

# Circular economy: the future of aquaculture sector in Ukraine

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**Abstract.** Ukraine stands on the threshold of economic development and outdated habits. At the same time, the situation with landfills and ecologically oriented productions is much wider than in Western countries. But thanks to the popularity of the transition to alternative energy sources, even the country's population already partially uses it. The aquaculture sector is one of the promising areas of the Ukrainian economy. Currently, it is only taking its modern form. This study examines the prospects for the development of the aquaculture sector in the circular economy, as a reliable pillar of Ukraine's food security in the long term. Weaknesses and opportunities of the sector, as well as pre-war growth trends, are identified. A number of recommendations are also offered to direct attention to the issues of the sector.

## 1. Introduction

In the last decade, leading scientists have paid special attention to the research of a new concept of economic development, called the "circular economy". According to supporters of this concept, circular growth will help overcome the climate crisis and promote the development of an inclusive green economy. The same definition of this type of economy was formed in their research in 2019 by Oxford University experts. The evolutionary development of the circular economy took place in three main stages: 1st stage (1970-1990) – work with waste; 2nd stage (1990-2010) – environmental efficiency strategies; 3rd stage (2010 - our time) - maximum conservation in the era of depletion of resources.

The circular economy is based on the following principles: recovery of resources, recycling of secondary raw materials and transition to renewable sources of energy (energy of the Sun, wind, water).

The use of circular economy principles is a challenge of the 21st century, as it is actually ensuring a sustainable future. But there are situations when long-term plans need to be built with a broad view of tactical goals.

In the midst of a full-scale war of the Russian Federation against Ukraine, it is necessary to clearly imagine which sectors of the economy are primarily in need of investment. First, it is a civil infrastructure that will provide the population with heat and water at any time. Secondly, it is a matter of nutrition. Therefore, the topic of aquaculture business is relevant and proposed for study.



## 2. Theoretical background

The issue of the development of the aquaculture sector within the framework of the circular economy has actually not been the first decade around the world. Because fishing and fish farming are actually one of the first forms of farming in history.. Also, a number of European scientists are actively engaged in the theoretical foundations and practical recommendations for the implementation of circular economy principles in all spheres of human activity. Empirical research methods were used in the study, time comparative analysis, SWOT analysis was carried out. The material is presented graphically and in the form of tables for comfortable viewing.

## 3. Results

A circular economy (referred to as CE at some junctures in the text) is ‘an economic system aimed at eliminating waste and ensuring the continual use of resources, through reuse, sharing, repair, refurbishment, remanufacturing and recycling to create a closed-loop system, minimizing the use of resource inputs and reducing the creation of waste, pollution and carbon emissions. The concept or idea of circularity in an economy was first propounded by Kenneth Boulding way back in 1966. Circular economy has strong links to the Sustainable Development Goal no. 12 of the UN 2030 Agenda for Sustainable Development—namely, Sustainable Production and Consumption [1].

The basis of the circular economy is formed by closed supply chains, which are understood as supply chains that ensure the maximization of added value during the entire product life cycle with dynamic recovery within relatively long-time intervals of values of various types and volumes [2].

In Ukraine, the main circular economy program documents are the following:

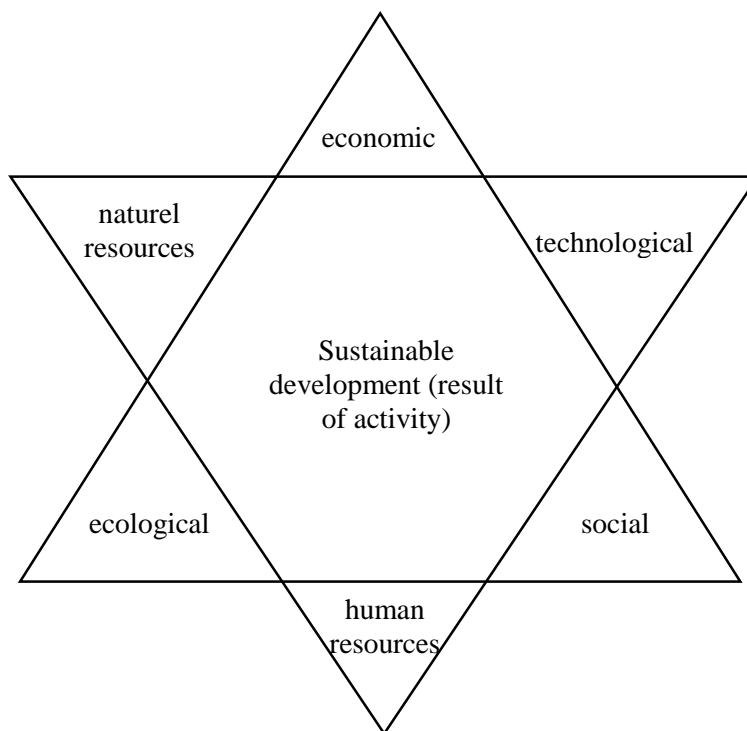
- National waste management strategy until 2030;
- National waste management plan until 2030;
- Strategy of the state environmental policy of Ukraine for the period until 2030;
- Concept of implementation of state policy in the field of climate change for the period up to 2030 and its implementation plan;
- Low-carbon development strategy of Ukraine until 2050, etc.

