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State regulation of the circular economy's development in the Republic of Kazakhstan

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NORMATIVE REFERENCES

1. “The Constitution of the Republic of Kazakhstan” dated 30 August 1995.
2. Decree of the Government of the Republic of Kazakhstan No. 883 “Concept for Transition to a Green Economy”, 30 September 2013.
3. Environmental Code of the Republic of Kazakhstan No 400-VI (2 January 2021).
4. Presidential Decree of the President of the Republic of Kazakhstan No. 3834 “On Measures for the Implementation of the Development Strategy of the Republic of Kazakhstan until the Year 2030”, 28 January 1998.
5. Presidential Decree of the President of the Republic of Kazakhstan No. 841 “Kazakhstan 2050: New Political Course of the Established State”, 14 December 2012.
6. Decree of the President of the Republic of Kazakhstan No. 121 “On Approval of the Strategy of the Republic of Kazakhstan on Achieving Carbon Neutrality by 2060”, 2 February 2023.
7. Code of the Republic of Kazakhstan No. 375-V “Entrepreneurial Code of the Republic of Kazakhstan”, 29 October 2015.
8. Code of the Republic of Kazakhstan No. 120-VI “On Taxes and Other Obligatory Payments to the Budget”, 25 December 2017.
9. Water Code of the Republic of Kazakhstan No. 481, adopted 9 July 2003.
10. Civil Code of the Republic of Kazakhstan (General Part) No. 268-XIII, 27 December 1994; Civil Code of the Republic of Kazakhstan (Special Part) No. 409-I, 1 July 1999.
11. Forest Code of the Republic of Kazakhstan No. 477-II, 8 July 2003.
12. Presidential Address of the President of the Republic of Kazakhstan K. J. Tokayev to the People of Kazakhstan, 1 September 2020.
13. Presidential Address of the President of the Republic of Kazakhstan K. J. Tokayev to the People of Kazakhstan, 1 September 2021.
14. Presidential Address of the President of the Republic of Kazakhstan K. J. Tokayev to the People of Kazakhstan, 1 September 2022.
15. Presidential Address of the President of the Republic of Kazakhstan K. J. Tokayev to the People of Kazakhstan, 1 September 2023.
16. Presidential Address of the President of the Republic of Kazakhstan K. J. Tokayev to the People of Kazakhstan, 2 September 2024.

NOTATIONS AND ABBREVIATIONS

3R	Reduce, Reuse, Recycle
9R	Nine “R-principles” of the circular economy (Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle/Recover)
AHP	Analytic Hierarchy Process
CE	Circular Economy
CEI	Circular Economy Index
CEPI	Circular Economy Performance Index
DMC	Domestic Material Consumption
ECA	Environmental Consolidated Act (Italy)
EIA	Environmental Impact Assessment
EMF	Ellen MacArthur Foundation
EPR	Extended Producer Responsibility
EU	European Union
FARC	Framework Act on Resource Circulation (South Korea)
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IPPC	Integrated Pollution Prevention and Control
LCA	Life Cycle Assessment
MDG	Millennium Development Goal
MCI	Material Circularity Indicator
MSW	Municipal Solid Waste
OECD	Organization for Economic Co-operation and Development
PAYT	Pay As You Throw (waste-fee system)
SII	Social Impact Indicators
SDG	Sustainable Development Goal
UNECE	United Nations Economic Commission for Europe
UN	United Nations

INTRODUCTION

Relevance of the research topic. The global economy is currently facing a systemic crisis due to the linear resource consumption model, which operates on a "take-use-throw away" principle. This approach results in the inefficient use of natural resources and worsens environmental challenges. According to the Circularity Gap Report 2024, only 7.2% of materials worldwide are returned to the economy after use. This critically low level of material recycling indicates serious risks to both economic sustainability and environmental safety.

Transitioning to a circular economy (CE) is viewed as a crucial strategy for mitigating climate change, reducing waste, and promoting sustainable economic growth. Forecasts from the UN and OECD predict that 2050 global material consumption will double while waste volumes will rise by 70%.

In response to these challenges, the European Union implemented the "Circular Economy Action Plan: for a cleaner, more competitive Europe" in March 2020. Similar national strategies have been adopted by countries such as China (for example, "14th Five-Year Plan of China for Circular Economy Development" in 2021) and Japan ("Basic Act on Establishing a Sound Material-Cycle Society" in 2000), along with various other developed and developing nations. The shared goal of these initiatives is to ensure long-term sustainable growth, reduce the climate footprint, and achieve Sustainable Development Goal 12: "Ensure sustainable consumption and production"

In Kazakhstan, establishing an effective mechanism for state regulation of the circular economy is of paramount importance. The increasing focus on sustainable development as a strategic objective of the state further emphasizes this relevance. In his addresses for 2020-2024, President K. Zh. Tokayev repeatedly highlighted the need for a transition to a "green" economy, the rational use of water and other natural resources, as well as the digitalization of infrastructure and modernization of waste management systems. For instance, the September 1, 2020, address called for the introduction of water-saving technologies and the digitalization of the irrigation network; the 2021 address emphasized the modernization of reservoirs and digital monitoring of water bodies; the 2022-2023 addresses focused on developing renewable energy, reforming the waste management system, and implementing circular principles in industry and agriculture; and the 2024 address advocated for large-scale adoption of "green" technologies across all economic sectors.

The development of comprehensive state policies and legislative frameworks for a circular economy in Kazakhstan is largely dependent on the priorities set by national leaders. This approach is essential for achieving the goals of sustainable development and environmental security in the country. The transition to a circular economy is particularly important for Kazakhstan, which continues to heavily depend on oil, gas, and mineral exports. By adopting circular economy principles, Kazakhstan can reduce its reliance on primary resources through recycling and reusing materials. This shift will enhance economic resilience against fluctuations in raw material prices while mitigating the risks associated with resource depletion.

According to the "Concept of Transition to a Green Economy," the country aims to increase its waste recycling rate by 40% by 2030 and 50% by 2050. The program outlines measures for separate waste collection, the construction of green infrastructure, and attracting investment in waste management. This initiative emphasizes the need for the national economy to embrace the utilization of renewable and sustainable natural resources, as articulated in circular economy theory.

Furthermore, the inclusion of circular economy principles as the fourth pillar in the "Strategy for Achieving Carbon Neutrality by 2060" underscores the importance of fully utilizing secondary resources and reducing consumption. These actions are critical for significantly lowering greenhouse gas emissions and promoting sustainable economic growth.

While the country has a foundation of legislative frameworks in place, there is a need for further improvements and additions. It is also essential to establish systemic incentives for the implementation of circular models. Therefore, studying practical approaches and recommendations for accelerating the transition to a circular economy is relevant and timely.

The purpose and objectives of the study. The purpose of this study is to undertake a comprehensive analysis of the processes underlying the establishment of a circular economy in the Republic of Kazakhstan and to develop evidence-based recommendations for strengthening state regulatory mechanisms that support the transition to a circular development model.

To achieve this goal, the following tasks are solved in the work:

1. To study theoretical and methodological approaches to the formation and development of the circular economy, as well as to clarify the conceptual apparatus used in this area.
2. To analyze the international experience of state regulation in the circular economy and determine the possibilities for its adaptation to the context of Kazakhstan.
3. To examine methodological approaches for studying public policy related to the circular economy.
4. To evaluate the current development status of the circular economy in the Republic of Kazakhstan at a macro level, considering institutional, regulatory, organizational, and economic factors.
5. To conduct an empirical analysis of the circular economy development in the Republic of Kazakhstan, focusing on public perception, key stakeholders' positions, and industry specifics, using the agro-industrial complex as an example.
6. Identify the primary problems, obstacles, and institutional constraints that hinder effective government regulation of the circular economy.
7. Develop scientifically-based proposals and recommendations for enhancing government policies in the circular economy at the macro level.
8. Provide practical recommendations for the development of the circular economy in the Republic of Kazakhstan's agro-industrial complex.

The subject of the study. Organizational and economic relationships resulting from state regulation of the circular economy.

The object of the study. The circular economy in the Republic of Kazakhstan.

The theoretical basis of the research. The theoretical and methodological basis of this study references the literature from domestic and foreign scholars in the disciplines of circular economy, state regulation, and sustainable development. It also mentions regulatory legal acts of the Republic of Kazakhstan, program documentation, and methodological recommendations of international organizations. In this process, theoretical concepts regarding the formation and development of the circular economy were discussed, along with its institutional aspects and characteristics. This integrated approach enabled a comprehensive analysis of government regulation and the development of the circular economy, leading to practical recommendations aimed at strengthening efforts to support the shift toward a circular economic model.

The information base of the study. The study's information base includes regulatory and legislative acts from the Republic of Kazakhstan that govern natural resource management and the transition to a circular economy, as well as relevant international documents and strategies from other countries. The empirical and analytical foundation of the study is supported by statistical data from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, as well as organizations such as the OECD, the World Bank, Eurostat, UNEP, and others.

The research also integrates insights and data from prominent international organizations, such as the Ellen MacArthur Foundation and the World Economic Forum, both of which play key roles in promoting the global circular economy agenda. In addition, the study references scientific articles and monographs authored by Kazakhstani and international scholars, drawing from respected bibliographic and abstract databases like Scopus, Web of Science, ScienceDirect, and SpringerLink. To complement this, a range of online sources and open-access repositories were utilized to collect relevant information and global best practices that support the study's aims.

The main scientific results and their novelty.

— the theoretical and conceptual content of the circular economy has been clarified with an emphasis on the role of the state in the formation of sustainable production and consumption models;

— a comparative analysis of international experience in government regulation of the circular economy in countries with different income levels has been conducted; institutional and regulatory models recommended for adaptation in the Republic of Kazakhstan have been identified;

— methodological approaches to assessing the development of the circular economy at the macro, meso and micro levels have been systematized; tools for conducting empirical research have been developed;

— the current state of development of the circular economy in Kazakhstan has been analyzed based on secondary data and a review of the regulatory framework reflecting the specifics of national regulation;

— a comprehensive empirical analysis has been conducted using quantitative research methods (population survey, expert stakeholder survey); the determinants of circular behavior have been identified and the degree of readiness of key groups for the transition to a circular development model has been assessed;

— based on expert interviews, barriers to the implementation of the circular economy in the agro-industrial complex were identified and opportunities for its development in the industry context were determined;

— proposals were developed to improve the mechanisms of state support for the circular economy at the macro level, including tax and financial incentives, regulations and strategic documents;

— support measures were proposed at the meso level, including the creation of eco-industrial parks and introducing digital technologies (IoT, AI) as tools for integrating the principles of the circular economy into industry practice.

The main statements for the thesis defense:

1. A multi-level framework has been established to evaluate the circular economy's progress in the Republic of Kazakhstan at the macro, meso, and micro scales that capture institutional, economic, and behavioral dimensions.

2. It has been established that an increase in costs does not have a statistically significant effect on the level of recycling and reuse of waste, which is confirmed by regression analysis and emphasizes the importance of intangible factors - environmental awareness, government regulation and infrastructure.

3. A comprehensive analysis of the results of a population survey (SPSS 25) and an expert survey using the structural modeling method (SmartPLS 3) made it possible to identify the key determinants of circular behavior and assess the degree of readiness of various stakeholder groups to transition to the principles of a circular economy.

4. Drawing on semi-structured interviews with agro-industrial representatives in the Republic of Kazakhstan, key barriers to circular-economy implementation were identified, including inadequate economic incentives, fragmented regulations, limited stakeholder engagement, and insufficient infrastructure support.

5. Practical recommendations were developed to stimulate the circular economy at the macro and meso levels, including tax and financial instruments, standards, and strategies. For the agro-industrial complex, the introduction of eco-industrial parks and the implementation of digital technologies for implementing the principles of the circular economy was proposed.

Theoretical and practical significance. The theoretical significance of the research lies in the contribution to the scientific understanding of the circular economy as a new model of sustainable economic development, as well as in the development of conceptual and methodological approaches to state regulation in the context of the circular transition. The results help expand the theoretical foundations of environmental economic policy, public administration, and sustainable development by contextualizing the principles of the circular economy within

Kazakhstan's institutional and economic environment. The practical significance of the research is reflected in the proposed recommendations for improving regulatory, institutional, and economic mechanisms for supporting the development of the circular economy in Kazakhstan. The findings and tools developed within the dissertation can be used by government agencies in shaping and implementing circular economy policies, by development institutions in creating sectoral roadmaps and supporting pilot projects, and by local executive bodies in integrating circular principles into regional development strategies.

Aprobation and implementation of the research results. The results of the study were reported and discussed at a number of international and national conferences, including the International Conference of Students and Young Scientists “Farabi Alemi” 2022, the IV International Scientific and Practical Conference “Fundamental Scientific Discoveries”, the IV International Scientific Conference “Sustainable Development of Bioeconomy 2024: Theory and Practice”, the International Scientific and Practical Conference “Paradigm of Sustainable Economic Development” in the Context of Global Change: Challenges, Consequences, Opportunities”, “Challenges of Modernity and Strategies for the Development of Society in the New Reality” (MKVSS).

The relationship of this work with other research works. The dissertation work was carried out within the framework of the implementation of scientific projects of grant funding AP09259851 “Development of a circular economy in Kazakhstan: potential, trends, prospects” (2021-2023) and AP19576593 “Responsible production in Kazakhstani enterprises as a tool for achieving SDG 12: assessment of potential and development prospects” (2023-2025).

Publication of research results. The results of the dissertation research have been published in 12 publications, including 5 in journals recommended by the “CQAFSHE of the Ministry of Science and Higher Education of the Republic of Kazakhstan”, 2 in Q1 journals included in the Scopus database, 1 in a collective monograph, and 4 in the materials of international scientific conferences.

The structure of the dissertation. The work consists of an introduction, three chapters, a conclusion, a list of sources used, and contains 39 tables, 61 figures and 10 appendices.

1 THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF STATE REGULATION OF THE CIRCULAR ECONOMY'S DEVELOPMENT

1.1 Theoretical and conceptual foundations of the circular economy and its role in sustainable development

The idea of a circular economy was first introduced in the Brundtland Report in 1987. This report highlighted the negative effects of consumer attitudes and emphasized the need to transition toward sustainable development. Sustainable development aims to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. It is also worth mentioning the work "Sustainable Economic Development", in which the authors Pearce & Turner, in 1990, first used the term "circular economy" and became the pioneers and founders of this term. In their work, the authors described the relationship between the economy and the environment. They argued that: "the traditional economic model, which is based on the profit-cost principle, is inefficient, and this model should be replaced with a new circular economy that emphasizes sustainable consumption and the concept of intergenerational utility" [1,2].

In 1992, the concept of "green growth" was discussed at the UN World Conference in Rio de Janeiro, Brazil, as a key element of sustainable development. Strategies were developed to achieve the established goals. Later, in 2012, at the Rio+20 conference, a document titled "The Future We Want" was approved, outlining the main Millennium Development Goals (MDGs). However, three years later, in 2015, new Sustainable Development Goals (SDGs) were introduced to replace the MDGs. Currently, there are 17 SDGs and 169 targets aimed at facilitating the transition to sustainable development [3,4].

According to the Ellen Macarthur Foundation, we must transform our "take-produce-throw" approach. How we manage resources, produce and use various products, and how we subsequently dispose of the waste from these same products. The transition to a circular economy addresses all these issues, and through this, a prosperous economy can be created that would benefit all generations with minimal environmental damage. According to the Ellen Macarthur Foundation, a circular economy is an economy that is renewable and regenerative in nature. The concept of a circular economy indicates the importance of the efficiency of the country's economy in all sectors, from large and small companies, organizations, and individuals, at the global and local levels. The principles that the circular economy adheres to are: 1) Create waste-free design, 2) Keep materials and resources in constant use, 3) Regenerate natural systems and resources [5].

In 2014, according to the European Commission, for the first time in Europe, a circular economy project was adopted. This project included the following tasks: transition to a circular economy, proposals for revision of the legislation regarding waste management, etc. The Circular Economy Action Plan was one of the first documents on the transition from a linear (inefficient) economy model to a circular economy (efficient) [6].

The circular economy model is based not only on the minimization of waste of various origins, but also on their "return" into the production process. Based on this, laws and regulations regarding the circular economy should focus on the area of waste management, in particular the disposal of industrial waste.

The literature reviews also showed that when describing the principles of the circular economy, most authors use the prefix "–re" (reduce, reuse, recycle), which shows the regenerative essence of this concept.

From the UNECE Information Note 2020, regarding the circular economy, the following main levels can be identified in the transition to a circular economy [7]:

1. Macro level - laws, national programs, and other regulations
2. Meso level - institutions and organizations
3. Micro level - enterprises (companies)

The fact that the population of the Earth will only increase from year to year means that the needs of the population will increase accordingly. This fact points to the importance of recycling and changing the economic model in order to avoid a collapse in the future. According to the World Economic Forum, at present, the volume of production and consumption is so great that it takes 1.7 planets of the Earth to recycle all this waste [8].

Based on the literature review, it can be concluded that the relevance of the circular economy has just begun to gain momentum, and in the future, it will become the main economic model of most countries on our planet, because resource constraints and population growth will require dramatic changes to preserve the environment for current and future generations.

The circular economy has its origins in the field of industrial ecology, in which the functioning of various ecosystems has been used as a model for industrial processes and systems. For the first time in history, this concept was introduced at the economic level and gained its notoriety at the World Economic Forum (WEF, 2012) when Ellen MacArthur read her talk "Towards a Circular Economy". This report provides a detailed description of the circular economy, its origins, and the path to this direction of the economy. A circular economy is an industrial system that, by its nature, has regenerative and renewable features from the outset in creation and design. It replaces the concept of "end-of-life" with a new "regenerative and renewable", i.e., the service life of which has no end, but has a cycle. Like all other types of economy, the circular economy has its own principles:

— Create products and resources that reduce or eliminate waste.
— Utilize products and resources in a cyclic manner.
— Restore and regenerate natural resources and the environment.

The terms that are most often found in the concept of the circular economy are the following, according to the literature [9]:

Table 1 – Terms that are used most in the CE concept

Terms	**Definition**

Reuse of goods	Reuse products/resources for the same purpose for which it was created, in its original form or with minor changes.
Product refurbishment	Restoring a good working condition of a product/resource by repairing or replacing any damaged part (this also includes "cosmetic" repairs, i.e. updating the appearance of a product/resource).
Component remanufacturing	This includes the disassembly process itself (into smaller parts) and the restoration of the product/resource. That is, reusable work parts are removed from a damaged or non-working product/resource, and remanufactured or incorporated into a new product/resource.
Cascading of components and materials	"Providing materials and components for different end-of-life purposes in different value streams and extracting stored energy and material "coherence" over time. In the cascade, this material order decreases (in other words, entropy increases)", - (Ellen MacArthur, 2013)
Material recycling	It is divided into three groups: - Functional recycling: a process in which materials are recovered to a new or original purpose, excluding energy recovery. - Downcycling: a process in which materials are recycled and new materials are created from them, but of lower quality and functionality. - Upcycling: the opposite process to downcycling - here materials are processed and new materials are created from them, having better characteristics in terms of quality and functionality, materials
Biochemicals extraction	Application of biomass conversion processes for the production of chemical products or liquid fuels.
Composting	The process of natural recycling in which the soil is fertilized with nutrients (i.e., the process of breaking down organic materials by microorganisms).
Anaerobic digestion	The same as composting, only the process takes place in an environment in which there is no oxygen. As a result of anaerobic digestion, biogas and a solid residue are obtained, which can later be used as fertilizer for the soil.
Energy recovery	The process of converting unrecyclable waste into usable fuel, heat or electricity. That is, by incineration, anaerobic digestion, landfill gas utilization, heat treatment, etc.
Landfilling	Location of waste in the site used for the purpose of controlled storage of MSW in the land.
Note - compiled by the author according to the literature [9]	

Table 2 - Chronology of the formation of directions in the economy, the purpose of which is the reasonable consumption and conservation of nature

1987	1989	1990	1992	2012	2015	2017
The term "**sustainable development**" was first mentioned. Report Brundtland "Our common future"	The term "**green economy**" was first mentioned in a UK government report (Pearce, Markandya and Barbier)	The term "**circular economy**" was first mentioned in the work "Sustainable Economic Development" by Pearce & Turner.	UN World Conference, the concept of "**green growth**" was discussed at the UN world conference	Conference "Rio + 20", approved the document "The Future We Want", identified the MDGs (millennium development goals). Also, the term "**Blue Economy**" was first mentioned (Gunter Pauli)	To replace the MDGs (millennium development goals), new SDGs were created (**sustainable development goals**), 17 SDG goals, and 169 targets were designated	Popularization of the concept of "**circular economy**"
Note - Compiled by the author, according to the literatures [1-9]						

Based on Table 2, it can be seen that for the first time in official documents the concept of sustainable development was mentioned in 1987, in the report of Mrs. Gro Harlem Brundtland (Norway), entitled “Our Common Future”. In this report, the main problem of the future was identified - the threat to the environment. The concept was defined in the Brundtland report (1987) as follows: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” The term sustainable development includes two key elements - the concept of “needs” and the concept of “constraints”. These concepts can be explained as follows (Figure 1):

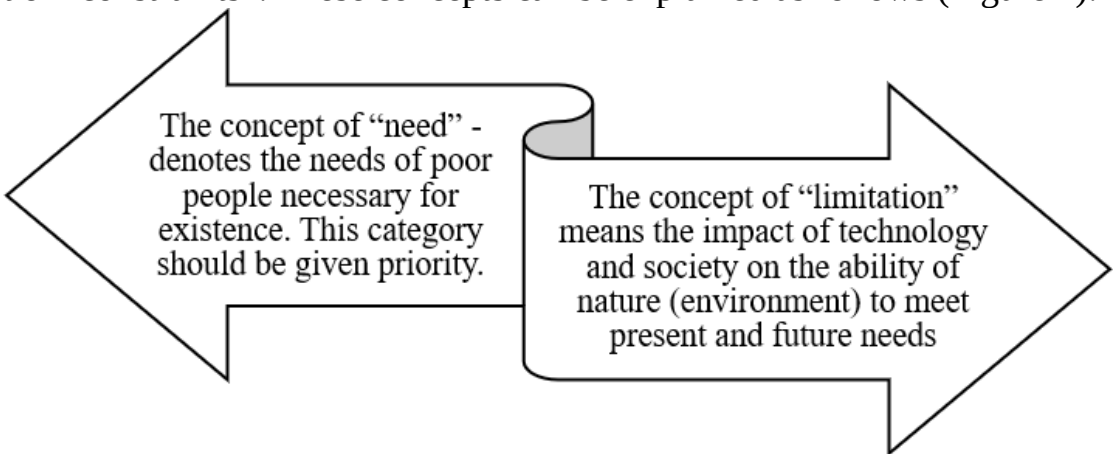


Figure 1 - Sustainable development: key concepts.
*Note: Compiled by the author according to the [1]

The next breakthrough concept, according to the chronology, is the “green economy”. The term “green economy” itself was first coined in 1989 by a team of environmental economists that included the well-known David Pearce, as well as Anil Markandya and Edward Barbier. Then, scientists first used this term in their report “Plan for a Green Economy” (Blueprint for a Green Economy) for the UK government. The purpose of this report was to educate the government about sustainable development. The main problem at that time was that the report did not contain a specific definition of this term - “green economy”- which was why its disclosure was delayed until 2009. According to the definitions of various organizations and scientists, the term “green economy” was defined as follows in different years (Table 3):

Table 3 - Interpretations of the concept “green economy”

Author	Definition	Link
UNEP (2009)	The green economy is a direction in the economy, whose activities are related to meeting the needs of the present generation without environmental harm to future generations, while reducing the shortage of environmental resources.	[10]
UNEP (2011)	A green economy is an economy that has the following characteristics: low carbon and carbon emissions, efficient and prudent use of natural resources (preservation, improvement and increase of natural capital), conservation of biodiversity and ecosystems, and improvement of the welfare of society.	[11]
UNCTAD (2010)	“In the long term, a green economy can be defined as an economy that results in increased human well-being and reduced inequalities without exposing future generations to significant environmental risks and environmental deficits.”	[12]
Green Economy Coalition	A green economy is what ensures prosperity for all within the ecological limits of the planet.	[13]
ICC (International Chamber of Commerce)	“The green economy is described as an economy in which economic growth and environmental responsibility complement each other, supporting progress in social development. Business plays a critical role in providing the economically viable products, processes, technologies, services and solutions needed for the transition to a green economy.”	[14]
Tara Rao, Danish Group 92, Forum for Sustainable Development	“A green economy is not a state, but a process of transformation and constant dynamic progress that removes the systemic distortions and dysfunctions of the current mainstream economy and results in human well-being and equal access to opportunity for all people, while maintaining ecological and economic integrity. The economy cannot be green without equity.”	[15]
Note - Compiled by the author, according to the literatures [10-15].		

The term “circular economy” was first introduced in "Sustainable Economic Development" by Pearce and Turner. In their work, they were skeptical of the traditional linear economy, drawing attention to its limitations and environmental damage. Instead of a linear economic model, the authors proposed a new model, which is based on the principle “everything contributes to everything else”, i.e. -

closed loop. It is also mentioned that the circular economy model includes the first and second laws of thermodynamics, which state the following (Figure 2):

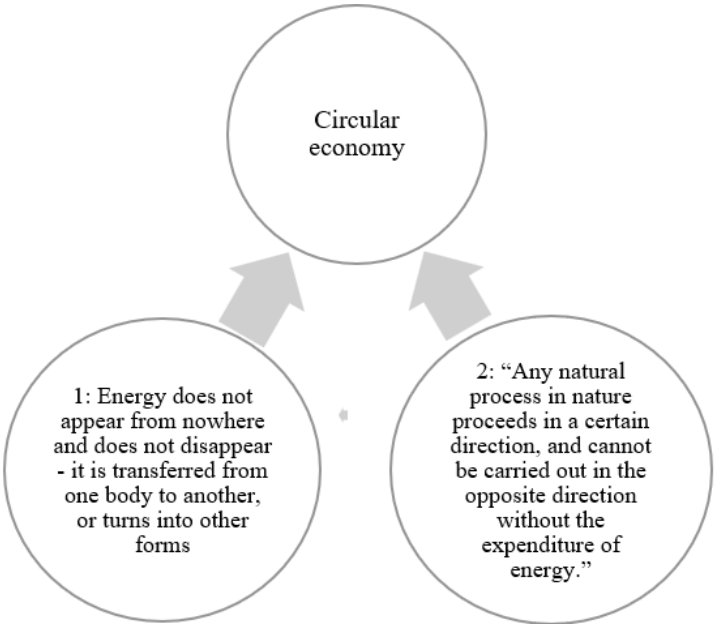


Figure 2 - The laws of thermodynamics as elements of a circular economy
*Note: compiled by the author according to [2]

The circular economic model describes an important link between the environment and the economy.

Since the term "circular economy" itself is relatively new, today there are a lot of interpretations and definitions from different authors. So, for example, the term "circular economy" itself is also called "circular", "cyclic", "closed-loop", "regenerative", etc.

The main interpretations and definitions of this term can be seen in the following Table 4:

Table 4 - Interpretations of the circular economy concept

Author	**Interpretation**	**Link**
Kirchherr, 2017	A circular economy is an entire economic system based on business models that meet these criteria: reduce, reuse, recycle, recover resources and materials involved in production and consumption.	[16]
Ghisselini, 2016	Circular economy - a concept based on minimizing waste and emissions, increasing the "life" of products and materials, regenerating natural resources.	[17]
EMAF, 2012	The circular economy is a systemic solution system that addresses global issues such as climate change, biodiversity loss, waste and pollution.	[18]
Murray, 2015	The circular economy is an economy that does not have negative effects on the environment: it makes up for the damage that was caused in the process of obtaining a	[19]

	natural resource, it also pays attention to reducing waste, and extending the life of products.	
Geissdoerfer, 2018	The circular economy is a possible solution to achieve a sustainable economy.	[20]
The Waste and Resources Action Programme, 2004	The best alternative to the "linear" economy.	[21]
Yuan, 2008	A development strategy that aims to reduce waste and pollution to the environment, as well as the conservation and replenishment of natural resources.	[22]
Wen C. F., 2007	A way to solve problems on the way to sustainable development	[23]
Tukker A., 2015	A philosophy in which a developed economy and a healthy environment exist together	[24]
Guryeva M.A.	"The concept of the circular economy is a universal way of green growth in the development of countries, allowing to replace the linear economy model"	[25]
Geng Y., et al.	Implementation of a closed cycle of material flows in the economic system	[26]
Zhu Q., et al.	A way of continuous (economic) development without harming the environment	[27]
Su B., et al.	It is a strategy for sustainable development, main goal of which is improving material and energy efficiency	[28]
Note - Compiled by the author, according to the literatures [16-28]		

The term "circular economy" emerged relatively recently, while its foundational concept was discussed by earlier scholars. For example, it is generally accepted that the fundamental description of the circular economy was noted in 1966 by Boulding, followed by a report on sustainable development by Mrs. Brundtland in 1987, and after that there were works by authors such as Pierce and Turner. That is, one can observe that the concept of CE has evolved over the years, because environmental problems grew every year. Based on this, the main characteristics of the CE were also supplemented. Today, according to the EEA (European Environment Agency), the following characteristics of the CE exist (Figure 3) [29]:

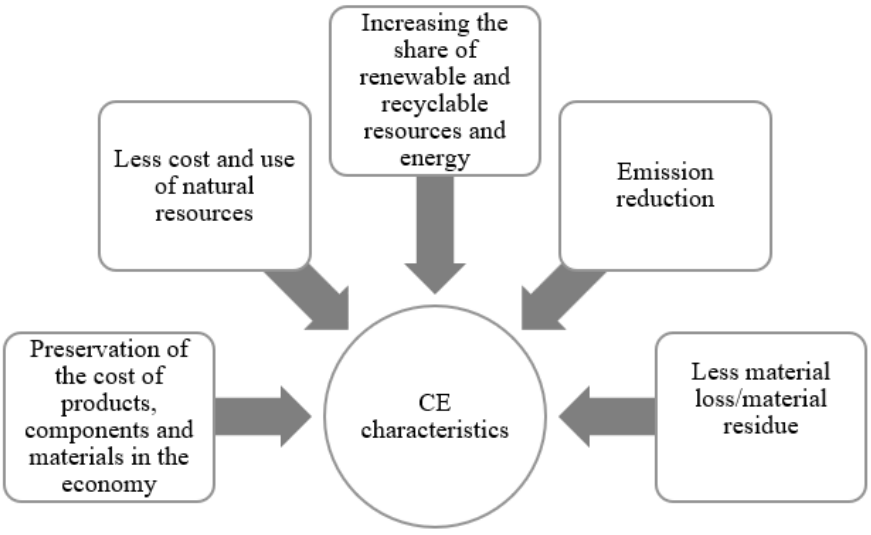


Figure 3 – Characteristics of the circular economy
*Note: Compiled by the author according to the [29]

According to Guryeva M.A.: “The misunderstanding and construction of the consumer model that emerged during the industrial revolution of the 19th and 20th centuries formed the basis of the linear economic system. This model was built on the belief that natural resources were inexhaustible and did not consider waste disposal issues”. Today, it is evident that resources are limited, and most ecosystems, having lost their ability to self-cleanse, are no longer stable. If we do not change our current path of development and reconsider our key approaches to production and consumption, we will face a production crisis and a decline in the quality of life [25].

Potting et al. provided a framework of strategies towards a circular economy. Strategies for achieving a circular economy can be mapped as follows in Figure 4 [30]:

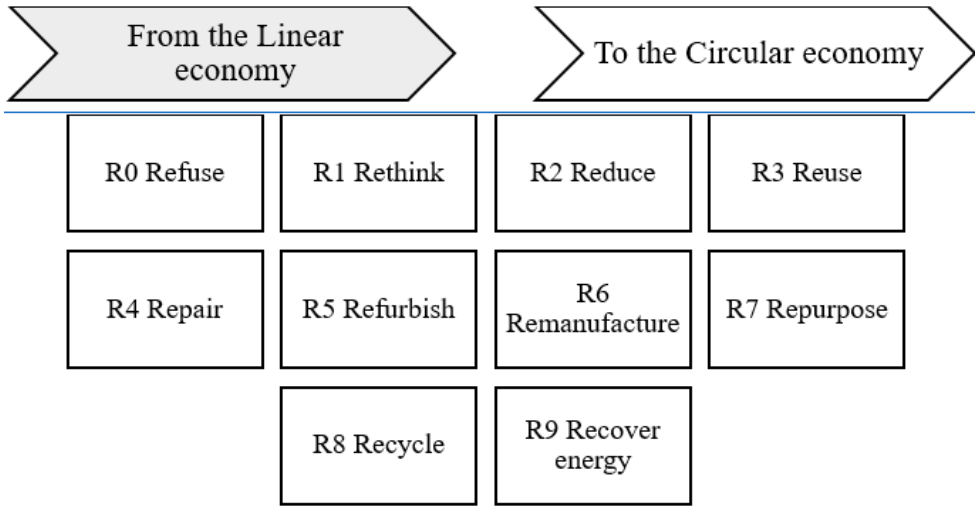


Figure 4 – Strategies for achieving a circular economy
*Note: Compiled by the author according to the [30]

This Figure 4 provides the general strategy directions to the circular economy, which is called “9R principles”. These principles can also be grouped into three main categories:

1) Smarter use and manufacture of a product/service: R0 – Refuse, R1 – Rethink and R2 – Reduce;
2) Increasing the life cycle of goods and its parts/components: R3 – Reuse, R4 – Repair, R5 – Refurbish, R6 – Remanufacture, and R7 – Repurpose;
3) Beneficial use of materials: R8 – Recycle and R9 – Recover energy [30].

According to Fonseca et al. (2018), transitioning to a circular economy involves more than just recycling to reduce waste. It also requires minimizing the overall use of raw materials and extending the life cycle of products and services. The scientific literature on circular economy (CE) proposes various classification variants based on the following principles of "R" (Table 5) [31]:

Table 5 – 9R principles

«9R» principles	**Aims**
Refuse	Prevention or even refuse from the use of raw materials and resources
Reduce	Reducing the use of raw materials
Reuse	Reuse of products, resources, materials
Repair	Maintenance and repair of products
Refurbish	Product updating
Remanufacture	Creation of new products from parts or entirely from old/previous products
Repurpose	Reusing a product for another purpose
Recycle	Recycling and reuse of materials
Recover energy	Waste recycling process that produces energy in the form of heat, electricity, fuel, etc.
Note - Compiled by the author, according to the literature [31]	

The circular economy was originally founded on three key principles known as "3R": reduce, reuse, and recycle. This concept has since evolved into "9R." Future developments of these principles, however, remain uncertain.

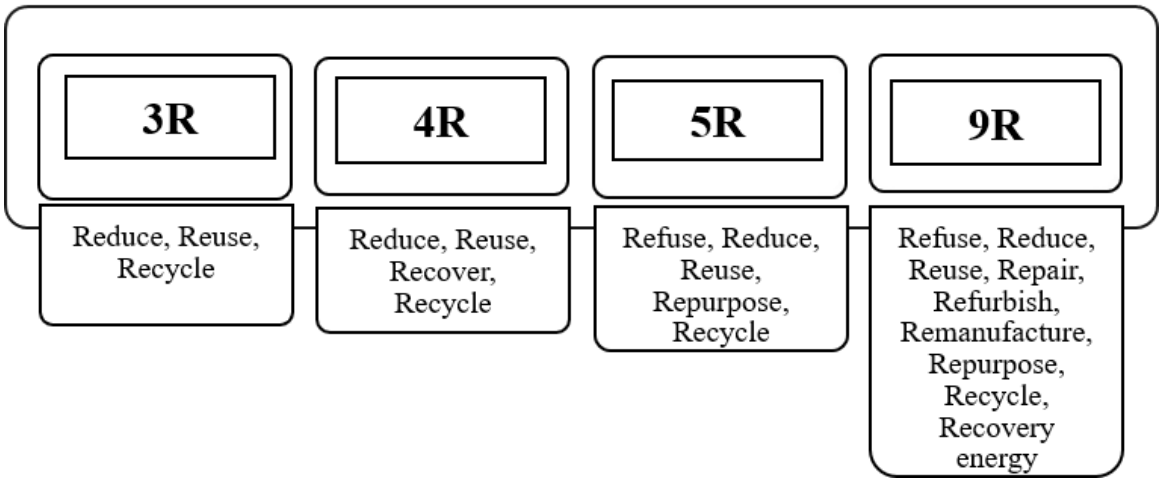


Figure 5 - Principles of the circular economy: development and overview
*Note: Compiled by the author

Thus, when considering the concept of a circular economy, it is likely to come across such terms as "sustainable development", "green economy", "green growth", "an alternative to the brown economy", "closed-loop economy", etc. And in this table, we will consider their similarities and differences (Table 6):

Table 6 - Comparative analysis of concepts aimed at preserving the environment:

Features	**Sustainable development**	**Green economy**	**Blue economy**	**Circular economy**
Concept	Meeting the needs of the current generation without harming the future generation	Improving human well-being while minimizing environmental risks	Focus on sustainable development in areas of the economy associated with using water (oceans, seas) resources.	A closed model of the economy in which resources are "used" rather than "spent".
Establishment year	1987	1989	2012	1990
Goal	17 sustainable development goals, according to the UN	Improving human well-being and social justice without harming the environment	SDG 14	Transition from a linear economy to a circular economy
Principles	16 principles published at the UN conference in Rio de Janeiro	Sustainable and prudent use of natural resources, equality, and increasing the welfare of the population	Sustainable use of the planet's water resources	Principles 3R to 9R
Common features	Smart consumption/production and saving the planet			
Note - compiled by the author				

According to the OECD report on circular economy in 2019, a complete picture of a CE can be designed as follows:

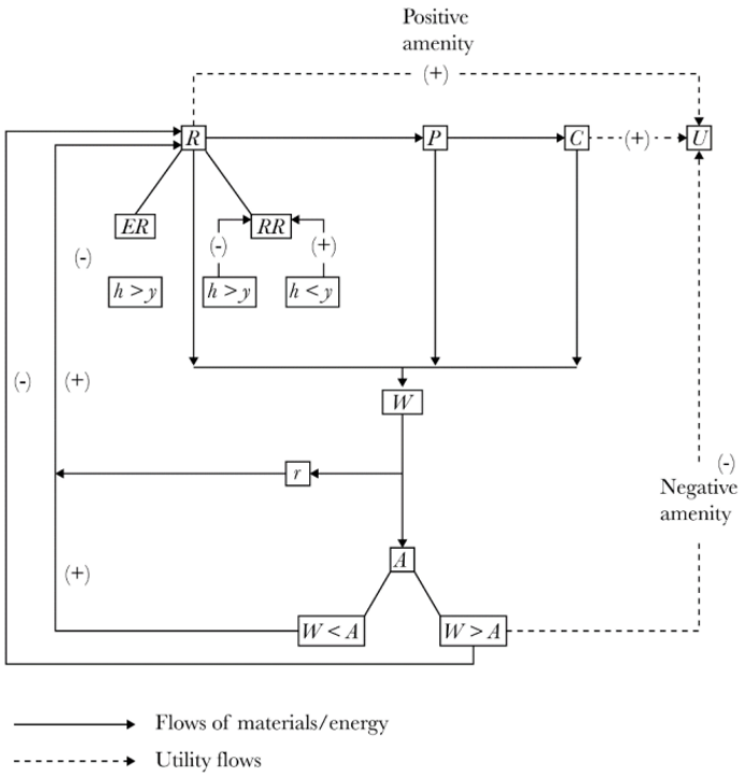


Figure 6 - Components and process of the circular economy, adapted from OECD report [32]

As shown in figure 6, the description of the abbreviations is as follows: R=resources, P=production, C=consumption, U=utility, ER = exhaustible resources, RR = renewable resources, W=wastes, A=assimilative capacity, r-recycling, h=harvest, y=yield (=0 for ER).

