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IMPLEMENTATION OF THE CIRCULAR ECONOMY MODEL IN THE AGRICULTURAL SECTOR OF UKRAINE

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Abstract. The urgency of studying the issues of the development of the circular economy in the agro-industrial complex is caused by the demand for national and international food security, the importance of preserving the environment in conditions of irrational environmental management, the need to harmonise the economic, ecological and social spheres of human activity involved in the production, sale and consumption of agricultural products. *The purpose* of the study is to justify a comprehensive approach to the implementation of the circular economy model in the agro-industrial complex, in the context of ensuring food independence, economic security of the country and achieving the goals of sustainable development. In the course of the research the general scientific methods of analysis and synthesis, statistical methods (comparison, analysis of absolute and relative values) and graphical methods were used in the evaluation of indicators of organic waste management of agricultural production, methods of a systematic approach – to justify a set of priority measures in the process of implementation of the model of circular economy in the agro-industrial complex. The information base for the research: legislative and regulatory acts; official materials of the State Statistical Service of Ukraine, the Ministry of Agrarian Policy and Food of Ukraine. Based on the *results of the research*, a comprehensive approach to the implementation of the principles of circular economy in the agro-industrial complex was formed. The key factor is an effective public policy capable of ensuring high rates of development of innovative resource-saving technologies and the introduction of circular business models. State activity includes the development of tax, credit and pricing policies to stimulate the implementation of circular economy principles. It is important to develop and approve strategic plans, legislative and regulatory acts that regulate activities in the field of circular economy and are adapted to the standards and norms of the legislation of the European Union. The activities of agricultural enterprises should be directed towards cooperation with scientific and educational institutions in order to solve the problems of introducing innovations and improving the qualifications of employees, technical and technological modernisation, establishing partnership relations with investors, raw material suppliers and local self-government bodies. Ultimately, the implementation of these measures will contribute to the growth of the competitiveness of the domestic agricultural sector, the growth of investment attractiveness and the preservation of the environment.

Key words: circular economy, closed loops, agricultural production, organic waste, business models, food security.

JEL Classification: O13, Q01, Q57

1. Introduction

Today, the effective functioning of the agricultural sector plays an important role in the stable development of the country and in ensuring food security. This is due, first and foremost, to the growing demand for agricultural commodities as the world's population grows. It should also be noted that the existing global food system has a huge impact on the environment. Agriculture is one of the four most environmentally damaging sectors of the economy, after transport, energy and industry (FAO, 2009). As food production increases, so does the amount of agricultural waste that needs to be disposed of. When analysing the entire agricultural food production chain, up to a third of the food produced for human consumption is not taken into account,

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meaning that the global loss of modern food reaches 30% (Ward, Holden, White, Oldfield, 2016). This means that a certain part of land and water resources is used irrationally and is actually lost in terms of the end result, and that its exploitation is inefficient and environmentally destructive.

Modern economic realities require a fundamentally new approach to economic activity in the agricultural sector. In order to ensure sustainable development, it is necessary to modernise the linear model of the economy and move towards a new model of economic development aimed at increasing responsibility for environmental issues and irrational use of environmental management. The implementation of the circular economy concept can contribute to solving these problems.

Circular economy – is an economic system of closed cycles in which raw materials, components and products lose their value to the absolute minimum, renewable energy sources are used and systems thinking is at the forefront (Korhonen, Honkasalo, Seppälä, 2018). The concept of circular economy is based on the 3R theory (Reduce – Reuse – Recycle), which includes three key components: waste prevention (as little waste as possible), reuse (maximum reuse of products and components) and recycling (production of high-quality products from recycled waste) (Lieder, Rashid, 2016).

The circular economy approach to solving the environmental challenges of the present day is not limited to the treatment of waste at the end of the product life cycle, but is constantly expanding due to the proposed innovative methods that are integrated into all stages of production and consumption (Tura, Hanski, Ahola, 2019).

The purpose of the study is to justify a comprehensive approach to the implementation of the circular economy model in the agro-industrial complex, in the context of ensuring food independence, economic security of the country and achieving the goals of sustainable development.

In the course of the research the general scientific methods of analysis and synthesis, statistical methods (comparison, analysis of absolute and relative values) and graphical methods were used in the evaluation of indicators of organic waste management of agricultural production, methods of systematic approach – to justify a set of priority measures in the process of implementation of the model of circular economy in the agro-industrial complex. The information base for the research: legislative and regulatory acts; official materials of the State Statistical Service of Ukraine, the Ministry of Agrarian Policy and Food of Ukraine.

