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CIRCULAR ECONOMY IN LIVESTOCK PRODUCTION UNDER CLIMATE CHANGE: MAIN ELEMENTS AND OPPORTUNITIES

КЛИМАТТЫҢ ӨЗГЕРУІ ЖАҒДАЙЫНДА МАЛ ШАРУАШЫЛЫҒЫНДАҒЫ АЙНАЛМАЛЫ ЭКОНОМИКАСЫ: НЕГІЗГІ ЭЛЕМЕНТТЕРІ МЕН МҮМКІНДІКТЕРІ

ЦИРКУЛЯРНАЯ ЭКОНОМИКА В ЖИВОТНОВОДСТВЕ В УСЛОВИЯХ ИЗМЕНЕНИЯ КЛИМАТА: ОСНОВНЫЕ ЭЛЕМЕНТЫ И ВОЗМОЖНОСТИ

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Annotation. *The goal* is to analyze the current state of development of agro-industrial production in the context of circular and climate economy of Kazakhstan with emphasis on identifying the elements of its key aspects in livestock farming and determining the influence of climatic factors on this economic system. *Methods* – statistical analysis and graphical interpretation of data, comparative assessment of linear and circular economic models. Materials from scientific publications, regulations, as well as interviews with experts were used. *Results* - recommendations for transition to sustainable circular economy structure in agricultural sector of Kazakhstan have been developed, aimed at increasing the efficiency of resource potential, reducing negative impact on environment and creating new opportunities for business and innovation in the country's agro-industrial complex. Measures have been proposed to improve the infrastructure for processing and disposal of agricultural waste and use of modern technologies in the industry. *Conclusions* - implementation of the principles of circular economy helps to increase energy efficiency and reduce negative impact on biosphere and ecosystems, creating conditions for expanding the scope of innovative entrepreneurship - "green" business: new jobs, appropriate infrastructure, "green" logistics, etc. Principles of circular economy: circular supply (limited resources are replaced by completely renewable sources); extending the life cycle of products through modernization and reconstruction; recycling (restoration and recycling of product residues). Resource-

efficient modification is an opportunity for innovation at all stages of new value formation, which gives not only good final results, but also leads to them with lower material, energy and environmental costs.

Аңдатпа. *Мақсаты* - Қазақстанның айналмалы және климаттық экономикасы шеңберінде агроөнеркәсіптік өндірісті дамытудың қазіргі жай-күйін талдау, оның мал шаруашылығындағы негізгі аспектілерінің элементтерін анықтауға және климаттық факторлардың осы экономикалық жүйеге әсерін анықтауға баса назар аудару. *Әдістері* - деректерді статистикалық талдау және графикалық интерпретациялау, сызықтық және айналым экономикалық модельдерді салыстырмалы бағалау. Ғылыми жарияланымдардың материалдары, нормативтік актілер, сондай-ақ сарапшылармен сұхбат пайдаланылған. *Нәтижелері* - ресурстық әлеуеттің тиімділігін арттыруға, қоршаған ортаға теріс әсерді азайтуға және еліміздің АӨК-де бизнес пен инновациялар үшін жаңа мүмкіндіктер жасауға бағытталған Қазақстанның аграрлық секторындағы тұйық айналмалы экономикасының орнықты құрылымына көшу бойынша ұсынымдар әзірленген. Ауыл шаруашылығы қалдықтарын өңдеу және кәдеге жарату және салада заманауи технологияларды қолдану үшін инфрақұрылымды жетілдіру шаралары ұсынылған. *Қорытындылар* - айналмалы экономика қағидаттарын жүзеге асыру энергия тиімділігін арттыруға және биосфера мен экожүйеге теріс әсерді азайтуға, инновациялық кәсіпкерлік – «жасыл» бизнес саласын кеңейту үшін жағдайлар жасауға ықпал етеді: жаңа жұмыс орындары, тиісті инфрақұрылым, «жасыл» логистика және т.б. Айналмалы экономиканың принциптері: айналмалы ұсыныс (шектелген ресурстар толығымен жаңартылатын көздермен ауыстырылады); жаңғырту және реконструкциялау арқылы өнімнің өмірлік циклін ұзарту; қайта өңдеу (өнім қалдықтарын қалпына келтіру және қайта өңдеу). Ресурстарды тиімді модификациялау - бұл жаңа құнды қалыптастырудың барлық кезеңдеріндегі инновациялардың мүмкіндіктері, бұл жақсы нәтиже беріп қана қоймай, сонымен қатар материалдық, энергетикалық және экологиялық шығындардың төмендеуіне әкеледі.

Аннотация. *Цель* – анализ современного состояния развития агропромышленного производства в контексте циркулярной и климатической экономики Казахстана с акцентом на выявление элементов ее ключевых аспектов в животноводстве и определение влияния климатических факторов на данную экономическую систему. *Методы* – статистический анализ и графическая интерпретация данных, сравнительная оценка линейной и циркулярной экономических моделей. Использованы материалы научных публикаций, нормативных акты, а также интервью с экспертами. *Результаты* – разработаны рекомендации по переходу на устойчивую структуру экономики замкнутого цикла в аграрном секторе Казахстана, ориентированную на увеличение эффективности ресурсного потенциала, снижение негативного воздействия на окружающую среду и создание новых возможностей для бизнеса и инноваций в АПК страны. Предложены меры совершенствования инфраструктуры для обработки и утилизации сельскохозяйственных отходов и применению современных технологий в отрасли. *Выводы* – реализация принципов циклической экономики способствует повышению энергоэффективности и сокращению отрицательного влияния на биосферу и экосистемы, созданию условий для расширения сферы инновационного предпринимательства – «зеленого» бизнеса: новые рабочие места, соответствующая инфраструктура, «зеленая» логистика и т.д. Принципы экономики безотходного производства: циркулярные поставки (ограниченные ресурсы заменяются на полностью возобновляемые источники); продление жизненного цикла продукции за счет модернизации, реконструкции; рециклинг (восстановление и вторичная переработка остатков продукции). Ресурсоэффективная модификация – это возможности для инноваций на всех стадиях формирования новой стоимости, что дает не только хорошие конечные результаты, но и приводит к ним с более низкими материальными, энергетическими и экологическими затратами.

Key words: agriculture, circular economy, livestock farming, waste-free production, renewable sources, low material, energy, environmental costs.

Түйінді сөздер: ауыл шаруашылығы, айналмалы экономика, мал шаруашылығы, қалдықсыз өндіріс, жаңартылатын көздер, төмен материалдық, энергетикалық, экологиялық шығындар.

Ключевые слова: сельское хозяйство, циркулярная экономика, животноводство, безотходное производство, возобновляемые источники, низкие материальные, энергетические, экологические затраты.

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Introduction

Currently, the importance of transitioning to a more sustainable economic. The importance of the transition to a more sustainable economic model in the agro-industrial complex of Kazakhstan is currently being discussed. Environmental sustainability and climate conservation are key priorities, and in this context, the need to implement the concept of a circular economy arises. The circular economy offers a new approach to resource use and waste management, aimed at minimizing negative environmental impacts and increasing resource efficiency.