Improved model of the circular economy was firstly established by Ellen McArthur. The Ellen MacArthur Foundation (EMF) was founded by Ellen MacArthur in 2010. In partnership with a number of major companies, EMF published three works named “Towards a Circular Economy” in 2013. The first of which contained the famous butterfly diagram reproduced in Figure 7.

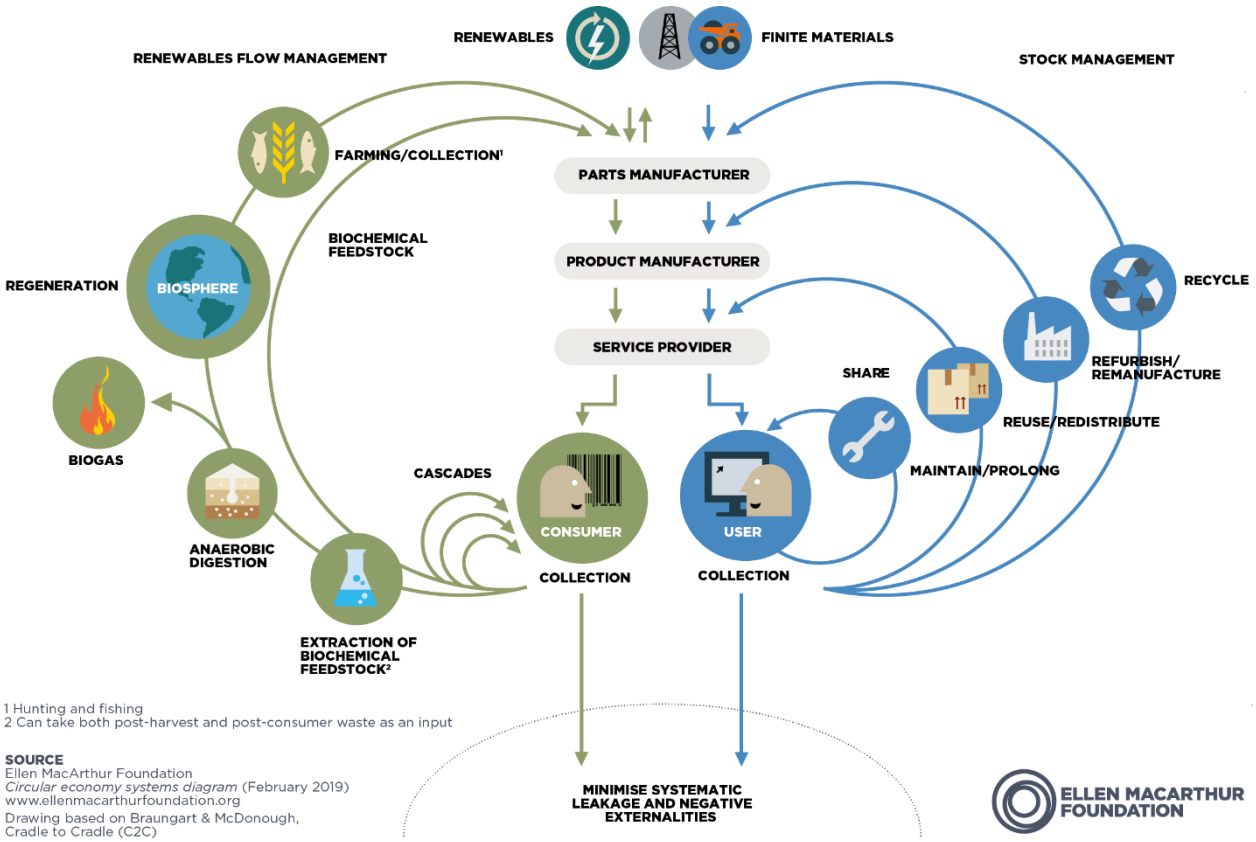


Figure 7 - "Butterfly" diagram describing the processes in the CE
*Note: adapted from EMF 2013

It is also worth noting the level of dissemination and popularity of the concept of circular economy over the years, according to the Scopus database. Nowadays, for the keyword "circular economy", there are 53,103 scientific papers on this topic in the Scopus database (2023). The fields are given below:

Environmental Science – 11 093 papers
Energy – 7 880 papers
Engineering – 3 218 papers
Chemical Engineering – 3 201papers
Social Sciences – 2 801 papers
Materials Science – 2 177 papers
Agricultural and Biological Sciences – 2 037 papers
Earth and Planetary Sciences – 1 282 papers
Decision Sciences – 964 papers
Chemistry – 1 021 papers.

If we break down all existing articles by year, we get the following picture:

Table 7 - Number of published articles related to the circular economy by years

Year	**Number of articles**
1992-2002	8
2003-2009	71

2010-2015	738
2016-2017	1492
2018-2019	4059
2020	3546
2021	5663
2022	7031
2023	160
Note - Compiled by the author, according to the Scopus database	

If we consider the scientific works of domestic scientists, then there are no voluminous works on the topic of the exact term “circular economy” today. But, there are many works related to ecology, green economy, and sustainable development, which are a prerequisite for a circular economy. Below are given the works of domestic scientists on environmental issues:

Table 8 - Publications of domestic scholars related to the environment

Author(s)	**Journal name**	**Publication topic**	**Year**
Torgautov B., Zhanabayev A., Tleuken A. [33]	Sustainable Production and Consumption Volume 33, September 2022, Pages 991-1004	Performance assessment of construction companies for the circular economy: A balanced scorecard approach	2022
Tokazhanov G., Galiyev O., Nauryzbay A., Ismagulov R. [34]	Journal of Cleaner Production Volume 362, 15 August 2022, 132293	Circularity assessment tool development for construction projects in emerging economies	2022
Zhidebekkyzy A., Sansyzbayeva G.N., Temerbulatova Z., Ashirbekova L. Zh. [35]	Journal of International Studies	Evaluating the transition to green economy in Kazakhstan: A synthetic control approach	2020
Trifilova, A.A., Zhidebekkyzy, A.[36]	Journal of International Studies	Commercialization of green technologies: An exploratory literature review	2016
Smagulov A. M., Zhatkanbaev Y.B., Tumbai J.O., Abdikul Sh., Muratbekova K., Agymbay A. [37]	E3S Web Conf. Volume 159, 2020 The 1st International Conference on Business Technology for a Sustainable Environmental System	The impact of the environmental crisis on the purchasing power of consumers	2020

Sansyzbayeva G.N., Ashirbekova L.Zh., Nurgaliyeva K., Ametova Zh. A. [38]	E3S Web of Conferences 159(3):07002	Realities and prospects of using green technologies in Kazakhstan	2020
Diyar S., Akparova A., Toktabayev A., Tyutunnikova M. [39]	Procedia - Social and Behavioral Sciences Volume 140, 22 August 2014, Pages 695-699	Green Economy – Innovation-based Development of Kazakhstan	2014
Orazalin N. [40]	Journal of Cleaner Production Volume 164, 15 October 2017, Pages 389-397	Green governance and sustainability reporting in Kazakhstan's oil, gas, and mining sector: Evidence from a former USSR emerging economy	2017
Abuov Y., Seisenbayev N. [41]	International Journal of Greenhouse Gas Control Volume 103, December 2020, 103186	CO2 storage potential in sedimentary basins of Kazakhstan	2020
Alikhanova A., Kakimzhan A. [42]	Sustainable Energy Technologies and Assessments Volume 36, December 2019, 100544	Design of a bus shelter based on green energy technologies for extreme weather conditions in Nur-Sultan, Kazakhstan	2019
Akhanova G. [43]	Sustainable Cities and Society Volume 52, January 2020, 101842	A multi-criteria decision-making framework for building sustainability assessment in Kazakhstan	2019
Karatayev M. [44]	Heliyon, Volume 8, Issue 1, 2022	Monitoring climate change, drought conditions and wheat production in Eurasia: the case study of Kazakhstan	2021
Islam G., Darbayeva E., Rymbayev Zh., Dikhanbayeva D. [45]	Sustainable Cities and Society Volume 51, November 2019, 101790	Switching-off conventional lighting system and turning-on LED lamps in Kazakhstan: A techno-economic assessment	2019
Biakhmetov B., Dostiyarov A. [46]	Low Carbon Stabilization and Solidification of Hazardous Wastes	Chapter 33 - Sustainable waste management and circular economy	2022

	2022, Pages 545-554		
Kazhmuratova, A., Akhmetkaliyeva, S., Boltaeva, A., Moldabekova, A. [47]	E3S Web of Conferences, 2020, 159, 01005	Introduction of environmental innovations in Kazakhstan	2020
Note - Compiled by the author according to the [33-47]			

A brief overview of the key findings and methodological approaches of leading articles on the circular economy worldwide in the Scopus database was also provided. The detailed content of each paper – including the authors, titles of the papers, methods used, and citation rate – can be found in Appendix A.

In summary, the first subchapter emphasizes the importance of transitioning to a circular economy, which presents a viable alternative to the traditional linear economy. Natural resources and land are finite, and everything has its limits. Meanwhile, the consumption of goods and services is increasing rapidly due to the growing population on Earth.

Politicians, scientists, producers and consumers, and all other economic actors in the country must keep these issues in mind. According to the principles and concept of the circular economy, which underpins the longest life cycle of goods and services, regeneration and renewability, and generally focuses on the term “use” instead of “consumption”, it is possible to save the environment from pollution and excess consumption, which leads to catastrophic problems in the future.

The concept of a circular economy offers a viable alternative to the traditional linear economy. It aims to reduce resource dependence in production, address socio-economic inequalities among the global population, and tackle environmental issues arising from the global crisis. Ultimately, this approach seeks to achieve a sustainable state for the planet and preserve life on Earth.

1.2 State regulation of the circular economy: functions, methods and instruments of influence

According to F. Bator, government regulation emerges in response to market failures, which occur when the free market fails to produce socially optimal outcomes. Bator identified four key reasons for government intervention:

1. Externalities arise when one agent's production or consumption activities create benefits or costs for others without compensation.

2. Public goods are defined by their non-excludability and non-rivalry in consumption, which means that the consumption by one individual does not diminish the availability for others.

3. Information asymmetries occur when market participants have unequal access to information, resulting in an imbalance in decision-making.

4. Natural monopolies occur when competition is ineffective, often due to high fixed costs that make it impractical for multiple firms to operate in the same market.

In these contexts, the government intervenes by adjusting prices and production levels through methods such as taxes (which aim to internalize negative externalities), subsidies (to promote societal welfare), and the establishment of quality standards for products or services [48].

The three main functions of state regulation of the economy are allocation, distribution, and stabilization. The state employs a combination of direct (command-and-control) and indirect (market-based) instruments [49, 50] (Figure 8).

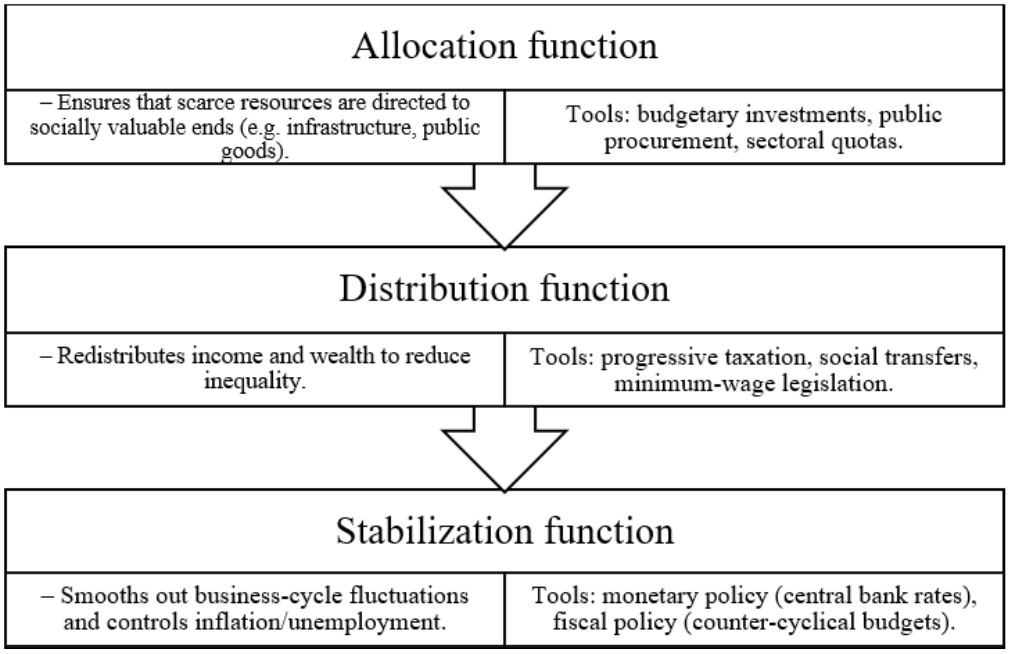


Figure 8 – Functions of state economic regulation
*Note: adapted from [49, 50]

The allocation function directs scarce resources toward uses that yield the greatest social benefits and corrects for the market's under-provision of public goods and externalities. In practice, governments allocate resources through budgetary expenditures, such as investments in infrastructure, education, and healthcare. They also use targeted subsidies or production quotas in sectors deemed strategic, such as energy, transportation, or research and development.

Command-and-control tools in this area include licensing regimes, sectoral production caps, and technical standards that either limit or mandate output. These tools ensure, for instance, that utilities provide universal service or that hazardous substances are handled according to safety protocols. In addition, market-based tools such as investment tax credits, low-interest public loans, and public-private partnership frameworks can indirectly shape resource allocation by encouraging private sector investment in socially beneficial projects.

The state's distribution function plays a crucial role in adjusting market-generated income and wealth to foster greater fairness and social unity. Through mechanisms like progressive income taxes, wealth taxes, and social insurance contributions, governments raise revenue that is channeled into social transfer programs. These programs include unemployment benefits, pensions, housing

subsidies, and targeted cash assistance for vulnerable groups. Moreover, policies such as minimum wage laws and collective bargaining systems help raise the earnings of low-wage workers, while user fees or income-based charges ensure continued access to vital public services.

The stabilization function aims to smooth out cyclical fluctuations in output, employment, and prices. Fiscal policy, through counter-cyclical adjustments in government spending and taxation, can stimulate aggregate demand during recessions or cool down an overheating economy during boom periods. Monetary policy, typically implemented by an independent central bank, influences credit conditions and inflation expectations through interest rate targets, open market operations, and reserve requirements. In terms of command-and-control measures, stabilization may also involve administrative actions, such as strategic stockpiling of commodities or temporary price controls during crises. Additionally, market-based tools like automatic stabilizers - such as unemployment insurance payments that increase when unemployment rises - provide built-in resilience to economic shocks without requiring discretionary intervention.

Governments often integrate “command-and-control” regulations, such as standards, bans, and licensing, with market instruments like taxes, subsidies, and tradable permits, along with voluntary approaches including eco-labeling and public–private partnerships [51].

Building on the classic functions above, circular-economy regulation adds two cross-cutting objectives [52] (Figure 9):

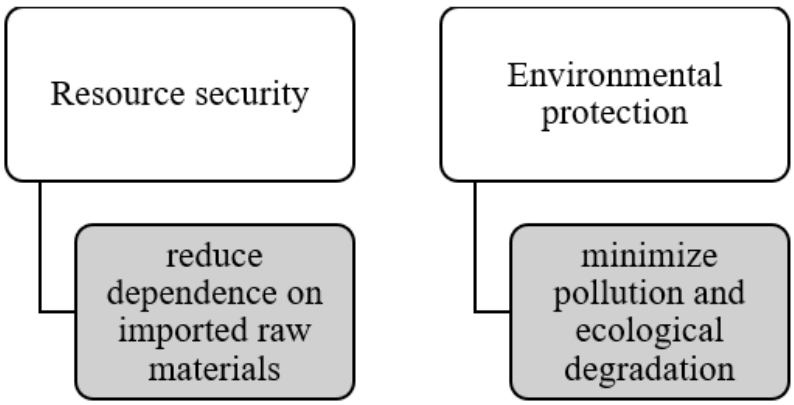


Figure 9 - Two cross-cutting objectives of the CE
*Note: adapted from [52]

These objectives translate into:

— Preventive allocation - steering investment into remanufacturing, recycling and eco-innovation.

— Equitable distribution - ensuring that benefits (jobs, cost savings) accrue across regions and income groups.

— Dynamic stabilization - promoting resilience against commodity-price shocks via closed-loop supply chains.

Below is given the instruments for circular economy regulation:

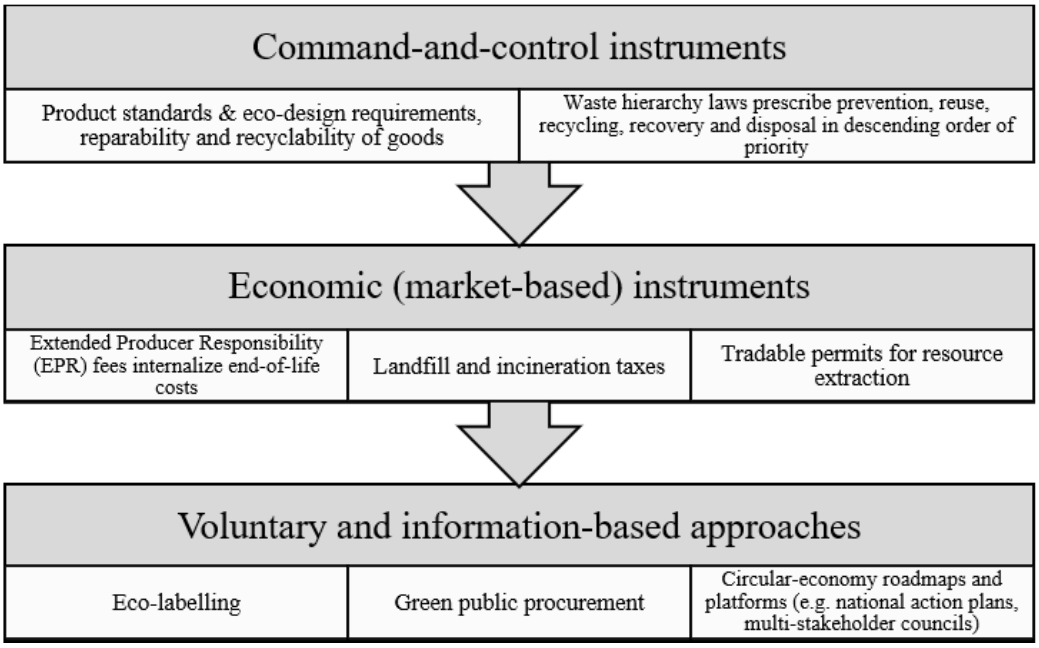


Figure 10 – Instruments for circular economy regulation
*Note: adapted from [52]

Figure 10 presents a comprehensive overview of the policy tools available to governments seeking to promote a circular economy. These tools are organized into three complementary categories:

1. Command-and-control instruments include legal mandates, technical standards, and enforceable regulations that ensure products and waste streams meet minimum environmental performance criteria. Notable examples of these instruments are eco-design requirements, which focus on the durability and recyclability of products, and waste-hierarchy laws that prioritize prevention, reuse, recycling, recovery, and disposal.

2. Market-based economic instruments adjust cost-benefit signals to incorporate the external costs associated with resource use and waste disposal. Extended Producer Responsibility (EPR) schemes require manufacturers to take responsibility for the end-of-life management of their products. Additionally, landfill and incineration taxes discourage disposal, while tradable resource permits cap raw material extraction in a flexible and cost-effective manner.

3. Voluntary and information-based approaches serve as “soft” instruments that rely on consumer choice, collaboration, and transparency. Eco-labels, such as the Nordic Swan and the EU Ecolabel, help consumers identify sustainable products. Green public procurement encourages government demand for environmentally friendly goods, while national roadmaps and multi-stakeholder platforms facilitate knowledge-sharing and the co-creation of best practices.

From this, it can be seen that these methods establish a cohesive regulatory framework: command-and-control measures ensure minimum performance standards, economic tools shape market incentives, and voluntary strategies, along with information-sharing, involve stakeholders and foster capacity for sustainable transformation.

The successful operation of a circular economy model relies on well-defined institutional arrangements (Table 9):

Table 9 – Governance of a circular economy framework

Institute	Participant	Main functions
Lead ministries	Ministries of Ecology, Industry, and Economy	Formation of strategies; Budget allocation;
Inter-ministerial council	Representatives of the Ministry of Ecology, the Ministry of Industry, and the Ministry of Agrarian Policy	Policy coordination; Goal alignment;
Regulatory agencies	Environmental protection committees, inspections, etc.	Compliance monitoring; Implementation of sanctions
Note: adapted from [52]		

As can be seen from Table 9, at the top level, designated lead ministries - typically those responsible for environment, industry, and economy - are tasked with drafting overarching policies, allocating budgets, and guiding sectoral strategies to ensure that sustainability objectives are integrated into national economic planning.

To foster collaboration and break down silos, inter-ministerial councils bring together representatives from environmental, industrial, and agricultural sectors. These councils improve consultation and collective choice-making, enabling reconciliation of possible trade-offs (e.g., resource security vs. food production) and policy consistency.

Also, it should be noted that specialized regulatory bodies, including environmental protection agencies and independent inspectors, serve as the government’s enforcement mechanism. Their duties include monitoring regulatory compliance, performing inspections, enforcing penalties for violations, and offering technical support to both public and private entities. This ensures that broad policy directives are effectively translated into real-world outcomes.

Government regulation of the agro-industrial complex (AIC) is largely motivated by the twin objectives of safeguarding food security and advancing rural development. At the same time, it is increasingly guided by circular economy principles to enhance the efficient use of resources.

To maintain a stable supply of agricultural products, governments implement both allocative and stabilization measures. These include setting minimum purchase prices and establishing border protections to shield domestic producers from volatile global markets, as well as managing strategic grain reserves to buffer against supply

shocks. Additionally, state agencies oversee land-use planning and water allocation to ensure equitable access to essential natural resources and prevent the over-exploitation of soils and aquifers.

A comprehensive toolkit of direct and indirect instruments supports this regulatory framework. Direct controls encompass the licensing of agrochemical use, quota systems for crop planting, and mandatory reporting on pesticide applications. These measures aim to protect the environment and safeguard public health. The allocation function plays a key role in channeling limited resources toward activities that yield the greatest social benefits, while also addressing the market's shortcomings in providing public goods and managing externalities. In practice, governments fulfill this function through public spending on infrastructure, education, and healthcare. They may also use targeted subsidies or set production quotas in crucial sectors like energy, transportation, and research and development.

Aligned with the principles of a circular economy, regulation further supports nutrient recycling by establishing standards for manure management and promoting techniques such as anaerobic digestion. It also encourages the recovery of organic waste through biogas production and composting. Furthermore, precision agriculture technologies - like IoT-enabled sensors and variable-rate application equipment - are encouraged. These measures are often implemented through public-private partnerships and green credit programs, which help finance eco-innovations in farms and agro-industrial clusters, thereby closing material loops and reducing dependence on imported inputs.

The theoretical foundations of regulating the agro-industrial complex in a circular economy are based on a multi-level approach that identifies macro-, meso-, and micro-levels of interaction between state and market institutions [53]. The multi-level regulation model can be seen in Figure 11:

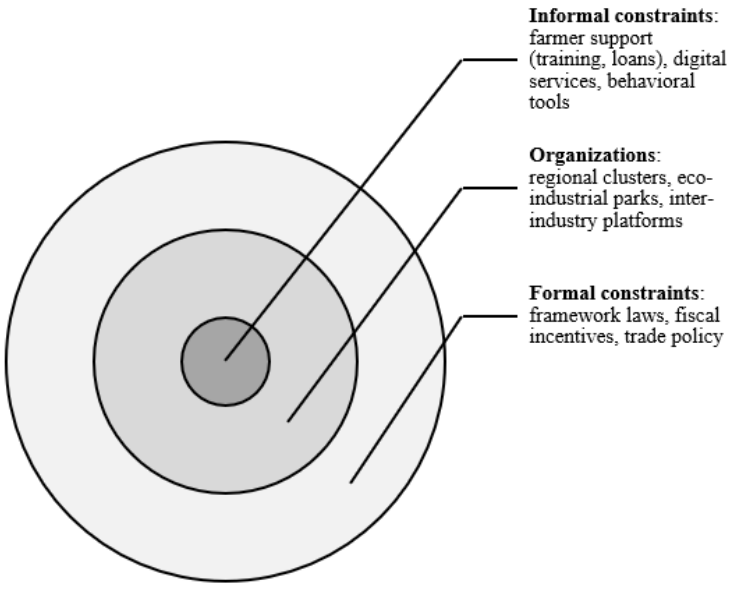


Figure 11 – Multi-level AIC regulation model
*Note: adapted from [53]

This “onion” diagram illustrates the hierarchy and interrelationships of three levels of state intervention in the agro-industrial complex during the transition to a circular economy:

1) Outer layer – “formal constraints”:

This level represents framework legislation, fiscal policies, and trade policies that establish the general rules of the game and create economic incentives for the entire industry. Here, strategic laws are adopted, taxes, subsidies, and tariffs are set, and systems of quotas and import duties are formed.

2) Middle layer – “organizations”:

This layer encompasses regional initiatives and inter-industry structures, such as eco-industrial parks, agro-clusters, and platforms for facilitating resource exchange. At this stage, projects are coordinated at the regional level or among groups of enterprises to ensure closed material and energy flows beyond individual farms.

3) Inner layer – “informal constraints”:

This level focuses on individual farmers and their farms. It includes providing training, soft loans, digital services (such as IoT solutions and resource accounting platforms), and “soft” behavioral tools (like gamification and recommendations). Here, measures to modify farming practices and improve waste management are implemented directly on the ground.

The concentric circle model illustrates how local-level actions (micro) function within broader strategic frameworks at the meso and macro levels. The success of the circular economy transition relies heavily on the alignment and coherence across all three tiers.

In summary, government regulation during the shift to a circular economy involves the coordinated use of three core functions: allocation, redistribution, and stabilization. These are implemented through both “hard” instruments, like regulatory mandates, and “soft” tools, such as market-based incentives and informational campaigns. Two overarching goals also shape this framework - securing resource availability and promoting system-wide sustainability through closed-loop supply chains.

The circular economy toolkit includes a blend of environmental standards, market-based approaches (like extended producer responsibility schemes and landfill taxes), and voluntary measures (such as eco-labeling and green public procurement). Together, these tools help shape a cohesive policy that impacts every stage of the value chain. Successful implementation requires a well-defined distribution of responsibilities among key ministries, interdepartmental councils, and specialized regulatory agencies. A tiered strategy across macro, meso, and micro levels - especially within the agro-industrial complex - is crucial to maintain

continuity and effectiveness, ensuring alignment from policymakers to individual farmers.

This tool-and-institutional combined approach forms a basis for a sustainable agro-industry sector, minimizing wastage and maximizing resource use. Finally, these programs ensure food security and overall competitiveness of the national economy in the long run.

1.3 Comparative analysis of international practices in government regulation of the circular economy

The circular economy is gaining its importance and popularity in many developed and developing countries of the world. This concept is one of the best alternatives to the existing linear economy. That is why, taking into account all the factors that affect the environment, there is an opinion that a circular economy can become the main foundation for the development of a sustainable country.

In this subchapter, countries have been identified in three income groups based on information from the World Bank (2022) [54]. Thus, the first group is high-income, the second group is upper-middle income, and the third group is lower-middle income. In each group, 7 countries were selected for further analysis, as a result, the number of countries reached 21 [55].

For the purpose of comparative analysis, the following countries have been categorized by income level:

- High income level: Germany, Japan, Sweden, Great Britain, South Korea, Estonia, and Italy.
- Upper middle-income level: China, Russia, Brazil, Mexico, Malaysia, Moldova, and Turkey.
- Lower middle-income level: Ukraine, Uzbekistan, Tajikistan, Kyrgyzstan, India, Pakistan, and Indonesia.

The content analysis explored many materials, such as strategic documents, government programs, laws, and local initiatives. The materials consisted of scientific publications, both foreign and native, analytical reports from international organizations and local authorities, expert articles in the media, and relevant government programs and regulatory frameworks, among others.

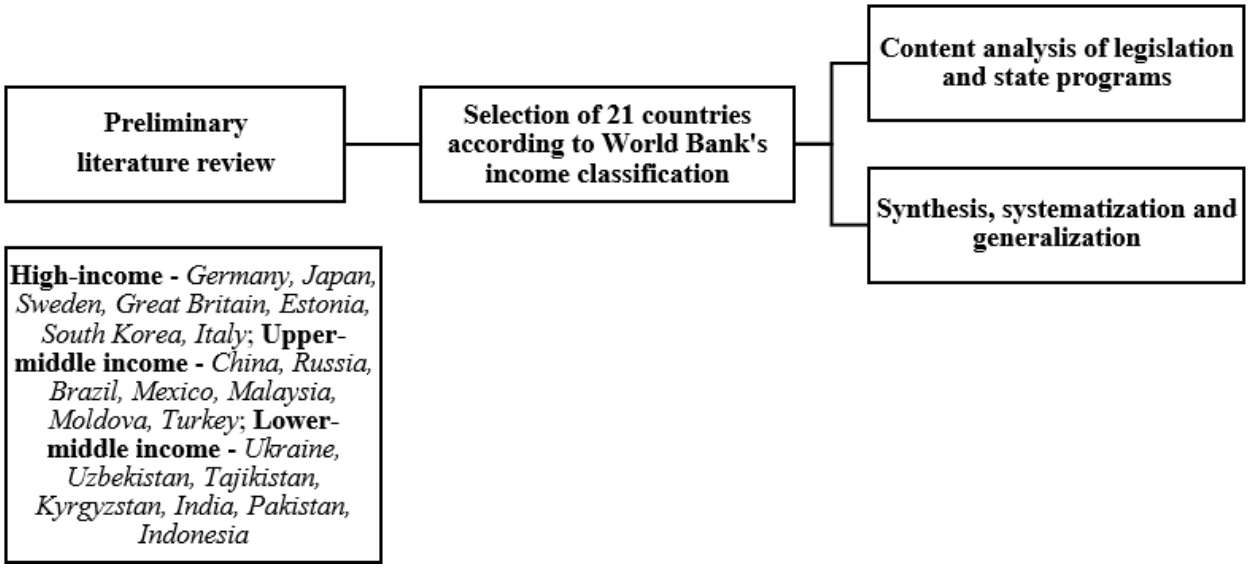


Figure 12 – Research design on the foreign experience of state regulation in the circular economy (CE).
*Note – Adapted from the [55]

After analyzing government measures to support and develop the circular economy across 21 countries (Appendix B), the following conclusions can be drawn [55]:

Development of the CE in high-income countries.

Countries with high per capita income usually implement systematic and consistent government policies focused on establishing a circular economy.

Germany is a leading country in this area, having started its waste sorting initiatives as far back as the early 1970s. This effort was bolstered at both the legislative and production levels. Today, Germany ranks among the leaders in the recycling of paper and glass, with approximately 80% of all glass and paper produced in the country being reused [55, 56].

The current state of Germany's circular economy can be more accurately described as “recycling-based waste management.” The government has implemented a program known as “The Circular Economy Act,” which primarily focuses on waste prevention, recycling, and disposal. According to a report from the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, nearly 270,000 people are employed in around 11,000 companies in this sector, generating an annual turnover of approximately 70 billion euros. Around 15,500 facilities are dedicated to improving resource efficiency through recycling and recovery processes. The high recycling rates—about 67% for municipal waste, 70% for commercial waste, and 90% for construction and demolition waste—highlight the effectiveness of these efforts.

Since 2005, waste in Germany cannot be landfilled without undergoing pre-treatment. This pre-treatment occurs in waste incinerators or mechanical-biological treatment plants. Waste must be processed in such a manner that it cannot

decompose in a landfill, and recovered materials must be separated before disposal. Additionally, the energy contained in waste must be recovered. This circular management practice not only contributes to environmental protection but also represents a return on investment. As a result, the waste management industry has evolved into a significant and powerful sector of the economy [55, 57].

Notable institutional measures implemented in Germany include:

Adopted Regulatory Legal Acts:

- Energiewende – Germany's transition to low-carbon energy
- Circular Economy Act (2012)
- Resource Efficiency Program ProgRess I (2012)
- Climate Action Program 2020 (2014)
- Resource Efficiency Program ProgRess II (2016)
- Climate Action Plan 2050 (2016)
- German Circular Economy Initiative (CEID) (2019)
- Roadmap for a Circular Economy in Germany

Economic Instruments:

- Tax on gasoline
- Tax on transportation (higher emissions result in higher taxes)
- Payment for emissions (PAYT)

Additionally, the German government has made significant investments in the development and commercialization of electric vehicles.

According to Nelles M. et al. (2016), waste hierarchy can be described as follows (see Figure 13) [58].

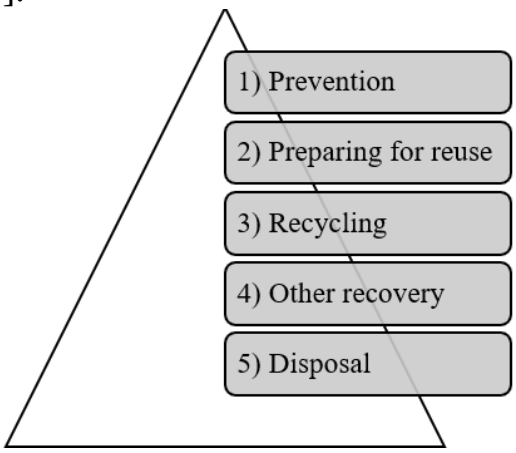


Figure 13 - Waste hierarchy (European and German Law)
*Note: Compiled by the author according to the literature [58]

In Germany, manufacturers are already implementing the circular economy concept during the production of goods to minimize waste throughout their lifecycle.

Japan is also a leader in waste management and in implementation of circular economy principles. Japan is known for its culture of caring for people and the environment. The history of legal systems for waste disposal and prevention in Japan began in the post-war period - in the 1950s. The first legal document can be considered the Public Cleansing Act (1954), the purpose of which was the management of waste for environmental sanitation. The main legal document that

regulates the entire waste management industry is the Basic Environment Act (1993). Further, this hierarchy can be drawn as follows [59]:

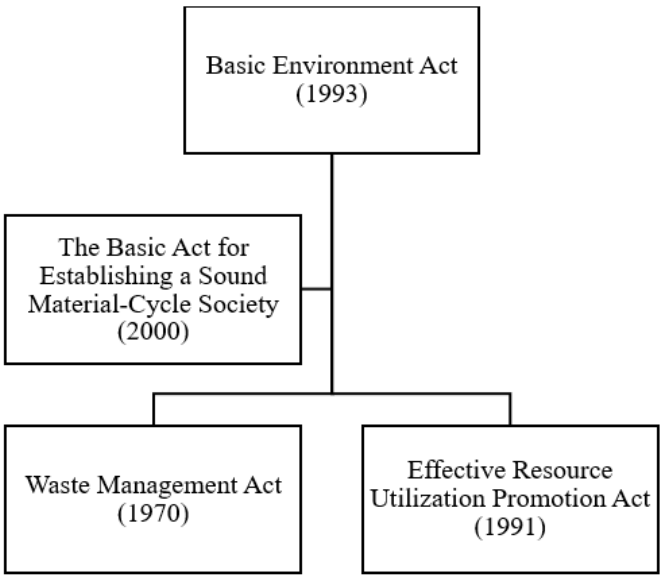


Figure 14 - Legal systems regarding waste management in Japan
*Note: compiled by the author according to the literature [59]

63% of all paper in Japan is recycled. The rest is incinerated, like most other waste. Although MSW incineration isn't considered as environmentally friendly, Japan, along with the USA, is an exception, because these countries use the most advanced recycling technology – "plasma gasification". MSW with this technology is processed by a plasma flow with a temperature of 1200ºC and higher. At this temperature, resins are not formed, and toxic waste is destroyed. From 30 tons of waste, as a result, 6 tons of ash remain, which is then cleaned and used in construction sector. At the same time, the factory not only destroys waste, but also generates electricity. As for plastic bottles, 85% of them are recycled, one of the highest rates in the world. Also, Japan targets to reach in this 100% by the year 2030.