Despite the large number of adopted program documents, Ukraine has not yet formed a coherent system of support for the development of the circular economy. The state of development of the branches of the "closed cycle" economy is still at a low level [3].

The resource-technological format of the model of sustainable development, which is relevant for all spheres of activity and sectors of the market economy without exception, is illustrated in Figure 1, which reflects the relationship of its basic triad (economic, environmental and social results) with natural resources, human resources and technologies that have guarantee the safety of development and conditions of human life [4].

On the basis of this, it is necessary to highlight that the development of any sector of the economy has already begun in one way or another, that is, such changes and concepts must be introduced into the already working system. This is the difficulty of reforming the economy of Ukraine, all sectors are extremely difficult to reform.

On the other hand, the circular economy model for food products focuses on the reuse of waste so that the results of a value chain become part of other value chains. An example is the processing of fish - fillets, trimmings, and other leftovers are obtained from it. Such residues are part of pet food. A circular economy also uses by-products that could otherwise be discarded altogether or recycled into other items after their useful life has expired. For example, biodegradable packaging is made from crustacean shells. And there are many such examples. [5].



**Figure. 1.** The model of sustainable development in the resource-security format.  
Source: based on [4].

That is, from an economic point of view, in the future, each industry should use resources in the most rational way, and even better, independently generate them and multiply the commodity value. Then the model of sustainable development will acquire a safe vector.

In Ukraine, there is a sector that is just starting to develop, despite the enormous prospects. This is the aquaculture sector.

Aquaculture, which encompasses the cultivation of both animals (including crustaceans, fish and calms) and plants (including seaweed and freshwater macrophytes), can be practiced in inland (fresh) and coastal (marine) waters, affecting the ecosystems of both bodies of water. objects the intense production of industrial aquaculture requires large amounts of water, fertilizers, feed and other chemicals, which generate a significant amount of waste and all other related environmental problems. All these consequences, if the ecological safety of production is not observed, can lead to the extinction of fish and eutrophication of water bodies, harmful blooms of algae, loss of biodiversity, lack of oxygen at the bottom and pollution of coastal waters.

Aquaculture is a major component of the fisheries and agricultural sectors. Aquaculture products are a strategic resource of the state, as a source of high-quality products mainly in the places of their consumption, which do not require large costs for their transportation (compared to the sea and the ocean).

In today's conditions of a sharp reduction in oceanic catch and the critically depressed state of inland water bodies, the actualization of the aquaculture segment in Ukraine objectively becomes a sign of an alternative strategic vector for the development of fisheries. However, having a rich natural resource potential for large-scale development of fisheries, the state loses these advantages due to the lack of necessary institutional conditions. Thus, according to the State Fisheries Agency, of the 250,000 ha of aquaculture suitable for aquaculture, only half is used in modern conditions. Of them, 60% are used inefficiently and therefore have low fish productivity [6].

Let's take a closer look at the results of the aquaculture sector in Ukraine in recent years [7].

