Ukrainian producers must meet high product quality, safety, and environmental friendliness requirements to do so. This requires continuous improvement of production processes, including through certification and compliance with European standards.
8. Improving the level of education and training. To successfully integrate into European standards, it is necessary to improve the level of education and training in the agricultural sector. This includes training highly skilled professionals capable of using the latest technologies and effectively managing agricultural enterprises. It is also important to support research and innovation in agriculture to adapt Ukrainian agriculture to changing environmental conditions.

Thus, ensuring Ukraine's food security in European integration requires a comprehensive approach covering various aspects of agricultural development, legislation adaptation, infrastructure improvement, and support for small farms.

4 DISCUSSION AND CONCLUSIONS

The strategy for ensuring Ukraine's food security in the European integration vector of innovative economic development should be based on a comprehensive approach, considering the modern world's internal and external challenges. European integration opens new opportunities for Ukraine in terms of access to advanced technologies, investments, and European markets, while at the same time requiring high standards of product quality, environmental friendliness, and production efficiency. The strategy should focus on modernizing the agricultural sector, introducing innovations in food production, storage, and logistics, developing a research and technological development system, and creating a favorable business environment for farmers and agricultural enterprises. Particular attention should be paid to the sustainable use of natural resources, including land and water, which are key to agriculture. Effective government policy to develop the agricultural sector should

include support for small and medium-sized farms, promoting organic farming, creating modern food security monitoring systems, and combating food losses. In this context, it is important to harmonize Ukrainian legislation with EU norms, which will facilitate the integration of Ukrainian products into European markets and strengthen the country's competitiveness.

It is proven that innovations play a key role in transforming Ukraine's agro-industrial complex as a fundamental component of food security. In the context of military risks, climate change, and global instability, innovative solutions allow us to adapt to new challenges and increase the resilience of the agricultural system. In particular, they help to: optimise production processes through digital technologies; reduce dependence on imported resources; develop environmentally sustainable approaches; improve energy efficiency; and create added value through new processing formats, storage, and sales. Thus, innovation is a tool for technological progress and the strategic reorientation of the agricultural sector towards sustainable, competitive, and integrated development in the European space. Many innovative developments and technologies in the Ukrainian agricultural sector aim to increase yields, improve product quality, optimize costs, and preserve soil fertility. These solutions include precision farming systems that provide differentiated application of fertilisers and plant protection products; biotechnology and new crop varieties that are resistant to stressful conditions (droughts, pests, diseases); intelligent irrigation systems that allow for real-time moisture control; organic and regenerative farming that ensures high quality products with a minimal environmental footprint. These innovations increase productivity and contribute to harmonisation with European food quality and safety standards, which is key to the European integration process.

The results of the analysis show that Ukraine's European integration course is a powerful catalyst for innovative renewal of agricultural policy, as well as for structural reforms in the field of food security. The main interrelationships are manifested through: harmonisation of the regulatory environment with EU norms (food safety, quality, environmental standards); access to finance and technology through participation in joint programmes and markets; institutional restructuring of agricultural governance in line with the Green Deal and Farm to Table principles; development of human capital and agricultural education in the context of digital transformation. Thus, innovations in the agricultural sector are not an end but a means of achieving the strategic goal of food security, economic sustainability, and Ukraine's full integration into the European economic and agricultural space.

Thus, ensuring Ukraine's food security in the European integration vector of innovative economic development is a matter of national security and an important tool for achieving sustainable economic growth, improving the population's welfare, and strengthening Ukraine's position internationally.

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KEY TERMS AND DEFINITIONS

Food Security: the state in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs for an active and healthy life.

European Integration: the process of harmonizing national laws, standards, and practices with those of the European Union to allow closer economic, political, and institutional cooperation.

Precision Farming: an innovative agricultural management concept that uses technologies like GPS, sensors, and data analytics to optimize field-level management regarding crop farming.

Sustainable Agriculture: farming practices that meet current food needs without compromising the ability of future generations to meet theirs, typically involving eco-friendly techniques and conservation of resources.

Innovation in Agriculture: the introduction and application of new technologies, processes, or products to improve the efficiency, productivity, and sustainability of farming practices.

Agroecology: an approach to agriculture that integrates ecological principles into farm management, emphasizing biodiversity, sustainability, and the socio-economic well-being of farming communities.

Farm to Fork Strategy: a key component of the European Green Deal aimed at creating a fair, healthy, and environmentally friendly food system by reducing the use of chemicals and promoting sustainable food production.

Infrastructure Development: the construction and modernization of physical facilities (e.g., storage, logistics, transportation) that support agricultural production and distribution, essential for reducing losses and ensuring market access.