2. Agricultural potential of Ukraine

The agro-industrial complex is an important strategic industry of the national economy, which provides the basis for maintaining the country's food sovereignty and, within certain limits, economic, environmental and energy security, ensures the development of technologically related branches of the national economy, and forms the socio-economic framework for the development of rural areas. In 2021, the share of the agro-industrial complex in the structure of Ukraine's GDP was the highest among all sectors of the economy and amounted to 10.6%. Agro-food products account for the largest share of Ukraine's total exports – about 41% annually. The agricultural sector remains almost the only industry that has ensured a positive foreign trade balance for many years in a row (Leshchenko, 2022).

The modern structure of agriculture in Ukraine has its own peculiarities. According to the results of 2021, crop production accounted for 81.4% and animal husbandry – 18.6% of total agricultural production. Cereals, sugar beet and potatoes are the most important crops. The cultivation of sunflowers, vegetables and fruit also plays an important role. In animal husbandry, cattle farming, pig farming and poultry farming are the leading areas of development.

The real test for agricultural producers was the full-scale war that began in February 2022. The invasion of Russian troops led to the destruction of processes and logistical chains established over the years. Many farmlands have been mined, some of them inaccessible. According to the Ministry of Agriculture, the area of arable land in the zone of active hostilities decreased by 3.5 million hectares in 2022 as a result of the war (Yaskyv, Brianska, 2022). The agricultural sector faced a number of challenges: occupation of territories and agricultural lands, theft of grain and its export outside the territory of Ukraine, blocked sea ports, destroyed elevators, farms, warehouses, machinery and fires in the fields.

The government's policy to support agriculture in wartime conditions includes a number of measures: minimising bureaucratic procedures for agriculture, allowing the use of agricultural machinery without registration, simplifying the import of seed material, introducing a zero excise duty rate and reducing the VAT rate on fuel to 7%. The government has also introduced special state programmes: available loans of 5-7-9%, grants for processing companies, for the development of horticulture and for the construction of greenhouses. Tax exemptions have been introduced, which provide for changes in payment for land of state and municipal forms of ownership during the period of military rule (Nehrey, Taranenko, Kostenko, 2022).

Thus, even under such difficult conditions, agricultural enterprises and farms continue to operate both for domestic consumption and for the international market, which depends on Ukrainian grain. The agribusiness is adapting logistics and cooperation, expanding its production facilities in the western part of the country to ensure Ukraine's food security.

Despite the growing importance of the agricultural sector in the expanded reproduction of the resource production potential of the Ukrainian economy, this branch of the national economy does not fully use all available reserves and opportunities to maximise income by increasing the production of products with high added value (Andreichenko, 2018).

Ukrainian farmers continue to expand the planting of the most export-oriented agricultural crops and increase the export supply of products with low added value, which also leads to soil depletion and structural imbalances in the agricultural sector of the national economy. This leads to a decrease in the level of comprehensiveness of the development of agro-industrial production, which in the long term will negatively affect the development of those regions where the processing of agricultural raw materials is the basic link of the economic complex (Shmarov, 2021).

The development of the agro-industrial complex and the expansion of agricultural areas lead to the generation of significant amounts of waste, which causes anthropogenic pressure on the environment (National Waste Management Strategy in Ukraine until 2030). According to statistical observations, the amount of waste generated by the agricultural sector in Ukraine varies from year to year, but has tended to decrease in recent years (Figure 1). In 2020, more than 9.8 million tonnes of waste will be generated from agricultural production. The share of vegetable waste is 62%, the share of animal faeces, urea and manure is 34%, the share of animal waste and mixed food waste is 4% (State Statistics Service of Ukraine, 2022). Taking into account the above data, plant production, together with animal production, accounts for the majority of waste in the agro-industrial complex. The share of animal waste in food production is insignificant in comparison with the previous two sources of waste.

Utilisation and processing of organic waste from agricultural production is one of the most acute modern environmental and economic challenges. The quantity of waste produced in agro-industrial production, as well as the degree of its further use, is now becoming the key indicator of the level of application of the achievements of scientific and technical progress in agro-industrial production. The more advanced the technologies of production and use of agricultural products, the less waste there will be.

The main ways of dealing with agricultural waste in Ukraine are incineration, recycling and landfilling (Table 1).

The analysis of the given data shows that the use of agricultural production waste is not efficient enough. Animal faeces is the main waste, accounting for 70.1% of the total volume of this waste category. The share of recycled vegetable waste is 24.6%, and the share of recycled animal and mixed food waste is 50.2%. The main directions of organic waste utilisation in the agricultural sector of Ukraine are: recycling, composting and fermentation. Vegetable waste is also incinerated for energy recovery, the share of such waste is 7.9%.