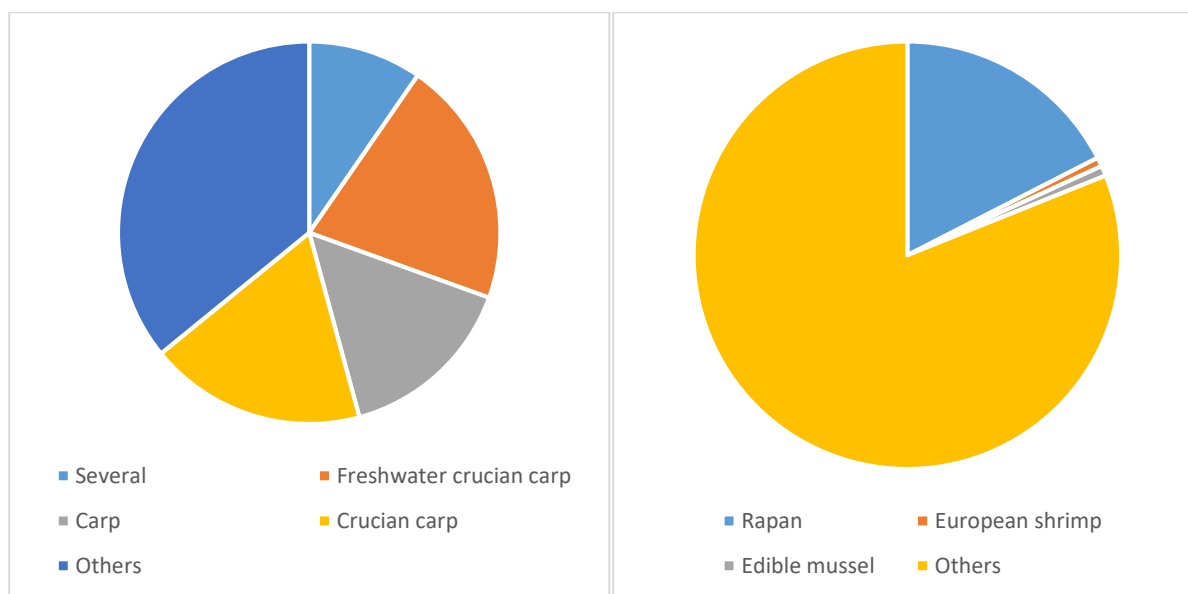
**Table. 1.** Extraction of aquatic bioresources by aquaculture in 2018-2021, tons.

All fishing areas	2018	2019,	2020,	2021,	Average price of extraction aquatic bioresources, UAH per 1 ton, 2021
Aquatic bioresources	13576.6	12675.4	11932.6	11100.7	41076.5
Fish	13569,8	12667,7	11925,7	11097,3	40829.9
Other aquatic bioresources	6.8	7.7	6.9	3.4	852051.6

Source: based on [7].

It can be seen from the table that the production is not stable, it is based on fish products that could not be processed. In this form, the fish is exported abroad and already there it goes through several stages of assigning additional value. Which is an omission on the part of the Ukrainian manufacturer. Let's consider the most promising areas of development of the aquaculture sector from the point of view of the circular economy.

Fish fillets and other types of fish meat are the most exported both in terms of volume and value in the structure of Ukrainian exports. In the following months, canned fish and shellfish will be available.



**Figure.2** Products of the aquaculture sector of Ukraine by production, as of 2021, tons.

Source: based on [7].

In cold years, marketable fish, as a rule, does not reach marketable weight, which negatively affects the profitability of production. Under such conditions, the fish planting material also does not reach the standard (as a rule, it is juveniles weighing no more than 15 g), besides, its survival rate is low. The lack of heat in the temperate zone, namely the main area of European fish farming, negatively affects the growth indicators of the main objects of pond fish farming - carp and herbivorous fish.

When growing carp in ordinary ponds, more than 70% of its weight gain occurs in the hottest months of the year - July and August.

Optimizing the conditions for growing carp and herbivorous fish, first of all, should provide for the creation of a favorable temperature regime of water bodies for cultivated fish farming facilities. Such conditions are achieved by special heating of water for fish farming, usage warm underground (geothermal) water, and usage warm industrial water for fish farming.

Industrial aquaculture is a new direction of fish farming, which reached a high level of development in the 1970s and 1980s. Ukraine should use all the assets of this direction right now, as this will ensure maximum capitalization. But this step requires significant capital investments at the basic level [8, 11].

In aquaculture, the circular economy proposes the use of waste and by-products in the formation of additional supply chains for human consumption. For example, the flour used in aquaculture can contain up to 35% of fish trimmings. Land animals are often used to produce flour with high nutritional value. Flour from insects and bacteria, which are new components of production, become another potential in the stream of using waste as raw materials.