It is known that in Kazakhstan, with its vast agricultural lands and diverse climatic zones - from steppes to semi-deserts and mountainous regions - adaptation of agriculture to changing climatic conditions is especially important. It is necessary to implement comprehensive strategies to improve the efficiency and adaptive capacity of the agricultural sector, including the development of new plant varieties that are resistant to extreme conditions, the introduction of advanced agricultural technologies, improving water and soil management systems, as well as the transition to a circular economy and organic agriculture.

The circular economy in livestock farming is based on the principles of recovery, recycling and reuse of resources. It allows resources to circulate throughout the production process for as long as possible, thereby reducing the need for additional raw materials and reducing waste. The idea of a circular economy includes not only environmental sustainability, but also economic benefits, as it offers cost reduction through more efficient use of materials.

This article will consider an analysis of the current state of the economy of the agro-industrial complex of Kazakhstan in the context of the circular and climate economy. We will analyze the main ideas and facts from several research papers to present a complete and unique picture of the current situation and potential of the circular economy in the livestock sub-sector of Kazakhstan.

The research has its own conceptual basis; the research results are presented within the framework of a scientific grant funding project, which allows us to substantiate in more detail recommendations on the possibilities of introducing a circular economy in the agro-industrial complex of Kazakhstan.

Literature Review

In the course of the research, scientific works of domestic and foreign scientists were studied, in particular, the principles of circular economy are considered as the development of products for ease of recycling and reuse. Global climate changes reflect on the overall production development, greatly affecting the agricultural economy, accordingly, questions arise about the impact of the circular economy on climate changes.

The transition to sustainable economic models in Kazakhstan's agriculture emphasizes the importance of circular economy principles, which promote increased energy efficiency and reduced environmental impact (Shcherbakova A.S.) [1]. Analysis of the experience of transitioning to a circular economy in other countries demonstrates that this approach can significantly enhance the economy's resilience to climate changes (Circular Economy: Waste-to-Resource …; Aleksandrova V.D., Abramova O.A.; Aleksandrova V.D.) [2, 3,4].

European experience in implementing circular agriculture shows potential for creating sustainable agri-food systems, which can be adapted in Kazakhstan (Akimova Yu.A.) [5]. Global climate changes pose significant challenges to the agricultural system, requiring adaptations to new conditions to ensure food security (Riccardo V.) [6]. Observed changes in the concentrations of greenhouse gases in the atmosphere underscore the need for rapid actions to minimize their impact on agriculture (WMO Greenhouse Gas Bulletin…) [7].

Information on the development of "green" economy was reflected in the Decree of the President of the Republic of Kazakhstan and the Decree of the Government of the Republic of Kazakhstan and Decree of the Government of the Republic of Kazakhstan "On approval of the Action Plan for the implementation of the Concept for the transition of the Republic of Kazakhstan to a “green” economy for 2021-2030" [8,9]. For the analysis of the state of the agro-industrial complex of Kazakhstan, the Decree of the Government of the Republic of Kazakhstan "On approval of the Concept for the development of the agro-industrial complex of the Republic of Kazakhstan for 2021 - 2030" was considered [10].

Additionally, the study on the impact of climate changes on the crop yields in Kazakhstan highlights the need for developing adaptation strategies (Wang D., Li R., Gao G. et al.) [11]. Research also points to the spatial and temporal variations in climate and their effects on wheat and barley yields in Kazakhstan, confirming the complexity of climate factors' impact on the agro-industrial complex (Schierhorn F., Hofmann M., Adrian I. et al.) [12].

This literature review more comprehensively reflects the multitude of aspects related to the circular economy and climate changes, their impact on agriculture, and possible ways to adapt to new conditions.

A literature review on the topic of the scientific article made it possible to determine the interaction of climate change with the agricultural sector of Kazakhstan, including the impact on crop yields, health and productivity of livestock, as well as the availability of water and soil resources. At the same time, the analysis of scientific research, reports and data related to climate change and its impact on agriculture contributes to a more detailed study of this problem in the future in the context of modern trends in the development of agribusiness.

Materials and methods

The theoretical and methodological basis of the scientific article consists of a system analysis of the circular economy in livestock farming, the theoretical foundations of the categories of a closed system, taking into account the factors of climate economics and measures to manage and regulate agribusiness in the context of circular principles.

The scientific article used the works of domestic and foreign academic economists who dealt with issues of the circular economy in agriculture, the formation and management of a closed production system in livestock farming, as well as issues of managing technological processes in the country's agribusiness.

The authors of the study used theoretical research methods, namely, an analysis of the principles of the circular economy and its impact on climate change was carried out, and the connection between them was identified through the inductive method. For a clearer example, statistical analysis and graphical interpretation of the information were carried out. A comparative analysis of linear and cyclical economic models was carried out, and comparison with the experience of other countries helped to identify the best practices for agriculture in Kazakhstan.

The information base for the study was information and analytical materials of the Ministry of Agriculture of the Republic of Kazakhstan, scientific articles and reports published in the open press and Internet resources and materials of various seminars, conferences, forums, monographs and other works of domestic and foreign scientists and research institutes.

Results

The circular economy contributes to improved health by reducing the negative impact on the environment, more effective resource management, and increasing food safety. Transitioning to a closed economic system is a key element in achieving Sustainable Development Goal 12 (SDG), associated with responsible consumption and production (Shcherbakova A.S.) [1].

The research results of the Ellen MacArthur Foundation have generated interest from government bodies and organizations. According to the 2015 report, transitioning to a circular economy could lead to the creation of 10 000 new jobs and reduce waste by 100 million tons (Circular Economy: Waste-to-Resource…) [2]. According to some scientists' forecasts, implementing closed loops in the economy of various sectors could increase the global GDP by up to 7% per year (Aleksandrova V.D., Abramova O.A.; Aleksandrova V.D.) [3; 4]. The main calculations to determine the GDP growth potential of agriculture, forestry and fisheries for the period 2019-2022 are presented in table 1.

Table 1 - Analysis of the GDP growth potential of agriculture, forestry and fisheries based on 2019-2022

Year	GDP, million tenge	Growth rate	Potential, million tenge	Difference, million tenge
2019	3 105 560,7	121,28%	3 295 782,91	190 222,21
2020	3 808 889,1	129,65%	4 026 359,45	217 470,35
2021	4 222 766,5	117,87%	4 489 537,60	266 771,10
2022	5 444 727,3	135,94%	5 740 428,78	295 701,48
2023	5 109 629,8	100,84%	5 490 463,00	380 833,20
Note: compiled by the authors based on data from stat.gov.kz				

The development of circular agriculture requires collaboration between farmers, organizations, citizens, scientists, and government bodies, taking into account the integration of environmental principles, modern technologies, new economic models, partnerships, and social services.

Akimova Yu.A. [5] highlights the successful model proposed by Johan Sanders for a Dutch region as an example where production

cycles are organically interconnected beyond individual farms. To implement new sustainable production methods within the circular model, a series of pilot projects aimed at developing agriculture at the level of regional farms were identified:

* agro-Innovatieregio Achterhoek (closing the nutrient cycle, improving soil quality, innovation);

* agro-Proeftuin de Peel (manure, sowing techniques, climate);

* noord-Nederland (natural farming, landscape, nutrient cycling, emission reduction, rural viability);

* CAP-pilot Akkerbouw Flevoland (precision farming, soil quality);

* mineral Valley Twente Twickel (farm self-sufficiency, fertilization, soil and water quality, regional food chain, added value of biomass).