The most common method of processing organic waste is the production technology of organic fertilisers. The demand for organic fertilisers is so great that the companies that produce organic waste

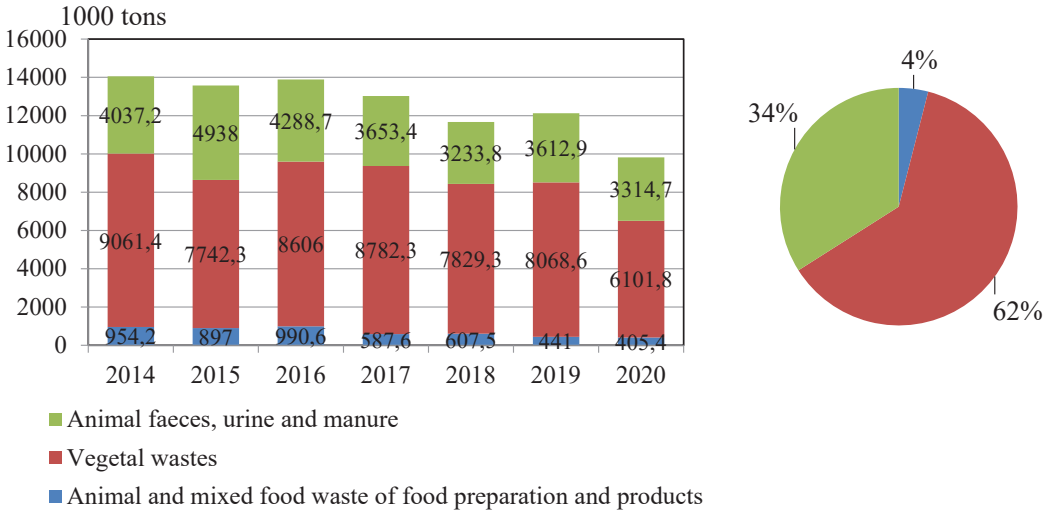

Figure 1. Distribution of agricultural waste by material category

Source: compiled by the authors based on data from: https://www.ukrstat.gov.ua

Table 1

Agricultural waste management by material category in Ukraine in 2020

Waste management	Waste generated, thousand tons	Waste utilization		Waste incineration		Waste disposal in specially designated places	
		thousand tons	%	thousand tons	%	thousand tons	%
Animal waste and mixed food waste	405.4	203.4	50.2	4.5	1.1	1.9	0.5
Vegetable wastes	6101.8	1502.5	24.6	480.2	7.9	15.5	0.3
Animal faeces, urine and manure	3314.7	2324.6	70.1	–	–	0	–

Source: calculated by the authors based on data: https://www.ukrstat.gov.ua

and fertilisers use them mostly in the cultivation of agricultural crops.

Part of the organic waste is used as raw material for feed production. A small proportion of organic waste is used in vermiculture to produce high quality organic fertiliser (vermicompost). Another ethod of processing organic waste is the production of biogas for the generation of heat or electricity and as a fuel for agricultural machinery. Vegetable waste can be a source of solid fuel for rural areas.

Other sectors of agricultural production and processing are lagging behind in the process of integrating organic waste into recycling. There are many reasons for this, ranging from problems with the collection, transport and storage of organic waste, to the lack of cost-effective technologies and technical means for processing organic waste, to insufficient interaction and information exchange across the entire hierarchy of the agricultural sector.

The requirements of the modern market dictate the need to develop and implement production technologies with low energy, resource and capital intensity, which enable the production of high quality and competitive products. Studying the agri-food system from the perspective of using the circular economy makes it possible to identify additional opportunities at all stages of the production process, starting from primary production using innovative methods of agricultural management and ending with various directions of recycling of waste from agricultural production (Table 2).

Involvement in the field of waste production, its recycling ensures the expansion of the raw material base of the agro-industrial complex, while at the same time saving on labour costs. The release of additional products from secondary raw materials ensures a reduction in production costs per unit of final product for the same cost of raw materials.

In the long term, the agro-industrial complex should switch to efficient, resource-saving, low-waste technologies, where the waste from one stage of production becomes the raw material for another stage of production. This will provide the framework for the transition to closed-loop production, where waste that is not processed into useful products is reduced to a minimum.