Also, a special part of introducing the principles of the circular economy in Japan is their culture, "mottainai". It's a philosophy that means: "Don't throw away until you've fully used it." Thus, the Japanese themselves consciously try to reduce their waste as much as possible [59].

Sweden is among the leaders in low-waste initiatives. The country has adopted a national circular economy strategy aimed at creating a society where all resources are used wisely and efficiently, reducing the need for new materials. The primary focus of this strategy includes eco-design, sustainable use of products, materials, and services, toxin-free and cyclical systems, and utilizing the circular economy to promote innovation and sustainable business models among enterprises and other economic participants.

Key measures include striving for products with a long lifespan, fostering an innovative climate that enables companies to thrive within a circular economy, improving consumer information in everyday life, and creating a supportive environment for the business sector to share, repair, and reuse products.

Additionally, there is a development of policy instruments to encourage the circular economy from both supply and demand perspectives.

In 2018, approximately 26,800 tons of materials and textiles were collected for reuse. Sweden boasts 583 recycling centers, which are visited by a total of 28 million people annually. Notably, in 2018, only 0.7% of household waste was sent to landfills [60, 61].

The United Kingdom has long been a global leader in environmental preservation and protection. A landmark step was the adoption of the Climate Change Act in 2008, which legally commits the country to reducing greenhouse gas emissions by at least 80% by 2050. This objective is delivered by a series of five-year carbon budgets that cap emissions, a managed and prudent way to achieve climate ambitions. The UK approach has then set a global benchmark, influencing systems abroad like the UN Paris Agreement.

England's Resources and Waste Strategy provides a wide framework to preserve material resources by reducing waste, increasing efficiency in resources, and promoting a circular economy. It accompanies the 25-Year Environment Plan, which includes a long-term ambition to improve the environment in a generation. It centers around a set of headline goals, which are

1. Clean air delivery.
2. Clean and plentiful water supply.
3. Maintaining healthy populations of plants and animals.
4. Reducing threats from natural disasters such as floods, as well as drought.
5. Promoting more intelligent, more efficient use of natural resources.
6. Increased interaction with the natural environment.
7. Mitigation of the effects of climate change and adaptation to it.
8. Waste minimization.
9. Management of exposure to chemicals.
10. Enhancing biosafety.

The Clean Growth Strategy is an ambitious plan aimed at achieving a low-carbon future for the United Kingdom [55, 62].

Estonia has set a target to develop a document and action plan for establishing a circular economy by the end of 2021. This initiative aims to create a systematic mindset and entrepreneurial image based on a closed economy model by 2035.

The Ministry of the Environment began preparing a paper on a circular economy in 2019. It began with a situation analysis, whereby waste sectors areas were outlined and areas in which activities should take place were determined. The research "Development of a Method for Preparation of a Strategy for a Closed Economy" was conducted, resulting in an indicative monitoring system as well as principles of a circular economy.

The research involved a total of seven sectors, including construction, plastics, textiles, forestry and wood processing, food processing, services, as well as waste management. The findings of this research have been used as baseline information to prepare the document and action plan for a circular economy for Estonia. Additionally, these findings will help create conditions for implementing new measures under the EU structural funds, which promote sustainable development

and support the competitiveness of enterprises. Primarily, the analysis in the study will provide a basis for measuring, implementing, and promoting the circular economy. Several key research findings are also reflected in the strategic program Estonia 2035.

In terms of modern elements of the circular economy in the country, Estonia has introduced a tax on waste disposal, which has been incrementally increased since 2005. The current tax rate is 30 euros per ton, applied in addition to the waste collection fee. This measure has contributed to a reduction in waste generation; in 2019, total waste production amounted to 20.21 million tons, a decrease of 14.1% compared to 2018. Hazardous waste generation was recorded at 8.18 million tons, down 25.5% from the previous year, and waste disposal decreased to 7.51 million tons, which is 25.9% less than in 2018 [55, 63, 64, 65].

South Korea is a country with limited natural resources but is one of the largest energy consumers in the world. This means that many vital sectors of the economy such as autos, steel and ships are heavily reliant on imported raw materials. At present, South Korea has shifted its energy source from fossil fuel and atomic power to new renewable energy. Renewable Energy 2030 Plan The government has unveiled the Renewable Energy 2030 Plan which aims to raise renewable energy's contribution to 20% of the country's energy generation by 2030.

In conjunction with this shift in the energy paradigm, South Korea also faces an industrial transformation amid the rise of "Industry 4.0" which embodies the convergence of such cutting-edge technologies as 3D printing, autonomous driving, drones, and renewable energy.

In an effort to introduce a sustainable resource flow, South Korea enacted the FARC (Framework Act on Resource Circulation). PRIORITY The overriding aim of FARC is to reduce volumes of waste by promoting resource efficiency, recycling and disposal of waste. The goal of this method is to conserve natural resources and energy as well as not to spoil the environment and create a sustainable society. Currently, South Korea has successfully recycled nearly 60% of its municipal waste and recycles 95% of its food waste [55, 66, 67].

Italy is also one of those countries that are concerned about the environment. Nowadays, Italy has the highest percentage of total waste recycling among all European countries – almost 79.4%. The circularity rate of the Italian industry (the ratio of recycled secondary materials to the total amount of materials - raw materials and secondary - used) is about 50%.

Thus, the main legislative document regulating this issue is the Environmental Consolidated Act (Norme in materia ambientale or Codice dell'Ambiente), which consists of 6 parts:

1) "General principles of environmental protection"

2) "Environmental Impact Assessment (EIA) and Integrated Pollution Prevention and Control (lPPC) permit"

3) "Water resources management and soil protection"

4) "Waste management"

5) **"**Remediation of contaminated sites"

6) "Air protection and air emissions"

7) “Environmental damage”.

The state has sufficient and exclusive competence in the field of environmental regulation. The main national body in regulating the environmental issues is the Ministry of Ecological Transition. Other regulatory authorities, which regulate the circular economy process in Italy, are as follows: the Ministry of Health, the Ministry of Economic Development, the Ministry of Cultural and Landscape Heritage, the Interministerial Committee for Ecological Transition, and Scientific agencies with a regulatory role. Environmental norms and standards are mandatory for all participants in the country's economy, and they are also regulated by sanctions: criminal and administrative. Regulatory regime for waste is regulated through the ECA (Environmental Consolidated Act).

In Italy, there is a “liability regime”. For example, end-of-life vehicle manufacturers should accept used vehicles and used vehicle parts from vehicle repairs by organizing, directly or indirectly, individually or collectively, a network of collection centers distributed throughout the country [68, 69].

CE development trends in upper-middle-income countries.

In upper-middle-income countries, reforms aimed at transitioning to a circular economy (CE) are typically at an early stage or being implemented in a decentralized manner across various sectors.

China is one of the world's leading countries in transitioning to the principles of the circular economy. It has been actively pursuing legislative initiatives in this area since the 1980s. These initiatives have resulted in a comprehensive system of environmental legislation. A significant milestone was the adoption of the 'Law on the Promotion of the Circular Economy' in 2008. This law emphasises development plans, extended producer responsibility, management systems for key enterprises with high energy and water consumption, and circular economy metrics. Overall, China's circular economy policy incorporates command-administrative measures, tax incentives, financial incentives and price adjustments aimed at modernising industrial structures, promoting cleaner production, enhancing recycling and maximising waste utilisation [55, 70, 71].

The circular economy is primarily practised at enterprise and regional levels in China, where preferential tax and financial incentives are available. Enterprises involved in waste recycling and the efficient use of resources benefit from preferential tax rates. Price measures are also implemented to regulate energy-intensive industries.

At the regional level, eco-industrial parks encourage industrial relationships that promote industrial metabolism and symbiosis between enterprises.

China has recently experienced growth in several sectors, including solar photovoltaic manufacturing, renewable energy (excluding hydropower), transportation (with a focus on hybrid and electric vehicles), forestry and ecotourism [58].

China's goals for its circular economy by 2025 include:

- Increasing resource productivity by 20% compared to 2020 levels.
- Reducing energy and water consumption per unit of GDP by 13.5% and 16%, respectively, compared to 2020 levels.

- Utilising 86% of crop stems, 60% of solid household waste and 60% of construction waste.

- Recycling 60 million tons of waste paper and 320 million tons of steel scrap.

- producing 20 million tons of recyclable non-ferrous metals.

- Increasing the output of the recycling industry to 5 trillion yuan (approximately 773 billion US dollars).

In addition to these goals, three key objectives have been set for this period:

1. Establishing an industry-wide recycling system and enhancing resource efficiency.

2. Creating a waste recycling system and fostering a recycling-oriented society.

3. Promoting the development of a circular economy and establishing closed-loop agricultural production.

These objectives will require transformations throughout society and the economy, especially since China accounted for 30.1% of global greenhouse gas emissions in 2019. However, China has significant potential to address its environmental challenges by transitioning to a circular economy [72, 73].

The transition to a circular economy in ***Russia*** began recently. In 2018, the Ministry of Industry and Trade published the "Strategy for the Development of Industry for the Processing, Utilisation and Disposal of Industrial and Consumer Waste up to 2030? [55, 74].

This strategy sets out the key principles of a circular economy, such as waste recycling and reuse, and reducing or preventing waste generation. A key aspect of the strategy is the establishment of ecological technology parks that adhere to these principles, encouraging the efficient use of resources and the recycling of products made from secondary raw materials.

According to the Federal Service for Supervision of Natural Resources (Rosprirodnadzor), approximately 5–7 billion tons of waste are generated in Russia each year. In 2018, the largest proportion of this waste (66%) was associated with the extraction of fuel and energy minerals, primarily from coal enterprises. Furthermore, 22.6% was associated with the extraction of metal ores, 1.9% with metallurgy, 0.6% with the chemical industry and 8.9% with other sectors, including housing and utilities. Solid domestic waste (MSW) accounted for just 1–2% of the total, with over 90% of waste in Russia being disposed of in landfills [75].

Currently, more than 80% of waste processing plants in Russia are operational. However, they are only operating at 30–40% capacity due to a lack of raw materials. The level of waste recycling remains low, at just 5–7%. The national project 'Ecology', which was launched in Russia in 2019, aims to improve this situation. As part of this initiative, plans have been made to build 200 waste processing plants across the country by 2024. A separate waste collection system will also need to be established to supply these facilities with raw materials.

The strategy outlines the fundamental principles of a circular economy, including waste recycling and reuse, as well as reducing or preventing waste generation. A key aspect of the strategy is the creation of ecological technology parks that adhere to these principles and promote the efficient use of resources.

Russian legislation predominantly focuses on waste disposal methods, particularly storage, and often includes general provisions for recycling. Consequently, Russia's transition to a circular economy is closely linked to waste disposal, as this issue has become increasingly critical, particularly in large cities, over the past 30 years [55, 76].

In 2011, it was noted that ***Mexico*** was far from achieving a circular economy (CE). The transition to a circular economy would require significant changes not only in recycling and waste reuse but also in production, consumption, and the institutional systems that govern these processes. This includes changes in legislation, education, knowledge transfer, environmental awareness, and entrepreneurial culture [55, 78].

One major concern is the generation of waste, which has surpassed 44 million tons annually and is projected to reach 65 million tons by 2030. Each year, Mexico produces approximately 8 million tons of plastic waste, 32% of which is recyclable. For certain types of plastic, this figure is as high as 56%.

Although Mexico has established a National Program for the Prevention and Integrated Management of Waste, aimed at increasing the value of waste and minimizing environmental impacts - particularly on human health - the country only introduced the concept paper “National Vision for Sustainable Management: Zero Waste” in January 2019. This document serves as a roadmap for transitioning towards a circular economy and outlines six guiding principles:

1. Sustainable development
2. Circular economy
3. Commitment to anti-corruption and transparency in public administration
4. Support for vulnerable populations and social justice
5. Reducing risks and impacts on health and the environment
6. Enhancing social security and reducing inequality

Additionally, there is a trend in Mexico where large corporations are participating in the development of a circular economy by implementing standards that align with those of developed countries and integrating these efforts with the United Nations Sustainable Development Goals (SDGs) [77].

Although ***Brazil's*** public policy on the circular economy is still in its early stages, various elements of the CE concept have been integrated into different laws, plans, programmes and projects. For example, the National Solid Waste Policy emphasises the responsibility of waste producers, including those along the entire supply chain: producers, importers, distributors, and retailers. The policy establishes the principle of shared responsibility for products after consumption. Each stakeholder is responsible for ensuring the proper disposal of products and facilitating their reuse or recycling [55, 78].

Furthermore, the National Policy defines a waste hierarchy that prioritizes waste management strategies. This hierarchy includes: the elimination of waste generation, reduction, reuse, recycling, solid waste treatment, and finally, environmentally sound waste disposal. As a result, landfilling is considered the last and least desirable option.

In Brazil, circular economy opportunities are particularly prominent in the construction sector, which represents 7% of the GDP and 9% of the labor market. More than half of the waste sent to landfills in Brazilian cities originates from demolition and construction activities.

Additionally, the steel industry is effectively implementing circular economy practices. Products in this sector can be reused, recovered, and recycled without any loss of performance. Items such as cars, refrigerators, fittings, and other steel products are collected at the end of their service life and returned to steel mills for the production of high-quality steel [79].

Currently, only about 50% of PET bottle material is recycled after use, with around 17% either improperly disposed of - thrown away or openly burned. This reflects an uneven adoption of circular production practices across different sectors and industries in Brazil [80].

The circular economic model in ***Malaysia*** is in its infancy, although steps have been taken to promote it. In particular, Malaysia has developed a National Plan for Sustainable Consumption and Production for the period from 2016 to 2030. According to the plan, all types of waste will be managed in an integrated manner using a life cycle approach, rather than through disposal [55, 81].

The recycling rate in Malaysia was 28.1 % in 2019 and is projected to reach 40 % in 2025. In addition to recycling consumer and household waste, the focus is also on encouraging firms to reduce industrial waste generated from manufacturing activities. In order to limit waste generation, the government provides targeted incentives to companies whose activities are aimed at sustainable use of the environment, in particular the processing of toxic and non-toxic waste, chemicals and recycled rubber. These companies can be exempted from income tax of 70 % for 5 years. Also, companies can receive a tax deduction of 60 % of capital expenditures incurred over 5 years.

Nowadays, recycling facilities are scattered across the country, which geographically limits the ability to recover valuable waste and components that can be recycled. To solve this problem, an initiative (Waste Eco Park (WEP)) was developed to bring together recycling companies from different industries in one place. Due to these initiatives, it is possible to form a circular approach to waste management in order to achieve zero waste generation [82].

Turkey, which is famous for its developed tourism, is at the stage of implementing environmentally friendly policies and programs. However, the amount of household waste buried in landfills reaches 87%. Increasing the recycling of household waste is one of the priority goals. Thus, to combat this, Turkey is in the process of implementing several projects to reduce plastic waste pollution and increase recovery rates. In terms of industrial waste, the disposal of hazardous industrial waste has increased by 68% and the disposal of non-hazardous industrial waste has increased by 30% over the past few years. The main elements of environmental legislation are:

- Environment Law (1983),
- Mines Law,
- Forest Law,

- Environmental Impact Assessment regulation,
- Environmental Permits and Licences regulation,
- Waste management regulation,
- Control of Pollution Caused by Dangerous Substances in Aquatic Environment,
- Assessment and Management of Environmental Noise,
- Control of Soil Contamination and Point Source Pollution,
- Control of Industrial Air Pollution,
- Control of Water Pollution,
- Radioactive Waste Management,
- Control of Air Pollution [83].

The relevant law regulates waste management in the country. For example, waste generators that produce more than 1,000 kg of hazardous waste per month are required to obtain a temporary storage permit from the Ministry of Environment and Urbanization. This permit is issued for an indefinite period. CE development trends in lower-middle-income countries.

Like many other countries in this group, the ***Republic of Moldova's*** well-being largely depends on the use of its natural resources. However, the exploitation of these resources exceeds the environment's ability to restore them. This is why transitioning to a circular; renewable economy is essential for this country. Environmental legislation focuses on distributing functions and tasks among different organizations. These organizations' structures are defined by their functions (areas of responsibility, tasks, etc.). However, definitions of key terms are not always included in laws, so these definitions vary in accuracy. Typically, the procedural element is weak or nonexistent. In some cases, standards and laws are included in regulations or normative documents, but this is not always the case in practice. The lack of procedural clarity and definitions makes implementing the transition to a circular economy difficult. Regarding respect for the environment, the following laws apply in Moldova:

- Law on Protected Areas, 1998
- Law on Taxes on Environmental Pollution, 1998
- Law on Natural Resources, 1997
- Law on Hazardous Substances and Product Management, 1997
- Law on Air Protection, 1997
- Law on Waste, 1997
- Law on the Protection of Fauna, 1995.
- Law on Sanitary-Epidemiological Protection of the Population, 1993.

Currently, Moldova has environmentally related product taxes, including excise and environmental taxes. Most countries that have successfully implemented environmental taxes on goods have done so through coordination between the Ministry of Environment and the Ministry of Finance. Effective policy reform in this area in Moldova must begin with creating an institutional mechanism for this critical coordination and extending it to other key stakeholders [55, 84, 85].

In countries with low per capita income, the adoption of circular economy (CE) principles is either in its early stages or nonexistent. Additionally, there is a lack of

funding and limited awareness of CE among the population in these nations. As per capita income rises, there tends to be an increase in institutional involvement from the government in the shift towards CE principles.

CE development trends in lower-middle-income countries.

Currently, ***Ukraine*** is implementing the second stage of the National Waste Management Strategy. The first phase began in 2017-2018, the second phase covers 2019-2023, and the third and final phase is planned for 2024-2030.

This strategy aims to recycle at least 15% of waste by 2023 by introducing waste sorting lines and launching appropriate plants. The plan also aims to increase the percentage of the population that deliberately collects household waste to at least 23%. By 2030, these indicators are expected to increase to 50%. To consistently implement the planned measures, 250-300 new centers for the reception and collection of waste must be built, as well as 90 waste sorting lines. The number of landfills intended for garbage and waste disposal should be reduced from 5,000 to 100–150. These will reportedly be modern facilities that meet all safety rules and EU standards. Currently, most waste in Ukraine is disposed of in controlled landfills.

As in many countries at this level, there are problems associated with waste collection, particularly plastic waste. The problem lies with people's attitudes — people simply do not want to sort garbage, so recycling companies often have to buy garbage from neighboring countries for millions of dollars. Clearly, population awareness plays an important role in forming a circular economy [86].

According to experts, Ukraine's transition to the CE will be long and difficult. Despite the existence of programs and laws, this process is still accompanied by an absence of a unified system and tools that would allow for the creation of effective management methods. There is also a lack of financial support for the necessary measures. Enterprises without sufficient financial resources to reorganize and modernize production are waiting for potential sources of funding [87].

In **Uzbekistan**, national solid waste management programs are not equipped to handle the current waste situation. Outside the capital, SWM programs are limited to the removal of solid waste to inappropriate landfills where it remains. In regions and villages, solid waste management is almost completely absent. According to statistics, the efficiency of solid waste collection in rural areas is less than 50%. In Uzbekistan's cities, recycling is in its infancy, and its efficiency is unofficially estimated at less than 10%. In rural areas, processing is practically nonexistent.

In the future, the “Innovative Uzbekistan” project is set to be implemented with the aim of enabling civil society organizations to promote their proposals for cost-effective management methods in Uzbekistan. The project is designed to achieve several important objectives:

- Seeks to raise the standard of living for the population, including residents in remote areas of the country.

- Aims to strengthen collaboration between local authorities and civil society organizations, encouraging joint initiatives to protect the environment and improve regional economic conditions.

- It will also build the capacity of civil society and environmental groups by providing professional training, sharing international best practices, and fostering innovation in sustainable production and circular economy practices [55, 88].

Tajikistan has maintained a system of environmental quality standards since Soviet times. The following laws, programs, and documents are aimed at developing a circular economy:

• Law No. 44 "On Production and Consumption Waste," 2002.

• Law No. 1002 "On Radioactive Waste Management," 2013

• Law No. 705, "On Environmental Information," 2011

• Law No. 760 "On Environmental Protection," 2011

• "Concept of Environmental Protection in the Republic of Tajikistan," approved by the Government of the Republic of Tajikistan on December 31, 2008 (No. 645).

• The National Concept for the Rehabilitation of Uranium Ore Processing Waste for 2014–2024.

• The National Development Strategy of the Republic of Tajikistan for the period up to 2030 (2016).

• Tajikistan joined the "Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, 1989" in 2016.

The 2008 Dushanbe Solid Waste Management Project is also worth mentioning. The project aimed to help the city of Dushanbe rehabilitate the existing landfill and collection points and supply new equipment for the landfill, as well as new cash collection equipment and containers. Other goals included helping the city reorganize and improve the collection and disposal of solid waste in Dushanbe. There are no official statistics on waste management in Tajikistan [55, 89, 90].

The ***Kyrgyz Republic*** has made insufficient progress in transitioning to a circular economy. The amount of waste in this country increases every year. This is evidenced by official statistics from the United Nations Development Program (UNDP) and other sources. Household waste in the Kyrgyz Republic increases by approximately 20% annually. Although there are various programs to address these problems, these initiatives are not regulated enough and remain only on paper. None of the existing landfills comply with international environmental and human safety standards [55, 86, 91, 92].

To this day, ***India's*** population accounts for 18% of the world's population, and its percentage of global waste fluctuates around 12%. Due to India's growing population, forecasts predict a corresponding increase in waste. India's waste management facilities are under-equipped and ineffective. According to experts, this can lead to global and domestic problems, which makes the transition to a circular economy (CE) a necessary strategy for India.

India's Ministry of Environment and Forests has begun implementing a waste management system to improve management in this area and digitize the economy. As of June 2021, the United Nations Development Program's (UNDP) Plastic Waste Management Program in India had helped recycle 83,900 metric tons of plastic waste. The goal is to recycle 85,000 metric tons of plastic waste and reach over 50 cities by 2024 [55, 93].

Additionally, experts recommend paying attention to the construction sector, which generates over 8% of India's GDP and is expected to grow to meet the demand for new housing. The circular economy criteria applied to buildings under construction can obviously help create sustainable cities and enable the reuse of building components at the end of a building's life [55, 94, 95].

In accordance with the 1972 Stockholm Declaration, ***Pakistan*** first established a Federal Ministry of the Environment in 1975. The ministry was responsible for enacting the Pakistan Environmental Protection Ordinance in 1983. This was the country's first comprehensive environmental law. Pakistan has a legal framework that regulates ecological protection:

- National Environmental Quality Standards,

Environmental Samples Rules,

- the Provincial Sustainable Development Fund Board;
- Pollution Charge for Industry.

National Environmental Quality Standards

- Environmental Samples Rules
- Provincial Sustainable Development Fund Board
- Pollution Charge for Industry
- Pakistan Environmental Protection Agency

Pakistan Environmental Protection Agency

National Biosafety Rules

Hospital Waste Management Rules, etc. [55, 96].

Pakistan generates approximately 49.6 million tons of solid waste annually, increasing by more than 2.4 percent annually. Like other developing countries, Pakistan has problems such as a lack of waste management infrastructure, which creates serious environmental issues. Much of the household waste is incinerated, dumped, or buried in vacant lots, which threatens the health and well-being of the general population [55, 97].

Indonesia's current situation on waste management is not good. Because, almost all common waste management methods are just dumping and burning in open spaces, which is very harmful for the environment. However, government tries to solve this problem by investigating the root causes of waste management challenges. For example, by planning to shift to a circular plastic system, in partnership with Norwegian Ministry of Foreign Affairs. For now, legal framework related to the environment are as follows:

- Environmental Law, 2009
- Omnibus Law, 2020

The Environmental Law focuses mostly on a general requirement that the government is responsible for creating and implementing an environment protection and management plan, in which climate change is considered as an indicator. But in reality, this document has not yet been issued. However, there are some environmental taxes in Indonesia, which applies to any party whose business extract natural resources: ground water, non-metal minerals, motor vehicle fuel, motor vehicles, surface water, etc. [55, 98, 99].

The following lessons can guide developing and least developed countries in creating effective state support policies for the circular economy:

1. Implement initiatives that provide financing for companies and offer loans and other incentives to both governmental and non-governmental organizations to encourage a more circular approach.

2. Enhance public awareness and knowledge about the circular economy.

3. Establish a national strategy for the circular economy.

4. Harness the rapid uptake of modern technologies to drive the dynamic growth of the circular economy (CE), particularly in countries where governments are committed to offering stable institutional support and actively implementing CE principles. Market-based incentives should be prioritized for economic actors leading the transition in this context.

As the circular economy becomes increasingly recognized as a key solution to mounting resource and environmental pressures, many nations are intensifying their efforts to embed its principles into policy and practice. For example, the Chinese government views the circular economy as a central strategy for achieving sustainable development. This integrated approach connects the use of natural resources, investment strategies, scientific and technological innovation, and institutional reform, each contributing to the enhancement of both current and future capacity to fulfill human needs and ambitions.

Various non-governmental initiatives and organizations, including the Ellen MacArthur Foundation, the Dutch Circle, and the European Union's Horizon 2020 research program, are actively contributing to the development of the circular economy concept. This indicates that the success of transitioning from a linear economic model to a circular one depends on state-level efforts, which may include legislative initiatives, as well as on initiatives by companies to develop and implement circular business models. The state support policy for the circular economy should establish a favorable legal and regulatory framework to promote its development. Currently, the implementation of such governmental policies varies among countries due to different factors.

To sum up, this subchapter categorizes countries into three income groups and highlights successful government tools and innovative initiatives at the national level. The aim of presenting these experiences is to gather and classify current practices from various participating countries in order to identify shared patterns that can inform future research. Also, this study emphasizes the urgent need for knowledge support for policymakers and underlines the importance of documenting and sharing successful practices. The distribution of such materials is of great importance to stakeholders from developing countries, because it allows them to construct practical and effective strategies for adopting circular-economy business models - providing not only frameworks, but integrated instruments for practical application [55].

1.4 Methodological approaches to assessing and measuring the development of the circular economy

The circular economy (CE) is an economic model of development that aims to reduce consumption and waste. CE does not use resources in a linear fashion but seeks to reuse, repair, and recycle them.

A measure of progress in achieving the circular economy is important for governments, firms and others. It enables to monitor the implementation of CE as well as where it needs to develop further. There are a number of different approaches to measuring the circular economy. Some focus on quantitative indicators, such as the amount of waste recycled or reused, or the share of renewable materials in production. Other approaches focus on qualitative indicators, such as innovation in CE or consumer readiness to adopt it.

Thus, the examination of international experience and methodological approaches to assessing the circular economy has revealed that research needs to be conducted at macro, meso, and micro levels for a comprehensive evaluation. It is also worth noting that the selected methodological approaches should be adapted to the conditions of Kazakhstan to ensure a thorough investigation.

The main stages of research and the methodological approaches to assess and measure the development of the circular economy can be presented in the following sequence:

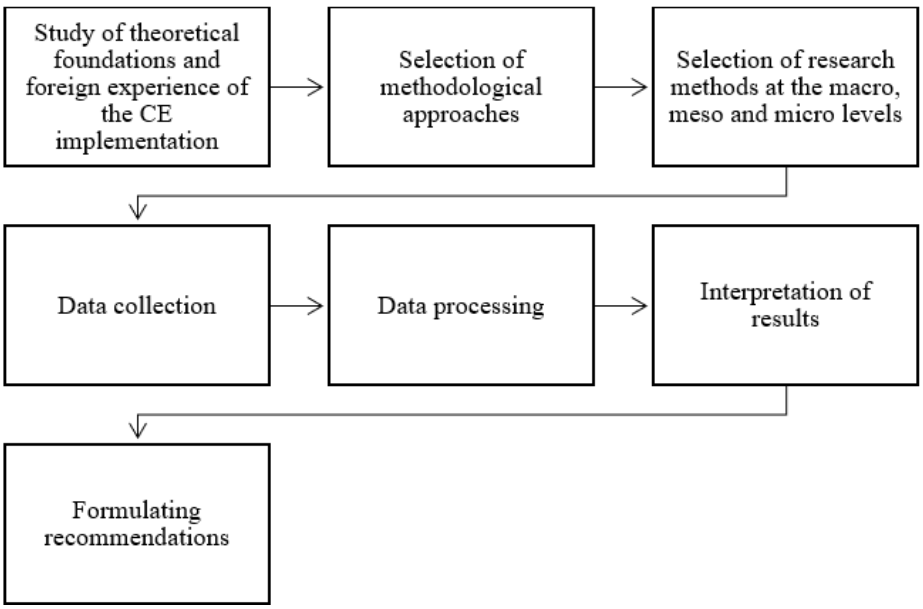


Figure 15 – Stages of the research
*Note: compiled by the author

The first stage involves a deep review of existing theories, models, and concepts of the circular economy and a study of international practice in assessing and measuring circular practices. Within the framework of this stage, the leading indicators and methodologies used in global scientific practice to evaluate the effectiveness of the transition to a circular economy are analyzed and given in Table 9.

Table 10 - Classification of circular economy analysis levels

Level	Description	Methods	Key authors and research papers
Macro	Macro-level research on the circular economy focuses on the influence of government policies, international initiatives and macroeconomic factors on the implementation of circular principles in the economy of a country.	Circular economy index Macroeconomic indicators Analysis of public policies and programs, etc	Ghisellini et al. (2016) [100], Kirchherr et al. (2018) [101] Ellen MacArthur Foundation (2015) [102]
Meso	At the meso level, the circular economy is examined through the prism of industries and regions, with an analysis of the sustainability and effectiveness of the application of circular practices within individual sectors and territorial clusters.	Closed-loop or circular cycles in production Circular Economy Index (CEI) for industries Circular Economy Performance Index (CEPI) Eco-Innovation Index, etc.	Geissdoerfer et al. (2017) [103] Bocken et al. (2016) [104] Murray et al. (2017) [105]
Micro	Evaluation of circular business models and practices at the level of companies, products, and individuals.	Material Circularity Indicator (MCI) Environmental impact (carbon footprint, energy consumption) Product Life Cycle Assessment (LCA) Social Impact Indicators (SII), Population-based assessment, etc.	Ellen MacArthur Foundation (2015) [106] The Carbon Trust: carbon footprint [107] ISO 14040:2006 - Life Cycle Assessment [108] Bocken et al. (2023) [109]
Note - Compiled by the author			

The Table 10 presents a classification of the levels of circular economy analysis: macro, meso, and micro. At the macro level, the influence of government policies, international initiatives, and macroeconomic factors on the implementation of circularity principles is studied. The meso level includes an assessment of industries, territorial clusters, and regions in terms of sustainability and efficiency of circular practices. The micro level covers the analysis of business models, products, and the behavior of individual consumers.

Methods for assessing the formation and development of a circular economy vary depending on the level under study – macro-, meso- and micro-levels. A detailed methodology for the CE assessment is shown in the following Figure 16:

A methodological approach to assessing the development of a circular economy	Macro level (nation, country)	Statistics, policies, available opensource data, national reports and other secondary data for a comprehensive assessment of CE development at the country level	Data sources: Bureau of National Statistics of the Republic of Kazakhstan, Eurostat, World Bank, and other databases Processing methods: descriptive statistics, correlation analysis, regression analysis, content analysis
	Meso level (branch of the economy)	Analysis of the current situation in the agro-industrial complex industry and prospects	Expert surveys to assess stakeholders' readiness level for the transition to the CE. Processing methods: content analysis, AHP, Atlas Ti. Expert interviews to identify barriers and opportunities for implementing a circular economy. Processing methods: content analysis SWOT analysis
	Micro level (product, company, individual)	Surveying the population to study environmental awareness and consumer behavior	A survey of the population of Kazakhstan aged 18 to 65 years Processing methods: descriptive analysis, univariate and multivariate analysis using SPSS 25 software

Figure 16 - A methodological approach to assessing the development of a circular economy at various levels
*Note: Compiled by the author

Evaluating the development of the circular economy necessitates the use of various research methods tailored to different levels of analysis. The methodological tools employed should be adapted to the specific nature of macroeconomic processes, industry characteristics, and the behaviors of individual economic entities. For Kazakhstan, a methodology for assessing circular economy development can be approached through three levels:

Macro-level analysis. At the macro level — such as at the country or regional scale — it is advisable to utilize statistical methods for analyzing both official and international data to identify overarching trends in the development of the circular economy. The most effective methods for evaluating circular economy progress include econometric techniques, the use of composite indices, such as the Circular Economy Index, if available for the country, and a detailed review of the regulatory framework. These tools help measure the influence of public policies on promoting circular practices. For processing and analyzing quantitative data, software like STATA or SPSS is recommended.

In the context of Kazakhstan, analyzing government support for the circular economy should begin with an assessment of the country's overall state of circular practices. This includes examining key macroeconomic indicators such as GDP, industrial production, resource consumption, and waste generation. Data can be sourced from national statistics, international databases, government publications, and related resources.

The analysis can involve several methods:

1. Descriptive statistics – to provide a general overview of the circular economy landscape in Kazakhstan.
2. Correlation analysis – to explore relationships between macroeconomic indicators and circular economy metrics.
3. Regression analysis – to evaluate how macroeconomic variables influence the development of the circular economy.
4. Content analysis – to review official texts and policy documents that reflect state efforts in supporting circular economy initiatives.

Meso-level analysis. At the meso level, which encompasses industries, industrial clusters, and regions, the most effective assessment tools include expert surveys and in-depth interviews. These qualitative approaches offer detailed, well-informed insights into the current status of circular economy practices within specific sectors. Additionally, SWOT analysis is helpful in identifying key barriers and opportunities related to circular transformation in various industrial contexts.

Micro-level analysis. At the micro level, focusing on individual companies, products, and consumers, consumer surveys and questionnaires are recommended to evaluate environmental awareness, behaviors, and the public’s willingness to engage with circular economy models. This level of analysis also provides a way to study the effects of government support for circular initiatives on households, employment, and individual behavior. Key focus areas include assessing public

understanding of circular economy principles, the extent of citizen and household participation, and the real-world impact of circular practices on daily life. To collect this information, large-scale sociological surveys and interviews are advised. For data analysis, descriptive statistics as well as single-factor and multifactor analysis methods within the SPSS software environment are highly effective.

To conclude, Chapter 1 looked at the theoretical and methodological foundations of the circular economy as a promising alternative to the linear economy. This chapter also laid out the development of the idea, from discourses on sustainability to a strong paradigm for greater efficiency around resources and waste and regeneration of the environment. The original “reduce, reuse, recycle” motto has transformed and been referred to the “9R” framework, capturing the diverse and complex dimensions of circular economy logistics.

A brief history of the circular economy, as well as important milestones and initiatives at the global level, was also presented, outlining the role of actors such as the Ellen MacArthur Foundation and the European Commission in the recent promotion of circularity. It was soon understood that the successful application of the circular economy required alignment at the macro, meso, and micro levels and strong regulation, technology, and stakeholders. The conclusions drawn in this chapter provide a good point of departure for the continued exploration of state regulation and how circular economy ideas are enacted in the subsequent chapters.

2 ANALYSIS OF THE CURRENT STATE AND ASSESSMENT OF CIRCULAR ECONOMY DEVELOPMENT IN THE REPUBLIC OF KAZAKHSTAN

2.1. Analysis of the legal framework for the development of a circular economy in the Republic of Kazakhstan

The second chapter of the dissertation explores the current state of the circular economy regulatory system in the Republic of Kazakhstan. As environmental well-being and safety have emerged as global priorities, Kazakhstan has also identified these issues as central to its national development strategy. Kazakhstan's environmental protection policies have been developed and are continuously adapted to address new needs and challenges. The country's environmental legislation establishes the purpose and execution of these policies at the state level through regulatory legal acts that define Kazakhstan's environmental policy. This legislation regulates the use of natural resources, promoting their rational use, restoration, and compliance with established norms and standards in a comprehensive manner. It also clarifies the rights and obligations of individuals and organizations regarding natural resources, outlining who is permitted to perform certain actions and who is not. Ultimately, the goal of Kazakhstan's environmental laws is to ensure the health and safety of its citizens. Additionally, ecological protection laws have been developed and are evolving over time.