The circular economy views waste as an opportunity to create new values and reduce the negative impact on the environment. Global climate change, on the other hand, is associated with the growing concentration of greenhouse gases in the atmosphere, primarily caused by human activities such as the burning of fossil fuels, land processing, and deforestation. Global climate change negatively affects agriculture. Changes in temperatures, precipitation patterns, and extreme weather events such as droughts and floods can negatively impact crops, livestock, and the overall productivity of agricultural systems.

Agriculture and global climate change are undoubtedly interconnected. The agricultural sector plays a crucial role both in contributing to and being affected by climate change. It is extremely important to understand this interrelationship and take necessary measures to address the issues it presents.

On one hand, agriculture contributes to climate change through the emissions of greenhouse gases. The use of synthetic fertilizers, livestock, and changes in land use release significant amounts of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) into the atmosphere.

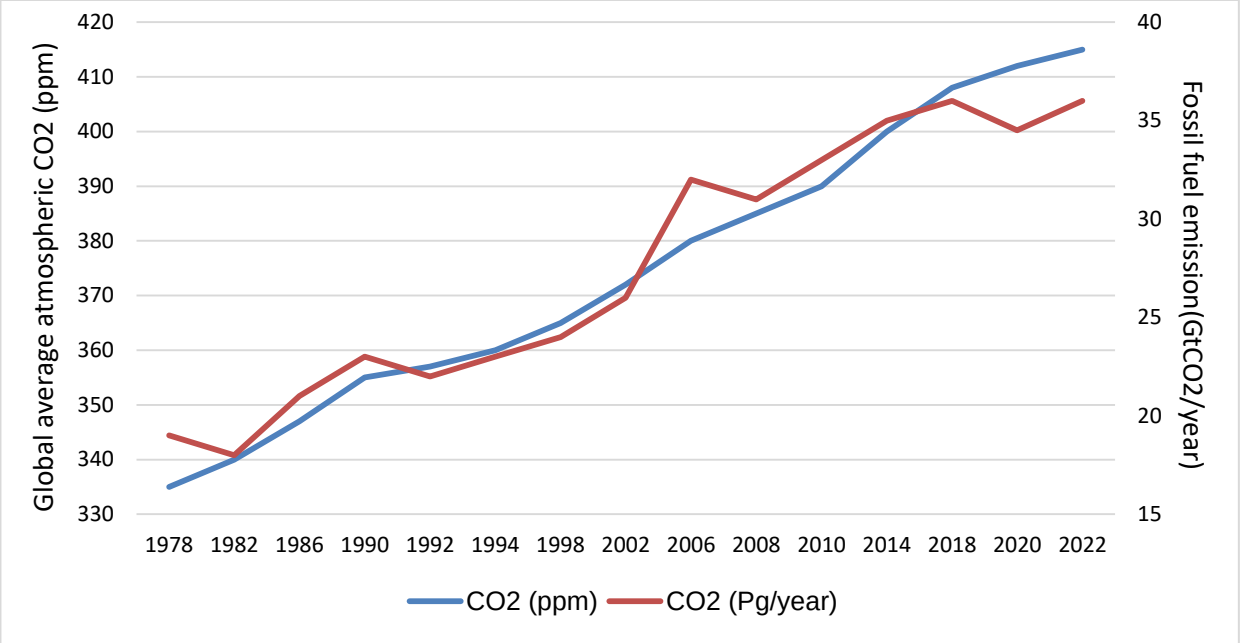
Concentrations of greenhouse gases in the atmosphere are at their highest level in the last 800 million years. Current CO2 levels have risen by 30% from 280 ppm (0.028%) in pre-industrial times to 401 ppm (0.0401%) by 2015 and continue to rise. Current CH4 levels are 2000 ppm (0.2%), nearly three times their pre-industrial level of 700 ppm (0.07%). The concentration of N2O reached 327 ppb in 2014 compared to 280 ppb in pre-industrial times (Riccardo V) [6]. A graphic interpretation of the above material is presented in figure 1, which was compiled on the basis of source 7.

Figure 1 shows that emissions decrease during major crises when global production processes were halted, positively affecting the environment, and this is just the effect of carbon dioxide. The circular economy can play a significant role in reducing greenhouse gas emissions and adapting to climate change. For example, by increasing energy efficiency, transitioning to renewable energy sources, improving resource use efficiency, and developing green technologies. Recycling waste and recovering materials can also reduce the need for extracting new resources, leading to lower greenhouse gas emissions, ultimately reducing the pace of global warming and positively affecting agriculture.

The relationship between the livestock sub-sector of agriculture and global climate change is undeniable. Recognizing this relationship and implementing sustainable practices is crucial for reducing greenhouse gas emissions, increasing agriculture's resilience, and ensuring food security in the face of climate change.

Agriculture today actively discusses the prospective direction of sustainable development. It is based on the implementation of innovative methods and technologies aimed at optimizing the expenditure of limited resources. These methods stimulate the replacement of non-renewable resources with renewable ones, prevent losses, and facilitate their reuse and recycling. For example, transitioning to renewable energy by 2050 is expected to reduce CO2 emissions by 80%, increase the share of renewable energy sources to 57%, and further increase energy production efficiency. Such an approach ensures a quality transition from production efficiency to resource use efficiency.

It is important to note that the concept of a circular economy does not contradict the fundamental principles of agriculture. On the contrary, due to the specificity of this industry, it has all the possibilities for successful implementation. For example, traditional livestock waste containing nutrients (nitrogen, phosphorus, potassium) can be used as fertilizers to improve soil quality. Organic waste from crop and livestock production can be directed towards the production of clean energy using biogas plants, which are a cheaper and more environmentally friendly option for energy production than coal-fired power plants of similar volumes.



Note: compiled by the author based on source WMO Greenhouse Gas Bulletin: the state of greenhouse gases in the atmosphere based on global observations through 2022 (WMO Greenhouse Gas Bulletin…) [7].

Figure 1 - Global CO2 versus fossil fuel emissions

One of the key ideas of the circular economy is to transition from a linear model of consumption and production, where resources are used once and then become waste, to a model based on recycling and reusing waste. This not only reduces the negative impact on the environment but also creates new opportunities for business development and innovation.

In Kazakhstan's agro-industrial complex, the circular economy can play a significant role in waste management and enhancing resource use efficiency. For example, recycling agricultural waste as fertilizers or biogas can help reduce the environmental impact and create additional income sources for farmers. Furthermore, using renewable energy sources, such as solar and wind energy, can help reduce dependence on fossil fuels and decrease greenhouse gas emissions.

One of the main problems identified in the article is the low efficiency of resource use in Kazakhstan's agro-industrial sector. In particular, a large amount of agricultural waste is not fully utilized and becomes a source of environmental pollution.