Table 2

Ways to use waste and secondary raw materials from agricultural production

Directions for usage	Waste and secondary raw materials used in agricultural production
Fodder for farm animals in raw or processed form	Straw and tops of agricultural plants, raw and dried beet pulp, cereal potato and molasses bards, potato and corn pulp, meal (cake), brewer's pellet, brewer's yeast sludge, malt sprouts, bone meal, whey, etc.
Bedding for livestock	Straw of rye, wheat, oats, barley, wood sawdust
Fertilizer production	Manure, poultry droppings, feces, potato cell juice, straw, stems, tops, roots and primary grain processing waste
Food production through industrial processing	Molasses, low-quality fruits and vegetables, phosphate concentrates, apple pomace, corn germ, fruit pits, blood, bones, whey, skim milk, buttermilk, and buttermilk
Production of building materials	Cereal stalks, sunflower and cotton husks, sawdust, shavings, grinding dust
Production of biofuels (pellets, briquettes, biogas, bioethanol, biodiesel)	Straw, plant residues, sawdust, manure, chicken manure, used vegetable oils, sunflower husks, cake, meal, coffee grounds, vine trimmings
Production of biopolymers, biodegradable packaging	Waste of corn, sugar cane, rice, grain husks (rice, buckwheat, millet), potato pulp, beet pulp
Use of wastewater for irrigation	Waste water of livestock farms, poultry complexes
Application in the pharmaceutical industry for the production of medical and veterinary products	Secondary raw materials generated after processing of meat products (blood, bones, by-products); husks, wheat and corn germs, potato and corn pulp
Production of cosmetic products	Cereal processing waste, fruit and vegetable seeds, grape marc, wheat germ, grape waste

Source: compiled by the authors on the basis of (International Finance Corporation, 2013)

3. Principles of implementing the circular economy model in the agricultural sector

The implementation of the circular economy model in agro-industrial production has its own characteristics and must be created and operated in accordance with certain principles, the applied use of which minimises the consumption of raw materials and energy resources, limits the negative impact of production on the environment, ensures the cyclicity of material and financial flows, rationalises the production and economic activity of the agro-industrial complex, stabilises the operation of the social, economic and external spheres of human life (Figure 2).

The implementation of the principles of the circular economy in agricultural production is primarily aimed at the creation of regulated biological and technical cycles and the transformation of energy and matter associated with them. The technical cycle is aimed at the recovery, repair and recycling of products and their components. In terms of biological cycles, the environmental benefit of the circular economy is the creation of fertile soils. Important nutrients are returned to the soil through anaerobic processes or composting, which has a positive effect on agricultural land and natural ecosystems. According to the researchers' conclusions, the circular economy model operating in European food systems is able to reduce the use of artificial fertilisers by 80%, thus contributing to the natural balance of soils (Van Eijk, 2015).

Therefore, one of the tasks of the circular economy is to optimise the use of resources through the circulation of products, components and materials with the maximum benefit in both technical and biological cycles. The implementation of the circular