Environmental legislation in the independent Republic of Kazakhstan is rooted in the Declaration of State Sovereignty of the Kazakh SSR and the Law on State Independence of the Republic of Kazakhstan. These foundational documents clearly establish the right of the people of Kazakhstan to utilize natural resources. According to A.K. Dzhangabulova, the development of environmental legislation has progressed through three distinct stages (Figure 17) [110, 111]:

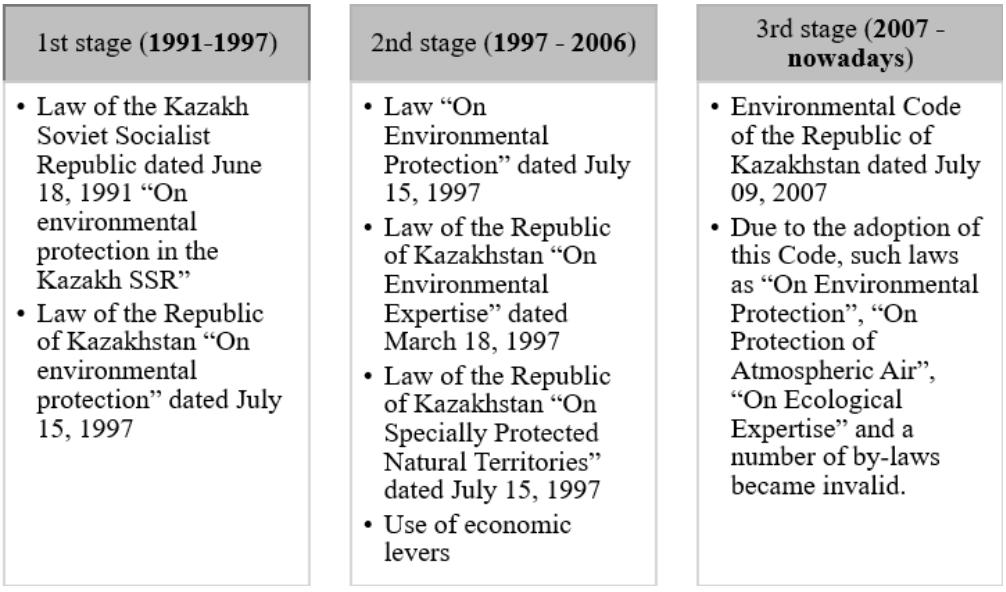


Figure 17 - Stages of the environmental legislation
*Note: Compiled by the author according to the [110, 111]

The first stage pertains to the attainment of independence by the Republic of Kazakhstan. Following the collapse of the USSR, state-owned enterprises predominantly operated within the country. Consequently, the legislation was primarily focused on the relationship between the government and these enterprises, which were heavily reliant on state authority.

The start of environmental legislation in Kazakhstan can be traced back to the law passed by the Kazakh SSR on June 18, 1991, titled “On Environmental Protection in the Kazakh SSR.” This initial law was eventually replaced by the Law of the Republic of Kazakhstan, “On Environmental Protection in the Republic of Kazakhstan,” which was enacted on July 15, 1997.

Article 1 of the 1991 Law sets forth the basic goals of environmental protection laws:

— Public relations are regulated in order to safeguard the natural environment and provide a healthy habitat for humans. It is also concerned with the reasonable use, reproduction and long-term preservation of natural resources of the republic. Part of this endeavor is a remediation of the natural environment and a disallowing of negative effects through economic and other activities.

— Protecting the interests and or rights of citizens, businesses, institutions and organizations involved in this type of relations.

— Establishing a sense of accountability for breaches of environmental law.

— Protecting biodiversity, ecosystems, and landscapes and natural features, and sites of natural significance and the cultural heritage with which they are associated.

— Strengthening the rule of law and regulating order in this space of relations.

The environmental protection law established essential principles for regulating and safeguarding nature. However, it was broad in scope and lacked specific details. To address existing gaps in resource management, several legislative acts were enacted to regulate the use and protection of specific natural resources. Notably, in 1992, key laws were passed, including the Code “On the Subsoil and Processing of Mineral Raw Materials,” as well as laws related to the “Social Protection of Citizens Affected by Nuclear Tests at the Semipalatinsk Test Site” and “Social Protection of Citizens Affected by an Environmental Disaster in the Aral Sea Region.”

In 1993, the Forest Code, the Water Code, and the Law of the Republic of Kazakhstan "On the Protection, Reproduction, and Use of Wildlife" were adopted. This was followed in 1994 by the Law of the Republic of Kazakhstan "On the Sanitary and Epidemiological Well-Being of the Population," the Law "On Oil" (dated June 28, 1995), and the Law "On Subsoil and Subsoil Use" (dated January 27, 1996).

However, the environmental legislation from this initial stage quickly lost its effectiveness in ensuring environmental well-being. This period, which lasted only five years, was marked by Kazakhstan's entry into the world market economy, which

necessitated the development of production in both the public and private sectors. This development required increased use of natural resources for export and import, prompting a shift in legislation as the existing framework was insufficient to regulate market relations.

In summary, the first stage of environmental legislation laid the foundation for future developments, but it quickly became apparent that more targeted and adaptable regulations were needed to address the evolving market dynamics. It can be seen in Table 11:

Table 11 – Timeline of legislative creation

Title of the law	**Year**
Law of the Kazakh SSR dated "On environmental protection in the Kazakh SSR"	1991
Code "On the Subsoil and Processing of Mineral Raw Materials",	1992
"On the Social Protection of Citizens Affected by Nuclear Tests at the Semipalatinsk Test Site"	1992
"On the Social Protection of Citizens Affected by an Environmental Disaster in the Aral Sea Region"	1992
The Forest Code	1993
The Water Code	1993
The Law of the Republic of Kazakhstan "On the Protection, Reproduction and Use of the Wildlife"	1993
The Law of the Republic of Kazakhstan "On the sanitary and epidemiological well-being of the population"	1994
The Law "On Oil"	1995
The Law "On Subsoil and Subsoil Use"	1996
The Law "On environmental protection in the Republic of Kazakhstan"	1997
Note* - compiled by the Author according to the [110, 111]	

In the second stage of development, the growth of market relations and the formation of corresponding organizational and economic structures revealed gaps and shortcomings in existing legislation since 1991. This raised concerns about the need for adequate legislative support. Simultaneously, there was also a significant rise in the environmental depredation or crisis in the country, that prompted the need for new rules in environmental protection law.

During this second stage, the Republic's environmental law aimed to address legal gaps and inconsistencies, ultimately creating a comprehensive system of environmental legislation. One key piece is the "Law on Environmental Protection," which was enacted on July 15, 1997.

According to paragraph one of Article 2 of this law, the objectives of environmental protection legislation are to manage society's relationship with nature, improve environmental quality, and promote the rational use and renewal of natural resources. This law establishes the legal, economic, and social foundations necessary for environmental protection, thereby ensuring ecological security for both present and future generations. It seeks to mitigate the negative impacts of economic development on the environment, maintain biological diversity, and encourage responsible stewardship of natural resources.

The law defines the rights and responsibilities of citizens and public organizations in protecting the environment. Additionally, it outlines the powers and duties of local and state governments regarding the management of natural resources and environmental issues.

For effective environmental management, the law specifies essential conditions, including the establishment of boundaries and quotas, resource use licensing, state oversight, and structured approaches to integrated management, utilization, and protection of natural resources. It emphasizes the need for a registry and accounting system for natural resources as part of the state's legal framework for ecological management.

Moreover, the law introduces economic measures aimed at environmental protection and establishes norms and certifications in this area. It also outlines provisions for land use and the exploitation of natural resources for economic activities, mandates environmental impact assessments, and designates areas for ecological, scientific, and other purposes.

In addition to the legislative Environmental Protection in 1997, the "On Ecological Expertise" and "On Specially Protected Natural Territories" were also passed 1997 on March 18 and July 15, respectively. These took existing laws and supplemented them with more specific provisions to allow for the protection of natural resources of a targeted nature.

Interestingly, also during this time, Kazakhstan's former President's attention to the importance of "continuing to strengthen environmental legislation" as well as an acknowledgement of the "global character of environmental challenges". "Concept of the Legal Policy of the Republic of Kazakhstan" was approved by Presidential Decree on September 20, 2002. It laid out a path for creating relevant laws and legal acts on the functioning of the environmental insurance system, strengthening inspection and state control, and strengthening the struggle against poaching and forest violations. It also advocated for guaranteed accountability for and compensation of environmental harms.

It also proposed to create a single system of environmental control on a national level and to mandate environmental audits for facilities that exceed pollution limits.

Following the principles of the Concept, the natural resource management system was adjusted to meet contemporary requirements, clarifying the distribution of powers among different levels of government and various types of natural resource management in water, land, and forestry legislation.

During this period, several important legislative acts were adopted in Kazakhstan, including the following: the Law of the Republic of Kazakhstan "On the Protection of Atmospheric Air" (dated November 3, 2002), the "Land Code" (dated June 20, 2003), the "Forest Code" (dated July 8, 2003), the "Water Code" (dated September 7, 2003), the Law "On the Protection, Reproduction, and Use of Wildlife" (dated July 9, 2004), the Law "On Compulsory Environmental Insurance" (dated December 13, 2005), and the Law "On Specially Protected Natural Territories" (dated July 7, 2006).

This period also saw environmental regulation framed in terms of economically based measures, such as environmental risk insurance to guarantee environmental security. To support these goals, the “Decree of the Former President of the Republic of Kazakhstan,” dated December 3, 2003 (No. 1241), endorsed the “Concept of Environmental Security of the Republic of Kazakhstan for 2004-2015.” This concept emphasizes the advancement of scientific research on issues related to environmental safety and resource management, ensuring that these insights are applied proactively to emerging problems in real time. Key components of this approach include the establishment of a unified state environmental monitoring system, ecological zoning, and thematic mapping of the Republic of Kazakhstan.

Kazakhstan's concept of environmental security is rooted in the priorities outlined in the “Kazakhstan-2030” strategy and aligns with the “Strategic Development Plan of the Republic of Kazakhstan up to 2010.” It also incorporates the ideals of the “Agenda for the 21st Century,” the “Rio de Janeiro Declaration on Environment and Development” from 1992, and the outcomes of the “World Summit on Sustainable Development” held in Johannesburg in 2002.

The implementation of this concept occurred in three stages: The first stage, from 2004 to 2007, focused on reducing environmental pollution and developing a plan for environmental stabilization. The second stage, from 2008 to 2010, aimed to maintain average environmental quality indicators and enhance environmental requirements for natural resource management. The third stage, from 2011 to 2015, emphasized improving environmental quality and achieving optimal environmental conditions for society.

To facilitate the implementation of the Concept, several strategic documents for state development were created, the foundations of environmental legislation were established, a number of international conventions on environmental protection were signed, and a system for managing environmental activities was introduced.

Summing up the results of the second stage, a short chronology of the legal documents in this period of time can be made as follows:

Table 12 - Timeline of legislative creation

Title of the law	Year
The Law "On Environmental Protection"	15.07.1997
The Law of the Republic of Kazakhstan "On Ecological Expertise"	18.03.1997
The Law of the Republic of Kazakhstan "On Specially Protected Natural Territories"	15.07.1997
Concept of the legal policy of the Republic of Kazakhstan	20.09.2002
The Law of the Republic of Kazakhstan "On the Protection of Atmospheric Air"	03.11.2002
The Land Code	06.20.2003
The Forest Code	07.08.2003
The Water Code	07.09.2003
Concept of Environmental Security of the Republic of Kazakhstan for 2004-2015	03.12.2003
The Law "On the Protection, Reproduction, and Use of Wildlife"	09.07.2004
The Law "On Compulsory Environmental Insurance"	13.12.2005
The Law "On Specially Protected Natural Territories"	07.07.2006
Note - compiled by the author according to the [110-112]	

In the third stage, the main comprehensive legislative act, the Environmental Code, was adopted on July 9, 2007. This Code regulates ecological relations within the Republic of Kazakhstan and aligns the country's level of environmental safety with international standards that emphasize advanced technologies. As a result of this Code's adoption, several legal documents, including those pertaining to ecological expertise, environmental protection, and air quality protection, became invalid.

According to Chapter 1, Article 1 of the Code, environmental protection is defined as a system of state and public measures aimed at preserving and restoring the environment. It focuses on preventing the negative impacts of economic and other activities on the environment and addressing any consequences that arise [113].

The Code is divided into two main parts: a General Part and a Special Part. It includes 9 sections, 47 chapters, and a total of 326 articles. The General Part contains 7 sections, which are as follows: "general provisions; licensing in the field of environment protection, ecological rationing, technical regulation in the field of environment protection, impact assessment on the environment, impact statement, environmental permit, and environmental audit; economic regulation of environmental protection and nature management; environmental control; environmental monitoring and cadasters; areas of an environmental emergency situation and environmental disaster; environmental education and awareness, research and international cooperation in the field of the environment protection" [113].

The special section of the Environmental Code comprises two parts: environmental requirements for the implementation of economic and other activities, and the liability for environmental offenses, along with the resolution of environmental disputes. As noted, the Environmental Code covers all areas related to environmental protection and includes a list of natural sites granted legal

protection. It clearly defines the primary environmental requirements that must be met in economic and other types of activities.

The 2007 version of the Code also contains provisions aimed at promoting environmental education and outlines the structure and responsibilities of state authorities tasked with environmental protection.

However, over time, the 2007 Environmental Code underwent 82 amendments, which ultimately resulted in its complete loss of legal validity. Consequently, the New Environmental Code of the Republic of Kazakhstan was adopted on January 2, 2021. According to Chapter 1, Article 1 of this new Code, “The Environmental Code regulates social relations regarding the interaction between humans and nature (environmental relations) that arise when individuals and legal entities engage in activities that have, or may have, an impact on the environment.” [113]

The primary distinction between the Environmental Code of 2007 and the Environmental Code of 2021 is that the latter not only focuses on environmental protection but also emphasizes preventive measures to avoid negative impacts on the environment. The new Code has strengthened the accountability of all parties involved and has increased administrative fines for violations that cause harm to nature.

Additionally, the principle commonly adopted in developed countries—the "polluter pays and corrects" approach—has been incorporated into the 2021 Environmental Code. This version also mandates that newly established enterprises obtain a comprehensive environmental permit. Significant attention has been given to waste minimization strategies, with the Environmental Code clarifying the hierarchy of waste management and promoting a phased approach. Waste classification has been aligned with the European waste catalog and will include both non-hazardous and hazardous waste.

In the Republic of Kazakhstan, the central executive body and specialized agencies are responsible for environmental protection. Under the regulations approved on December 8, 2007, the Ministry of Environmental Protection of the Republic of Kazakhstan serves as the central executive body responsible for coordinating environmental protection and nature management across sectors. Its main objective is to implement state policy in these areas while supporting sustainable development. The Ministry includes a specialized department called the Committee for Environmental Regulation and Control, along with various regional offices.

In addition to this Ministry, other central executive bodies in Kazakhstan also play key roles in environmental protection, the regeneration of natural resources, and the enforcement of relevant legislation. Over time, the Ministry has undergone several name changes and shifts in responsibilities. These changes are detailed in the following table (Table 13).

Table 13 - Timeline of changes

№	Year	Title
1	1990	State Committee of the Kazakh SSR for Ecology and Nature Management
2	1992	Ministry of Ecology and Bioresources of the Republic of Kazakhstan (by combining the State Committee of the Republic of Kazakhstan on Ecology and Nature Management and the Ministry of Forestry of the Republic of Kazakhstan)
3	1997	Ministry of Ecology and Natural Resources of the Republic of Kazakhstan
4	1999	Ministry of Natural Resources and Environmental Protection of the Republic of Kazakhstan
5	2002	Ministry of Environmental Protection of the Republic of Kazakhstan
6	2007	The First Environmental Code was adopted
7	2013	Ministry of Environment and Water Resources of the Republic of Kazakhstan
8	2014	Ministry of Energy and Ministry of Agriculture
9	2019	Ministry of Ecology, Geology and Natural Resources of Kazakhstan
10	2021 - nowadays	The New Environmental Code was adopted
Note - compiled by the Author according to the [110-113]		

1) The establishment of the State Committee of the Kazakh SSR on Ecology and Nature Management in 1990 marked the start of environmental governance in Kazakhstan according to Table 13. The State Committee of the Kazakh SSR on Ecology and Nature Management came into existence through a presidential decree from December 20, 1990, which was entitled “On the Reorganization of Government Bodies in the Kazakh SSR.”

2) The Republic of Kazakhstan established the Ministry of Ecology and Bioresources in 1992 through uniting the State Committee on Ecology and Nature Management with the Ministry of Forestry.

3) The Ministry of Ecology and Natural Resources came into existence due to a presidential decree issued on October 10, 1997. The newly formed agency took control of both responsibilities and assets from the previous Ministry of Ecology and Bioresources together with the Ministry of Energy and Natural Resources.

4) The Ministry of Natural Resources and Environmental Protection came into existence in 1999. The Ministry of Natural Resources and Environmental Protection took on the responsibilities pertaining to forestry, fishing, hunting, and water resources.

5) The Ministry underwent another reorganization in 2002 and transformed into the Ministry of Environmental Protection. The Ministry of Agriculture simultaneously assumed responsibility for water resources management along with forestry oversight and the regulation of fisheries and hunting.

6) Kazakhstan established its first Environmental Code in 2007 as a major legal advancement. Local executive bodies assumed responsibility for environmental assessments as mandated by this law. The Ministry’s territorial branches underwent restructuring on December 8 during the same year and renamed the Committee for Environmental Control to the Committee for Environmental Regulation and Control.

7) The Ministry of Environmental Protection received a new title as the Ministry of Environment and Water Resources in 2013.

8) The Ministry of Environment and Water Resources was dissolved because of a government restructuring in August 2014. The newly established Ministry of Energy received most of the responsibilities while some tasks went to the Ministry of Agriculture.

9) In the year 2019, the Ministry of Ecology, Geology and Natural Resources of Kazakhstan was established.

10) On January 2, 2021, the new Environmental Code of the Republic of Kazakhstan was enacted and replaced the Environmental Code of 2007.

In addition to adopting the new Code, the President of the Republic of Kazakhstan has issued several decrees related to environmental protection. These include the draft Decree on "The Concept of the Transition of the Republic of Kazakhstan to Sustainable Development for 2006-2024" and the draft Decree on "Approval of the Concept for the Effective Management of Natural Resources and the Use of Income from the Resource Sector." Additionally, there is the Decree from May 30, 2013, No. 577, which outlines the Concept for the Transition of Kazakhstan to a "Green Economy," among others.

Furthermore, in accordance with Article 4 of the Constitution of Kazakhstan, international treaty norms are also applicable. On October 23, 2000, Kazakhstan ratified the Convention on Access to Information, Public Participation in Decision-Making, and Access to Justice in Environmental Matters. As stated in paragraph 3 of Article 4 of the Constitution, once ratified, the Aarhus Convention, as an international treaty, takes precedence over national laws, and its provisions are to be applied directly. Kazakhstan has also ratified over 20 other environmental conventions.

According to the Environmental Code of the Republic of Kazakhstan, the instruments for state regulation in the field of environmental protection are as follows (Figure 18):

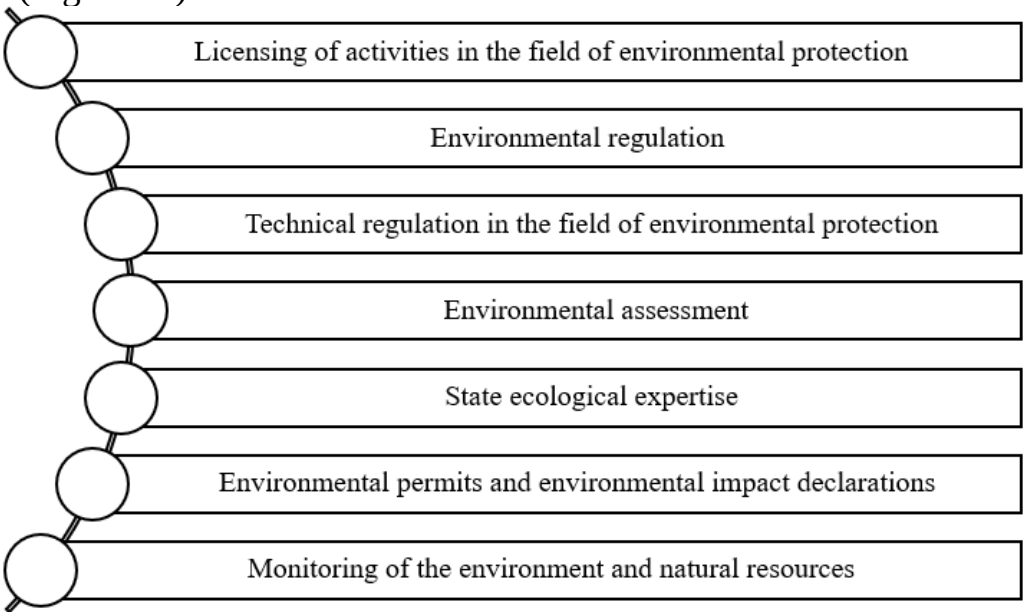


Figure 18 - The instruments of state regulation in the field of environmental protection

*Note: Compiled by the author according to the [113]

The authorized body of the Republic of Kazakhstan responsible for environmental protection implements state policy aimed at improving the environment through the following measures (Figure 19):

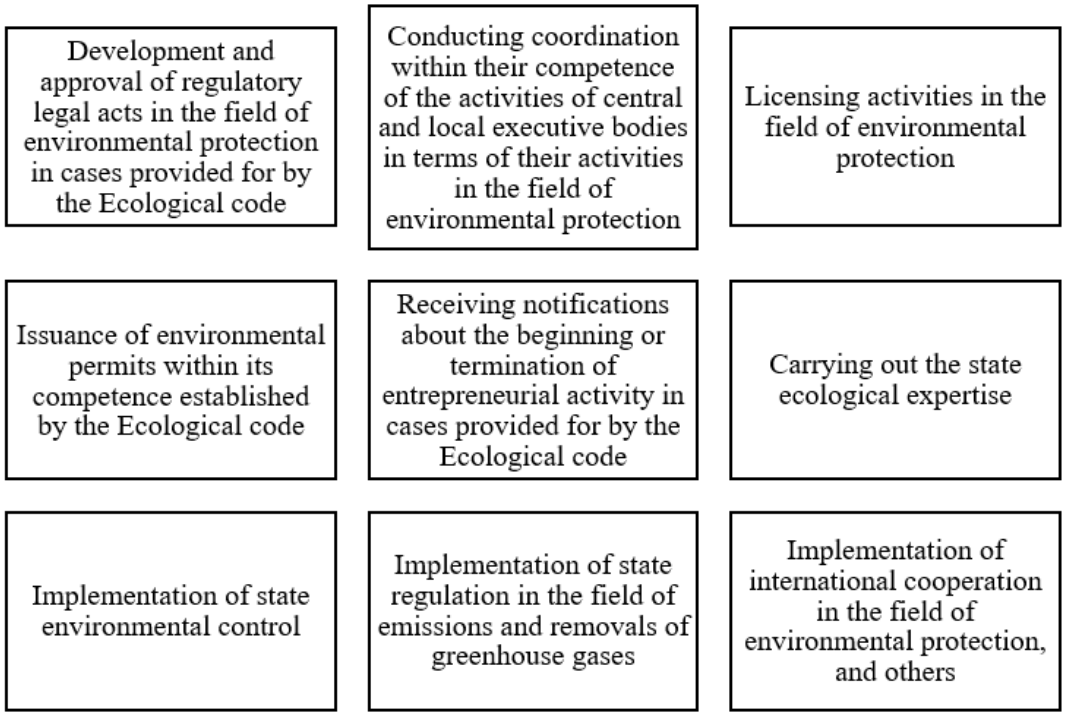


Figure 19 - Implementation of a unified state environmental policy

*Note: Compiled by the author according to the [113]

The institutional hierarchy of the Republic of Kazakhstan for environmental protection can be depicted as follows (Figure 20):

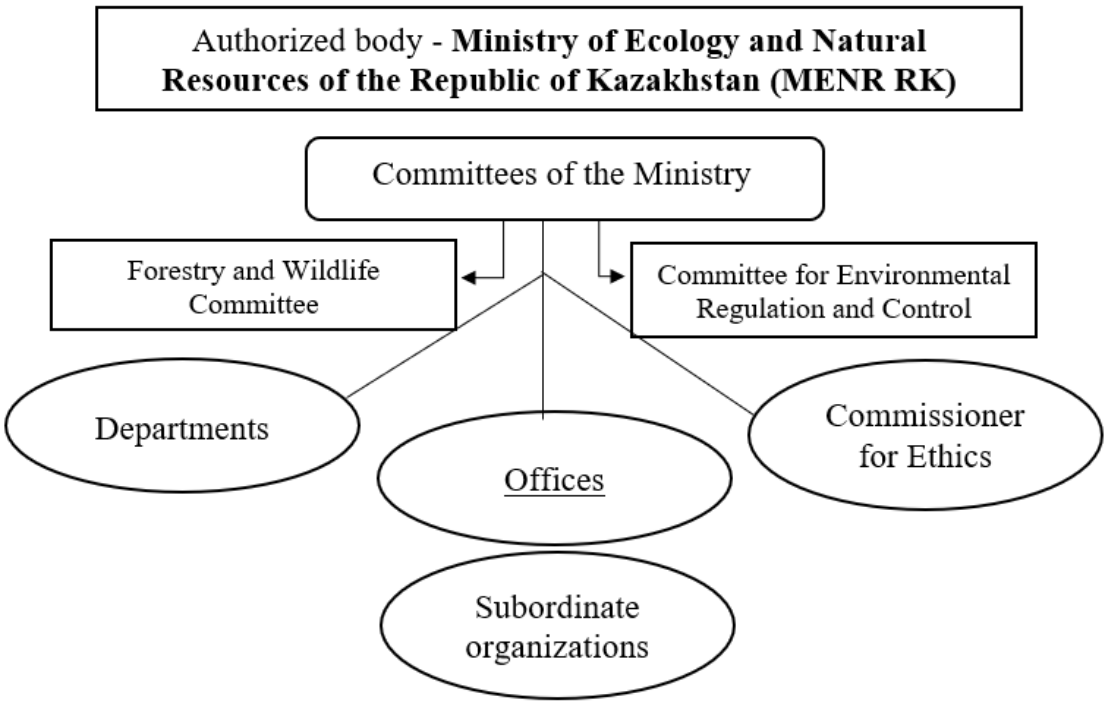


Figure 20 - The institutional hierarchy
*Note: Compiled by the author according to the [114]

Currently, the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan offers a range of online services through the E-Gov website. The following services are now available for online request:

Environmental permits (Applications for various environmental permits necessary for business operations that impact the environment.)
Water resource management (Services related to the use and protection of water resources, including permits for water usage and monitoring.)
Waste management services (Procedures related to the management of hazardous waste, including notifications and approvals for waste disposal and recycling)
Consultation services (Online consultations regarding environmental laws, regulations, and best practices in ecology and natural resource management)
Licensing for environmental activities (Obtaining licenses for activities that involve natural resource extraction or environmental monitoring)

Figure 21 - Available services from the Ministry on the E-gov website
*Note: Compiled by the author according to the [114]

In Kazakhstan, the development and implementation of environmental policy involves multiple ministries and departments, in addition to the Ministry of Ecology and Natural Resources. These include the Ministry of Agriculture; the Committee for Land Management under the Ministry of Agriculture; the Ministry of Science

and Higher Education; the Ministry of Investment and Development (MID); the Committee of Geology (MID); the Ministry of National Economy (MNE); as well as other departments and state institutions. It is important to highlight the significant role played by akimats in all regions and cities of republican significance (such as Astana, Almaty, and Shymkent), along with local governments, in executing environmental policy.

Kazakhstan has two systems for monitoring compliance with environmental protection legislation: the public control system and the state control system. The primary goal of state control in environmental protection is to ensure environmental safety, conserve natural and energy resources, promote the sustainable use of biological resources, and enhance the competitiveness of national products.

The following types of state control are implemented in this area (Figure 22):

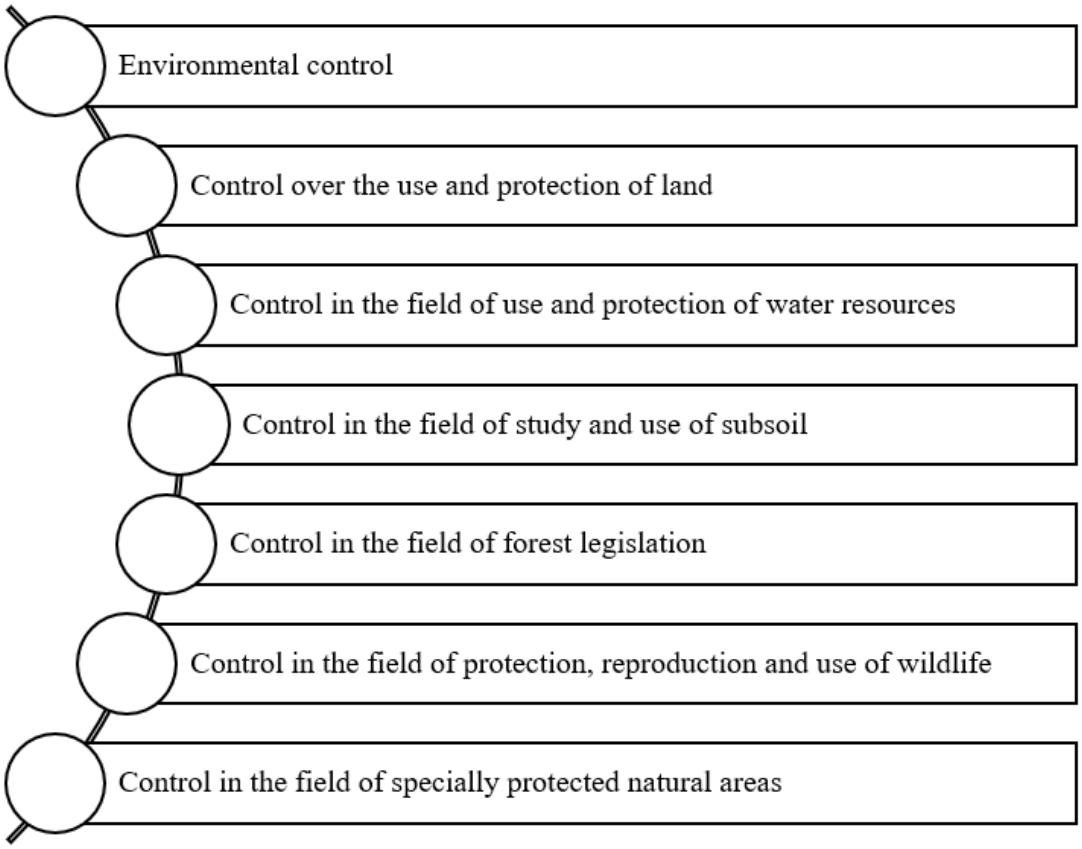


Figure 22 - Types of state control in the Republic of Kazakhstan
*Note: Compiled by the author according to the [114]

Also, today there are a number of state programs, concepts, and other documents aimed at protecting the environment. Such as:

1) National project "Green Kazakhstan". Launched in October 2021, designed for the period 2021-2025 [115].

2) On approval of the Strategy for achieving carbon neutrality of the Republic of Kazakhstan until 2060. Decree of the President of the Republic of Kazakhstan dated February 2, 2023 No. 121 [116].

3) On approval of the Concept for the development of ecological culture "Taza Kazakhstan" for 2024 – 2029. Resolution of the Government of the Republic of Kazakhstan dated October 31, 2024 No. 910 [117].

4) Decree of the President of May 30, 2013 No. 577, the Concept for the transition of the Republic of Kazakhstan to a “green” economy [118].

5) Strategic Development Plan of the Republic of Kazakhstan until 2025, etc [119].

Environmental legislation in the Republic of Kazakhstan is based on the following legal acts (Figure 23):

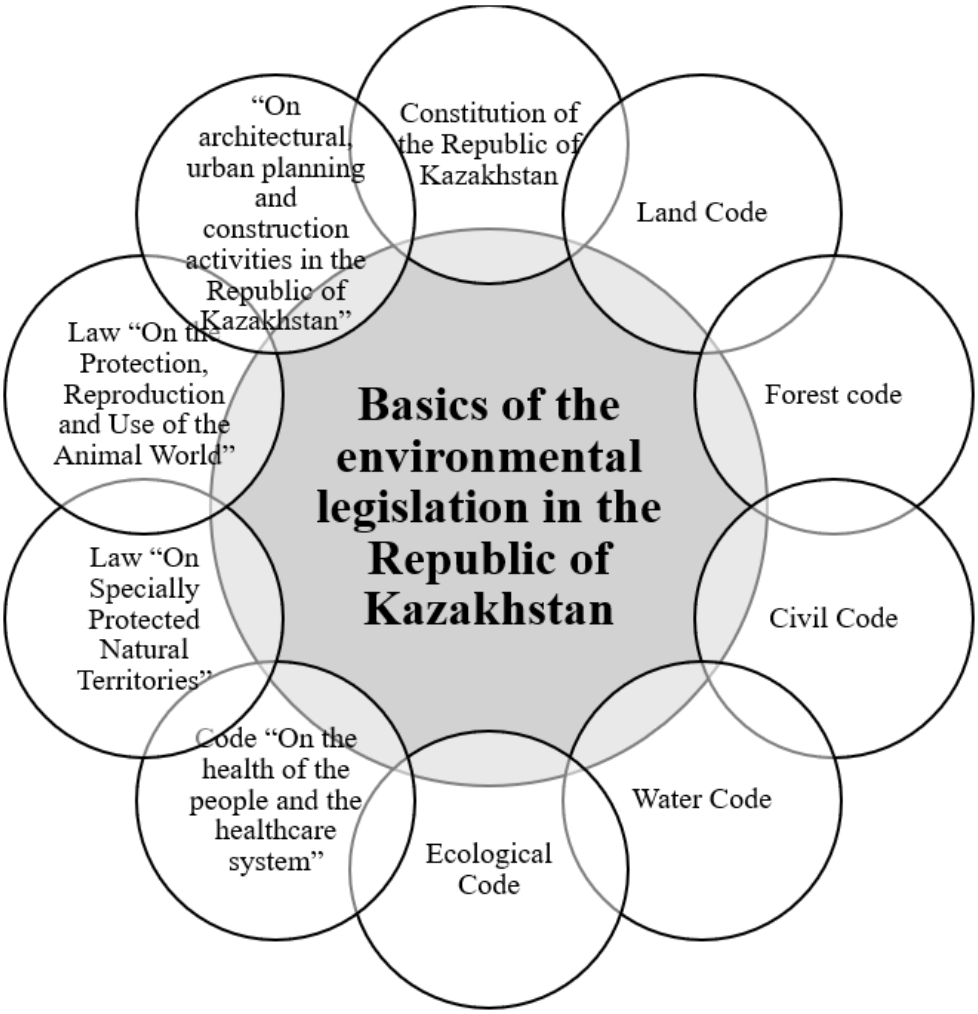


Figure 23 - Basics of the environmental legislation in the Republic of Kazakhstan

*Note: Compiled by the author according to the [110-119]

As for the analysis of legislation in the framework of the transition to a circular economy, it can be depicted as follows (Figure 24):

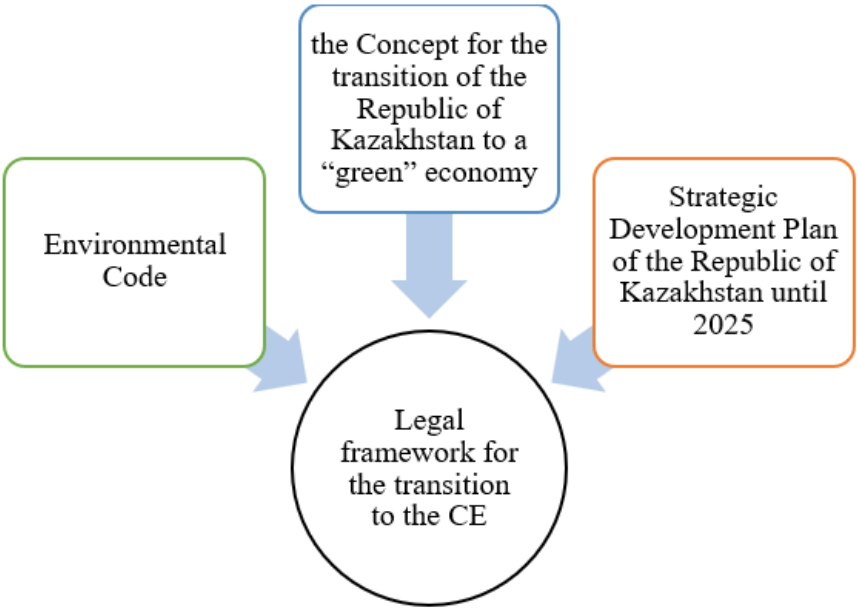


Figure 24 - Legal framework for the transition to the CE
*Note: - Compiled by the author

The primary framework for waste management legislation aimed at promoting a circular economy in the Republic of Kazakhstan is outlined in Figure 24. This framework includes the Environmental Code of the Republic of Kazakhstan, established in 2021, the "Concept for Transitioning to a Green Economy" from 2013, and the "Strategic Development Plan of the Republic of Kazakhstan", which extends until 2025.

In terms of the institutional framework for transitioning to a circular economy, Kazakhstan's approach consists of three levels (Figure 25):

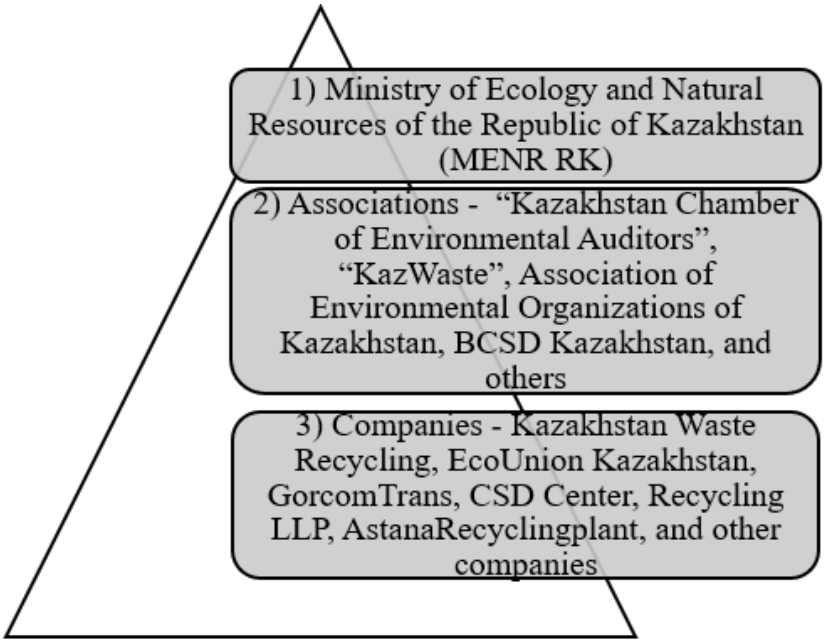


Figure 25 - 3 levels of the institutional framework for the transition to a circular economy

*Note: - Compiled by the author

1) **First level.** The Ministry of Ecology and Natural Resources is in charge of establishing and carrying out state policy in areas including protecting the environment, drafting laws, and advancing the "green economy." This ministry has a special regulatory position and is the leading authorized agency for environmental protection.