According to the Decree of the First President of the Republic of Kazakhstan dated May 30, 2013 No. 577 [8], providing for the country's transition to a "green" economy, it is planned to achieve a 40% level of waste recycling by 2030. The action plan for its implementation is reflected in the Decree of the Government of the Republic of Kazakhstan "On approval of the Action Plan for the implementation of the Concept for the transition of the Republic of Kazakhstan to a "green" economy for 2021-2030" [9], aimed at implementing this concept, includes a number of specific steps:

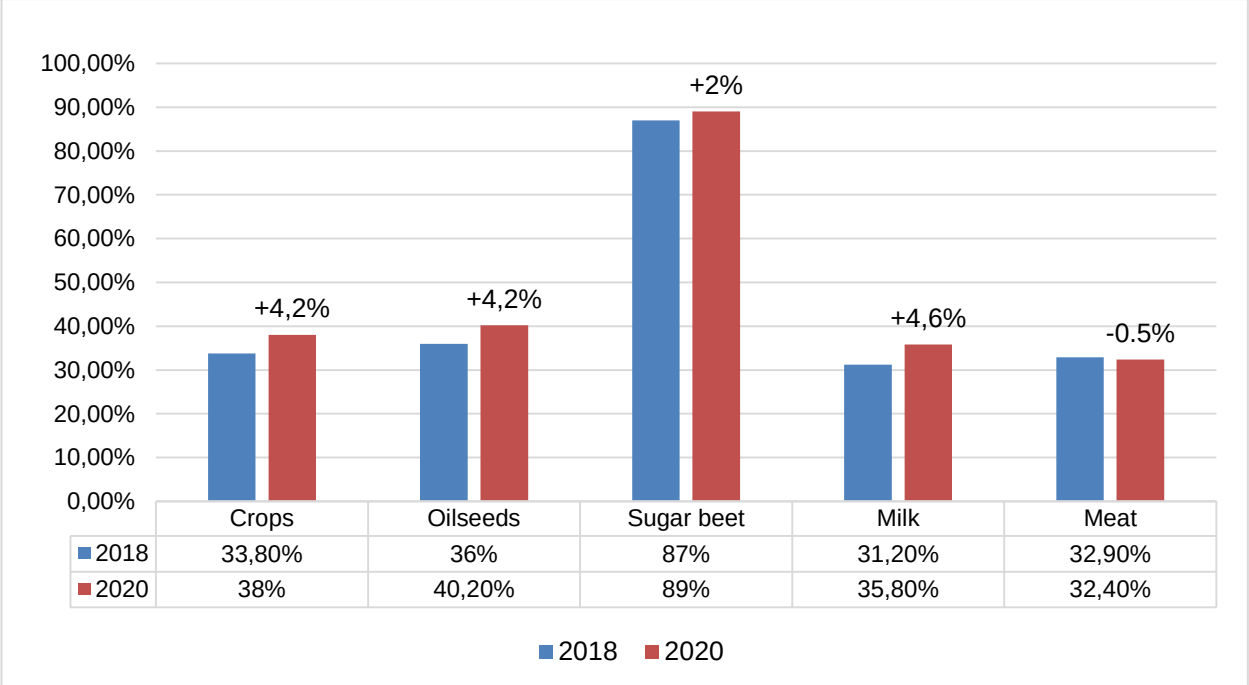
- implementing modern methods in organic agriculture: This step involves using the latest farming methods to increase productivity levels and reduce environmental impact;
- organizing separate waste collection in settlements: An efficient system of separate waste collection in cities and rural settlements will contribute to more effective recycling;
- constructing biogas plants at sewage and poultry plants: Establishing biogas facilities at wastewater treatment plants and poultry farms will allow the use of organic waste for biogas production, which is a clean source of energy;
- developing the recycling of organic waste with biogas production: Enhanced processing of organic materials using modern technologies will allow for the production of more biogas, which can be used as an alternative fuel;
- transitioning to high-value agricultural crops with lower water consumption: refocusing on more valuable and less water-intensive agricultural crops will optimize the use of water resources and increase the profitability of agriculture.

These steps are aimed at achieving the goal of transitioning to a sustainable, efficient, and environmentally safe waste management system in Kazakhstan's agro-industrial complex.

From 2018 to 2020, food production in Kazakhstan increased from 1 527.7 billion tenge to 1 957.2 billion tenge. The average growth rate for this period was 100.9%. The physical volume index reached 103.2% in 2020.

As of January 1, 2021, there are 1 168 enterprises operating in various sectors, such as grain processing (248), meat processing (172), oil and fat production (68), fruit and vegetable processing (36), dairy processing (172), cereal factories (59), pasta enterprises (40), confectioneries (40), bakeries (305), fish processing (25), sugar factories (4), deep grain processing (3), and others.

An analysis of the current situation of the agro-industrial complex presented in the Concept for the development of the agro-industrial complex of the Republic of Kazakhstan for 2021-2030 indicates that during the ongoing reforms there was a decrease in the influx of capital into the rural economy, production volumes decreased, the living standards of the rural population sharply fell, and social tension in rural areas increased (Decree of the Government of the Republic of Kazakhstan "On approval of the Concept…) [10]. An analysis of individual indicators of agricultural development is presented in figure 2.



	Crops	Oilseeds	Sugar beet	Milk	Meat
2018	33,80%	36%	87%	31,20%	32,90%
2020	38%	40,20%	89%	35,80%	32,40%

Note: compiled by the author based on source Decree of the Government of the Republic of Kazakhstan "On approval of the Concept for the development of the agro-industrial complex of the Republic of Kazakhstan for 2021 - 2030" (Decree of the Government of the Republic of Kazakhstan "On approval of the Concept…) [10].

Figure 2 - The share of processing of various agricultural products in 2020

Investments in fixed capital in food production in 2020 amounted to 109 billion tenge, while in 2018, this figure was higher at 125.7 billion tenge. During the specified period, 49 new enterprises for processing agricultural products were put into operation, including oil mills, fruit and vegetable processing plants, dairy enterprises, meat processing enterprises, rice mills, confectionery production, cereal, flour milling, pasta factories and deep grain processing.

Overall, in the field of agricultural product processing, there is potential to double production volumes using existing capacities.