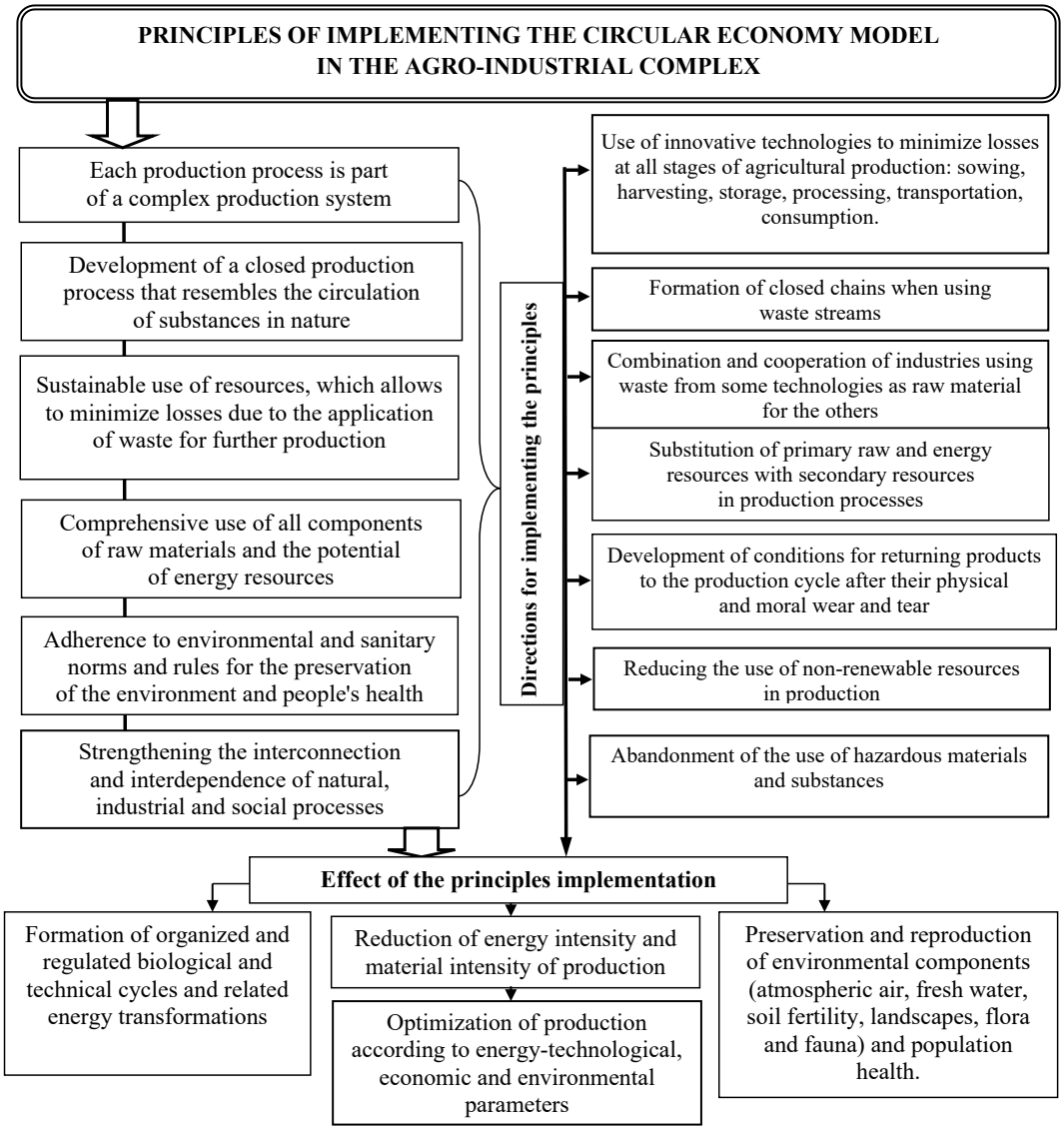

Figure 2. Principles of implementation of the circular economy model in the agro-industrial complex

Source: generated by the authors using data of: (UNIDO, 2020; Wijkman, Skånberg, 2015)

economy model in the agro-industrial complex involves minimising the use of external resources (fuel, fertilisers and agrochemicals) and maximising the use of its own production factors (renewable energy sources, biofuels, organic fertilisers, etc.).

It should be noted that implementing circular economy principles is not only about processing and reusing waste. It also involves technological, organisational, environmental and social innovations applied throughout the value chain.

4. Circular business models in the agro-industrial complex

In order to implement the principles of the circular economy, it is necessary to analyse various options of business models and choose the most effective one, as well as to make a comparative assessment of the benefits of using the model with the determination of factors that contribute to improving the quality of economic activity.

At the heart of the transition to a circular economy are five business models that help transform traditional linear approaches to production and consumption, such as "take, make, dispose", into circular approaches that minimise waste, reduce environmental impact and increase business efficiency. Such business models are already widely recognised by companies and organisations as an effective approach to implementing circular economy strategies (Table 3).

The resource recovery business model, which is a continuation of traditional waste management, has become the most common in agricultural production. In a perfect world, a recovered resource is used in such a way that it retains the highest possible value for the longest possible period of time. In this context, companies should consider the "waste hierarchy" when determining how to create value from end products. Today, there are a large number of farms that already have a waste management strategy in place, so this model requires minimal adjustment to existing business structures.

A feature of the circular supply model is the replacement of limited resources (traditional raw materials) with fully renewable sources or secondary materials. Recently, some versions of this model, based on the use of biodegradable resources, have been actively implemented in the agricultural sector. The technology for the production of biogas or bioethanol, which are products of the processing of agricultural production (corn husks, cobs, stalks), has already become quite common (Litvak, Litvak, 2020). Thanks to such developments, in addition to reducing the amount of production waste and the amount of greenhouse gases and pollutants emitted into the atmosphere, it leads to a reduction in the

Table 3
Circular business models of the agro-industrial sector

Business model	Model description	Implementing a business model in the agricultural sector
Resources Recovery	Implementation of technological innovations for the recovery and recycling of resources, which ensures the elimination of their losses and contributes to increasing the profitability of production.	In agricultural production, the most widespread use is composting and anaerobic fermentation of waste to produce fertiliser and biofuel.
Circular Supplies	In the production process, non-renewable resources are replaced by renewable, biodegradable, recycled or recyclable materials, which ensures the partial or complete elimination of waste and reduces the negative impact on the environment.	Implementing renewable resource technologies, such as using rainwater harvesting and livestock effluent for irrigation; and processing agricultural waste into biofuels, bioplastics and microbial agrochemical solutions.
Product life extension	The business model covers a range of activities – from repair, refurbishment and upgrading to trading and resale. Extended product life can become a competitive advantage and attract new customers.	Companies specialising in the manufacture of agricultural machinery and equipment can carry out repairs, conversions and upgrades of technical equipment. This business model aims to increase the reliability of technical equipment by using stronger, more wear-resistant materials.
Product as a service	Products are used by one or more customers through rental or service fees.	Instead of buying expensive equipment, it is more advantageous for farmers to buy a service package for a complex of production operations (soil treatment, crop care and pesticide treatment, harvesting, etc.) or to rent agricultural machinery.
Sharing Platforms	This model increases the efficiency of the use of goods (services) and can benefit companies whose products and assets have a low utilisation rate.	The sharing platform allows farmers to offer their equipment when not in use for use by other farmers from different regions who pay a rental fee. Customers have convenient access to products and services.