According to its legislation, the Republic of Kazakhstan's Ministry of Ecology and Natural Resources is tasked with establishing the circumstances necessary for the preservation, restoration, and enhancement of water and biological resources as well as environmental quality. The ministry is also responsible for the reproduction of the mineral resource base, the geological study of the subsurface, and the sustainable development of forestry, hunting, fishing, and water.

2) **At the second level**, there is a range of associations. Notable associations include the Kazakhstan Waste Management Association “KazWaste,” the Association of Environmental Organizations of Kazakhstan, the Kazakhstan Chamber of Environmental Auditors, and the Kazakhstan Association of Nature Users for Sustainable Development, among others.

Each association possesses its unique set of competencies. For example, the competence of the KazWaste association includes the following:

- Interaction with regulatory authorities on issues of supporting entrepreneurship in the field of waste;
- Providing legal and consulting assistance to the Members of the Association;
- Organization of professional events on waste management issues
- Search for enterprise support tools for the sustainable development of the waste processing business, etc.

Targets and goals of the “KazWaste” can be depicted as follows (Figure 26):

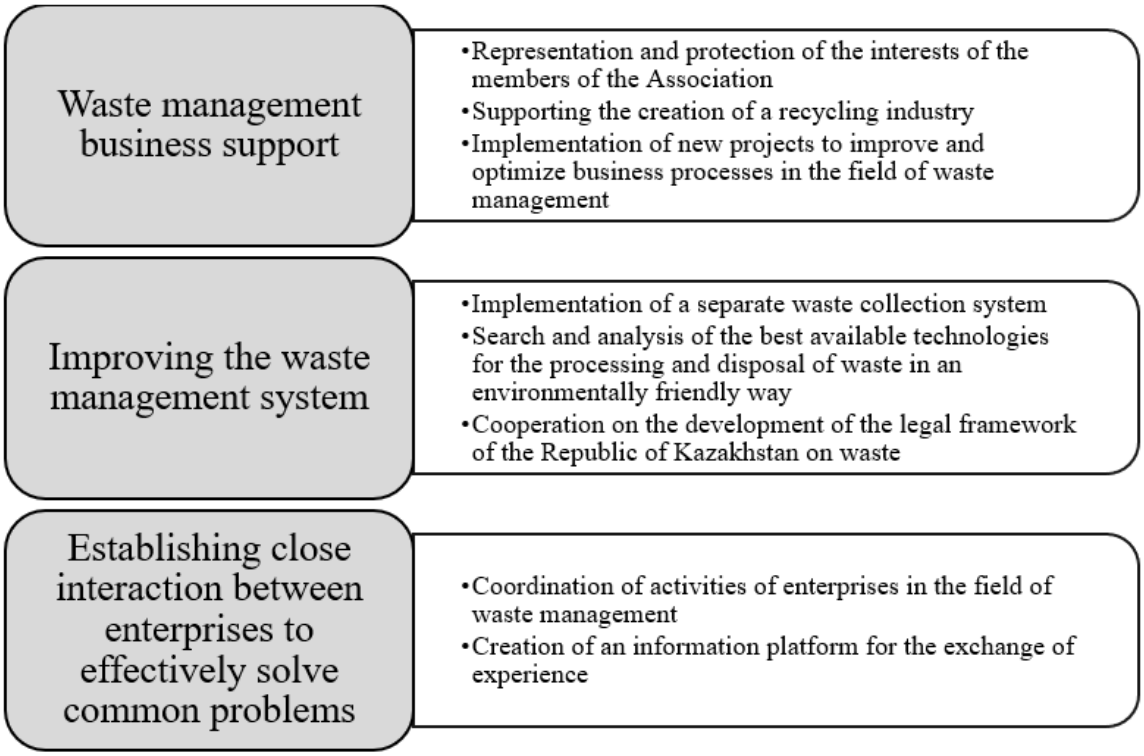


Figure 26 - Targets and goals of the "KazWaste"
*Note: - Compiled by the author according to the [120]

The management structure of the association is as follows:

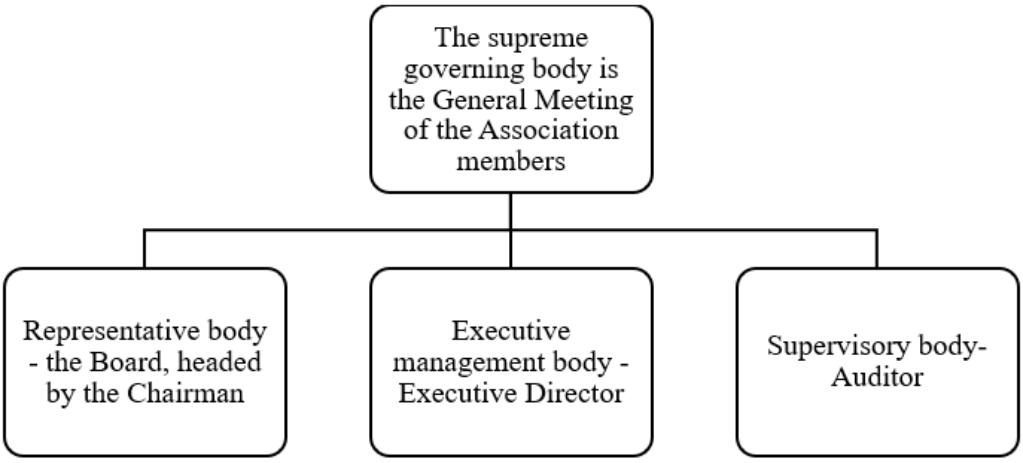


Figure 27 - The management structure of the association
*Note: Compiled by the author according to the [120]

As depicted in Figure 27, the highest body in the hierarchy is the General Meeting of the Members of the Association. This is followed by a representative body - the Board, which is headed by the Chairman. Next comes the Executive Body, which is headed by the Executive Director. And finally, the body exercising control over the entire process is the auditor.

The Association of Environmental Organizations of Kazakhstan serves as the second level of the institutional structure. Its tasks are to assist in improving

environmental legislation, developing green financing, and establishing principles and standards for environmental business.

Another good example of the second tier is the Kazakhstan Association of Environmental Users for Sustainable Development. This association unites more than 10 large nature users - industrial enterprises of the mining, metallurgical, energy, machine-building, chemical, oil and gas sectors of the economy of Kazakhstan with a total number of about 90 thousand employees. A key mission of KAEUSD is to bring together the state and the business sector to promote sustainable development and corporate social responsibility in Kazakhstan. The organization offers advanced training courses, such as:

- School for sustainable development,
- Natural-climate solutions,
- Eco-digest "together with nature", and others.

3) At the third level of the institutional framework, leading companies in waste management are represented, including Kazakhstan Waste Recycling, EcoUnion Kazakhstan, GorcomTrans, CSD Center, Recycling LLP, AstanaRecyclingplant, and others.

In conclusion of this sub-chapter, two key findings can be highlighted.

Firstly, the legal framework for Kazakhstan's transition to a circular economy has developed over time through several stages. It began with the introduction of the first environmental laws in 1991 and 1997, which established the principles of rational natural resource management. This was followed by the incorporation of closed-loop economy concepts in the "Concept of Transition to a Green Economy" in 2013. Comprehensive regulations were later introduced with the "Environmental Code" in 2021, along with strategic documents such as the "Strategy for Achieving Carbon Neutrality" in 2023 and the "Concept for the Development of Environmental Culture: Taza Kazakhstan" in 2024. In addition, this framework is reinforced by various sectoral codes, including those governing entrepreneurship, taxation, water, and forestry. It is also supported by regular Presidential Addresses and subordinate legislation related to waste management and environmental auditing.

However, despite the broad array of laws and strategies in place, analysis reveals a significant lack of coordination in their implementation. There is currently no unified interdepartmental body responsible for overseeing circular economy initiatives. Furthermore, the economic tools needed to support these efforts—such as financial incentives, green financing mechanisms, and subsidies—are underdeveloped. This disconnect contributes to a gap between the ambitious goals that have been set and the actual progress in creating closed-loop resource systems.

A complete circular economy law represents the essential foundation for maximizing resource utilization efficiency and flow. The existing Environmental Code should incorporate these efforts through specific standards for Extended Producer Responsibility (EPR) systems and digital material tracking and strategic tax incentives and enhanced environmental regulation enforcement. The implemented measures would both optimize circular practices and establish better accountability and resource lifecycle traceability.

2.2 Assessment of the current state of the circular economy's development at the macro level

A circular economy represents a sustainable development method which extends resource usage duration while minimizing waste production. The circular economy approach has gained significant importance for nations worldwide because they pursue both environmental sustainability and United Nations Sustainable Development Goals achievement. The assessment of macro-level circular economy development requires a thorough evaluation to understand both the achievements and obstacles and potential opportunities in circular economic transformation. This subchapter focuses on analyzing circular economy development at the macro level in the Republic of Kazakhstan.

In an effort to create a consistent measurement system for the circular economy, the European Environmental Agency (EEA) and the Italian Institute for Environmental Protection and Research (ISPRA) collaborated on the Bellagio Declaration. This declaration, endorsed by the European Network of the Heads of Environment Protection Agencies, outlines seven principles for establishing a circular monitoring system. Building on existing monitoring systems and the Bellagio Declaration, the United Nations (UN) has proposed a simplified framework for implementing a national-level circular economy monitoring system. This framework emphasizes the critical aspect of material and waste flows (Figure 28).

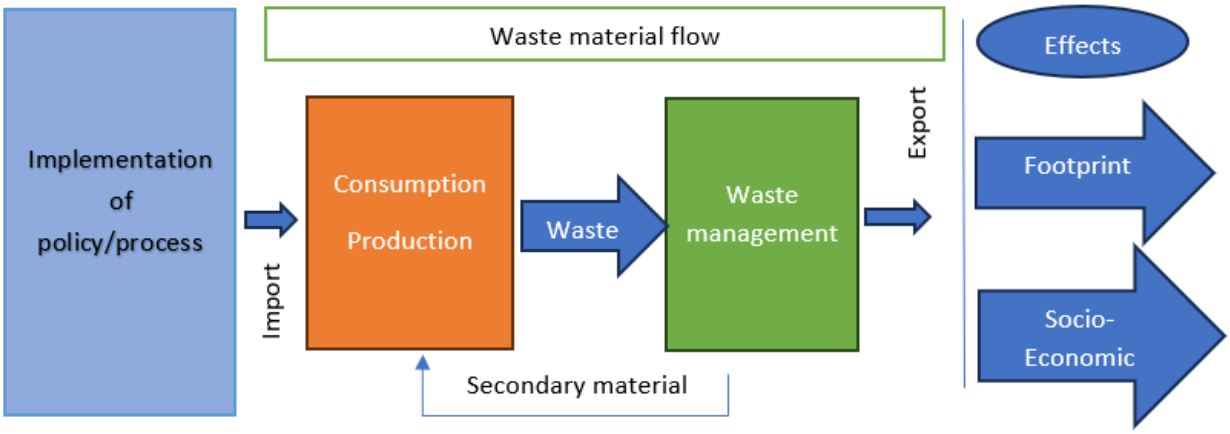


Figure 28 - A simple framework for monitoring the CE at the national level

*Note: Compiled by the author according to the [121, 122]

Based on the framework for setting up a monitoring system (shown in Figure 28) and the capabilities of the country, the UN proposed a set of indicators that align with the Bellagio Declaration. These indicators were chosen from existing environmental and circular economy frameworks, including the UN's SDG indicators, UNECE Environmental Indicators, OECD circular economy indicators for regions, and the European Commission's circular economy monitoring framework.

The 17 indicators that were selected are divided into four categories according to the Bellagio Principles:

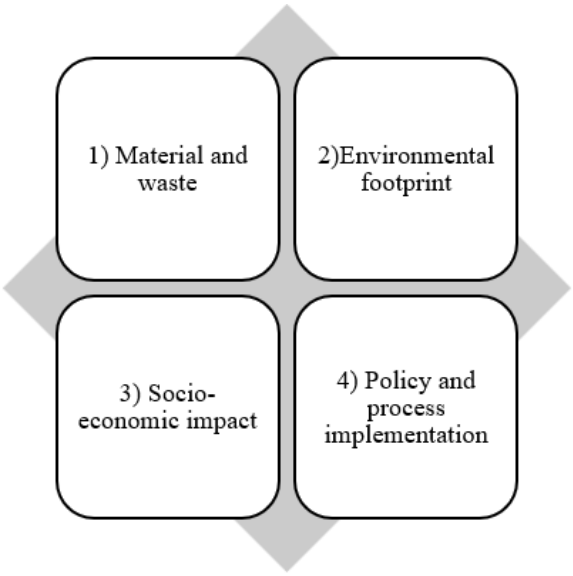


Figure 29 – Indicators in four categories

*Note: Compiled by the author according to the [121, 122]

According to the Bellagio principles, there are indicators that reflect the level of development of the circular economy at the macro level. Table 14 brings together 23 macro-level indicators of circular economy development according to the "Bellagio principles", grouped into four areas: ecological footprint (total and sectoral GHG emissions, water use, share of renewable energy sources, etc.), materials and waste (resource consumption, waste generation and intensity, level of its treatment and recycling, Food Loss Index, etc.), socio-economic impact (investments, employment and GDP in circular economy sectors, number of new and implementing enterprises) and policy implementation (parameters determined at the country level); for each indicator, the corresponding data sources (UNECE, UN, EC, OECD) are indicated (Table 14).

Table 14 - Indicators for monitoring circular economy at the macro-level proposed by the UN

	Bellagio classification	Indicator	Source
1	Footprint	Aggregated GHG emissions (CO2 equivalents)	UNECE
2	Footprint	Aggregated GHG emissions per capita	UNECE
3	Footprint	Aggregated GHG emissions by sectors	UNECE
4	Footprint	Change in water use efficiency over time	UNECE
5	Footprint	Proportion of wastewater safely treated	UN
6	Footprint	Share of reused water in total freshwater use	UNECE
7	Footprint	Renewable energy share in the total final energy consumption within the national territory	UNECE
8	Material and waste	Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP	UNECE
9	Material and waste	Annual total waste generation	UNECE
10	Material and waste	Waste generation intensity per unit of GDP	UNECE
11	Material and waste	Household waste generation intensity per capita	UNECE
12	Material and waste	Proportion of hazardous waste treated, by type of treatment	UNECE
13	Material and waste	National recycling rate, tons of material recycled	UNECE
14	Material and waste	Circular material use rate	EC
15	Material and waste	Food Loss Index	UN
16	Material and waste	Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban waste generated, by cities	UNECE
17	Material and waste	Material footprint, material footprint per capita, and material footprint per GDP	UNECE
18	Socio-economic impact	Private investments, jobs and GVA related to circular economy sectors: Gross investment intangible goods	EC
19	Socio-economic impact	Private investments, jobs and GVA related to circular economy sectors: Number of persons employed	EC
20	Socio-economic impact	Private investments, jobs and GVA related to circular economy sectors: Value-added at factor cost	EC
21	Socio-economic impact	No. of new circular business (e.g. companies, start-up, etc.) created to implement the circular economy initiative	EC
22	Socio-economic impact	No. of businesses (e.g. companies, start-ups, etc.) adopting circular economy principles	OECD
23	Policy and process implementation	To be defined at the country level	OECD
Note*: Indicators for monitoring circular economy at the macro-level were proposed by the UN report in 2021 Note**: Green shading indicates indicators for which data are currently available; yellow shading indicates indicators for which data may potentially be collected; red shading indicates indicators for which no data exist.			

According to the provided UN indicators, a macro analysis of circular economy development on the territory of the Republic of Kazakhstan was conducted by using data from the “National Bureau of Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan”. The results of the analysis are presented below (Figure 30):

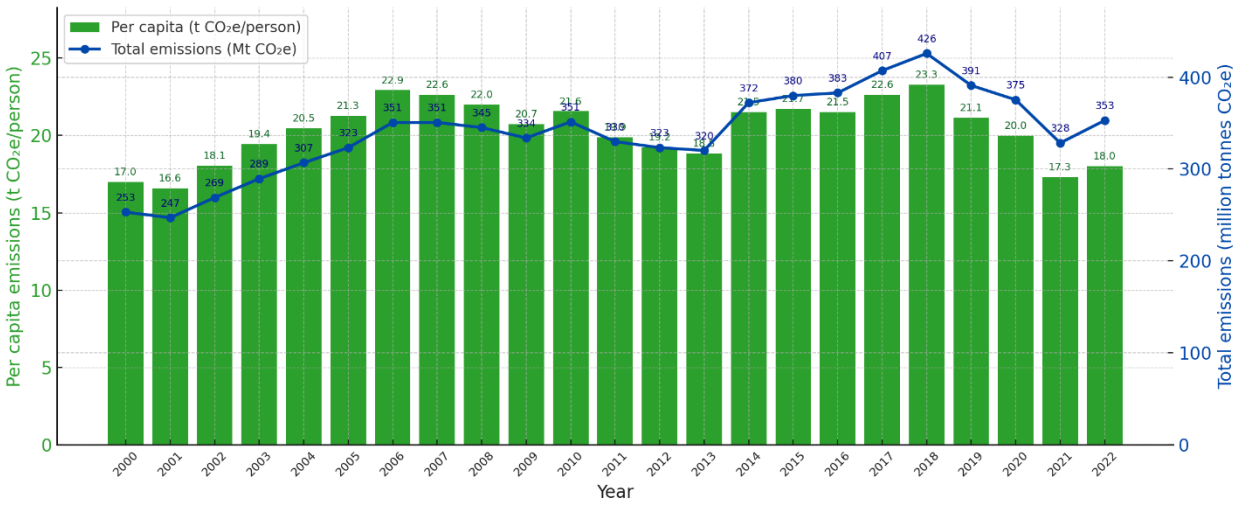


Figure 30 – GHG emissions

*Note: Compiled by the author according to the [123, 124]

Indicator: Footprint. Between 2000 and 2022, greenhouse gas emissions in Kazakhstan underwent three distinct phases.

From 2000 to 2007, total emissions rose from approximately 253 million tons to 351 million tons in CO_2 equivalent. During this period, per capita emissions increased from 17 tons to 23 tons of CO_2 per person.

In the second phase, from 2008 to 2013, both total and per capita emissions declined, reaching about 320–330 million tons and 19 tons per person, respectively.

The third phase, spanning from 2014 to 2018, saw another rise in emissions, peaking at 426 million tons and 23.3 tons of CO_2 per person in 2018.

After this peak, emissions began to gradually decline. By 2021, total emissions had fallen to 328 million tons, while per capita emissions decreased to 17.3 tons. However, in 2022, there was a slight rebound, with total emissions rising to 353 million tons and per capita emissions to 18.0 tons.

The following Figure 31 shows greenhouse gas emissions by sectors:

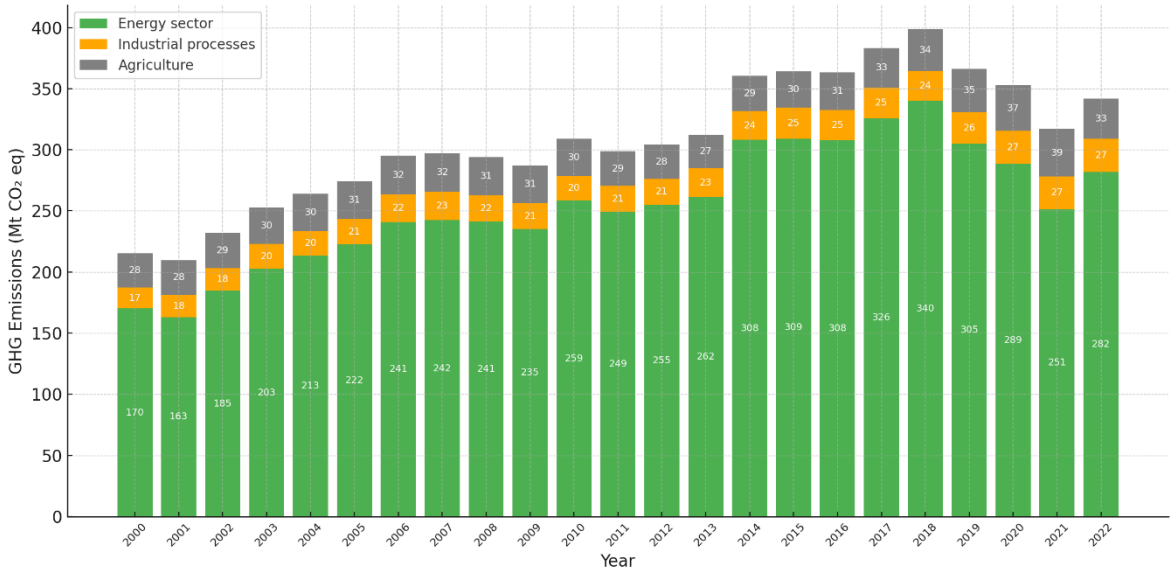


Figure 31 - Greenhouse gas emissions by sectors

*Note: Compiled by the author according to the [123, 124]

From 2000 to 2022, the energy sector was the largest contributor to emissions in Kazakhstan. Annual emissions increased from approximately 170 million tons of CO_2 equivalent ($MtCO_2eq$) in 2000 to a peak of 340 Mt in 2018, before declining to 282 Mt in 2022. Emissions from industrial processes remained relatively stable, gradually increasing from 17 $MtCO_2eq$ in 2000 to 27 Mt by the end of the period. In agriculture, emissions rose from 28 $MtCO_2eq$ in 2000 to a peak of around 38 Mt in 2021, after which they decreased to 33 Mt in 2022. Thus, over two decades, the energy sector has driven the primary trends in emissions, while industrial and agricultural sources have shown a more gradual increase.

Next, Figure 32 describes the reuse of fresh water in the Republic of Kazakhstan:

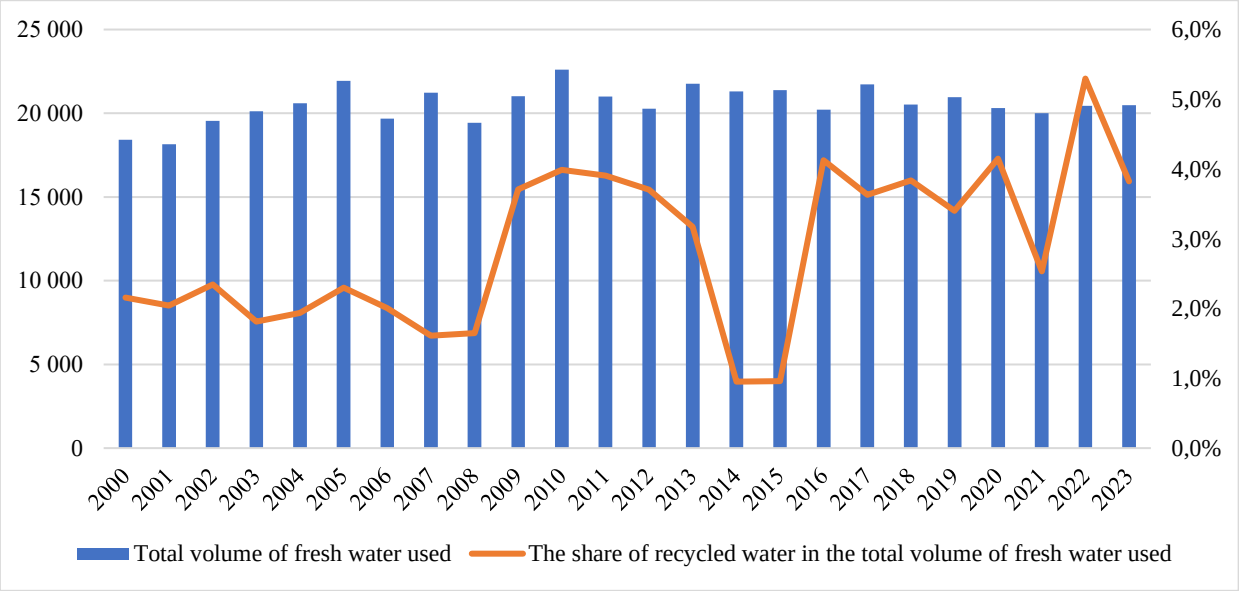


Figure 32 - Reuse of fresh water

*Note - Compiled by the author according to the [123, 124]

Between 2000 and 2005, freshwater withdrawals steadily increased from 18.4 billion m^3 to a peak of 21.9 billion m^3. However, in 2006, the withdrawals declined to approximately 19.7 billion m^3 and then fluctuated between roughly 19 and 22 billion m^3 until 2023, with the figure at 20.5 billion m^3 in 2023.

During the same period, the proportion of recycled water remained very low, starting at about 2% in the early 2000s. It then increased to approximately 3.7% to 4.0% between 2009 and 2011, but sharply dropped to just 1% in 2014 and 2015. After that, the percentage rebounded, reaching a new high of 5.3% in 2022 and settling at 3.8% in 2023.

The following Figure 33 shows contaminated untreated wastewater:

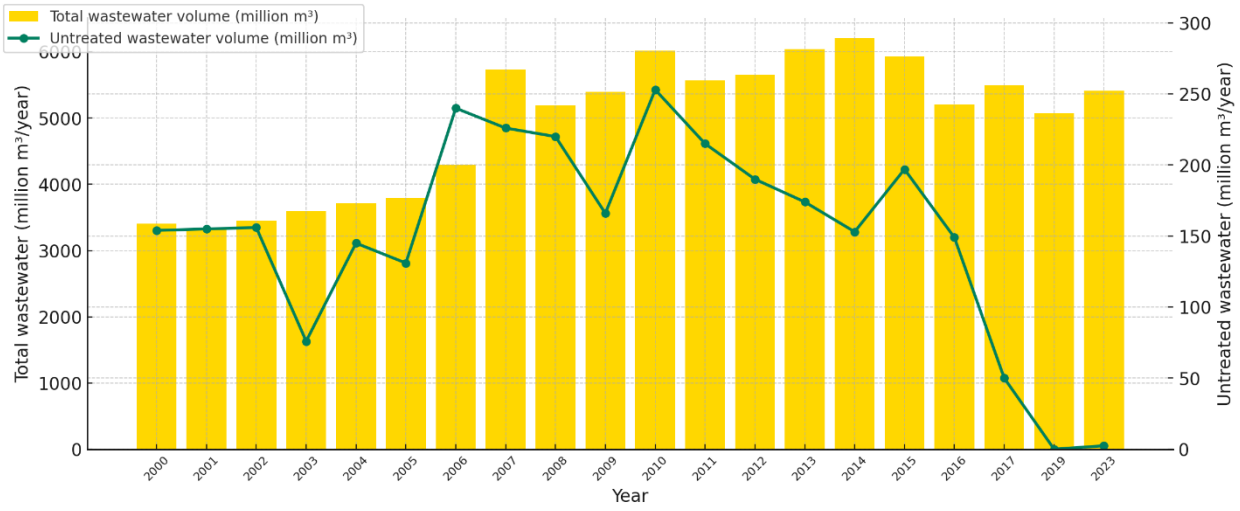


Figure 33 - Contaminated untreated wastewater
*Note: Compiled by the author according to the [123, 124]

Between 2000 and 2007, the total volume of wastewater increased significantly, rising from approximately 3.4 billion cubic meters (m³) to nearly 5.7 billion m³. During this period, the amount of untreated effluent also grew, from about 154 million m³ in 2000 to a peak of 253 million m³ in 2010. After 2010, while total wastewater generation remained high (at 6.2 billion m³ in 2014), the volume of untreated wastewater began to decline steadily, reaching around 50 million m³ by 2017. This decrease was attributed to major upgrades in treatment plants. By 2019, untreated wastewater had been nearly eliminated, dropping to just 0.05 million m³, although there was a slight increase to 2.4 million m³ in 2023. Overall, despite total wastewater volumes stabilizing between 5 and 6 billion m³, investments in secondary and tertiary treatment processes have nearly eradicated insufficiently treated discharges. It should be noted that years with no available data on untreated wastewater volumes (2018,2020,2021,2022) have been excluded from this analysis.

Figure 34 shows the efficiency of water resource utilization:

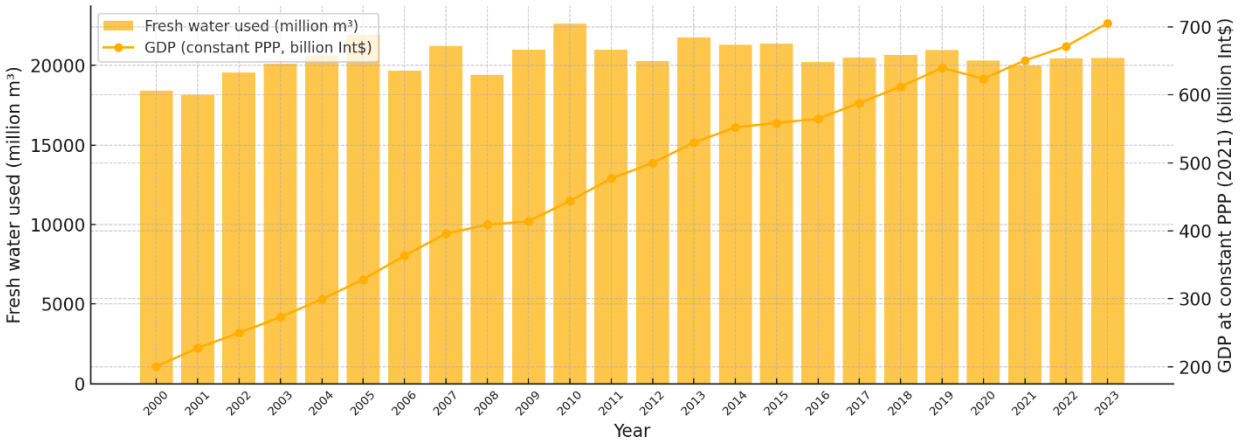


Figure 34 - Efficiency of water resource utilization

*Note: Compiled by the author according to the [123, 124]

Over the past two decades, Kazakhstan has noticeably decoupled economic growth from freshwater withdrawals. From 2000 to 2010, both water use and GDP increased together. Freshwater withdrawals rose from about 18 billion cubic meters to over 22.6 billion cubic meters, while GDP at constant purchasing power parity (PPP) more than doubled, increasing from roughly $200 billion to $444 billion.

However, after 2010, water use stabilized and even declined slightly, hovering around 20–22 billion cubic meters, while GDP continued to rise. By 2023, GDP reached $705.5 billion. This divergence indicates significant improvements in water-use efficiency: the economy has more than tripled in size since 2000 without any corresponding increase in freshwater withdrawal.

The following Figure 35 shows energy supplied from renewable sources:
s:

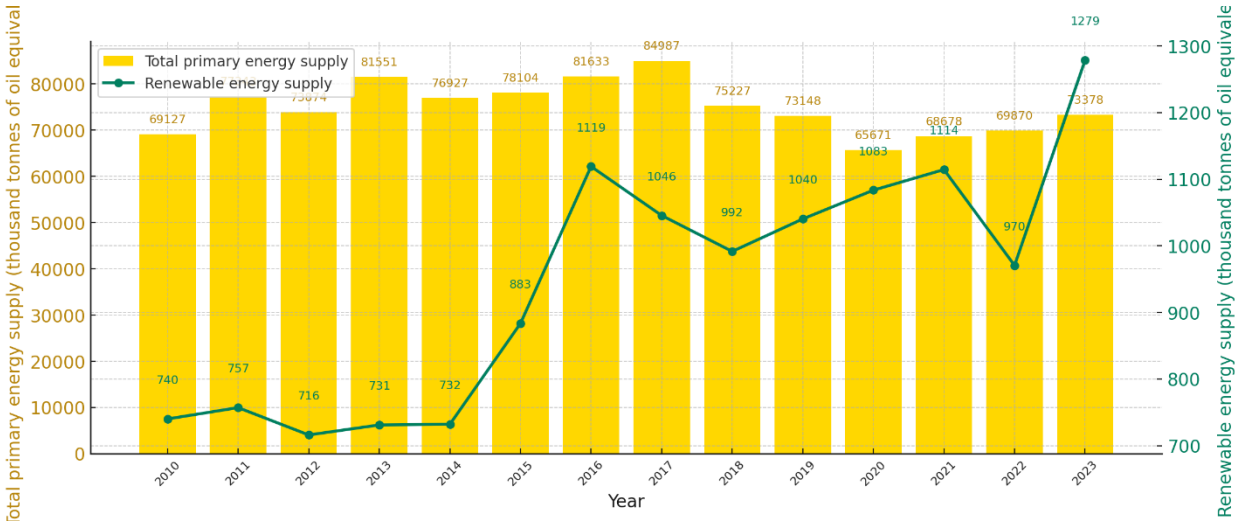


Figure 35 - Energy supplied from renewable sources

*Note: Compiled by the author according to the [123, 124]

From 2010 to 2023, Kazakhstan's total primary energy supply varied significantly, starting at approximately 69,127 thousand tons of oil equivalent in 2010. It peaked at 84,987 thousand tons in 2017 before declining to 65,671 thousand tons in 2020. However, the supply then rebounded, reaching 73,378 thousand tons in 2023.

During the same period, the contribution from renewable sources increased more than twofold, rising from roughly 740 thousand tons of oil equivalent in 2010 to about 1,119 thousand tons in 2016. After stabilizing around 1,000 thousand tons, it achieved a new high of 1,279 thousand tons in 2023.

Indicator: Materials and waste. The graph illustrates the total amount of waste generated in Kazakhstan from 2016 to 2021:

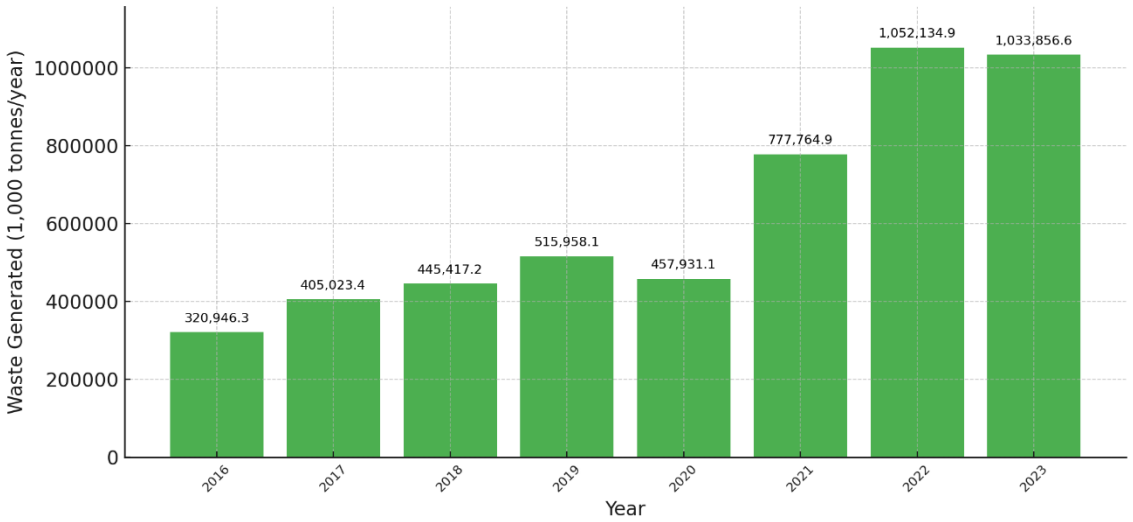


Figure 36 – Total waste generated

*Note: Compiled by the author according to the [123, 124]

The volume of waste generated has shown a consistent increase, rising from 320,946 thousand tons in 2016 to 515,958 thousand tons in 2019. The year-to-year increases were +26.2% in 2017, +10.0% in 2018, and +15.8% in 2019. However, in 2020, the volume decreased by 11.2%, dropping to 457,931 thousand tons. This decline was followed by a significant surge of 69.8% in 2021, bringing the total to 777,765 thousand tons. In 2022, growth continued, albeit at a slower pace, with an increase of 35.3%, resulting in a peak of 1,052,135 thousand tons. In 2023, the volume saw a slight decline of 1.7%, falling to 1,033,857 thousand tons, which is still more than three times the amount recorded in 2016.