The economic and ecological viability of special terrestrial energy crops is questionable. The production of large volumes of biomass (macroalgae) for biofuels in the marine environment was first tested in the late 1960s. Early attempts failed due to the engineering challenges of offshore farming. However, energy conversion through anaerobic fermentation has been successful because the biochemical composition of macroalgae makes it an ideal feedstock.

According to the results of research by G. Shevchenko, the main sources of biomass in Ukraine are waste and agricultural waste, in the future there is a plan to grow energy crops specifically for this purpose. Today, approximately 80% of renewable energy in Ukraine is biomass.

The expert assessment of the Ukrainian Bioenergy Association indicates the potential of biogas (agro-industrial waste, landfills, wastewater) in 1.234 billion m<sup>3</sup>. A significant part of it is the opportunities of the aquaculture production sector [15].

The advantage of producing biofuel feedstock in the marine environment is that it does not compete with food grown on land or fresh water. The basic idea behind the large-scale cultivation of macroalgae in the sea is the need for further anaerobic fermentation to produce biogas as a source of renewable energy. Growing land crops for biofuels can contribute little to greenhouse gas emissions and can cause other environmental impacts, while reducing freshwater resources and food security.

Interest in freshwater and marine biofuel production can be divided into two main components: biofuels derived from macroalgae (seaweed) and biofuels derived from microalgae (a single plant cell).

In Ukraine, a number of studies are also being conducted aimed at cleaning sewage with the use of aquaculture. It turned out that cleaning with algae is not only an excellent solution for cleaning from chemical cutters, but also contributes to the reduction of bacterial agents, especially enterococci, reducing their quantitative indicator by an order of magnitude in the wastewater of livestock enterprises [9, 10, 13].

Alexandra Pounds notes in her work that most aquaculture waste can be recycled. The example she gives concerns the fish sediment used to cultivate black soldier flies. In turn, they produce flour for insects - protein. This process reduces the amount of sludge that is discharged as waste into the environment. This significantly preserves nutrients in the system, as they do not actually leave its boundaries [5].

It is proposed to consider the SWOT analysis of the aquaculture sector of Ukraine with the prospects of developing the sector within the framework of the circular economy (Table 2). From the analysis, it can be concluded that natural resources in Ukraine are more than enough and there is a satisfactory level of reform practice. There is an urgent need for investment and state support. The complexity of these processes is currently related to the need to maintain critical infrastructure in war conditions and the exhaustion of the population due to this tension. National manufacturers are in no

hurry to invest in the development of a promising industry, due to uncertainty about the next day. And foreign investors simply have no idea about the real state of the sector and its needs.

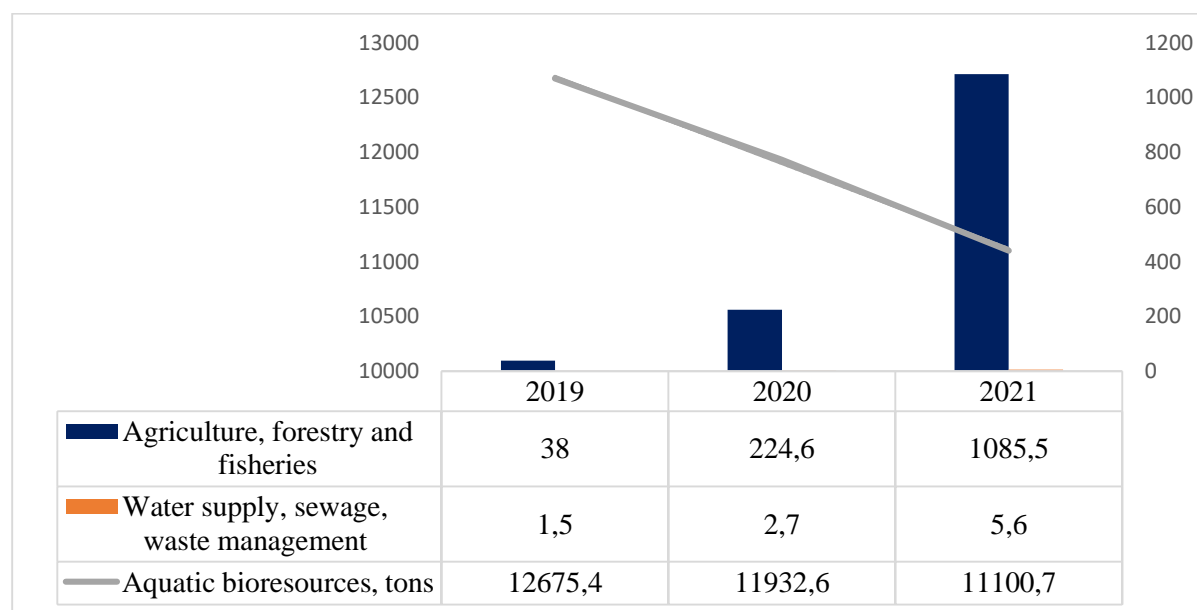
**Table 2.** SWOT analysis of the aquaculture sector of Ukraine as of 2022.