The impact of climate change on the yield of agricultural crops in Kazakhstan from 2020 to 2023 was the subject of detailed study, focusing on major crops such as wheat, barley, and potatoes. The study indicates an ambiguous response of crop yields to changing climatic conditions in different regions of Kazakhstan:

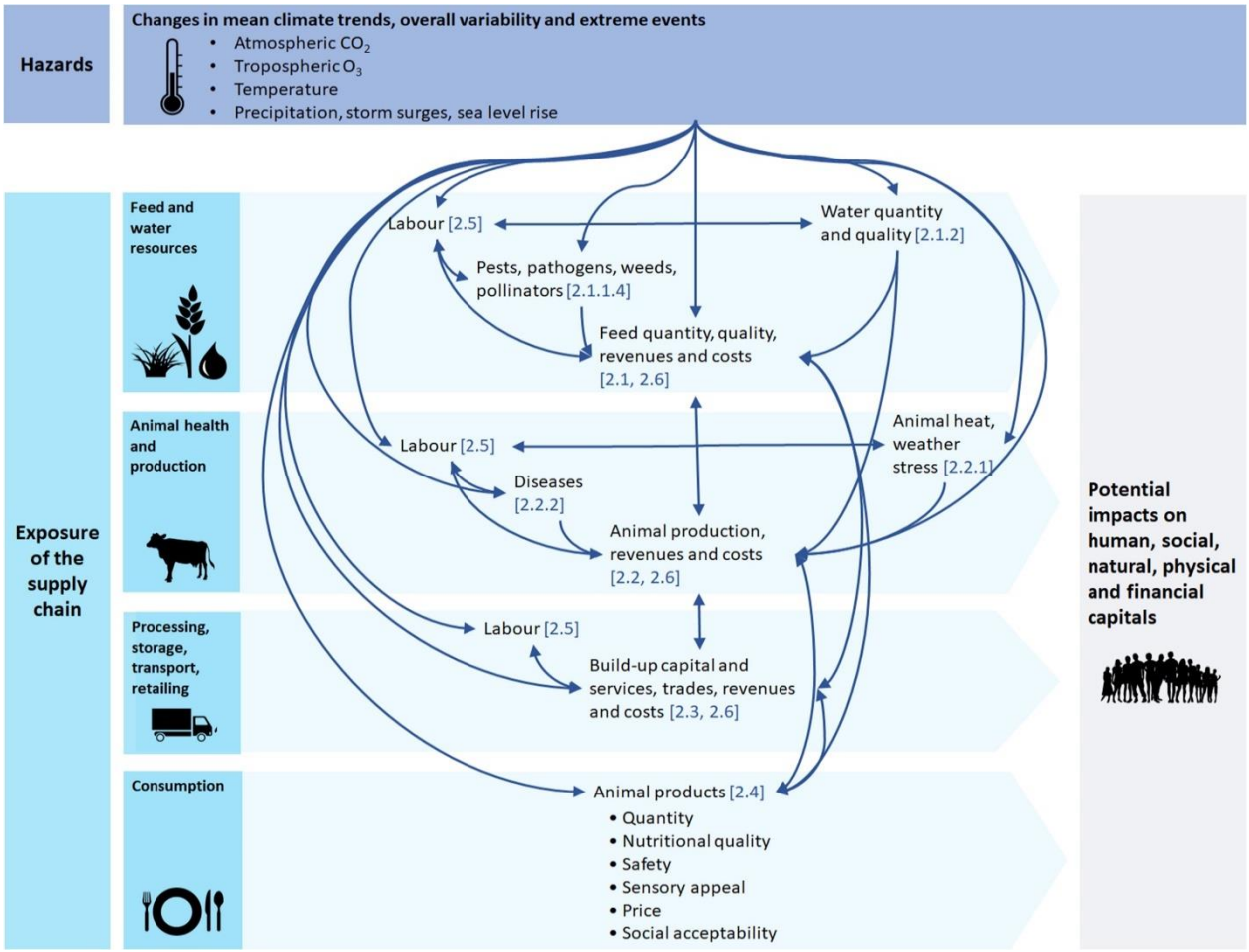
Increase in yield in certain regions. Across Kazakhstan, there is a trend towards

an increase in wind speed and potato yield. Additionally, in the southeast of the country, the yield of barley and wheat has increased. These changes suggest that certain climatic shifts have had a beneficial effect on the yield of agricultural crops in specific areas (Wang D., Li R., Gao G. et al.) [11].

Spatial differences in climate impact. Climate change has caused significant spatial differences in its impact on the yield of wheat and barley. For instance, observed climate changes led to a decrease in wheat and barley yields by 1.9% and 4.8%, respectively, in the main grain-producing region in western Kazakhstan. However, these negative impacts were partially offset by positive effects in the eastern region of North Kazakhstan (Schierhorn F., Hofmann M., Adrian I. et al.) [12].

Projected yield losses under various scenarios: the study predicted the impact of different Representative Concentration Pathway (RCP) scenarios on wheat yield, highlighting the vulnerability of the arid steppe zone to increased greenhouse gas emissions. Results showed a potential loss of more than 10% of the wheat yield in the arid steppe zone, 7.6% in the slightly hilly zone, and 7.5% in the forest-steppe zone under the RCP 8.5 scenario without technological modernization and genetic modification (Teleubay Z., Yermekov F., Rustembaye A. et al.) [13].

The impact of climate change on the yield of agricultural crops in Kazakhstan varies across different regions: in some areas, yields increase, while in others, they decrease. These changes, in turn, affect the yield of fodder crops, which will subsequently impact livestock in the regions. Adaptation strategies, including the development of drought-resistant crop varieties and improvement of irrigation methods, are crucial for mitigating the adverse effects and ensuring food security in the context of ongoing climate change. In general, a description of this process is presented in figure 3, which was studied based on the source (Godde C.M., Mason D.D., Mayberry D.E. et al.) [14].



Note: the impact of climate change on the livestock food supply chain and concludes the evidence review (Godde C.M., Mason D.D., Mayberry D.E. et al.) [14].

Figure 3 - Potential Impact of Climate-Related Hazards on the Supply Chain of Terrestrial Livestock Products

Provided figure 3 is a conceptual diagram illustrating various factors in the livestock product supply chain affected by climate change. Here is an analysis of the scheme:

■ hazards: the diagram identifies hazards related to climate change, including increased atmospheric CO2 levels, tropospheric O3, changes in temperature, precipitation, storm surges, and sea-level rise;

■ feed and water resources: these resources are directly affected by climate hazards, which in turn impact the availability of feed and water in terms of quantity, quality, and related costs;

■ animal health and production: changes in feed and water resources, as well as the direct impact of the climate, such as heat stress, affect animal health. This impacts overall livestock production, including both the physical volume of products and financial aspects such as revenues and costs;

■ processing, storage, transportation, retail: the diagram shows that these post-production processes are affected by the availability and cost of labor, which is also influenced by climate impacts. Capital accumulation, services, trade, and incomes in these areas may fluctuate due to climate changes at the primary production stage;

■ consumption: the quality of the final product, including quantity, nutritional value, safety, taste appeal, price, and social acceptability, ultimately depends on changes in the supply chain;

■ potential impact on capitals: overall, the consequences of climate change can potentially affect human, social, natural, physical, and financial capitals, encompassing a broader socio-economic context;

■ feedback loops: the diagram also shows feedback loops where changes in one component of the system can affect other components, highlighting the interconnected nature of the supply chain;

■ labor: labor is a recurring factor in the diagram, indicating its central role at every stage of the supply chain and how it is affected by various other factors.

The figure effectively reflects the complexity of the livestock supply chain and the multifaceted consequences of climate change. It demonstrates the need for a comprehensive approach to addressing climate change-related issues at all stages of livestock production and supply.