Figure 37 illustrates the amount of waste produced per unit of GDP across various economic activities:

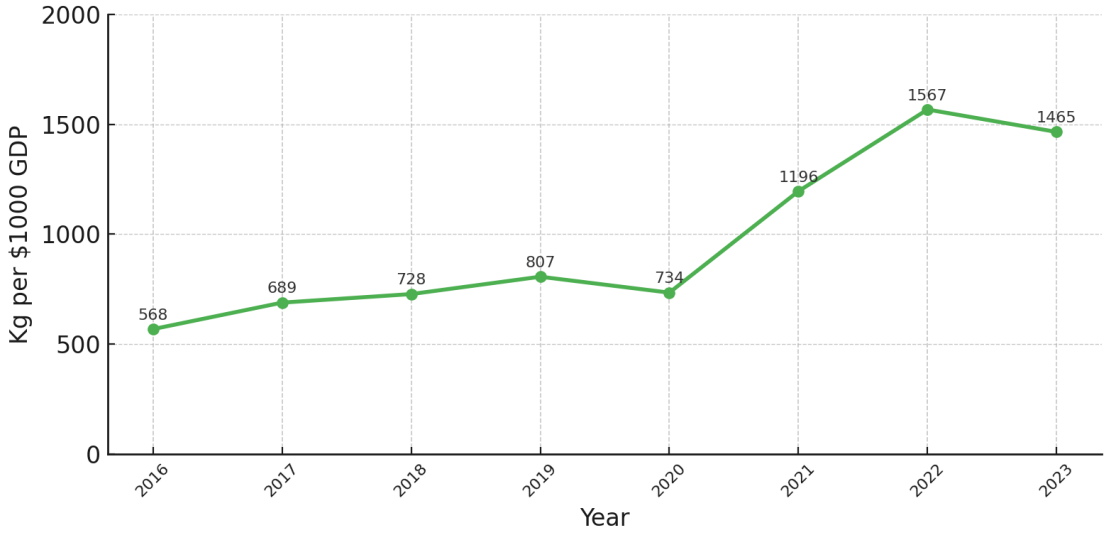


Figure 37 – Waste of all types of economic activities per unit GDP

*Note: Compiled by the author according to the [123, 124]

From 2016 to 2019, waste intensity increased consistently, rising from approximately 568 kg per $1,000 of GDP to 807 kg. This trend reflects a greater use of materials in relation to economic output. In 2020, waste intensity decreased to 734 kg, but then surged sharply to 1,196 kg in 2021, reaching a peak of 1,567 kg in 2022. In 2023, it slightly declined to 1,465 kg. The data indicates an upward trend in the amount of waste generated per unit of GDP, with a temporary decrease in 2020 followed by significant increases in the following two years.

The following Figure 38 shows the amount of municipal waste collected in terms of volume:

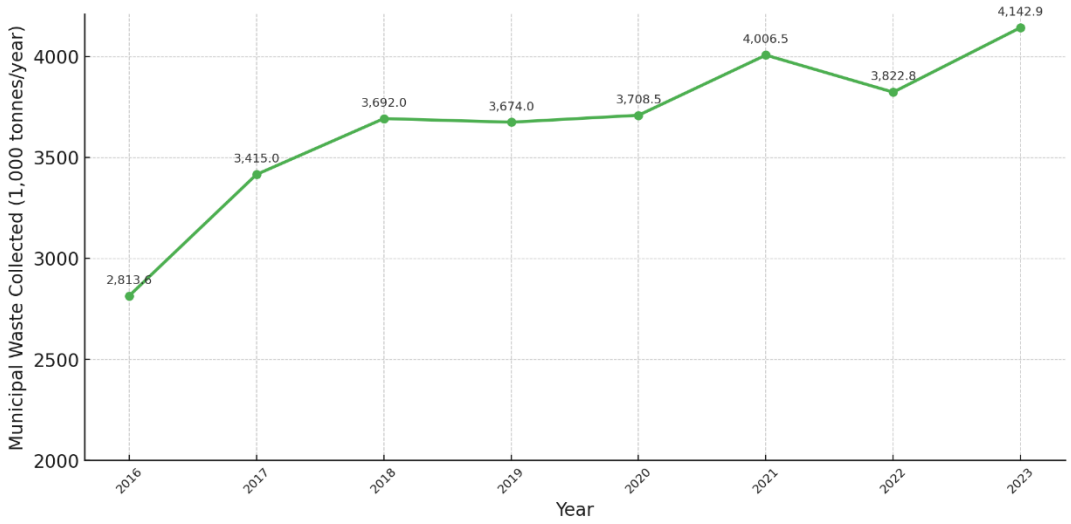


Figure 38 - The amount of municipal waste collected in terms of volume
*Note: Compiled by the author according to the [123, 124]

Between 2016 and 2023, the volume of municipal waste collected in Kazakhstan increased significantly, growing from approximately 2,813.6 thousand tons to 4,142.9 thousand tons. There was a notable rise from 2016 to 2018, when the volume surged from 2,813.6 thousand tons to 3,692.0 thousand tons. After reaching this peak, the collection volumes plateaued around 3,600 to 3,700 thousand tons until 2020.

However, from 2021 to 2023, waste collection volumes climbed once more, peaking at 4,006.5 thousand tons in 2021. There was a slight dip to 3,822.8 thousand tons in 2022, but the figure rose again to 4,142.9 thousand tons in 2023. This trend highlights a consistent growth in both the generation and collection of municipal waste over the eight-year period.

Figure 39 below shows the volume of collected municipal waste per capita from 2005 to 2021:

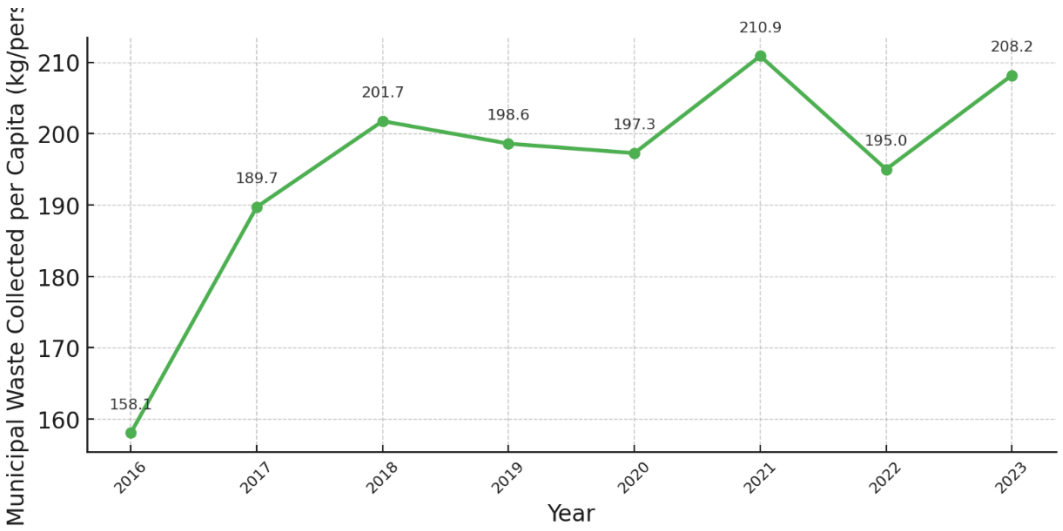


Figure 39 – Collected municipal waste per capita

*Note: Compiled by the author according to the [123, 124]

Between 2016 and 2018, the per-capita collection of municipal waste increased from approximately 158.1 kg to 201.7 kg per person. There was a slight decline to 198.6 kg in 2019 and then to 197.3 kg in 2020. However, this was followed by a rise to 210.9 kg in 2021. In 2022, there was a minor drop to 195.0 kg, but by 2023, the figure rose again to 208.2 kg. There is a general upward trend in the amount of municipal waste collected per person, with fluctuations noted during the years 2019-2020 and 2022.

The following is a representation of the amount of municipal solid waste generated and the corresponding recycling rate from 2015 to 2023 (Figure 40):

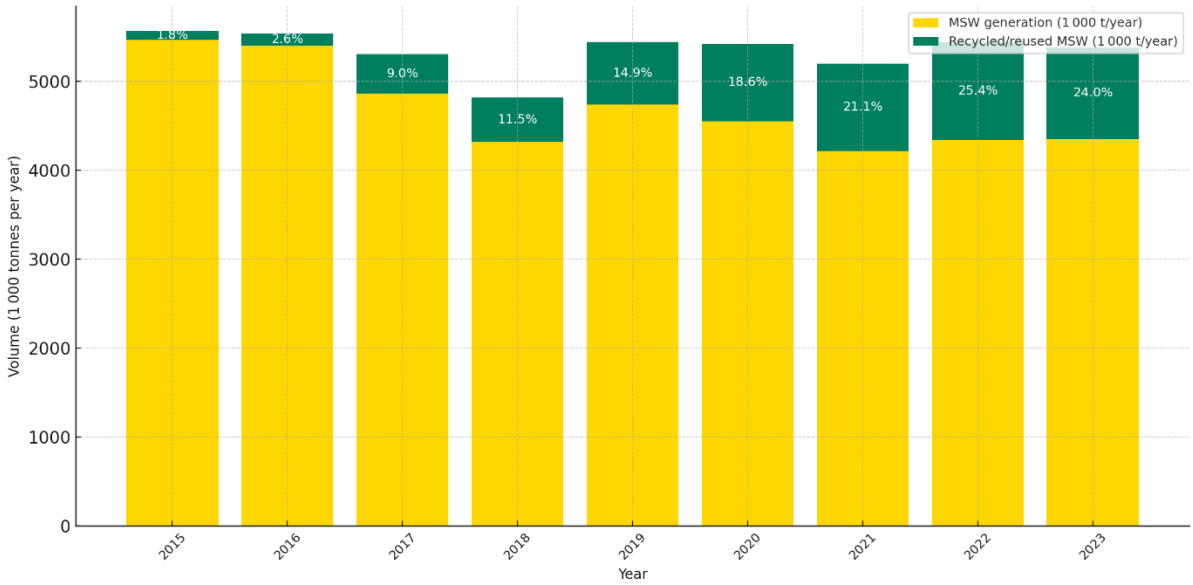


Figure 40 - The amount of municipal solid waste generated and the corresponding recycling rate from 2015 to 2023

*Note: Compiled by the author according to the [123, 124]

Between 2015 and 2018, the total generation of municipal solid waste in Kazakhstan decreased from approximately 5,467,000 tons to 4,319,200 tons. This trend reversed in 2019, with waste generation rising again to about 4,736,600 tons. From 2019 through 2023, waste generation stabilized within a range of 4,200,000 to 4,400,000 tons.

During the same period, the volumes of recycling and reuse experienced significant growth, increasing from just 99,700 tons (1.8%) in 2015 to 1,103,100 tons (25.4%) by 2022. However, there was a slight decrease to 1,029,600 tons (24.0%) in 2023. This trend highlights a rapid expansion of circular economy practices, even as overall waste volumes fluctuated.

The graph below illustrates the rate of industrial waste generation and recycling from 2015 to 2023:

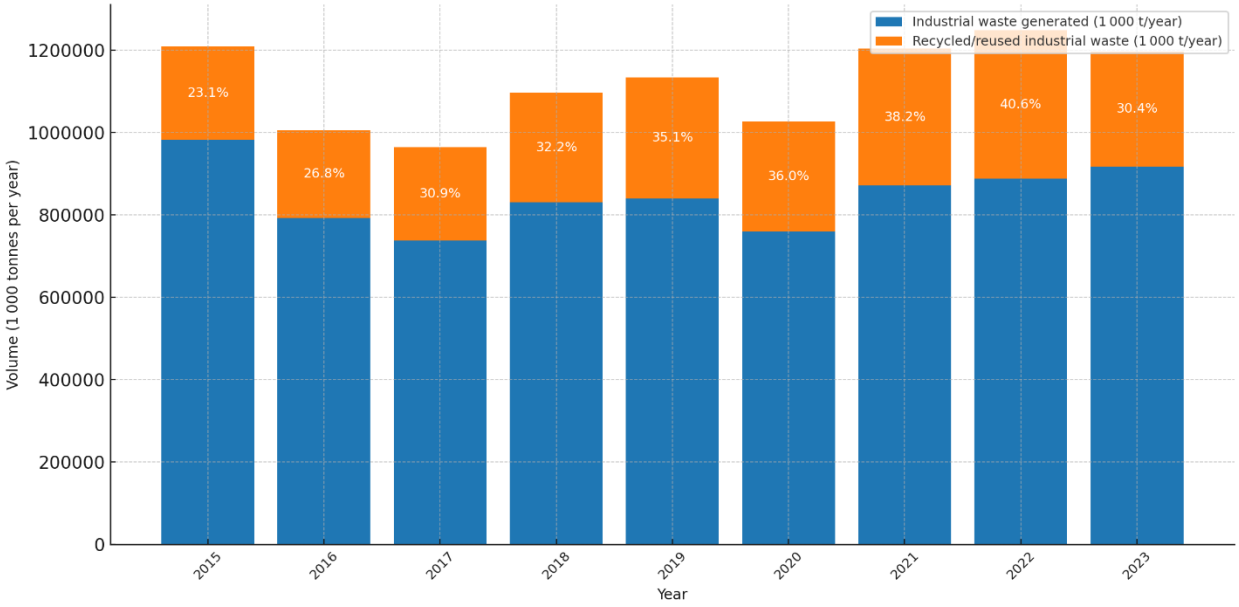


Figure 41 – Industrial waste

*Note: Compiled by the author according to the [123, 124]

Between 2015 and 2017, industrial waste generation in Kazakhstan decreased from approximately 982,236 thousand tons to 737,343 thousand tons. It then rose to about 839,646 thousand tons by 2019, dipped to 759,905 thousand tons in 2020, and climbed steadily to a peak of 917,993 thousand tons in 2023. During the same period, recycling and reuse volumes increased from 227,114 thousand tons (23.1%) in 2015 to 295,018 thousand tons (35.1%) by 2019. There was a slight decline to 266,878 thousand tons (36.0%) in 2020, followed by a surge to 360,720 thousand tons (40.6%) in 2022, before falling to 278,518 thousand tons (30.4%) in 2023. These trends highlight both the fluctuations in overall waste generation and the

improvements in industrial waste recycling rates through 2022, with a noticeable setback occurring in 2023 [124].

The Figure 42 below illustrates the trend of hazardous waste generation and recycling rates from 2005 to 2023:

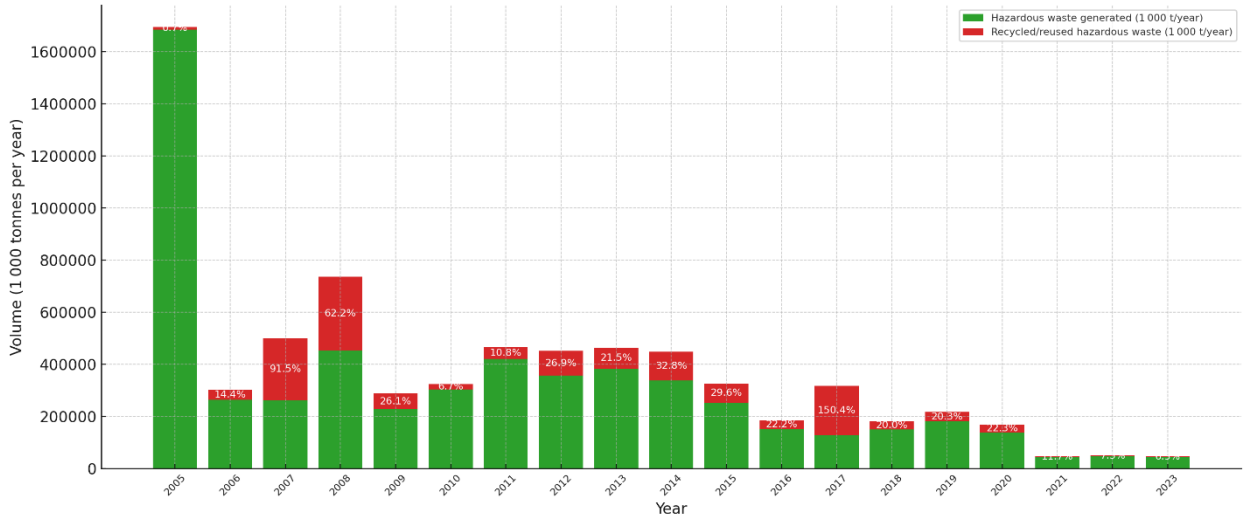


Figure 42 – Hazardous waste

*Note: Compiled by the author according to the [123, 124]

From 2005 to 2023, Kazakhstan's hazardous waste profile displayed significant year-to-year fluctuations. The generation of hazardous waste increased from approximately 263,000 tons in 2006, peaking at around 453,000 tons in 2008 and 420,000 tons in 2011. However, it then declined to under 50,000 tons by 2021 before stabilizing at around 44,000 tons in 2022 and 2023.

Recycling and reuse rates also varied considerably. They rose from just 10,900 tons (0.6%) in 2005 to over 282,000 tons (62%) in 2008, peaking at about 110,600 tons (32.8%) in 2014. Afterward, these rates fluctuated between 29,500 tons (22%) in 2016 and an anomalous 333,100 tons (150%) in 2017, before eventually settling at around 2,800 tons (6-7%) in 2022 and 2023. The given graph illustrates genuine increases in recycling capacity during the early 2010s, but it also highlights inconsistencies in later reporting. Recent years have shown much lower absolute volumes and recycling rates.

The graph below displays the management of hazardous waste in Kazakhstan between 2012 and 2023:

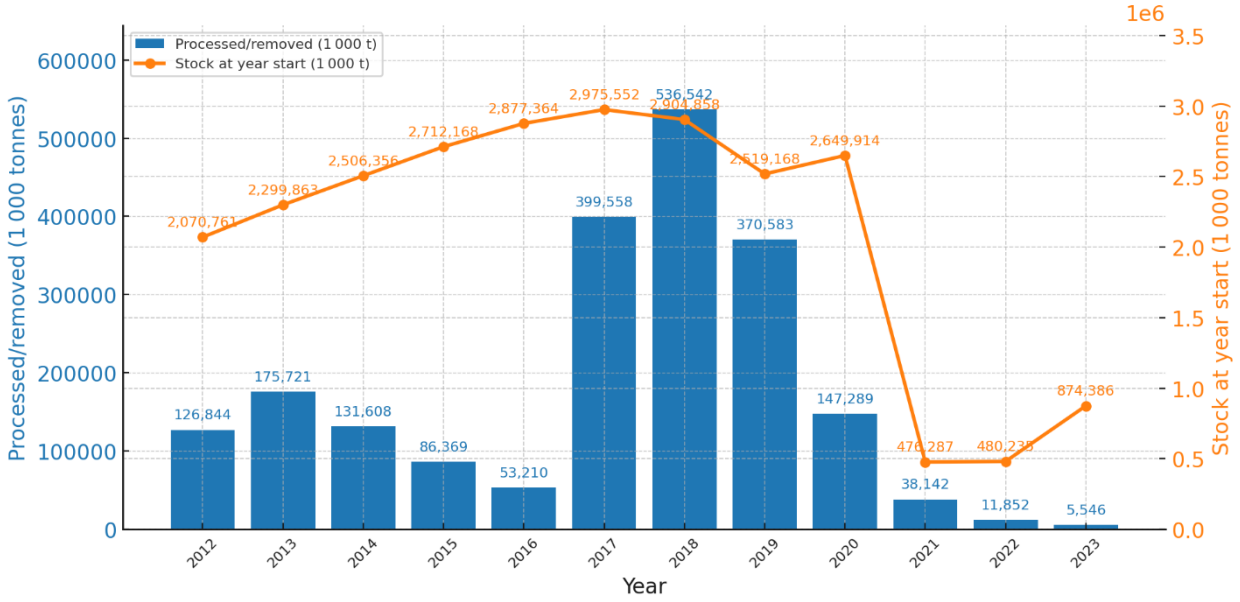


Figure 43 – Hazardous waste management

*Note: Compiled by the author according to the [123, 124]

From 2012 to 2023, the volume of hazardous waste treated or disposed of (blue bars) in Kazakhstan initially fluctuated between 127,000 and 175,000 tons in 2012–2014, then dropped to 53,000 tons by 2016, before sharply increasing to a peak of 537,000 tons in 2018 and 371,000 tons in 2019. Since 2020, treatment volumes have sharply decreased: to 147,000 tons in 2020, 38,000 tons in 2021, 11,900 tons in 2022, and only 5,500 tons in 2023. At the same time, hazardous waste stocks at the beginning of the year (orange line) gradually increased from approximately 2,070,761 thousand tons in 2012 to 2,975,552 thousand tons in 2017, then began to decline to 2,519,168 thousand tons in 2019 and sharply decreased to 476,286 thousand tons in 2021, after which they increased again to 874,386 thousand tons by 2023.

The following Figure 44 provides a more comprehensive view of the hazardous waste treatment:

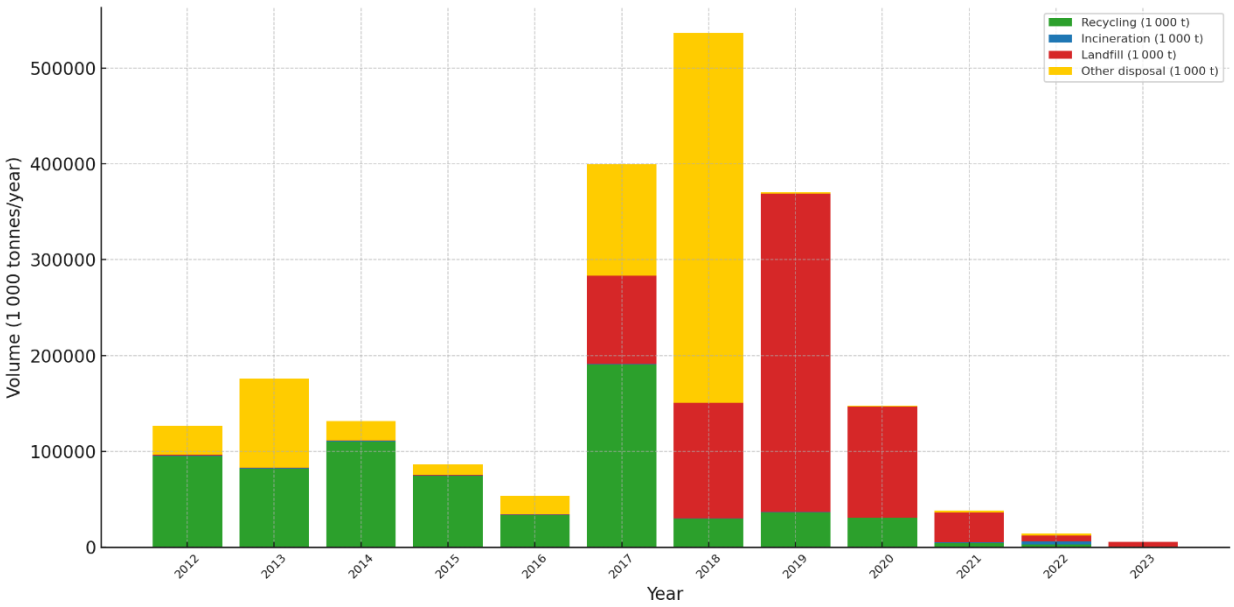


Figure 44 - Hazardous waste management by type

*Note: Compiled by the author according to the [123, 124]

The recycling figures began at 94,720 thousand tons in 2012 but dipped to 81,826 in 2013. In 2014, they climbed to 110,138, only to fall back to 74,132 in 2015 and further to 33,280 in 2016. A dramatic surge followed in 2017, reaching a peak of 190,401, before recycling volumes collapsed over the next few years, dropping to 29,625 in 2018, 36,087 in 2019, and 30,269 in 2020. By 2021, the number plunged to 4,412, then fell further to 2,735 in 2022 and just 667 in 2023, marking a steep decline in recycling activity post-2017.

Incineration started at 908 thousand tons in 2012, then dropped to 511 in 2013 and 417 in 2014. From 2015 through 2017, it remained fairly stable at 422, 378, and 385. However, it dipped to 368 in 2018, then rose slightly to 558 in 2019. It fell again to 443 in 2020, edged up to 512 in 2021, spiked to 3,389 in 2022, and then virtually disappeared by 2023 at just 7 thousand tons. This reflects minor fluctuations overall, but with negligible volume by the end of the period.

Landfilling began at 980 thousand tons in 2012, dipped to 485 in 2013, and rose gradually to 582 in 2014 and 677 in 2015. It jumped modestly to 679 in 2016, then experienced an enormous spike to 92,387 in 2017, followed by an even higher surge to 120,783 in 2018. A further peak occurred in 2019 at 332,459, after which there were declines to 116,278 in 2020, 31,246 in 2021, 6,029 in 2022, and 4,526 in 2023. This trend highlights major landfill backlogs in the late 2010s and a sharp drop thereafter.

Methods categorized as “other” started at 30,235 thousand tons in 2012 and rose sharply to 92,899 in 2013. They then decreased to 20,471 in 2014 and 11,139 in 2015 before climbing to 18,873 in 2016 and surging to 116,385 in 2017. A record high of 385,766 followed in 2018, but volumes crashed to 1,478 in 2019 and further to 299 in 2020. They recovered slightly to 1,972 in 2021 and 2,123 in 2022 before falling to 346 in 2023, reflecting extreme variability in alternative disposal methods.

Indicator: Socio-economic impact. The figure below displays the total number of total employees and employees in green jobs in Kazakhstan:

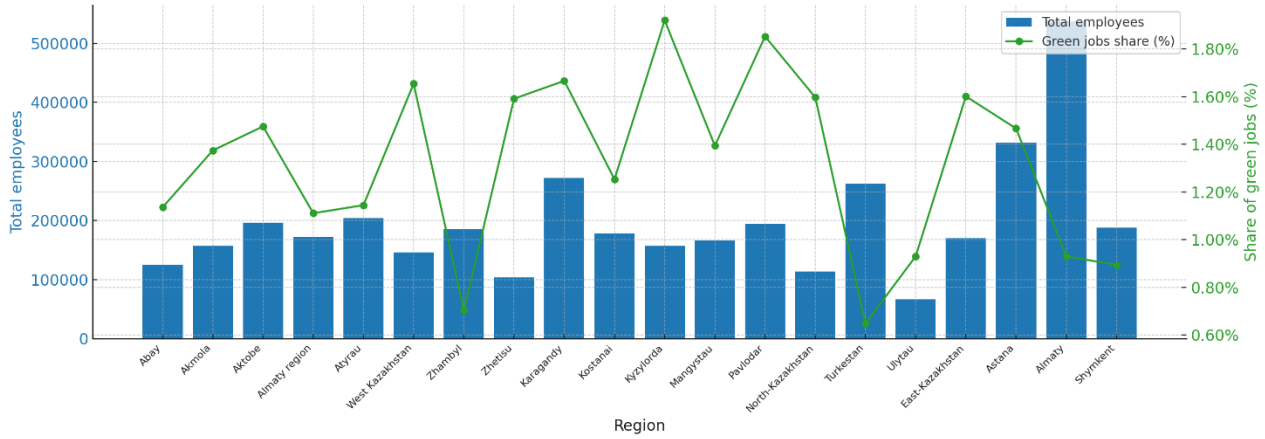


Figure 45 – Green jobs
*Note: Compiled by the author according to the [123, 124]

In 2023, total employment across regions in Kazakhstan varies significantly, with approximately 66,000 workers in Ulytau and over 537,000 in Almaty. The percentage of workers in green jobs ranges from 0.6% in Turkestan to 1.9% in Kyzylorda and Pavlodar. Notably, regions like Karaganda and East Kazakhstan have larger workforces—around 272,000 and 331,000 respectively—and also feature relatively high shares of green jobs at 1.7% and 1.5%. In contrast, smaller regions like Ulytau and Shymkent have fewer absolute numbers of green jobs (618 and 1,682, respectively) but similar percentages of around 0.9%. Green job penetration remains below 2% across all regions, despite significant variations in total employment numbers.

The following graph displays the total number of employees working in green jobs in Kazakhstan:

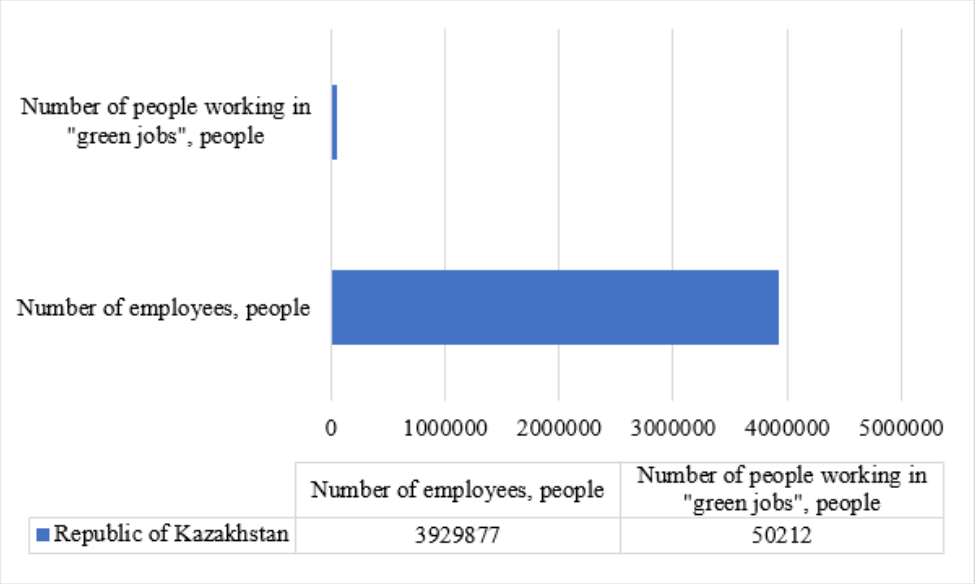


Figure 46 - The total number of employees working in green jobs in Kazakhstan

*Note: Compiled by the author according to the [123, 124]

In 2023, Kazakhstan employed a total of 3,929,877 people in large and medium enterprises, of whom just 50,212 worked in “green” occupations—equivalent to 1.3 % of the workforce. This stacked-bar visualization highlights the small minority of green-job roles relative to the overall labor force, with the green segment at the base clearly dwarfed by the much larger blue segment representing all other employees.

The following graph displays the overall count of enterprises that have implemented environmental innovations in a country:

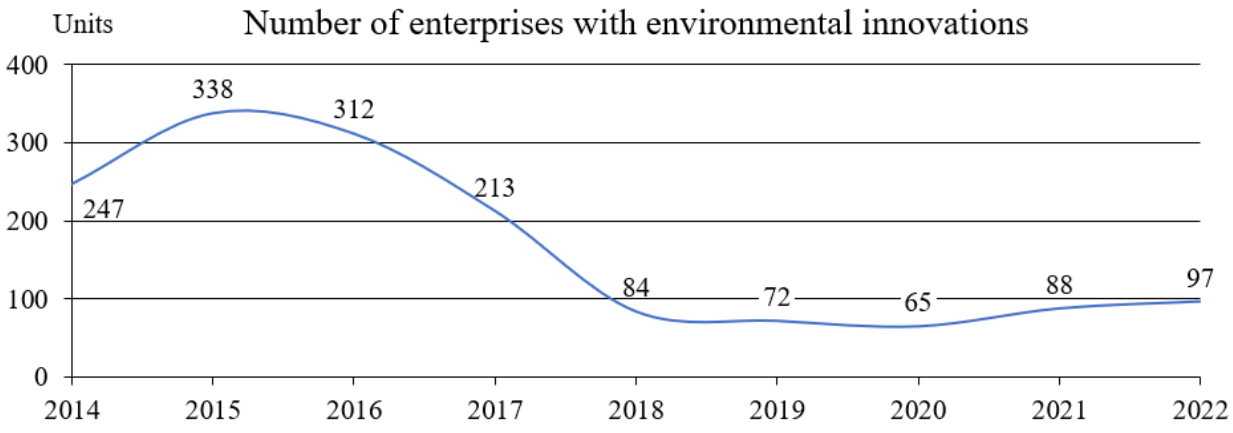


Figure 47 – Number of enterprises with environmental innovations

*Note: Compiled by the author according to the [123, 124]

There is a noticeable decrease in the number of enterprises with environmental innovations from 2014 to 2021, with a slight increase in 2022. Between 2014 and 2015, there was a significant increase from 247 to 338 enterprises. The peak occurred in 2015 with 338 enterprises. After 2015, there is a consistent decline until 2020. The sharpest decline appears between 2017 and 2018.

The graph below displays the total number of scientific and scientific-technical projects related to the concept of “green economy”:

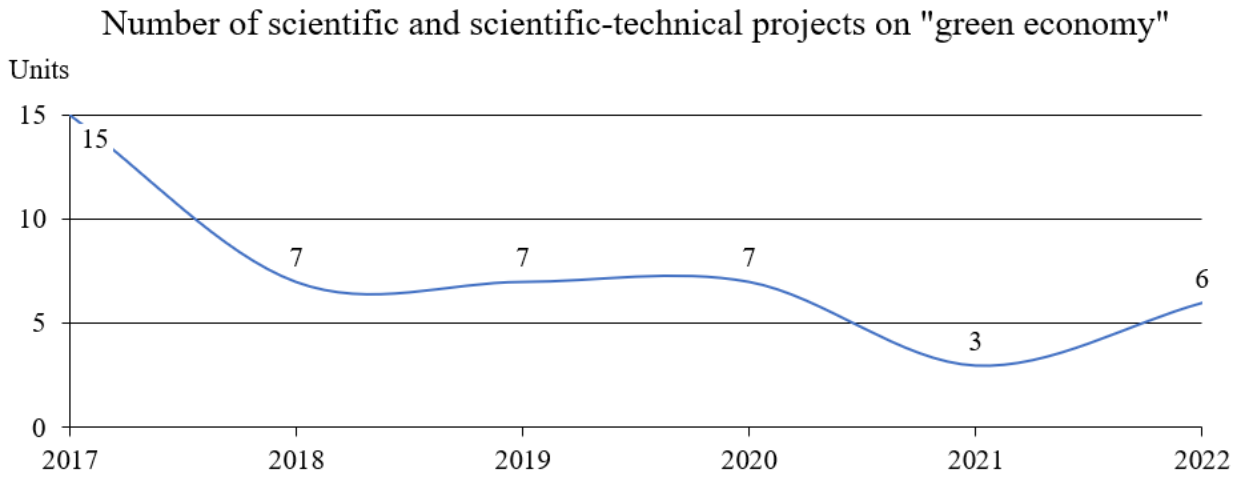


Figure 48 – Number of scientific and scientific-technical projects on green economy

*Note: Compiled by the author according to the [123, 124]

According to Figure 48, there was a significant drop from 15 projects in 2017 to 7 in 2018, which was maintained in 2019 and 2020. The number of projects remained stable at 7 for three consecutive years (2018-2020), which indicates a period of consistency or possibly a limit in capacity or funding for such projects. There's a noticeable decline to 3 projects in 2021. In 2022, the number increased to 6.

Empirical analysis of circular economy development in Kazakhstan

The next phase of this study involved hypothesis testing through data regression analysis.

Hypothesis: The current level of waste management costs positively impacts the level of recycling and reuse in Kazakhstan.

Data for both statistical and regression analyses were obtained from the official website of the Bureau of National Statistics, part of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. The analysis focused on annual data, and the study period selected was from 2015 to 2021, based on the availability of the data [124].

The dependent variable considered was the level of recycling and reuse of waste in Kazakhstan, measured in two ways: in absolute terms (thousand tons per year) and as a percentage of total waste generation.

In this study, waste is defined as the entirety of all types of waste, including:

- Solid household waste
- Municipal waste
- Industrial waste
- Hazardous waste.

Table 15 – Dependent and independent regression variables

Notation	Variable
y1	dependent variable, the share of reuse and recycling of the waste in the total volume of waste generation, %
y2	dependent variable, the volume of reuse and recycling of waste, thousand tons
x1	the volume of current costs for waste management, mln tenge
x2	investments in waste management, mln tenge
x3	generation of all types of waste, thousand tons
x4	the intensity of waste generation per capita, kg
x5	population, million people
x6	GDP at constant 2005 prices, million tenge
Note: Compiled by the authors	

The indicators shown in Table 15 were chosen as independent variables for the analysis [124].

To avoid endogeneity, the dependent variables in the model are lagged by one year. This approach helps eliminate the effects of potential simultaneity. If the explanatory variables are measured during the same time period as waste recycling and reuse, it could introduce endogeneity, since these processes do not occur immediately. By including lagged regressors, we can address this issue effectively.

Table 16 - Descriptive statistics

Variable	*Obs*	*Mean*	*Std. dev.*	*Min*	*Max*
y1	6	29,492	12,835	8,325	48,09
y2	6	271023,1	131231,2	29961,9	419587,8
x1	6	55328,73	8902,841	42104,86	66280,73
x2	6	9528,763	2826,001	6209,542	14130,75
x3	6	1003211	133830,1	872496,5	1242505
x4	6	55370,86	8318,429	48305,04	70827,03
x5	6	18,153	0,452	17,543	18,756
x6	6	13826266,07	755723,6	12919190,1	14794066,7
Note: Compiled by the authors					

Prior to constructing the regression model, a test for multicollinearity was conducted among the explanatory variables to prevent specification errors. The findings of the correlation matrix are displayed in Table 17.

Table 17 – Correlation matrix for independent variables

	x1	x2	x3	x4	x5	x6
x1	1					
x2	0,157	1				
x3	0,067	0,532	1			
x4	-0,072	0,462	**0,988**	1		
x5	**0,794**	-0,197	-0,507	-0,625	1	
x6	**0,903**	-0,203	-0,315	-0,445	**0,937**	1
Note: Compiled by the authors						

As shown in Table 17, the variables x5 (population) and x6 (GDP) are closely related to the main variable of interest, x1, which represents the volume of current costs for waste management. Therefore, these two variables have been excluded from the model. Additionally, there is a strong correlation between x3 (generation of all types of waste) and x4 (intensity of waste generation per capita). As a result, we will not consider these two variables together in the same model during the subsequent stages of the study.