Source: generated by the authors using data of: (Lacy, Keeble, McNamara, 2014; Kovalchuk, Lukiianenko, 2020; Batova, Sachek, Tochitskaya, 2018; Donner, Gohier, de Vries, 2020)

extraction of fossil fuels and is a new source of income and the creation of new jobs.

The circular supply model is being successfully implemented in Ukrainian agricultural business. Renewable energy and the use of biological fertilizers have become part of the business model of many agricultural enterprises. It is possible to replace 9 billion m^3 of gas annually only thanks to the use of agricultural waste. Moreover, farmers can get this amount of fuel by using only 37% of agricultural crop waste for energy needs (UkrSugar, 2018).

By the end of 2022, 64 biogas plants will have been built in Ukraine and will operate under a "green" tariff. The total electrical capacity of these plants is 130 MW, which is more than 7 times higher than at the end of 2015 (18 MW) (Bezus, 2023).

The agricultural holding PrJSC "MHP" is considered the flagship of the circular economy in Ukraine. The company effectively uses organic waste (chicken manure) generated by the activities of the agricultural holding's enterprises for energy production in two biogas complexes. Biogas is converted into electricity, heat and steam, ensuring the company's energy independence. At the same time, organic fertiliser is produced to restore soil fertility (MHP, 2023).

There are also other unique circular economy projects in Ukraine. For example, the "Obolon" group sells by-products of beer production to agricultural companies, which become animal feed (Nechytailo, 2020). Some private companies are involved in the processing of fallen leaves into paper, the production of flour from the waste of non-alcoholic beer production, the production of spectacle frames from coffee grounds, and so forth (Baiura, 2021).

From the point of view of the circular economy, it is also important to solve the problem of plastic recycling. This approach can be effectively applied in the field of processing and turnover of polyethylene film for greenhouses, plastic canisters for fuel and lubricants, liquid pesticides and fertilizers, containers for water and beverages, plastic bags for mineral fertilizers, waste fittings for drip irrigation, etc. (OECD, 2018).

The ban on plastic bags is prompting food processors to review their packaging materials. At the same time, new opportunities are opening up for entrepreneurs involved in the production of products made from biodegradable materials. For example, "Greencup" LLC, Lviv Oblast, produces environmentally friendly disposable tableware from corn starch, rye, reed, bamboo and wheat bran (Melnyk, Zlotnik, 2020).

The effective application of circular business models in the agro-industrial complex plays a strategic role and has a positive impact on the growth of interest in the circular economy in society and becomes an incentive for steady economic growth. Management decisions regarding the transition of agricultural enterprises to the principles of the circular economy as a result of the introduction of new business models are aimed not only at gaining additional competitive advantages, but also at compliance with environmental and consumer standards, a higher level of social and environmental responsibility.

5. Prerequisites for the implementation of the circular economy model in the agro-industrial sector of Ukraine

The implementation of circular economy principles should be initiated by the country's government, so it is important to explore legislation that encourages companies to comply with environmental standards and to develop and implement efficient, low-waste technologies.

In Ukraine there is still no regulatory legal act regulating the development of the circular economy, but separate elements are set out in various programme documents. The main legislative acts that form the legal framework of waste management and the principles of state environmental policy are as follows:

– "National Waste Management Strategy in Ukraine until 2030", adopted in 2017;
– National Waste Management Plan until 2030", approved by the Cabinet of Ministers of Ukraine in 2019;
– The Law of Ukraine "Basic Principles (Strategy) of State Environmental Policy of Ukraine for the period until 2030", approved in 2019.

The specified legislative acts introduce European principles of waste management in Ukraine, promote the principles of circular economy and expand the responsibility of producers, which will encourage representatives of agricultural production to implement innovative circular business models.

Systemic change in the area of effective circular economy development is only possible if all parties are interested in it. This requires, on the one hand, support for projects at the state level and, on the other hand, a change in consumption patterns towards more rational ones. This requires a certain responsibility on the part of both consumers and producers.

The main reasons for the gap of the Ukrainian agribusiness in the implementation of the principles of circular economy are:

– the imperfection of the legislative and regulatory framework, the lack of effective economic instruments regulating the processes of transition to new circular business models;
– the technical and technological backwardness of most production processes;

– limited information on the characteristics and composition of waste, on the available technologies for its processing;
– lack of qualified professionals;
– problems in investing in innovative projects in the agro-industrial complex;
– high transport, logistical and technological costs for processing waste and secondary raw materials;
– unstable demand for waste processing products;
– the political situation and the conduct of military operations on the territory of the country.