<b>Internal environment</b>	
<b>Strengths (S)</b>	<b>Weaknesses (W)</b>
1. Geographical location and natural resource potential	
Advantageous geographical position; Location at the intersection of international transport highways; Availability of navigable rivers; Provision of biological and biosphere resources.	Unevenness of the relief and water preparation in different parts of the country; Adverse climatic conditions; Limitation of the mineral and raw material base.
2. Economic potential	
Strong industrial potential; An increase in the number of production processes with a high level of knowledge-intensive production; A developed maritime complex; A developed market of tourist services; Availability of special economic zones; Availability of large production facilities for the production of mineral fertilizers and pharmaceutical products.	High wear and tear of fixed assets; A low share of enterprises that introduce innovations and even fewer of those that are ready to move from fishing to production; Insufficient volume of investments in fixed capital; External competition and weak competitiveness of domestic products.
3. Scientific and technical potential	
A significant concentration of scientific institutions and centers of scientific and technical information; Development of alternative sources of electric energy generation (SPP, WPP).	Reduction of the number of organizations performing scientific research and development and the scope of scientific research works; Reduction of costs for scientific and technical activities; Actual lack of state support for innovative developments.
4. State of the surrounding natural environment	
A developed network of nature conservation areas; The water bodies are almost completely ready for use.	Tense, sometimes crisis, environmental situation; High level of disposal of waste in landfills (about 68% of the total amount generated).
5. Infrastructure development	
Sufficiently developed and extensive infrastructure with high throughput; Availability of means for long-term storage of aquaculture products.	Unsatisfactory state of infrastructure, primarily roads; Unsatisfactory state of water supply and sewage system.
<b>Environment</b>	
<b>Opportunities(O)</b>	<b>Threats(T)</b>
1. Geo-economic and geopolitical situation	
Active cooperation with the states of the Black Sea region; Continuation of integration processes with the EU; Further development of alternative energy and gradual provision of energy independence of the country from external suppliers; Expansion of product export geography and development of import substitution; Decentralization of power, implementation of administrative reform and growth of budgetary independence of communities.	Dependence on the supply of mineral resources; Energy dependence on external sources of energy supply; Unsatisfactory structure of external investments; Weak awareness of potential partners about the opportunities of the sector; Distrust of foreign business circles in the state's guarantee of protection of investments and economic interests of investors; Presence of corruption risks.
2. Macroeconomic and political situation of the state	
Attracting cheap financing at the expense of grants and other funds of international financial organizations: EBRD, NUF, IFC, etc.; Expansion of demand for locally produced products; State policy aimed at stimulating the development of regions.	High level of population migration, including labor, abroad; Growing labor shortage in certain labor professions; The increase in the level of shadow employment due to the lack of systematic measures to detinize the labor market.
3. Foreign economic and foreign political situation	
International cooperation with European countries	Dependence on world prices; Increasing the import of

within the framework of cross-border cooperation, tourism business membership in European interregional associations; Attracting investments, ensuring marketing of territories.	products; Difficulties of transition to EU technical regulations; Constant risks of various nature due to the invasion of the Russian Federation.
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Source: developed by authors.

Let's consider the state of attraction of direct foreign investment in Ukraine and determine whether there is an impact on the production of aquaculture products (Figure 3). The level of attraction of FDI in the sector of agriculture, forestry and fisheries of Ukraine (statistical data are still presented in general) and the state of attraction of capital in the process of combating emissions and garbage will be presented.