For model evaluation, two specifications were selected. One model includes the generation of all types of waste as an independent variable, while the other includes the intensity of waste generation per capita. In both specifications, the dependent variable is the volume of reuse and recycling of waste, measured in thousands of tons rather than in percentage terms. When the share of reuse and recycling in total waste generation was used, neither the overall model equation nor the coefficients of the variables showed statistical significance.

Both model specifications are presented in Table 18 (Equations I and II). For each model, the Fisher test assesses the quality and statistical significance of the overall model equation. Regression analysis was conducted using the STATA statistical software package [124].

Table 18 – Results of the regression analysis, dependent variable – y2 (volume of reuse and recycling of waste)

Independent variable	Equation	
	I	II
x1 – the volume of current costs for waste management	-5,982 (3,668)	-3,959 (4,211)
x2 – investments in waste management	-57,32 (18,31)	-55,114 (19,876)
x3 – generation of all types of waste	1,047 (0,383)	
x4 – the intensity of waste generation per capita		16,075 (6,685)
Constant	97969,32 (343008,5)	125151,8 (376879,5)
Number of observations	6	6
R^2	0,88	0,85
Fisher test	F(3, 2) = 6,9 [0,042]	F(3, 2) = 6,5 [0,04]
Note – in parentheses are the standard errors of the regression coefficient. Compiled by the authors		

The analysis showed that although the overall model had a high coefficient of determination and was statistically significant, the coefficients for all variables were not statistically significant, even at the 10% level. Consequently, the hypothesis that the volume of current waste management costs has a positive and significant impact on the levels of recycling and reuse of waste in Kazakhstan has been disproven. This suggests that there is insufficient correlation between current waste management costs and the levels of recycling and reuse of waste in Kazakhstan [124].

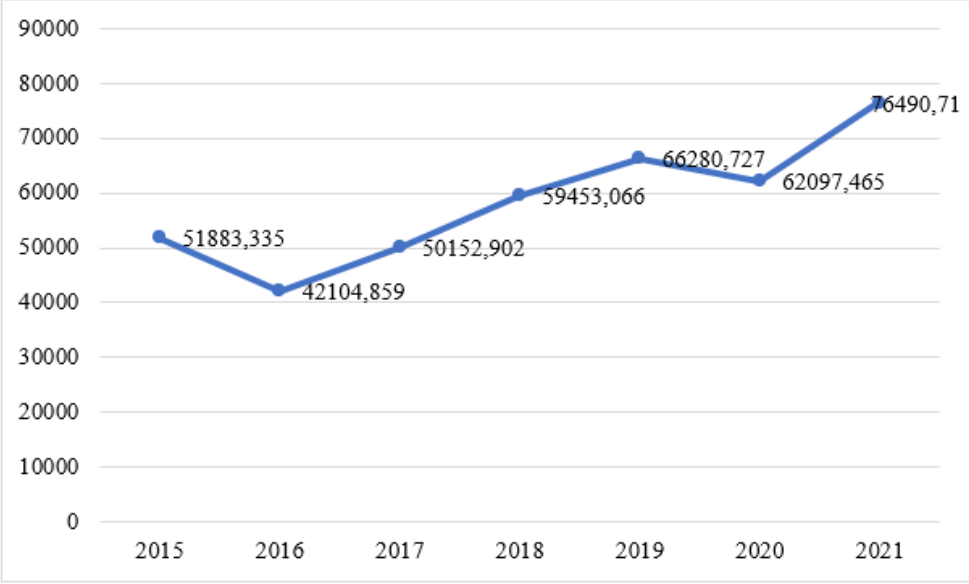


Figure 49 – The volume of current costs for waste management, million tenge

*Note: Compiled by the author

Each year, waste management costs account for about 30% of total environmental expenses, and this percentage is on the rise. In 2021, these costs exceeded 75 billion tenge. Regression analysis suggests that simply increasing

funding for waste management does not effectively improve reuse and recycling rates.

To sum up, the volume of waste generated tends to grow even more rapidly. To positively impact funding for waste management, it is essential to first reduce the generation of all types of waste by raising environmental awareness among both individuals and businesses [124].

Systemic errors and governance issues

In Kazakhstan, several systemic issues and governance challenges impede progress. These problems arise from inconsistencies in policy implementation, inadequate coordination among governmental bodies, and a lack of comprehensive monitoring systems.

Table 19 – Issues and interpretations

Issues	**Interpretation**
Fragmented policy implementation	Circular economy initiatives are often implemented independently by various ministries without a unified national strategy. There is limited synchronization between environmental, economic, and industrial policies, leading to inefficiencies.
Insufficient monitoring and data collection	The absence of a centralized system for tracking CE indicators complicates the evaluation of progress. Inconsistent data collection across regions undermines the reliability of national statistics.
Lack of incentives for businesses	While some tax incentives exist, they are insufficient to motivate widespread adoption of CE practices among enterprises. Limited access to green financing further hampers business participation in circular initiatives.
Public awareness and engagement	Public awareness campaigns are sporadic and not comprehensive, resulting in low participation in waste sorting and recycling.
Underdeveloped infrastructure	The availability of waste sorting and recycling facilities is inconsistent across Kazakhstan. Rural areas, in particular, suffer from a lack of infrastructure, making it difficult for residents to engage in proper waste management practices. Additionally, many urban centers lack adequate eco-points for recycling collection.
Note - Compiled by the author	

Despite the positive developments in Kazakhstan's transition to a circular economy (CE), several systemic issues and governance challenges hinder progress. These problems stem from inconsistencies in policy implementation, insufficient

coordination between governmental bodies, and a lack of comprehensive monitoring systems.

One of the most significant barriers is fragmented policy implementation. Circular economy initiatives are often implemented independently by various ministries without a unified national strategy. This lack of cohesion results in duplicated efforts, missed opportunities for synergy, and inefficient resource allocation. Environmental, economic, and industrial policies are not sufficiently synchronized, leading to inconsistencies and gaps in achieving sustainability goals.

Another important challenge is that there is no central system for tracking CE indicators. In the absence of developed monitoring frameworks, it becomes impossible to measure progress and determine areas that need improvement. Data collection methods differ from one region to another, leading to unreliable and unverified national data. This disunity makes it difficult to design evidence-based policies and also impedes the evaluation of current programs' effectiveness.

Without any incentive to change, companies would be more reluctant to adopt circular practices. Although tax incentives have been provided, they are not enough to encourage a radical change. Companies are also partially restricted in accessing green financing, which makes it difficult for them to invest in sustainable technologies and processes. This financial barrier constitutes discouragement for businesses to move with circular models and diminishes overall participation in CE initiatives.

Public awareness and participation is another important aspect. The outreach programs are occasional and not at all comprehensive, resulting in low citizen participation in waste segregation and recycling initiatives. Most people do not understand the advantages of circular practices or what they could contribute to making sustainability happen. It is hard to change behavior on a large scale without sustained, targeted education.

Toward such an integrated approach, where improved coordination among different agencies is also required, as well as enhanced frameworks for data collection, stronger business incentives and comprehensive public awareness campaigns. With the implementation of these measures, Kazakhstan will be able to transition faster toward a circular economy while ensuring sustainably developed resilient environmental in the long term.

In conclusion, this sub-chapter addresses the overall progress of the circular economy (CE) in the Republic of Kazakhstan macro. Key indicators based on the Bellagio Principles have been framed to analyze the movement regarding the circular economy in different dimensions: environmental, material, waste, and socio-economic.

The findings of this paper imply that Kazakhstan is moving toward a circular economic model but has yet to overcome many challenges. The footprint analysis shows the changing trend of greenhouse gas emissions, where fall periods have been noted due to the impact of economic restructuring and external factors like the COVID-19 pandemic on emissions. Inconsistencies in the recycling and reuse of water resources indicate that these areas still have potential for improvement in sustainability practices. In contrast, waste generation studies show that total waste

production has increased consistently, implying that waste management efforts must be scaled up to counteract the rising intensity of waste per unit of GDP. On the bright side, municipal solid waste recycling and reuse have been growing steadily but at a lesser rate than needed for a fully circular economy.

A regression analysis tested the hypothesis that current waste management expenditures significantly affect recycling and reuse rates in Kazakhstan. The results refuted this hypothesis, suggesting that simply increasing financial allocations is not enough to advance progress in the field of CE. Instead, a systemic approach is needed that combines policy coordination, business incentives, public awareness, and infrastructure development.

2.3 An empirical analysis of circular behavior and stakeholder readiness: results of a questionnaire and expert survey

This subchapter presents an empirical investigation of circular behaviour and stakeholder readiness in Kazakhstan, structured in two parts. The first part describes a nationwide population survey conducted via a 5-point Likert questionnaire and analysed using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS 3. The theoretical model and hypotheses address the effects of circular awareness, mindset, and external factors on pro-circular behaviour and sharing.

The second part outlines an expert survey across business, government, academia, and NGOs. Sample formation, questionnaire domains, and statistical methods in SPSS 25 are described [125].

Population survey

For the quantitative analysis, the method of structural modelling based on partial least squares (PLS-SEM) using SmartPLS 3 software was used. This method allows for the identification of relationships between latent variables and assesses their impact on circular behavior. The main method of primary data collection was a population questionnaire.

Hypotheses:

H1. The level of circular awareness has a positive effect on the pro-circular behavior of the population.

H2. A circular mindset positively influences the pro-circular behavior of the population.

H3. External factors determine the pro-circular behavior of the population.

H4. Pro-circular behavior has a positive effect on circular sharing.

The study was conducted through a survey, which included 3448 respondents. The questionnaire assessed participants' awareness of the circular economy, external influencing factors, and their readiness to engage in circular behaviors. Responses were measured on a 5-point Likert scale, where 1 represented “completely disagree” and 5 indicated “completely agree.” The data were analyzed using SmartPLS 3 to evaluate the hypotheses through Partial Least Squares Structural Equation Modeling (PLS-SEM) [125].

Table 20 - Demographic characteristics of respondents

Characteristics	***Name***	***Percentage***
Gender	Man	48,8
	Woman	51,2
Age	Under 18 years	3,3
	19-29 years	45,1
	30-45 years	43,9
	46-55 years	6
	56-65 years	1,7
	66 years and more	0,1
Education	Secondary general education	7,7
	Secondary specialized (technical school, college, etc)	15,9
	Incomplete Higher	12,4
	Higher (including bachelor's and master's degrees)	64
Income	Under 60 000 tenge	21,8
	61 000 – 100 000 tenge	15,8
	101 000 – 200 000 tenge	28
	201 000 – 300 000 tenge	17,2
	301 000 – 400 000 tenge	9,8
	More than 401 000 tenge	7,4
Locality	City of republican significance	42,9
	City of regional significance	24,1
	City of district significance	12,8
	Village	20,2

The following calculations were conducted using the Smart PLS 3 program to assess the reliability of the proposed research model. Convergent validity determines the dependability of a researcher's findings. Table 21 presents the variables along with their results for convergent validity. According to Cronbach's Alpha, constructs with a score higher than 0.70 are considered reliable. The results show that circular awareness ($\alpha = 0.877$), pro-circular behavior ($\alpha = 0.852$), circular mindset ($\alpha = 0.946$), circular sharing ($\alpha = 0.887$), and external factors ($\alpha = 0.819$) exhibit convergent validity [125].

Cronbach's Alpha evaluates the internal consistency of the variable statements within a model. However, it may sometimes under- or overestimate scale reliability, which is why composite reliability is favored by researchers using Smart PLS. According to prior studies, a composite reliability score of 0.70 or higher is considered acceptable, with a score of 0.80 reflecting good reliability.

Additionally, as noted by Chin (1998) and Höck & Ringle (2006), the Average Variance Extracted (AVE) should exceed 0.50 for a construct to be deemed acceptable. In our study, three out of five constructs met this criterion, while the other two recorded AVE values of 0.454 (pro-circular behavior) and 0.428 (circular sharing).

Table 21 – Convergent validity

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Circular awareness	0.877	0.879	0.910	0.670
Pro-circular behavior	0.852	0.863	0.881	0.454
Circular mindset	0.946	0.958	0.958	0.821
Circular sharing	0.887	0.894	0.905	0.428
External factors	0.819	0.830	0.881	0.651

Convergent validity assesses the reliability of research conducted by a researcher. The results for various constructs are outlined in the first column, indicating their convergent validity scores based on Cronbach's Alpha. Constructs with a Cronbach's Alpha higher than 0.70 are generally considered reliable. In this study, the following constructs demonstrated reliability: circular awareness (α = 0.877), circular mindset (α = 0.946), pro-circular (α = 0.852), external factors (α = 0.819), and sharing (α = 0.887) [125].

However, it is important to note that Cronbach's Alpha can either underestimate or overestimate scale reliability. Therefore, composite reliability is preferred by researchers using PLS (Partial Least Squares) methods. According to various studies (Chin, 1998; Höck & Ringle, 2006; Henseler, Ringle, & Sarstedt, 2012; Daskalakis & Mantas, 2008), composite reliability is considered acceptable when the score is equal to or greater than 0.70 or 0.80.

Additionally, as discussed in the works of Chin (1998) and Höck & Ringle (2006), the Average Variance Extracted (AVE) is deemed acceptable when it exceeds 0.50. In this study, three out of five constructs achieved scores higher than 0.50, while two constructs had AVE scores of 0.454 and 0.428, respectively.

Table 22 – Discriminant validity

	Circular awareness	Pro-circular behavior	Circular mindset	Circular sharing	External factors
Circular awareness	**0.819**				
Pro-circular behavior	0.472	**0.674**			
Circular mindset	0.233	0.442	**0.906**		
Circular sharing	0.246	0.439	0.339	**0.654**	
External factors	0.257	0.480	0.678	0.491	**0.807**

Table 22 outlines the Fornell–Larcker discriminant validity criterion. This criterion indicates that research is well-structured when the square root of the Average Variance Extracted (AVE) for each latent variable is greater than its correlation with any other constructs. In our study, the square root of the AVE for each construct was indeed higher than its correlation with other constructs: CA = 0.819 (the highest), CM = 0.906 (the highest), EF = 0.807 (the highest), CB = 0.674 (the highest), and SHR = 0.654 (the highest) [125].

Table 23 – Total effects

	Original Sample (O) (Path coeff.)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Circular awareness -> Pro-circular behavior	0.405	0.406	0.026	15.738	0.000
Circular awareness -> Circular sharing	0.203	0.204	0.016	12.630	0.000
Pro-circular behavior -> Circular sharing	0.500	0.503	0.029	17.235	0.000
Circular mindset -> Pro-circular behavior	0.104	0.101	0.044	2.341	0.020
Circular mindset -> Circular sharing	0.052	0.051	0.022	2.374	0.018
External factors -> Pro-circular behavior	0.367	0.370	0.048	7.658	0.000
External factors -> Circular sharing	0.183	0.187	0.029	6.313	0.000

Table 23 presents the results of the total effects analyzed. The total effect of circular awareness on external factors was found to be positive and highly significant ($p < 0.01$). Similarly, the total effect of a circular mindset on external factors was also positive and significant ($p < 0.05$). Furthermore, the total effect of circular behavior on external factors was highly significant ($p < 0.01$). Lastly, the total effect of circular behavior on sharing was positive and highly significant ($p < 0.01$). This indicates that all four null hypotheses were rejected [125].

The calculations presented were made using the Smart PLS 3 program. As shown in the structural model and path coefficients (Figure 50), the direct impact of circular awareness on pro-circular behavior intentions is both positive and significant ($\beta = 0.405$, $p < 0.001$). Hypothesis 1 (H1) suggests that the level of circular awareness positively influences the pro-circular behavior of the population.

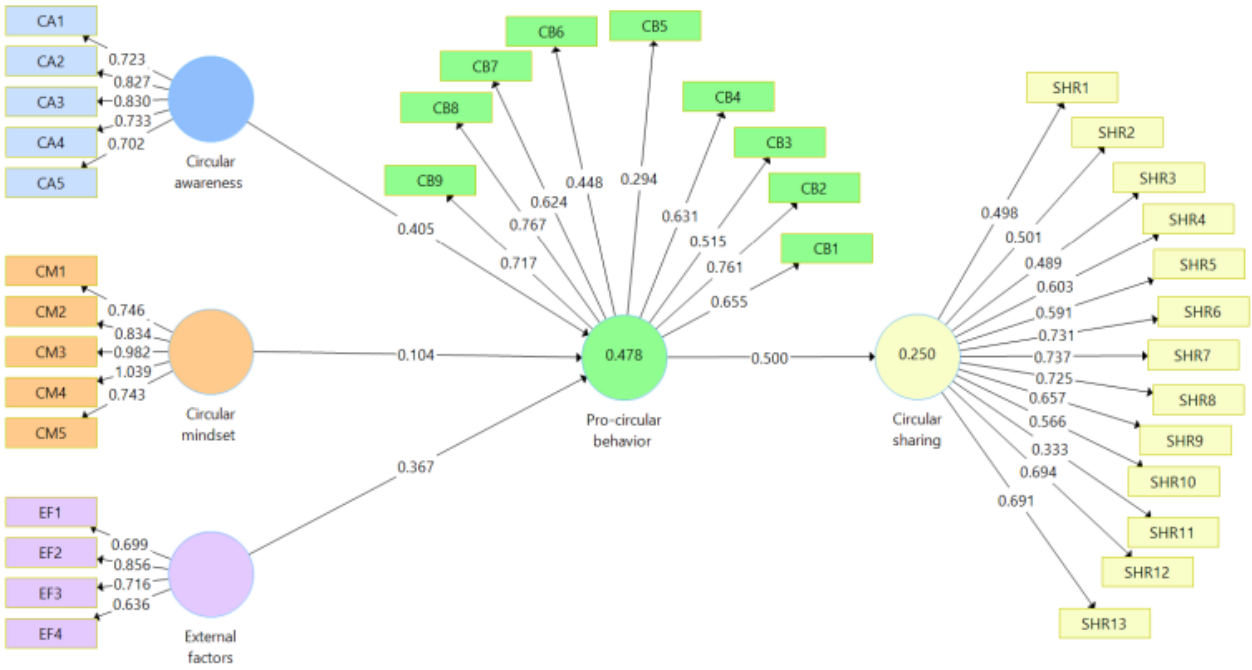


Figure 50 – Structural model and path coefficients

*Note: Adapted from the [125]

Table 24 – Total effects

	Original Sample (O) (Path coeff.)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Circular awareness -> Pro-circular behavior	0.405	0.406	0.026	15.738	0.000
Circular awareness -> Circular sharing	0.203	0.204	0.016	12.630	0.000
Pro-circular behavior -> Circular sharing	0.500	0.503	0.029	17.235	0.000
Circular mindset -> Pro-circular behavior	0.104	0.101	0.044	2.341	0.020
Circular mindset -> Circular sharing	0.052	0.051	0.022	2.374	0.018
External factors -> Pro-circular behavior	0.367	0.370	0.048	7.658	0.000
External factors -> Circular sharing	0.183	0.187	0.029	6.313	0.000

The earlier conclusion is reinforced when evaluating the specific indirect effects of various variables on circular sharing through pro-circular behavior. Both circular awareness ($\beta = 0.203$) and external factors ($\beta = 0.183$) positively influence circular sharing, with a significance level of $p < 0.01$ [125].

Table 25 - Specific indirect effects

	Original Sample (O) (Path coeff.)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Circular awareness -> Pro-circular behavior -> Circular sharing	0.203	0.204	0.016	12.630	0.000
External factors -> Pro-circular behavior -> Circular sharing	0.183	0.187	0.029	6.313	0.000
Circular mindset -> Pro-circular behavior -> Circular sharing	0.052	0.051	0.022	2.374	0.018

According to hypotheses H2 and H3, both a circular mindset ($\beta = 0.104$, $p < 0.005$) and external factors ($\beta = 0.367$, $p < 0.001$) have a positive impact on the pro-circular behavior of the population. Additionally, pro-circular behavior is significantly related to circular sharing ($\beta = 0.500$, $p < 0.001$). Therefore, all hypotheses were supported. It is important to note that circular awareness influences pro-circular behavior more than the other factors examined. Furthermore, the mediating role of pro-circular behavior between various factors and circular sharing was validated; the total and specific indirect effects were analyzed. Overall, circular awareness, circular mindset, and external factors positively influence both pro-circular behavior and circular sharing. Except for the relationship between circular mindset and pro-circular behavior as well as sharing, all indicators are significant at $p < 0.01$. Previous conclusions are reaffirmed when assessing the specific indirect effects of the variables on circular sharing through pro-circular behavior. Circular awareness ($\beta = 0.203$) and external factors ($\beta = 0.183$) positively impact circular sharing, both with a significance level of $p < 0.01$ (Table 26).

Table 26 – Hypothesis testing results

		Original Sample (O) (Path coeff.)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Supported (Yes/No)
H 1	Circular awareness -> Pro-circular behavior	0.405	0.406	0.026	15.738	0.000	Yes
H 2	Pro-circular behavior -> Circular sharing	0.500	0.503	0.029	17.235	0.000	Yes
H 3	Circular mindset -> Pro-circular behavior	0.104	0.101	0.044	2.341	0.020	Yes
H 4	External factors -> Pro-circular behavior	0.367	0.370	0.048	7.658	0.000	Yes

Analysis of the coefficients showed that all directions of influence are significant. Particularly noteworthy are the relatively high coefficients of circular awareness and external factors influencing pro-circular behavior. In turn, pro-circular behavior also has a positive effect on sharing. At the population level, circular awareness and external factors are more influential: we are talking about government support in the development of environmental infrastructure and the stimulation of environmentally friendly behavior. In addition, as the study showed, the level of awareness is not always a trigger for pro-circular behavior of the population.

Based on the results of the analysis in SmartPLS 3, the following conclusions can be drawn:

• Awareness of the circular economy is a key factor influencing circular behavior.

• External incentives, including government support and infrastructure development, play a decisive role.

• Implementation of circular economy principles requires an integrated approach involving all stakeholders [125].

Expert survey

To obtain objective and reliable data, an expert survey was conducted to identify barriers, opportunities and prospects for the development of the circular economy in Kazakhstan. The expert survey method was chosen as one of the most effective tools for analyzing complex social, economic and environmental processes.

Formation of a sample of experts

At the initial stage, a list of potential experts (about 100 people) representing key areas was compiled:

— Business and industry

— Government and financial institutions

— Scientific and educational organizations

— Public institutions, NGOs and international organizations

From the general list, 100 experts were invited to participate in the study, of whom 54 agreed to participate. Table 27 shows the distribution of experts by field of activity [126].

Table 27 - Distribution of experts by areas of activity

Field of activity	Share	Number of experts for distribution	Final sample
Business & Industry	30%	30	15
Science/Education	25%	25	13
Government institutions	25%	25	15
NGOs, international organizations, etc.	20%	20	12
Total	100%	100	54

The survey was developed taking into account international experience in assessing readiness for the circular economy and included questions in the following areas:

— level of implementation of the principles of the CE
— readiness of business and industry
— level of government support
— readiness of science, education and public institutions
— level of awareness of society and consumers

Experts assessed factors on a Likert scale from 1 to 5, where 1 is a low level and 5 is a high level.

An analysis of the respondents' profile was conducted to check the expert sample's relevance. Table 28 presents the main characteristics of the experts: field of activity, number of employees in the organization, and position held.

Table 28 - Profile of the experts

Question	Answer options	Frequency	Percent
Your activity	Business & Industry	12	22,2
	Science/Education	18	33,3
	State structures	13	24,1
	NGOs, international organizations, etc.	11	20,4
	Total	54	100
Number of employees in the organization	To 10	16	29,6
	11-50	13	24,1
	51-100	6	11,1
	101-250	8	14,8
	Over 250	11	20,4
Your position	Total	54	100
	CEO / Head	14	25,9
	Head of department	7	13
	Employee	33	61,1
	Total	54	100

During the study, key parameters for assessing stakeholders' readiness level for the transition to the CE were identified. All parameters were grouped into 5 main areas:

1. CE principles.
2. Readiness of business and industry.
3. Readiness of government and financial institutions.
4. Readiness of science, education and public organizations.
5. Readiness of society and consumers [126].

Each direction included a number of sub-parameters, presented in detail in the Table 29.

Table 29 - Parameters for assessing the readiness of stakeholders for the CE

Parameter	Sub-parameter
1. Principles of CE (P)	Improving the efficiency of product use: reusing a product that performs its original function (reuse) (P1)
	Recycling (P2)
	Product restoration and renewal (remanufacture): repair and maintenance of the product, changing product parameters, using parts of an obsolete product in a new product (P3)
	Using fewer natural resources and materials in the production of goods. (reduce) (P4)
	Transferring the product to the category of excess. Product rejection (refuse) (P5)
	Transferring product features to another product (repurpose) (P6)
2. Business and industry readiness level (BI)	Optimizing the use of raw materials and utilizing environmentally friendly materials (BI)
	Effective utilization of production resources, materials, and human capital (BI2)
	Reducing the consumption of resources in the production process (BI3)
	Minimizing waste during production and consumption (BI4)
	Minimization of environmental pollution (BI5)
	The availability of reverse logistics, the extension of product lifespan, and the reuse of components (BI6)
	Development of eco-design of the product, using the principles of the circular economy at the stage of product design (BI7)
	The level of competence of personnel in green technologies (BI8)
	The presence of a corporate environmental culture (BI9)
	Apply digital technologies for more efficient use of resources (BI10)
	Use of renewable energy sources and renewable materials (BI11)
3. Level of readiness of state and financial institutions (GFI)	State support for circular business models (GFI1)
	Investing in eco-projects (GFI2)
	Development of innovative projects on green technologies (GFI3)
	Development of “green” finance and socially responsible investment (GFI4)
	Legal and regulatory support for the development of a circular economy (GFI5)
	Development of infrastructure in settlements for efficient waste disposal (GFI6)
	Recycling household waste and ensuring its environmentally friendly disposal (GFI7)
	Recycling and reuse of industrial waste (GFI8)

4. The level of readiness of science and education, public institutions (SE)	Training in the circular economy (environmental industry, etc.) (SE1)
	Updating the content/competence of educational programs (SE2)
	Development of R&D on green technologies (SE3)
	Development of public initiatives, NGOs and other organizations on environmental issues, green technologies, etc. (SE4)
	Application of the principles of DE in the university/educational institution itself (SE5)
5. The level of readiness of society, consumers (SC)	The level of development of "green" consumption (SC1)
	The level of public awareness of the circular economy (SC2)
	Repair and reuse of products (second-hand market, repair of household appliances) (SC3)
	The level of waste sorting by the population (SC4)
	Reducing consumption or abandoning excesses in favor of the environment (SC5)
	The level of development of sharing consumption (rental, carsharing, etc.) (SC6)

To assess the internal consistency of the measurement scale, the Cronbach's α coefficient was calculated. The calculations showed high reliability for all groups of factors ($\alpha > 0.8$), which confirms the logical and internal consistency of the selected parameters [126].

Table 30 - Cronbach's alpha coefficients for the parameters

1. The level of implementation of circular economy principles	0,81	6
2. The level of readiness of business and industry	0,86	11
3. The level of readiness of government and financial institutions	0,86	8
4. The level of readiness of science and education, public institutions	0,83	5
5. The level of readiness of society, consumers	0,82	6
	0,84	36

Data analysis was performed using SPSS 25 software. The following statistical methods were used in the processing:

— Analysis of variance (ANOVA) – to identify significant differences between stakeholder groups.
— Correlation analysis – to determine relationships between indicators.
— Paired comparisons – to identify significant differences between groups.

The results of the analysis of variance are shown in Table 31.

Table 31 - Results of ANOVA on the principles of CE

		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
P1	Between Groups	14,238	4	3,56	3,414	0,015
	Within Groups	51,095	49	1,043		
	Total	65,333	53			
P2	Between Groups	11,039	4	2,76	4,263	0,005
	Within Groups	31,72	49	0,647		
	Total	42,759	53			
P3	Between Groups	14,142	4	3,536	3,499	0,014
	Within Groups	49,506	49	1,01		

	Total	63,648	53			
P4	Between Groups	7,277	4	1,819	2,184	0,085
	Within Groups	40,815	49	0,833		
	Total	48,093	53			
P5	Between Groups	8,476	4	2,119	2,276	0,074
	Within Groups	45,617	49	0,931		
	Total	54,093	53			
P6	Between Groups	10,656	4	2,664	3,017	0,027
	Within Groups	43,27	49	0,883		
	Total	53,926	53			

To identify differences in the perception of circular economy principles among different stakeholder groups, an analysis of variance (ANOVA) was conducted (Table 31). This method allowed us to determine whether there were statistically significant differences in assessments between groups, which helps to identify problematic aspects of circular economy implementation [126].

The results of the analysis showed that statistically significant differences ($p < 0.05$) were observed for such principles as Reuse ($p = 0.015$), Recycling ($p = 0.005$), Remanufacture ($p = 0.014$), and Repurpose ($p = 0.027$). This indicates that stakeholders perceive these aspects of the circular economy differently, which may create barriers to their effective implementation.

No statistically significant differences were found between the groups regarding the principles of reducing resource consumption (Reduce, $p = 0.085$) and refusing excessive consumption (Refuse, $p = 0.074$). This suggests that these principles are perceived by all stakeholders in the same way, which may indicate either uniform implementation or a general lack of awareness of them. The most significant differences in assessments, as indicated by high F values, were observed for the principles of recycling (Recycling, $F = 4.263$) and reuse (Reuse, $F = 3.414$). This highlights the importance of more active dissemination of information and incentives for stakeholders to implement these principles.

Correlation analysis demonstrated a high degree of interrelationship between the different stakeholder groups [126].

Table 32 - Pairwise correlation of stakeholder readiness level

		N	Correlation	Sig.
Pair 1	Society, consumers readiness & State and financial institutions readiness	54	0,796	0
Pair 2	Society, consumers readiness & Business and industry readiness	54	0,792	0
Pair 3	Society, consumers readiness & Science and education, public institutions readiness	54	0,655	0
Pair 4	State and financial institutions readiness & Business and industry readiness	54	0,842	0
Pair 5	State and financial institutions readiness & Science and education, public institutions readiness	54	0,824	0
Pair 6	Business and industry readiness & Science and education, public institutions readiness	54	0,764	0

The results of the analysis showed that there is a statistically significant positive correlation ($p < 0.05$) between all stakeholder groups, indicating the interrelation of their perception and readiness to implement the principles of the circular economy. A particularly high level of correlation ($r > 0.75$) is observed between:

- the readiness of society and consumers and the readiness of government and financial institutions ($r = 0.796$), which means that increased public involvement can be associated with the activity of the state in the development of the circular economy;
- the readiness of society and consumers and the readiness of business and industry ($r = 0.792$), which confirms the influence of business practices on the formation of consumer habits;
- The readiness of government and financial institutions, along with the readiness of businesses and industries ($r = 0.842$), indicates the dependence of enterprises on government support and financial incentives for implementing circular models.
- the readiness of government and financial institutions and the readiness of science, education and public organizations ($r = 0.824$), which emphasizes the importance of cooperation between science and the state in the development and implementation of environmental initiatives [126].

In addition, paired comparisons revealed statistically significant differences between the levels of readiness of different stakeholder groups.

Table 33 - Paired comparisons of stakeholder readiness levels

		Paired Differences			t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean			
Pair 1	Society, consumers' readiness - State and financial institutions' readiness	0,129	0,590	0,080	1,605	53	0,114
Pair 2	Society, consumers' readiness - Business and industry readiness	-0,195	0,635	0,086	-2,251	53	**0,029**
Pair 3	Society, consumers' readiness - Science and education, public institutions' readiness	0,178	0,733	0,100	1,780	53	0,081
Pair 4	State and financial institutions' readiness - Business and industry readiness	-0,324	0,568	0,077	-4,189	53	**0,000**
Pair 5	State and financial institutions' readiness - Science and education, public institutions' readiness	0,049	0,556	0,076	0,642	53	0,524
Pair 6	Business and industry readiness - Science and education, public institutions' readiness	0,372	0,678	0,092	4,032	53	**0,000**

The results of the analysis presented in Table 33 show that the most significant differences are observed between business and industry and government and financial institutions ($p = 0.000$), as well as between business and industry and science, education and public organizations ($p = 0.000$). This indicates that educational and scientific institutions are more prepared for the implementation of the circular economy than the industrial sector, which may be due to active research

in this area, while business lacks motivation and government support for the transition to circular models.

Statistically significant differences were also found between society and consumers and business and industry ($p = 0.029$). This suggests that business is more willing to embrace the circular economy than the population, which may be due to insufficient awareness of citizens and weak involvement in environmental initiatives.

At the same time, no significant differences were found between society and consumers and government and financial institutions ($p = 0.114$), indicating a similar level of readiness of these groups. This may indicate that Kazakhstan has not yet formed a clear system of measures to support the circular economy at the state level, and that consumers do not show active interest in circular practices. Thus, paired comparison confirmed the presence of gaps in the level of readiness of various stakeholders. Scientific and educational institutions turned out to be the most prepared for the implementation of the circular economy, while society and government institutions were the least prepared. This indicates the need for additional measures to stimulate business, raise public awareness and develop government strategies for a more effective transition to the circular economy [126].

In conclusion of this subchapter, it should be noted that the level of circular economy development in Kazakhstan remains low, and the readiness of different stakeholder groups varies significantly. Quantitative analysis (PLS-SEM) confirmed that awareness of the circular economy and external factors, such as government support and infrastructure, significantly impact the population's pro-circular behavior. In addition, stakeholders, including society and consumers, demonstrate a low level of engagement in environmental behavior. Research has identified several factors hindering the development of environmentally-friendly practices among the population, such as a lack of awareness and infrastructural challenges, particularly in the regions of Kazakhstan. Additionally, the readiness of state and financial institutions is limited due to the absence of regulatory documents that govern the circular economy at the legislative level. As a result, financial institutions and banks lack specific proposals for green and circular projects [126].

2.4 Expert interview to identify problems and barriers to the development of a circular economy in the agro-industrial complex of Kazakhstan

As part of this study, 15 semi-structured interviews with representatives from key stakeholder groups in Kazakhstan's agro-industrial complex were conducted.

The study included five government officials, five academics, and five practitioners, including farmers and business representatives. The main objective of the interviews was to identify barriers to implementing the circular economy (CE) in the agro-industrial sector and explore possible mechanisms to facilitate this transition. Interviews were conducted both in person and remotely, which ensured anonymity and allowed respondents to openly share their views during discussions and telephone conversations. The responses were analyzed using thematic analysis,

which helped to identify the main barriers to CE implementation and promising measures to encourage its adoption.

The interview questions focused on respondents' awareness of the basics of the circular economy, the barriers they face, possible incentives, and promising areas for CE implementation in the agro-industrial sector. The structure of the respondents involved in the in-depth interviews is presented in Table 34. To ensure a diverse representation, participants from different sectors of the agro-industrial complex were included, which encompassed scientists, civil servants, and practitioners.

Table 34 - Structure of respondents

№	Field of activity	Experience	Job title
1	Civil service	5-10 years	Head of department
2	Civil service		Analyst
3	Civil service		Specialist
4	Civil service		Specialist
5	Civil service		Deputy head of department
6	Science	7-9 years	Researcher
7	Science		Professor
8	Science		Associate professor
9	Science		Researcher
10	Science		Researcher
11	Practitioner (farmer)	6-15 years	Owner of the farm
12	Practitioner (AIC)		Production manager
13	Practitioner (farmer)		Owner of the farm
14	Practitioner (AIC)		Employee
15	Practitioner (AIC)		Employee

Key findings from the interview

During the analysis of the interviews, key issues and quotes from respondents were identified, allowing for the categorization of several main types of barriers. Key statements from interview respondents regarding barriers to the transition to the circular economy are presented in Table 35.

Table 35 - Barriers to the transition to the CE

Barriers	Quotes from experts
Financial difficulties	“Financing is the key; without it nothing will work” - Expert 15.
	“Investors are not ready to invest in long-term projects without clear guarantees of return” – Expert 7.
	“The CE is good on paper, but in practice we can't afford it” – Expert 4.
	“Even if you invest, the payback period is too long” – Expert 8.
	“CE sounds nice, but without real money no one will do it. What's important for us now is to survive, not experiment.” – Expert 12.

Lack of government support	“There are no clear government support programs, and without them everything remains at the initiative level” – Expert 5.
	“There are grants, but it is difficult to get them, there is too much bureaucracy” – Expert 12.
	“If the state wants the CE, let it first create the conditions” – Expert 9.
Cultural barriers and low motivation	“Why change anything if it works the way it is?” – Expert 3.
	“Most farmers don't understand why they need it” - Expert 11.
	“We tried to introduce waste recycling, but we encountered mistrust from our colleagues” – Expert 14.
	“These are additional costs that do not yet generate profit” – Expert 9.
	“I don't need it. The circular economy is an additional expense, not a profit. Until it becomes profitable, no one in our farm will do it.” – Expert 11.
	“Farmers work the way they have been taught for years. No one will change established practices just because it is fashionable.” - Expert 3.
Lack of processing infrastructure	“Logistics is too expensive, transporting waste for recycling is unprofitable” – Expert 1.
	“There are simply no waste processing plants in our region” – Expert 6.
	“If there were processing centers, everything would be simpler” – Expert 8.
	“We need regions to start investing in processing capacities” – Expert 14.
	“Where are these recycling plants? There are none, and there won't be any in the coming years. We can't even properly dispose of garbage, what kind of circular economy can we talk about?” - Expert 11.
Low awareness and lack of educational programs	“People just don't know what a circular economy is” – Expert 10.
	“We need more educational programs, seminars, trainings” – Expert 2.
	“If we understood how it works, we might have already switched over” – Expert 13.
	“Training farmers could make a difference” – Expert 13.
	“Everyone should start with themselves. You shouldn't rely only on others and laws. Everything starts with the person themselves” - Expert 9.
	“Not everyone realizes this problem with garbage and waste” - Expert 14.