In order to overcome the aforementioned negative trends and effectively develop the agricultural sector of the economy of Ukraine, a comprehensive approach has been formed, which provides for the introduction of a set of measures to implement the circular economy model (Figure 3).

Active government support is one of the key success factors for the development of the circular economy in the agro-industrial complex. State regulation and economic incentives (taxes, environmental regulations, green tariffs, etc.) are of great importance as they affect the competitiveness of circular models and the possibility of achieving an acceptable level of economic efficiency.

To stimulate demand for products made from waste or secondary raw materials, public green procurement, budget subsidies, etc. are important tools. Taking into account the important role of the state, public sector demand can become the main condition for the development of the circular economy. At the same time, the relationship between the state and local authorities and agricultural producers should be developed on a long-term basis, so that enterprises have the opportunity to organise a planned, sustainable and stable production.

The organisation of production within a closed technological chain is possible provided that vertically integrated agro-industrial structures are created. At the same time, significant progress in the implementation of the circular economy model in conditions of shortage of working capital can be achieved only by attracting large business funds. Therefore, one of the important tasks is the optimisation of the infrastructure into an industrial scientific and technological complex in the form of an innovative organisational, legal, managerial and economic structure ecotechnoparks, agrarian bioclusters.

With the cluster form of integration, regional executive structures at the regional and district levels and local self-government bodies have the opportunity to play a more significant role in the financial, economic and organisational support of the implementation of projects in order to increase the level of complexity of the development of all links of the agro-industrial complex.

It is the processes of creating agricultural clusters that play a crucial role in the formation of a circular economy:
– clusters can facilitate the introduction of structured eco-innovation supply chains. Efficient and optimal supply chains are formed at the local level, where agricultural enterprises and farms are located in close proximity (Ketels, Protsiv, 2016);
– high concentration of highly qualified employees, interaction with scientists and educational institutions are the characteristics of clusters;
– clusters solve the problem of information support, information exchange of markets, best practices and technologies;
– the problems of compliance of new circular business models with the requirements of legislation, environmental standards and norms are solved with the help of training programmes and consultancy by cluster organisations (Barsoumian, Severin, van der Spek, 2011).

The process of cluster creation in Ukraine is complicated by the lack of a regulatory and legislative framework governing the creation, operation and state support of cluster structures. In countries where clusters operate successfully, 50-70% of the cluster budget is spent on local and state support programmes for cluster development. Therefore, it is difficult for Ukrainian clusters to start their activity, they have to rely only on their own strength and the support of international technical assistance programmes (Ozturk, 2017). According to experts, Kyiv, Zakarpattia, Zaporizhia and Kharkiv oblasts are the most active oblasts in the development of clusters. And the best examples of clusters in Ukraine recently are Ukrainian Food Valley, Agro Food Cluster Kharkiv and "Ukrainian Organic Cluster".

Thus, the introduction of a comprehensive approach to the implementation of the circular economy model in the agro-industrial complex will make it possible to increase labour productivity, reduce the material and energy intensity of production, increase the efficiency of recycling secondary raw materials and increase the production of high-quality, environmentally friendly products. Ultimately, these processes will contribute to the growth of the competitiveness of the domestic agricultural sector and increase its investment attractiveness.

6. Conclusions

The analysis has shown that there are significant opportunities for transforming the dominant model of the linear economy in Ukraine into an ecologically and economically effective circular model. Favourable natural and climatic conditions, as well as land potential, are an important condition for the