**Figure.3** Foreign direct investments in Ukraine and the trend of aquaculture bioresources extraction. Source: based on [7].

It can be concluded from the graph that the volume of pre-war investment increased every year. Both in the development of the aquaculture sector and in support of the fight against pollution and the introduction of alternative energy sources. On the other hand, biomass production in the sector that interests us is moderately decreasing. This is primarily due to the growth of shadow fishing and poaching, and secondly to the complexity of such work. Farmers who were attracted to aquaculture 5 years ago are now faced with a host of legislative restrictions, investment failures and relentless climate change. In addition to investing, Ukraine actively attracts "green" credit. Ukraine received climate financing under various financial instruments from the International Monetary Fund during 2015-2018. \$3,157 million, incl. in 2015 – \$940 million, 2016 – \$865 million, 2017 – \$833 million, 2018 – \$519 million.

In a joint statement of nine multilateral development banks dated September 22, 2019, made at the UN Climate Action Summit in New York, a plan to increase until 2025 was announced. annual investments for climate goals up to \$175 billion [16]. Aquaculture production is a key provider of healthy protein sources for the ever-growing human population, and it has shown global exponential growth over the past ten years. Waste from aquaculture production cannot be disposed of in general municipal sewage treatment plants, nor in landfills. Therefore, the aquaculture industry will require the inclusion of final technologies for the treatment of saline organic substances, phosphorus and nitrogen

effluents [17, 18]. For the most part, it is necessary to attract investments for the implementation of such plans.

The European experience of creating fisheries support funds provides an opportunity to gain better experience regarding the sources of the formation of such funds and priority financing actions. The experience of European countries shows that considerable attention is paid to scientific and research support for the functioning of fisheries on the basis of sustainability and advisory support of industrial enterprises.

According to Black Sea's annual report, there are proposals for the implementation of three innovative projects in Ukraine and Odesa region. It is dedicated to the development of the sector and the multiplication of the practices of local entrepreneurs. In fact, this is an organization of sturgeon cultivation with an annual productivity of 2 tons of black caviar and 10 tons of sturgeon using closed water supply technology [14]. Despite the war and the colossal costs of maintaining the current life of the population in the country, investment projects will continue to be implemented. The available resources are not enough, there is a need to develop a marketing plan to increase the attractiveness of the aquaculture sector in Ukraine.

#### 4. Conclusions

In line with ongoing reforms and economy transition related to the Association Agreement with the EU (EU Legislation 161, 2014), Ukrainian aquaculture has a chance to thrive after a long stagnation period, to produce local market and export-oriented value-added fish products. A large consumer market, constant growing demand for fish, abundance of natural resources, low wages and proximity to the European Union market are some main competitive advantages of Ukraine. However, governmental attempts to rejuvenate the national aquaculture industry has been unsuccessful in Ukraine and aquaculture production is not increasing. The lack of a comprehensive development strategy as well as the absence of a suitable indicator for steering Ukrainian aquaculture governance decision could be considered as the major obstacles for development.

Indeed, the only indicators used to drive governmental policy are production statistics and public demand, highlighting the need for all government's decisions to have a clearer strategic vision. There is no doubt that aquaculture can provide considerable input to the economy, nutritional wellbeing for the nation and ensure food security to the country. Farmed Ukrainian fish is a valuable alternative to the imported fish and aquaculture will help to release anthropogenic pressures on overfished native stocks. Ukraine has a great potential for aquaculture development in inland waters, considering actual geographical and hydrological conditions. Coordinated actions by all aquaculture stakeholders and assistance from the government are needed to fulfil aquaculture potential. Also, Ukraine has a free trade zone with the European Union, the largest importer of fish in the world, stipulated in the Association Agreement. Therefore, Ukrainian fish and seafood can be sold to the EU without customs duties. According to the State Fisheries Agency, there are about 4,500 aquaculture enterprises in Ukraine that breed fish, clams and crustaceans in natural conditions or artificial reservoirs. About two dozen of them are state-owned. In fact, aquaculture is a necessary sector, investment in it should take place under state control. In the conditions of active hostilities, Ukraine demonstrates the necessary endurance and support of farmers. These volumes are not enough, and the actions of the state apparatus should be aimed at preserving the already existing growth rates.

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