From the analysis of the Decree of the Government of the Republic of Kazakhstan "On approval of the Comprehensive Action Plan for the development of processing of agricultural products and the food industry for 2024-2028"», key aspects were highlighted (Decree of the Government of the Republic of Kazakhstan "On approval of the Comprehensive Action Plan for the development of processing….) [15]:

- Kazakhstan aims to become a regional hub for the production and processing of organic and halal products with potential markets in China, Siberia, and eastern Russia;

- the government has approved a comprehensive plan for the development of agricultural product processing and the food industry for 2024-2028, which includes measures for state stimulation and support of agricultural product and raw material processing through subsidies and incentives;

- the plan includes measures to improve milk quality, focusing on reducing the number of somatic cells and subsidizing milk used for producing dairy products for children;

- the necessity of programs to promote the consumption of dairy products, especially among children, as well as the development of information campaigns and scientific research illustrating the benefits of milk and dairy products, is recognized.

These aspects underline the focus on developing and promoting the agricultural and food industry in Kazakhstan, as well as measures taken to improve product quality and stimulate consumption.

The article suggests implementing modern waste processing technologies, such as biogas plants and composting, to increase resource use efficiency and reduce the negative impact on the environment. Furthermore, the article notes the great potential for using renewable energy sources in Kazakhstan's agro-industrial sector. Solar and wind energy can be used to power farms and generate energy for rural settlements, helping to reduce dependence on fossil fuels and decrease greenhouse gas emissions.

An analysis of the Environmental Code and other legislative acts of the Republic of Kazakhstan shows that most regulatory provisions and country support measures in the waste management sector are directed at managing existing waste, leaving underdeveloped mechanisms for waste prevention. This leads to a misalignment of waste management hierarchy priorities.

Developed countries have made significant progress in ensuring food security, actively encouraging the modernization of machinery and technologies in the processing sector. In Russia, the development strategy for the processing industry includes supporting

the production of agricultural raw materials, modernizing, and expanding production capacities through technical re-equipment and construction based on innovative technologies and energy-saving equipment. There is also encouragement for cooperation between agricultural producers and processors.

In the European Union, producers and processors of agricultural raw materials, as well as other participants in the development of rural areas, can take advantage of favorable loans or guarantees to cover operational expenses, offered under very favorable conditions, such as low-interest rates or flexible payment schedules.

Some European coun-tries, including the Netherlands, already apply circular economy measurement systems based on ten blocks of indicators. These blocks allow for the assessment of various aspects of the circular economy, such as re-source usage, energy efficiency, material recovery, and others. The application of such systems enables a more comprehensive as-sessment of the state and efficiency of the circular economy and the adoption of corres-ponding measures and policies.

In the USA, measures are being taken to encourage private companies to invest in innovation and develop competencies in the agricultural sector. This is achieved through the introduction and widespread use of scientific developments based on new technologies aimed at increasing labor productivity.

Globally, strengthening sustainable long-term relationships between producers of agricultural raw materials, processing enterprises, and trading companies is becoming important, which is considered a key factor for increasing productivity and the value of products.

Kazakhstan, with its vast land resources and diverse agriculture, faces a serious challenge in the form of climate change. Global changes in weather conditions and the world's climate have a direct impact on the country's agro-industrial complex (AIC).

Circular economy strategies in agriculture can provide indicators capable of assessing the level of production impact on the environmental situation, forecasting social aspects, awareness levels, and the energy efficiency of products (Nurmukhametov N.N., Nurtaeva Zh.Sh., Talapbaeva G.E.) [16].

Threats to the AIC Economy:

- climate change may lead to reduced yields of major agricultural crops such as wheat, barley, and cotton. This threatens the country's food security and export capabilities;
- variability in precipitation and the increase in the number of floods can lead to soil erosion and loss of fertility, reducing the area under cultivation and decreasing yields;
- some types of agricultural crops may become unsustainable in new climate conditions, requiring farmers to shift to new types, complicating the adaptation of the agricultural sector.

The analysis of the above information allows us to conclude that there is significant potential for the development of the circular economy in Kazakhstan's agro-industrial complex. Implementing circular economy principles can contribute to more efficient resource use, increased energy efficiency, and reduced negative environmental impact, which is critical for Kazakhstan's AIC.

One of the main aspects to consider when developing a circular economy strategy in Kazakhstan's agro-industrial sector is the creation of the appropriate infrastructure for processing and utilizing agricultural waste. Implementing modern processing and disposal technologies will reduce the negative impact on the environment and create new opportunities for using waste in production processes. For a more detailed analysis of the potential for biogas production in Kazakhstan, we examined the works of domestic economists (Orazbekov E., 2020) and the general statistical analysis is presented in table 2.

Table 2 - Biogas production potential in Kazakhstan

Biogas source	Total livestock (thousands of heads)	Biomass (tonnes/year per unit)	Total biomass (thousands of tons/year)	Biogas produced from 1 kg biomass (m3)	Total production of biogas (million m3 / year)
Food waste	-	-	1 400,00	0,09	126,00
Cattle	7 436,40	8,00	59 491,20	0,04	2 379,65
Horses	2 852,30	7,00	19 966,10	0,04	798,64
Sheep, goat	19 155,70	1,00	19 155,70	0,06	1 149,34
Pigs	813,30	2,00	1 626,60	0,06	97,60
Poultry	45 000,00	0,06	2 790,00	0,07	195,30
					Summary: 4 746,53
Note: compiled from the source (Orazbekov E.) [17].					

The energy produced in Biogas Plants (BPs) is renewable and complies with legislation on the use of renewable energy sources. In Kazakhstan, there are a number of small BPs operating on auxiliary sites to meet the needs of their own farms. In some cases, these are homemade installations not equipped with necessary controls for gas leaks and explosion prevention.

Currently, the market offers various modifications of BPs designed for both small and large sources of biodegradable waste, including the appropriate equipment for raw material preparation, energy cogeneration, and subsequent digestate processing.

Additionally, attention should be paid to the education and awareness of workers in the agro-industrial sector about the principles of circular economy. Training and raising awareness will help create a favorable environment for the introd uction of new approaches and technologies, as well as promote innovation and improve production efficiency.

Climate changes have a significant impact on agriculture, including abnormal weather conditions, lack or excess of precipitation, temperature fluctuations, rising groundwater levels, and loss of lands. To prevent climate impact on agriculture, the following solutions should be considered:

* agriculture adaptation to climate change: modern farmers need to adjust working methods considering climate characteristics, production potential and needs, availability, and profitability of chosen methods. There are several adaptation strategies, such as precision farming, creating environmentally safe drainage systems, improving irrigation efficiency, and using adaptive crops;

* software opportunities, such as EOSDA Crop Monitoring: this software provides farmers with tools for accounting for climate conditions and conducting precision farming, allowing to reduce production costs while maintaining high yields and minimizing environmental impact.

These solutions emphasize the importance of adapting agriculture to climate changes and the role of specialized software in this process.

Discussion

Academic research widely discusses real models of implementing closed loops and the application of circular technologies in the production processes of organizations. The Ellen MacArthur Foundation, established in 2010, plays a key role in merging theoretical concepts of the circular economy and their practical adaptation in the modern world. The developments of this Foundation are applied in various countries and are aimed at a new format of organizational operations, where the concept of "user," not "consumer," is central. In this model, the productivity of a product becomes a key factor for all participants in the production cycle.

Currently, the market offers various modifications of BPs designed for both small and large sources of biodegradable waste, including the appropriate equipment for raw material preparation, energy cogeneration, and subsequent digestate processing.