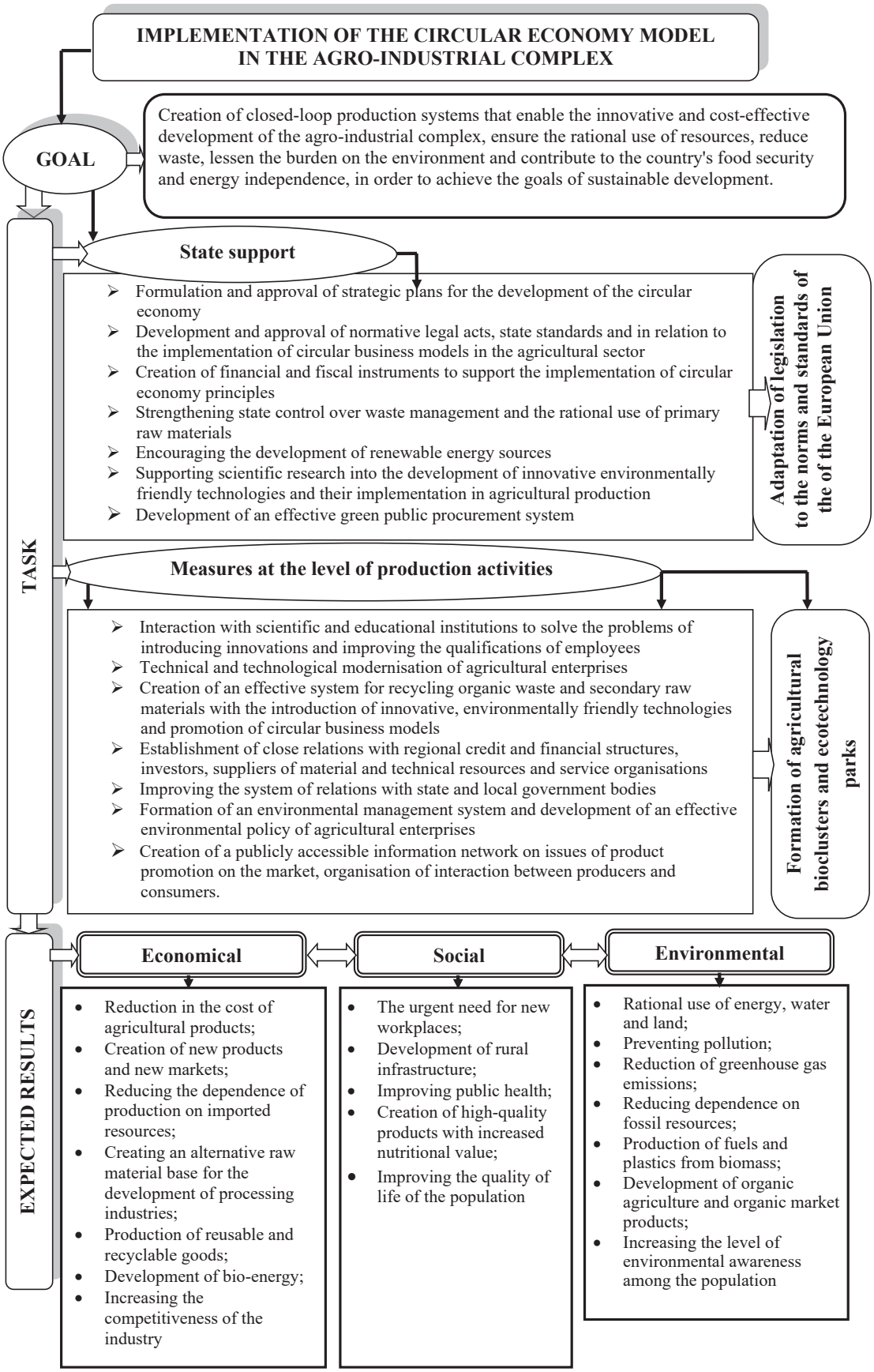

Figure 3. A comprehensive approach to the implementation model and circular economy in the agro-industrial complex

Source: developed by the authors

development of the agricultural sector based on the principles of the circular economy, which can significantly increase the competitive advantages of domestic agricultural enterprises and farms. The creation and development of an agro-industrial complex focused on closed production cycles will make it possible to solve not only the problems of environmental safety of food products and the natural environment, but also the social problems of rural areas by increasing the level of employment of the rural population. At the same time, it is solving the important national economic problem of ensuring the country's food security, saturating the domestic market with high-quality, ecologically safe goods, and creating energy independence for the regions.

Based on the results of the research, a comprehensive approach to the implementation of circular economy principles in the agro-industrial complex has been developed. The key factor is an effective state policy capable of ensuring high rates of development of innovative resource-saving technologies and the introduction of circular business models. The state's activities include the formation of tax, credit and pricing policies to stimulate the implementation of the principles of the circular economy; strengthening state control over waste management and the rational use of primary raw materials; stimulating the development of renewable energy sources; supporting scientific research into the development of innovative environmentally friendly technologies and their implementation in agricultural production; developing an effective system of green public procurement. It is important to develop and adopt strategic plans, legislative and regulatory acts that regulate activities in the field of circular economy and are adapted to the standards and norms of the legislation of the European Union.

In order to implement circular business models, the activities of agricultural enterprises should be directed towards interaction with scientific and educational institutions in order to solve issues of introducing innovations and improving the qualifications of employees; technical and technological modernisation; establishing close relations with state and local government bodies, regional credit and financial structures, investors, as well as suppliers of material and technical resources and service organisations; creating a publicly accessible information network for the promotion of products on the market, organising interaction between producers and consumers.

The development of the circular economy concept is an important task for the scientific community, Ukrainian entrepreneurs, state bodies and society as a whole. The application of the principles of circular economy in the creation of a competitive and efficient economy of the country will not only enable the rational use of resources, but also reduce the negative impact on the environment. This will create favourable conditions for the inflow of investments, increase tax revenues and solve the urgent problems of food security and energy independence of Ukraine in order to achieve the goals of sustainable development.

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