Additionally, attention should be paid to the education and awareness of workers in the agro-industrial sector about the principles of circular economy. Training and raising awareness will help create a favorable environment for the introd uction of new approaches and technologies, as well as promote innovation and improve production efficiency.

For Kazakhstan, it is important to develop its own circular economy measurement system that considers the country's specific features and needs. This will allow for a more accurate assessment of the development of the circular economy and the development of effective policies to promote it.

Conclusions

The analysis of the current state of Kazakhstan's agro-industrial complex economy under circular and climate economy conditions reveals significant potential for developing a sustainable agro-industrial sector. Implementing circular economy principles can contribute to efficient resource use, reduce the negative impact on the environment, and create new opportunities for business and innovation in Kazakhstan's agro-industrial sector.

Recommendations:

1. *Political and Regulatory Support:* the need for supportive policy and regulations that encourage the implementation of circular economy practices in the livestock sector. This includes incentives for sustainable practices, investments in research and development, and creating markets for processed products.

2. *Infrastructure Development:* emphasizing the importance of developing infrastructure for waste processing and resource recovery. This includes facilities for processing livestock waste into bioenergy, organic fertilizers, and other value-added products.

3. *Technological Innovations:* encouraging investment in innovative technologies that promote circular economy practices, such

as precision agriculture, sustainable feed production, and water-saving technologies.

4. *Capacity Building and Awareness Raising:* highlighting the importance of educational initiatives and capacity building to raise awareness among farmers, businesses, and policymakers about the benefits of circular economy practices.

5. *Collaboration and Partnership:* the document calls for expanding cooperation between the government, the private sector, scientific institutions, and international organizations to share knowledge, resources, and best practices of circular economy in livestock.

Transitioning to a waste-free economy in Kazakhstan's livestock sector is not only a necessity in the face of climate change but also an opportunity to promote sustainable development, enhance economic resilience, and ensure food security. Although there are significant challenges to overcome, the potential benefits justify the need for concerted efforts from all stakeholders. With political support, technological innovations, infrastructure development, and collaborative initiatives, Kazakhstan can become a leader in sustainable livestock management in Central Asia and contribute to global efforts to combat climate change.

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References

[1] Щербакова, А.С. Развитие циркулярной экономики в сельском хозяйстве / А.С. Щербакова // Корпоративное управление и инновационное развитие экономики Севера: Вестник Научно-исследовательского центра корпоративного права, управления и венчурного инвестирования Сыктывкарского государственного университета. -2021. – №4. – С. 405-413.

[2] Circular Economy: Waste-to-Resource. Food and Agriculture Organization of the United Nations [Electronic resource]. Available at: https://www.clck.ru/39t5nW (date of access: 20.01.2024).

[3] Александрова, В. Д. Анализ перехода опыта Китая по переходу на циркулярную экономику / В.Д. Александрова, О.А. Абрамова // Международный научный журнал «Синергия наук». –2018. –№ 24. –С. 126—135.

[4] Александрова, В.Д. Актуальность перехода к модели циркулярной экономики в России / В.Д. Александрова // Международный журнал гуманитарных и естественных наук. -2017. -№ 11. -С. 106-110.

[5] Акимова, Ю.А. Развитие циркулярного сельского хозяйства в Европе для формирования устойчивых агропродовольственных систем/ Ю.А. Акимова //Продовольственная политика и безопасность.-2020.-Т.7.- №4.-С.259-272.

[6] Риккардо, В. Глобальная агропромышленная система и изменение климата: вызовы и возможности для Российской Федерации / В.Риккардо // Финансы: теория и практика. -2017. -Т. 21. -№ 6. -С. 70–79.

[7] WMO Greenhouse Gas Bulletin: The state of greenhouse gases in the atmosphere based on global observations through 2022. [Electronic resource].-2023. Available at: https:// www.library.wmo.int/ records/item/ 68532-no-19-15-november-2023 (date of access: 12.07.2023).

[8] Указ Президента Республики Казахстан «О Концепции по переходу Республики Казахстан к "зеленой экономике"» [Электронный ресурс].- 2013.- URL: https://www.adilet.zan.kz/rus/docs/U1300000577 (дата обращения: 25.01.2024).

[9] Постановление Правительства Республики Казахстан "Об утверждении Плана мероприятий по реализации Концепции по переходу Республики Казахстан к "зеленой экономике" на 2021-2030 годы" [Электронный ресурс].- 2020.- URL: https://www.adilet.zan.kz/rus/ docs/ P2000000479(дата обращения:25.01.2024).

[10] Постановление Правительства Республики Казахстан "Об утверждении Концепции развития агропромышленного комплекса Республики Казахстан на 2021-2030 годы" [Электронный ресурс].- 2021. - URL: https:// www.adilet.zan.kz/rus/docs/P2100000960 (дата обращения: 25.01.2024).

[11] Wang, D. Impact of Climate Change on Food Security in Kazakhstan / D. Wang, R. Li, G. Gao, N.Jiakula, S. Toktarbek, S. Li, P. Ma, Y. Feng// Agriculture. -2022 -Vol. 12(8). -P.1087 https://doi.org/10.3390/agriculture12081087.

[12] Schierhorn, F. (2020). Spatially varying impacts of climate change on wheat and barley yields in Kazakhstan / F. Schierhorn, M. Hofmann, I.Adrian, I. Bobojonov, D. Müller // Journal of Arid Environments. -2020. -Vol.- 178.- Article 104164. https://doi.org/10.1016/j.jaridenv.2020. 104164.

[13] Teleubay, Z. Comparison of Climate Change Effects on Wheat Production under Different Representative Concentration Pathway Scenarios in North Kazakhstan / Z.Teleubay, F. Yermekov, A. Rustembayev, S. Topayev, A. Zhabayev, I. Tokbergenov, V. Garkushina, A. Igilmanov, V. Shelia, G. Hoogenboom // Sustainability. -2024. - Vol. 16. -P. 293. https://doi.org/10.3390/su16010293.

[14] Godde, C. Impacts of climate change on the livestock food supply chain; a review of the evidence / C. Godde, D. Mason-D'Croz, D. Mayberry, P. Thornton, M. Herrero // Global Food Security. -2021. -Vol. 28. - Art. 100488

[15] Постановление Правительства Республики Казахстан "Об утверждении Комплексного плана мероприятий по развитию переработки сельскохозяйственной продукции и пищевой промышленности на 2024-2028 годы" [Электронный ресурс]. -2024.- URL: https://www.legalacts.egov.kz/npa/view?id=14900973 (дата обращения: 10.02.2024).

[16] Нурмухаметов, Н.Н. Обзор концептуальных подходов к циркулярной экономике в АПК Казахстана / Н.Н. Нурмухаметов, Ж.Ш. Нуртаева, Г.Е. Талапбаева // Проблемы агрорынка. - 2023. - № 2. - С. 103-115. https://doi.org/ 10.46666/2023-2.2708-9991.10.

[17] Orazbekov, E. Отчет «Биоразлагаемые отходы в Республике Казахстан, оценка нормативно-правовой базы и инфраструктуры для управления бытовыми отходами» [Электронный ресурс]. -2020.- URL: https://www.switch-asia.eu/site/assets/files/3607/biodegradable_waste_kazakhstan_ru-1.pdf (дата обращения: 30.02.2024).

References

[1] Shcherbakova, A.S. (2021). Razvitie cirkulyarnoj ekonomiki v sel'skom hozyajstve [Development of circular economy in agriculture]. *Korporativnoe upravlenie i innovacionnoe razvitie ekonomiki Severa: Vestnik Nauchno-issledovatel'skogo centra korporativnogo prava, upravleniya i venchurnogo investirovaniya Syktyvkarskogo gosudarstvennogo universiteta – Corporate Governance and Innovative Economic Development of the North: Bulletin of the Research Center of Corporate Law, Management and Venture Investment of Syktyvkar State University*, 4, 405-413 [in Russian].

[2] Circular Economy: Waste-to-Resource. Food and Agriculture Organization of the United Nations. Available at: https://clck.ru/39t5nW (date of access: 20.01.2024) [in English].

[3] Aleksandrova, V.D., Abramova, O.A. (2018). Analiz opyta Kitaya po perekhodu na cirkulyarnuyu ekonomiku [Analysis of the transition of China's experience in the transition to a circular economy]. *Mezhdunarodnyj na-uchnyj zhurnal «Sinergiya nauk» - International scientific journal "Synergy of Sciences",* 24, 126-135 [in Russian].

[4] Aleksandrova, V.D. (2017). Aktual'nost' perekhoda k modeli cirkulyarnoj ekonomiki v Rossii [The relevance of the transition to a circular economy model in Russia]. *Mezhdunarodnyj zhurnal gumanitarnyh i estestvennyh nauk - International Journal of the Humanities and Natural Sciences*, (11), 106-110 [in Russian].

[5] Akimova, Yu.A. (2020). Razvitie tsirkulyarnogo selskogo khozyaystva v Evrope dlya formirovaniya ustoychivyh agroprodovolstvennyh sistem [Development of circular agriculture in Europe to create sustainable agri-food systems]. *Prodovolstvennaya politika i bezopasnost - Food Policy and Security*, 7(4), 259-272. Available at: doi: 10.18334/ppib.7.4.111233 [in Russian].

[6] Riccardo, V. (2017). The global agricultural system and climate changes: challenges and opportunities for the Russian Federation. *Finansy: teoriya i praktika - Finance: Theory and Practice*, 21(6), 70–79.

[7] WMO Greenhouse Gas Bulletin: The state of greenhouse gases in the atmosphere based on global observations through 2022 (2023). Available at: https://library.wmo.int/records/item/68532-no-19-15-november-2023 (date of access: 12.07.2023) [in English].

[8] Ukaz Prezidenta Respubliki Kazahstan «O Koncepcii po perekhodu Respubliki Kazahstan k "zelenoj ekonomike"» [Decree of the President of the Republic of Kazakhstan «About the Concept for the transition of the Republic of Kazakhstan to a "green economy"»] (2013). Available at: https://adilet.zan.kz/rus/docs/ U1300000577 (date of access: 25.01.2024) [in Russian].

[9] Postanovlenie Pravitel'stva Respubliki Kazahstan "Ob utverzhdenii Plana meropriyatij po realizacii Koncepcii po perekhodu Respubliki Kazahstan k "zelenoj ekonomike" na 2021-2030 goda" [Decree of the Government of the Republic of Kazakhstan "On approval of the Action Plan for the implementation of the Concept for the transition of the Republic of Kazakhstan to a green economy for 2021-2030"] (2020). Available at: https://adilet.zan.kz/rus/ docs/P2000000479 (date of access: 25.01.2024) [in Russian].

[10] Postanovlenie Pravitel'stva Respubliki Kazahstan "Ob utverzhdenii Koncepcii razvitiya agropromyshlennogo kompleksa Respubliki Kazahstan na 2021-2030 gody" [Decree of the Government of the Republic of Kazakhstan "On approval of the Concept for the development of the agro-industrial complex of the Republic of Kazakhstan for 2021 - 2030"] (2021). Available at: https://adilet.zan.kz/rus/docs/P2100000960 (date of access: 25.01.2024) [in Russian].

[11] Wang, D., Li, R., Gao, G., Jiakula, N., Toktarbek, S., Li, S., Ma, P. & Feng, Y. (2022). Impact of Climate Change on Food Security in

Kazakhstan. *Agriculture*. Available at: https://doi.org/10.3390/agriculture12081087.

[12] Schierhorn, F., Hofmann, M., Adrian, I., Bobojonov, I. & Müller, D. (2020). Spatially varying impacts of climate change on wheat and barley yields in Kazakhstan. *Journal of Arid Environments*, 178, 104164. Available at: https:// doi.org/10.1016/j.jaridenv.2020.104164 [in English].

[13] Teleubay, Z., Yermekov, F., Rustembayev, A., Topayev, S., Zhabayev, A., Tokbergenov, I., Garkushina, V., Igilmanov, A., Shelia, V. & Hoogenboom, G. (2024). Comparison of Climate Change Effects on Wheat Production under Different Representative Concentration Pathway Scenarios in North Kazakhstan. *Sustainability*, 16, 293. Available at: https://doi.org/10.3390/su16010293.

[14] Godde, C.M., Mason, D.D., Mayberry, D.E., Thornton, P.K., Herrero, M. (2021). Impacts of climate change on the livestock food supply chain; a review of the evidence. *Global Food Security*, 28, 100488. Available at: https:// doi.org/10.1016/j.gfs.2020.100488 [in English].

[15] Postanovlenie Pravitel'stva Respubliki Kazahstan "Ob utverzhdenii Kompleksnogo plana meropriyatij po razvitiyu pererabotki sel'skohozyajstvennoj produkcii i pishchevoj promyshlennosti na 2024-2028 gody" [Decree of the Government of the Republic of Kazakhstan "On approval of the Comprehensive Action Plan for the development of processing of agricultural products and the food industry for 2024-2028"] (2024). Available at: https://legalacts.egov.kz/npa/view?id=14900973 (date of access: 10.02.2024) [in Russian].

[16] Nurmukhametov, N.N., Nurtaeva, Zh. Sh., Talapbaeva, G.E. (2023). Qazaqstannyñ agroönerkäsıp keşenındegı ainalmaly ekonomikanyñ konseptualdy täsılderıne şolu [Overview of conceptual approaches to circular economy in AIC of Kazakhstan]. *Problemy agrorynka - Problems of AgriMarket*, 2, 103-115. Available at: https://doi.org/10.46666/2023-2.2708-9991.10 (in Kazakh).

[17] Orazbekov, E. (2020). Otchet «Biorazlagaemye othody v Respublike Kazahstan, ocenka normativno-pravovoj bazy i infrastruktury dlya upravleniya bytovymi othodami» [Report «Biodegradable waste in the Republic of Kazakhstan, assessment of the regulatory framework and infrastructure for household waste management»]. Available at: https://www.switch-asia.eu/site/assets/files/3607/biodegradable_waste_kazakhstan_ru-1.pdf (date of access: 30.02.2024) [in Russian].

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