The results of the expert interview confirmed that the main barriers to the implementation of the circular economy in the agro-industrial complex of Kazakhstan are related to financing, lack of state support, low awareness of farmers and lack of infrastructure. However, experts agree that with the availability of incentive measures and educational programs, the implementation of the CE will be possible.

Most experts agreed that the transition to circular principles in the agro-industrial complex will be extremely difficult without economic motivation and the corresponding infrastructure. A division of opinions among respondents was also revealed: some experts see the future in the CE, while others are skeptical about its implementation, considering it inappropriate. Thus, for the successful development of the circular economy in the agro-industrial complex, a comprehensive combination of legislative, economic and educational measures is needed, taking into account the specifics of the industry and the interests of its participants.

In conclusion, Chapter 2 of this dissertation work provides a comprehensive assessment of Kazakhstan's circular economy by first examining the existing legal and regulatory framework, highlighting a solid foundation of laws, decrees, and strategic plans, but revealing gaps in enforcement, integration, and economic incentives. It then evaluates macro-level development, showing the current situation in recycling rates and resource-efficiency indicators. A questionnaire and expert survey uncover mixed stakeholder readiness - while awareness of circular principles is growing, actual adoption remains limited by insufficient infrastructure, financial support, and institutional coordination. Finally, semi-structured interviews with agro-industrial complex experts identify key barriers - including regulatory fragmentation, lack of targeted incentives, and weak technical capacity - that impede circular practices in agriculture. Together, these findings underscore the urgent need for more cohesive policy integration, robust fiscal and technical incentives, and targeted capacity-building to accelerate Kazakhstan's transition to a fully circular economy.

3 RECOMMENDATIONS FOR IMPROVING STATE REGULATION OF THE CIRCULAR ECONOMY'S DEVELOPMENT IN THE REPUBLIC OF KAZAKHSTAN

3.1 Enhancing the state governance system for circular economy development in the Republic of Kazakhstan

The transition to a closed (or circular) economy requires not only technological innovations and new-generation business models, but also a systemic approach at the public policy level. The focus is on legal frameworks, fiscal incentives, strategic planning, interdepartmental coordination and international cooperation. Around the world, there is a desire to create a regulatory and institutional environment that can ensure sustainable resource circulation and waste minimization. This section summarizes modern approaches to public regulation based on the experience of the European Union, China and other countries, with an emphasis on best practices and identified shortcomings.

First and foremost is the development of a legislative framework. Research shows that successful transformation is only possible with a legislative framework based on clear principles of circularity. Thus, based on an analysis of the legislation of EU countries (Sweden, Finland, Germany, Great Britain, France), seven basic principles underlying the closed economy were identified. These principles include the circularity of materials, extended producer responsibility, transparency of resource flows, and others. These seven principles are given in the Figure 51 below:

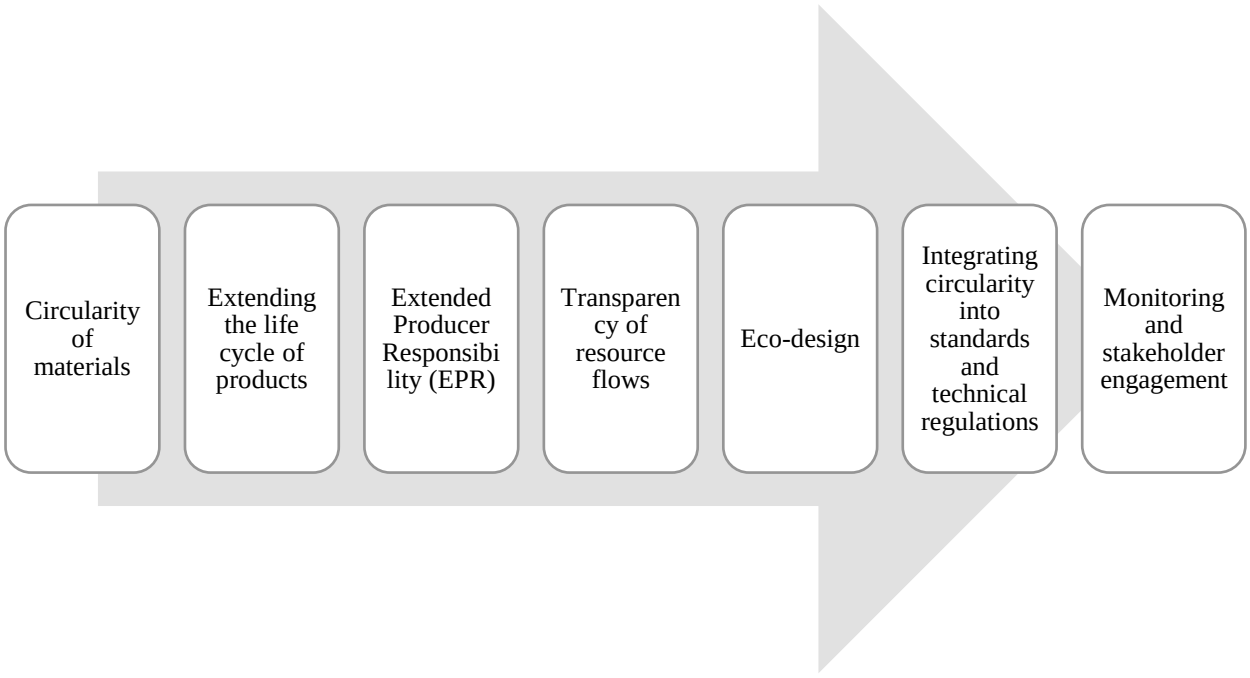


Figure 51 - Seven basic principles underlying circular economy policy
*Note: Compiled by the author

As can be seen in Figure 51, there are 7 basic principles according to which national policies can be designed.

One of the key directions for operationalizing these principles is through the integration of circular design standards at the macro level. In this context, it is essential to consider the entire life cycle of a product as the foundation for shaping sustainable production and consumption patterns. This is illustrated in Figure 52, which presents the main phases of a product's life cycle.

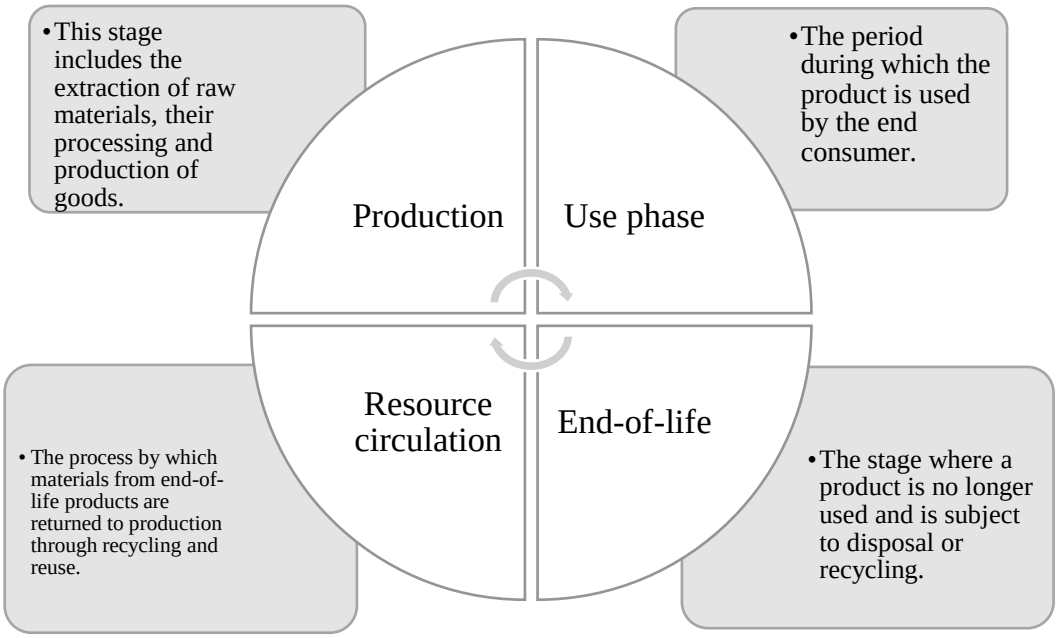


Figure 52 - Product life cycle
*Note: Compiled by the author

A potential policy idea is to adopt circular design standards and norms, related to the life cycle of a product is shown in the Figure 53 below:

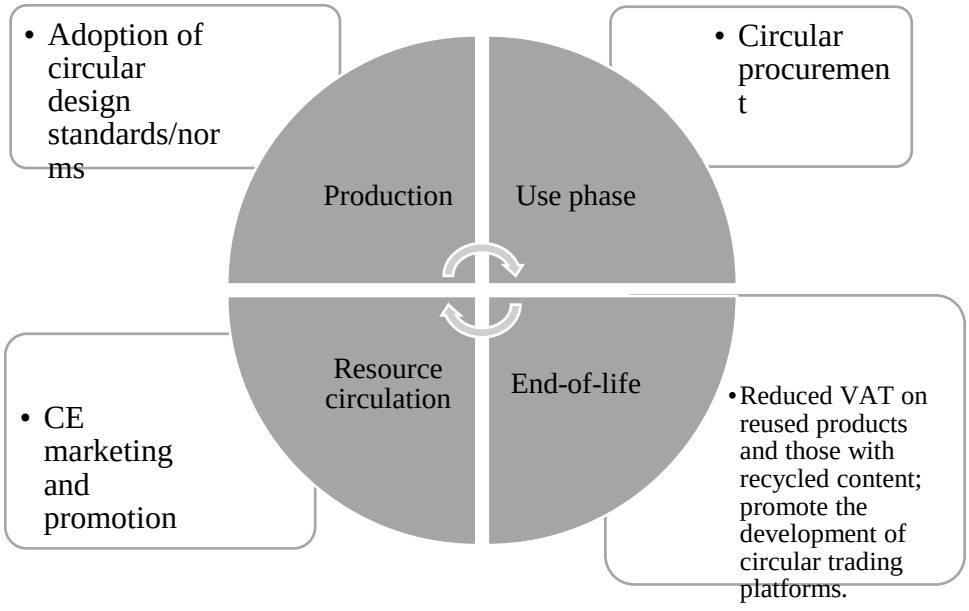


Figure 53 - Product life cycle recommendations
*Note: Compiled by the author

Promoting the uptake of circular design principles by producers through the establishment of standards and norms can encourage the transition towards a circular economy. Standards in design can facilitate the reuse and refurbishment of products, making it more convenient for businesses to adhere to circular economy principles. Most of the stakeholders, ranging from academics to sustainability practitioners, are in unison that governments should be held accountable for standards setting, as compared to leaving the responsibility to businesses. These kinds of criteria can encourage competitive level playing conditions via the cost-effectiveness and accessibility of circular products.

For example, in 2019, the European Commission released the initial two CE design protocols (EN45558 and EN45559), which established a framework of material efficiency and added ecodesign product requirements for durability, reparability, and recyclability. This action was a significant step in establishing a consistent and feasible approach to CE design. Rather than a top-down approach, it is preferable that the standards-setting process be carried out in a participatory manner. This will ensure that standards are in line with the interests of manufacturers and protect business interests, as well as prevent violations of applicable laws. Most manufacturers, especially those with a conservative approach, will appreciate the risks associated with implementing new design standards, especially when using recycled materials. However, information sharing and collaboration among stakeholders through various platforms such as virtual resources, live discussions, forums, and training sessions can help reduce risk perception, which in turn promotes the adoption of circular design standards. This strategy emphasizes how crucial collaboration and government intervention are in developing standards that enable the transition towards a circular economy in a way that gives producers more autonomy to innovate in an open and enabling regulatory framework.

Finland's Circular Economy Roadmap is a prime example of a national strategy based on circular economy principles. It is one of the first such strategies in the world, first adopted in 2016 and updated in 2021. The name and description of the strategy and the reflection of the seven fundamental principles can be seen in the following Table 35:

Table 35 - Strategy and the reflection of the seven fundamental principles

Principle	Implementation in strategy
Circulation of materials and resources	Targets have been set to reduce the use of primary resources by 30% by 2035, while also encouraging recycling and closed production cycles
Extension of the product life cycle	The program promotes business models that focus on repairing, renting, reusing, and modernizing goods
Extended producer responsibility (EPR)	Manufacturers' responsibilities for disposal and recycling have been strengthened, especially in the areas of electronics, packaging, and textiles
Transparency of resource flows	Digital platforms for tracking materials (for eample "Material marketplace") have been created, with mandatory reporting on the use of raw materials
Eco-design	Standards and incentives have been established for companies that produce goods that are easy to repair and reuse
Integration into policy	Incorporation of circular goals into national strategies for energy, transport, education, and public procurement
Participation of all stakeholders	The strategy provides mechanisms for involving businesses, NGOs, universities and municipalities in joint projects
Note – Compiled by the author according to the [127, 128]	

For Kazakhstan, implementation of the above principles is both a challenge and an opportunity. On the one hand, the nation has potential in the form of natural resources, nascent industry and willingness to innovate. On the other hand, current regulatory policy is fragmented and barely touches upon circular aspects. The concept of extended producer responsibility, for example, has yet to become current, and the tools for monitoring the flow of resources and eco-design are patchy.

The realization of these fundamental principles, considering national conditions and supported by international cooperation, can serve as the foundation for developing a circular model. This model would not only reduce environmental pressure but also create new economic opportunities.

A roadmap model for the transition to a circular economy in Kazakhstan can be seen in Figure 54.

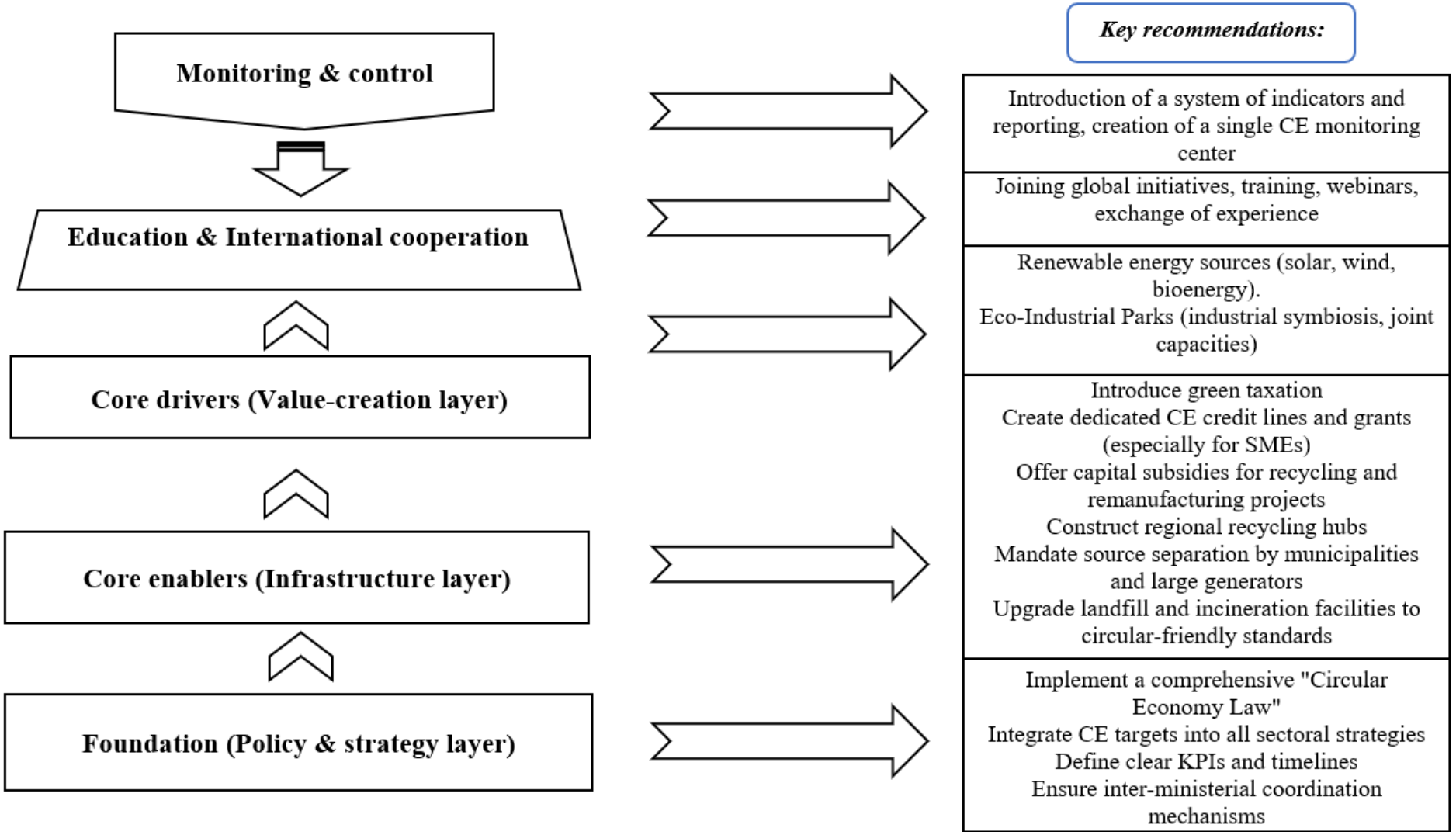


Figure 54 - Roadmap model for the transition to a CE

*Note: compiled by the author

Figure 54 presents a layered roadmap model for Kazakhstan's transition to a circular economy, organized into five vertically stacked tiers, each driving a distinct set of enabling actions and policy measures.

The model is structured as a five-layer stack. At the base is the Policy & strategy layer, which establishes a dedicated "Circular Economy Law" and integrates circular economy (CE) targets into various sectoral strategies, such as "Kazakhstan-2050," "Green Economy," "Taza Kazakhstan," and "Carbon Neutrality-2060." This layer sets clear key performance indicators (KPIs), timelines, and facilitates inter-ministerial coordination.

Directly above this layer is the infrastructure layer, which implements core enablers such as green taxation, Extended Producer Responsibility (EPR) schemes, dedicated CE credit lines, and grants - especially for small and medium-sized enterprises (SMEs). It also includes capital subsidies for recycling and remanufacturing, regional recycling hubs, source-separation mandates, and upgraded landfill and incineration facilities. This layer ensures that strategic plans can be translated into concrete projects.

Next is the Value creation layer, which focuses on achieving closed-loop outcomes. It supports the expansion of renewable energy capacity—such as solar, wind, and bioenergy—through policy tools like feed-in tariffs and net metering. This layer also encourages the creation of Eco-Industrial Parks that promote industrial symbiosis, shared infrastructure, and the exchange of by-products between enterprises.

Above these foundational layers is the Education & International Cooperation band, which focuses on building long-term sustainable capacity. This is achieved by integrating circular economy (CE) topics into university and vocational school curricula, offering professional development programs, hosting national webinars, and organizing study tours in collaboration with the EU, UN, and other global experts.

At the very top is the Monitoring & Control layer, which closes the feedback loop. It leverages technologies like IoT sensors and blockchain to monitor and trace material flows, ensuring transparency and accountability in CE implementation. It features a public-facing CE dashboard that provides real-time metrics, conducts quarterly audits, and performs annual performance reviews, thus enabling transparent and adaptive management of Kazakhstan's circular economy transition.

"Roadmap model" - is a systemic algorithm for implementing the principles of a circular economy in the Republic of Kazakhstan. The model consists of four interconnected phases:

The first stage is strategic alignment. It ensures unanimity among all stakeholders on key goals and objectives related to the transition to a circular economy.

The second stage of the project involves legal support. Within its framework, a specialized law on the circular economy will be developed and adopted, which will include digital mechanisms for tracking materials and tax preferences within the framework of the existing Environmental Code.

The third stage of the project development involves the creation of an interdepartmental/national platform within the government, which will facilitate the coordination of efforts, the exchange of information, and the monitoring of achieved results.

Fourth stage is about monitoring and scaling. Digital tools such as IoT and blockchain for accounting and reporting are introduced in this final phase. It also includes regular auditing and open publication of results to ensure transparency and accountability.

It is worth noting that in Kazakhstan today, the main document regulating the relationship between man and nature is the Environmental Code of the Republic of Kazakhstan, dated January 2, 2021. A SWOT analysis of this Code showed the following results:

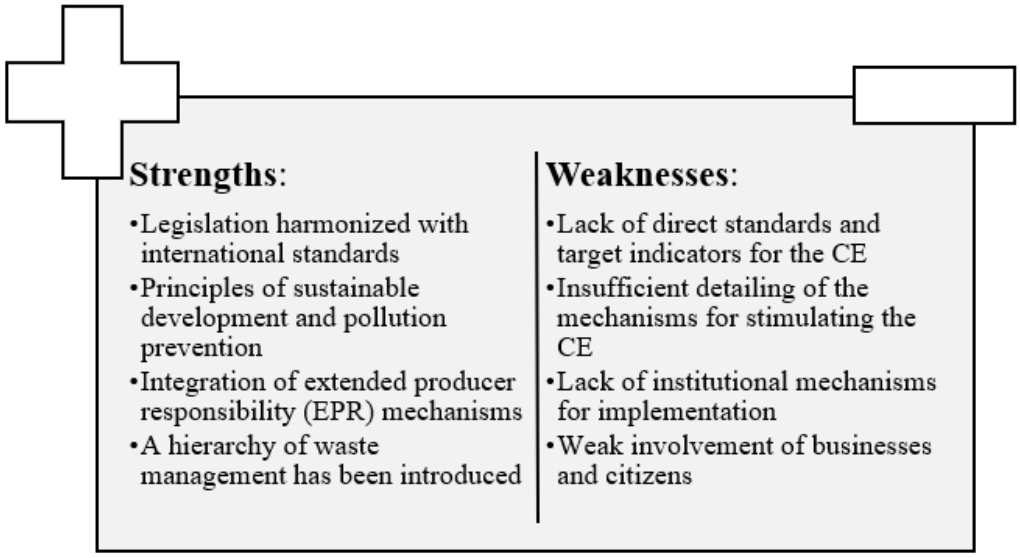


Figure 55 – Strengths and weaknesses of the Environmental Code
*Note: Compiled by the author

Figure 55 illustrates that the Environmental Code is aligned with international standards and outlines principles for sustainable development and pollution prevention. It includes the integration of the extended producer responsibility mechanism and establishes a waste management hierarchy. However, the Code lacks clear standards and target indicators for assessing progress in the area of the circular economy. Also, it does not provide sufficient details on procedures to promote closed resource cycles, fails to ensure effective institutional coordination, and does not actively involve businesses and citizens in the practical implementation of its standards.

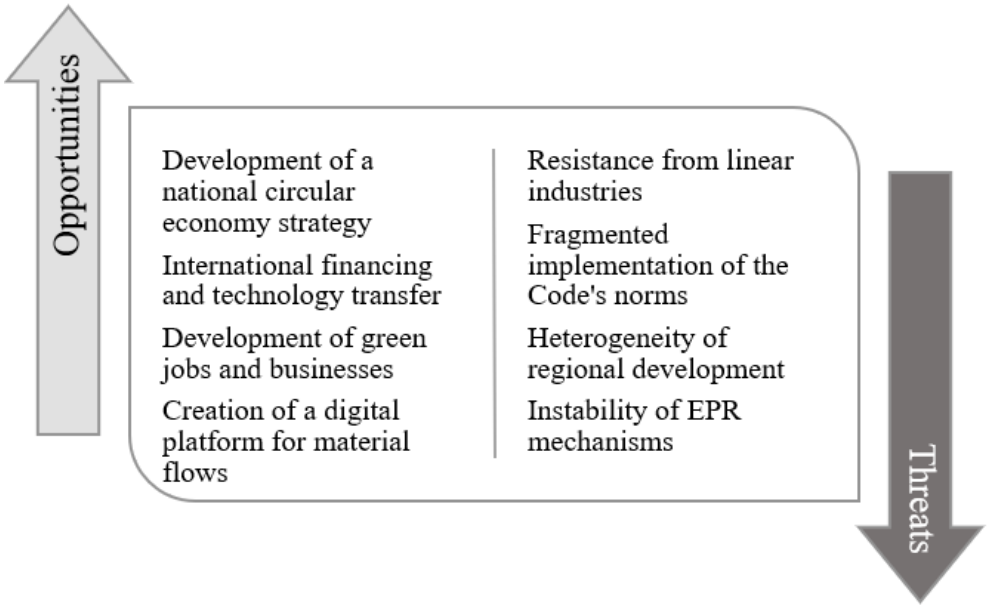


Figure 56 – Opportunities and threats of the Environmental Code
*Note: Compiled by the author

Figure 56 highlights both opportunities and threats. The opportunities include developing a national strategy for a circular economy, attracting international funding and advanced technologies, creating green jobs and eco-businesses, and establishing a digital platform for material flow accounting. On the other hand, the threats consist of resistance from linear industries, fragmented implementation of the Code across regions, uneven levels of regional development, and the instability of extended producer responsibility mechanisms.

Using international experience and relying to the principles of the CE will help Kazakhstan accelerate the transition to a circular economy, minimize errors and implement the most effective solutions. Implementation of these recommendations will reduce waste, increase resource efficiency and create a sustainable economic model that meets modern environmental and economic challenges. Key factors for success are government support, financial incentives, infrastructure development, business participation and raising the level of environmental education among the population.

Proposals for the transition to a circular economy at the macro level through the introduction of a single national digital platform

A crucial step at the macro level is to establish a national digital resource exchange portal that integrates with existing electronic government systems and logistics platforms. This platform would serve as a central hub for registering excess materials, by-products, and waste from businesses. It would automatically connect partners for “industrial symbiosis” and monitor raw material flows in real-time. The

proposed system will ensure prompt reconfiguration of resources across the country, reduce financial costs of operations and reduce potential harm to the environment.

The unified national portal will provide access to open interfaces for connecting IoT sensors at industrial enterprises, ensuring understandable information on the principles of the circular economy through a common office for civil servants. This will improve interaction between various departments and allow for prompt changes to public policy.

The implementation of this project will lay the foundation for the expansion of effective regional approaches, such as eco-industrial parks and agro-clusters, and will also form a reliable digital base for the transformation of Kazakhstan into a circular economy. As examples of information system platforms, the existing foreign websites on the development of the circular economy were selected, which can be seen in Appendix F.

Digital platforms are interfaces that enable transactions between various stakeholders, including buyers, sellers, partners, and consumers. Additionally, these platforms are playing an increasingly significant role in the transition to a circular economy.

As a key tool for Kazakhstan's large-scale transition to a circular economy, we propose creating a national digital platform, “QazaqCircular Hub” - a single portal for resource exchange, training, cooperation, and volunteer initiatives. The site architecture is aimed at various user groups (business, NGOs, educational institutions, individuals) and includes the following main modules:

1. Registration and personal account

– Unified access system via eGov-ID or e-mail.

– In the profile: organization/user profile, specialization (agriculture, industry, service), participant rating, and badges (“Eco-expert”, “Market maker”).

2. Resource marketplace

– Posting ads for surplus ready for transfer or sale: type (organic, metal, plastic, glass, technological waste), volume, condition, cost/donation conditions.

– Filters: region, industry, material, volume, brand, date of posting.

– Lot card: description, photo, “seller” contact, “Request an offer” button.

3. Training and certification center

– Course library: “Fundamentals of the circular economy”, “EPR standards”, “Eco-design”, etc.

– Webinars and online training from experts of the Ministries and international partners.

– Electronic certificates and badges upon successful completion of courses.

4. A platform for cooperation and projects

– Search for partners for pilot and commercial projects: public-private, scientific and industrial alliances, eco-parks.

– A board of current and future tenders/grants for CE initiatives.

– Communication channels: thematic forums, chats, video conferences.

5. Volunteer and expert corps

– Registration of volunteers and experts: ecologists, process engineers, and sustainable development consultants.

– Attraction mechanism: applications for assistance in specific initiatives (waste collection, training farmers, launching pilot eco-projects).

– Motivation system: digital badges, ratings, gift certificates.

6. Incubator of ideas and startups

– Acceptance of applications for innovative CE projects: from modernization of the agro-industrial complex to development of applications for tracking material flows.

– Mentoring support, access to laboratories, and grants from the state and foreign funds.

– Demo zone: virtual stands where startups present prototypes and MVPs to investors.

7. Analytics and reporting dashboards

– Real-time: volumes of transferred materials, resource savings, number of active users, and completed transactions.

– Regional map of CE activity “hot spots” (agglomerate clusters, eco-parks).

– Integration with IoT sensors at enterprises to track flows and “bottlenecks”.

8. Contacts and support

– Single support center 24/7: CE-Assistant chatbot, hotline, e-mail.

– Question-Answer section on typical scenarios for working with the platform and legislative norms.

– Feedback portal for suggestions for the development and refinement of functionality.

An example of a simple scenario for using QazaqCircular Hub (Figure 57):

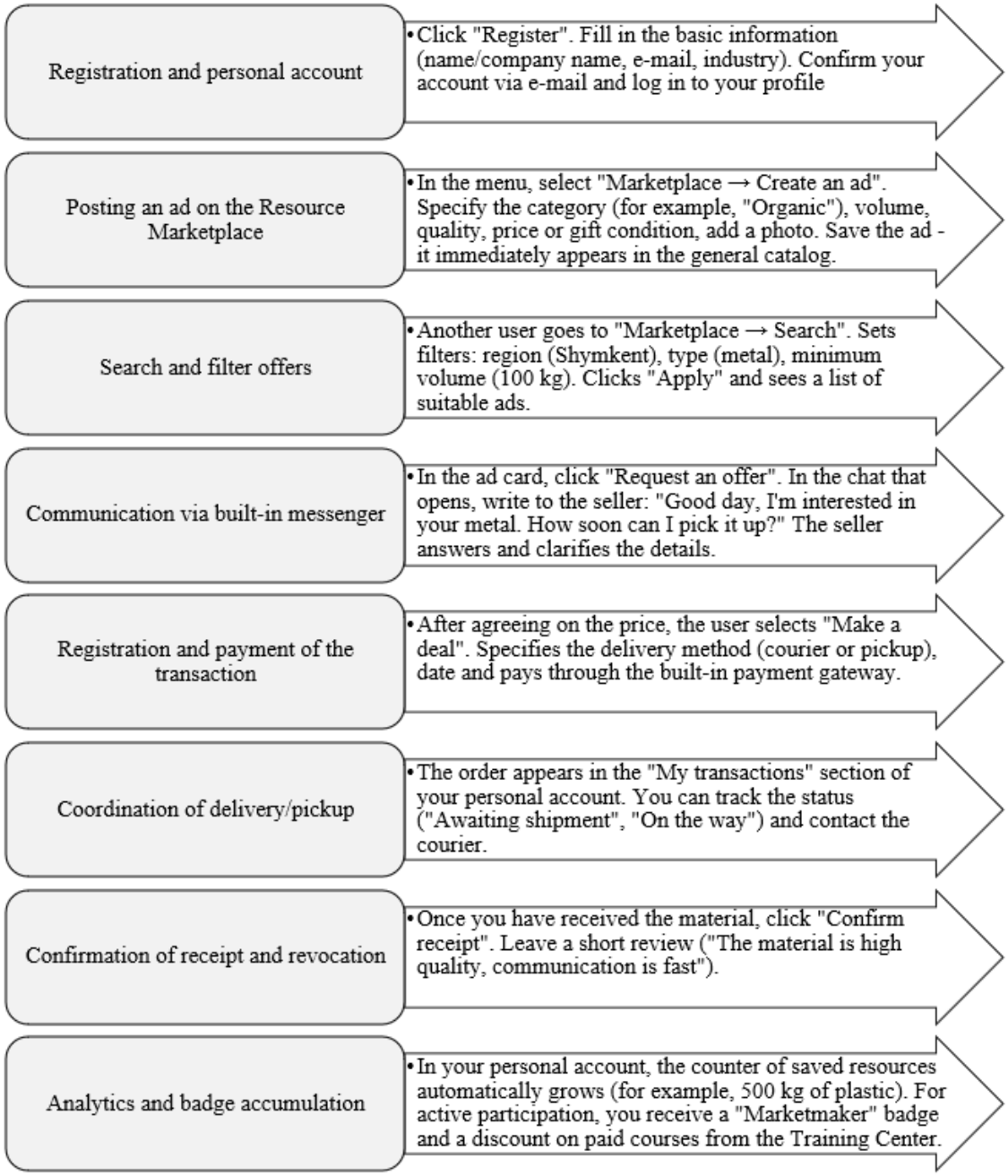


Figure 57 – Simple scenario for using QazaqCircular Hub
*Note: Compiled by the author

The proposed “QazaqCircular Hub” platform is a unified national digital ecosystem portal for promoting the circular economy in Kazakhstan. It combines the following sections: “Resource Marketplace” (where companies and individuals can post and search for surplus materials for reuse free of charge), “Training and Certification” (online courses, webinars and exams on key CE topics), “Projects and Cooperation” (tenders, grants and a platform for finding partners in eco-initiatives), “Volunteering and Expert Corps” (registration of specialists and support for local eco-events) and “Analytics and Monitoring” (real-time tracking of the volume of transferred resources, savings and key indicators). An intuitive interface, integration

with eGov-ID and open APIs for IoT sensors allow participants to easily interact and receive instant analytics, while a built-in payment gateway and rating system ensure transparency and security of transactions. Thanks to the QazaqCircular Hub, Kazakhstan can gain a powerful tool for closing material flows, reducing environmental impacts and stimulating green innovation. The detailed structure of the proposed national platform is given in Appendix G.

In conclusion, this subchapter presents a clear roadmap for integrating circular economy principles into Kazakhstan's policy framework. It begins with the establishment of a dedicated “National circular economy strategy,” which should include specific targets and timelines. Next, it recommends the integration of circular economy objectives into existing economic development programs and the introduction of targeted fiscal incentives, such as tax credits, grants, and low-interest loans, to promote circular practices.

Furthermore, the proposal includes the creation of a “National circular economy platform” to ensure coordination among ministries, engage stakeholders, facilitate data sharing, and monitor progress continuously. It also emphasizes the importance of transparent, multi-stakeholder standard-setting for eco-design and lifecycle requirements. Also, the implementation of digital material flow accounting are essential for harmonizing fragmented laws and accelerating Kazakhstan's transition to a truly circular economy.

3.2 Facilitating the transition to a circular economy through the creation of eco-industrial parks and the implementation of digital technologies

One of the key instruments for the transition to a circular economy at the meso level, especially in the agro-industrial sector, is the formation of eco-industrial parks (EIPs). An eco-industrial park is a cluster of enterprises united in a single territory, where industrial links are formed, allowing the use of waste from one industry as a resource for another, as well as the joint operation of energy and logistics infrastructure. EIPs facilitate the physical concentration of producers, providing conditions for the joint use of infrastructure and the exchange of waste between enterprises. This format of cooperation significantly expands the possibilities of circular interaction, going beyond traditional supply chains [129].

As noted by Heeres et al., EIPs not only bring economic benefits, but also significantly reduce the environmental burden on the environment in the places of their localization. They also play an important role in the development of inter-firm relations for the implementation of circular initiatives, acting as experimental sites and centers for joint research and innovation [130,131].

At the international level, more than 100 EIP projects had been launched by the early 2000s, with China being the most active in implementing them. Examples of parks such as Sino-Singapore Tianjin Eco-City (China) and Kalundborg Eco-Industrial Park (Denmark) demonstrate the possibilities of integrating environmental, economic and social aspects [132].

For Kazakhstan, where the agro-industrial complex has high resource potential, the creation of specialized agro-EIPs can stimulate not only the effective management of organic waste and by-products (manure, oilcake, agro-waste), but also the development of biotechnological production, bioenergy and agricultural symbioses (e.g., animal husbandry ↔ crop production ↔ processing/recycling).

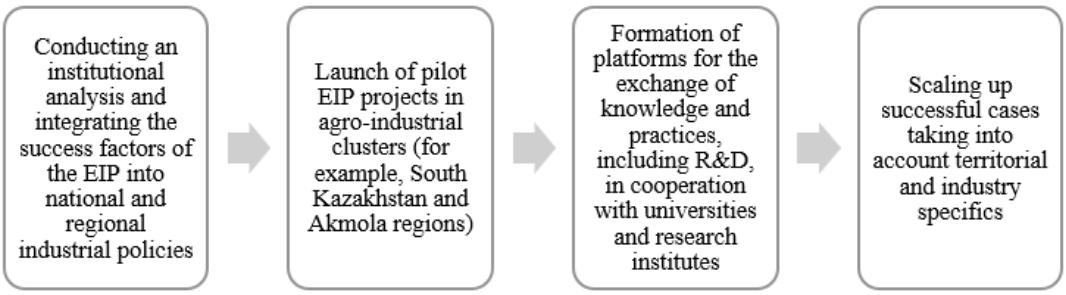


Figure 58 - Policy recommendations for creation of the EIP

*Note: Compiled by the author according to the [133]

According to researches, eco-industrial parks not only promote industrial cooperation, but also enhance trust between participants, creating a common "circular thinking" [133, 134].

By facilitating interaction between different industrial sectors within designated areas, eco-industrial parks (EIPs) facilitate the exchange of resources, production waste, and shared infrastructure, which significantly reduces waste and optimizes the use of materials. This approach supports industrial symbiosis: waste from one enterprise serves as a resource for another, forming closed cycles and reducing the negative impact on the environment. The introduction of EIPs can stimulate innovation in the field of waste recycling and rational use of resources, attract "green" investments, and stimulate the creation of new technologies and business models that correspond to the principles of the circular economy. Furthermore, EIPs can improve the competitiveness of local industries by lowering production costs through resource sharing and waste reduction, while simultaneously contributing to Kazakhstan's environmental sustainability targets and green growth initiatives.

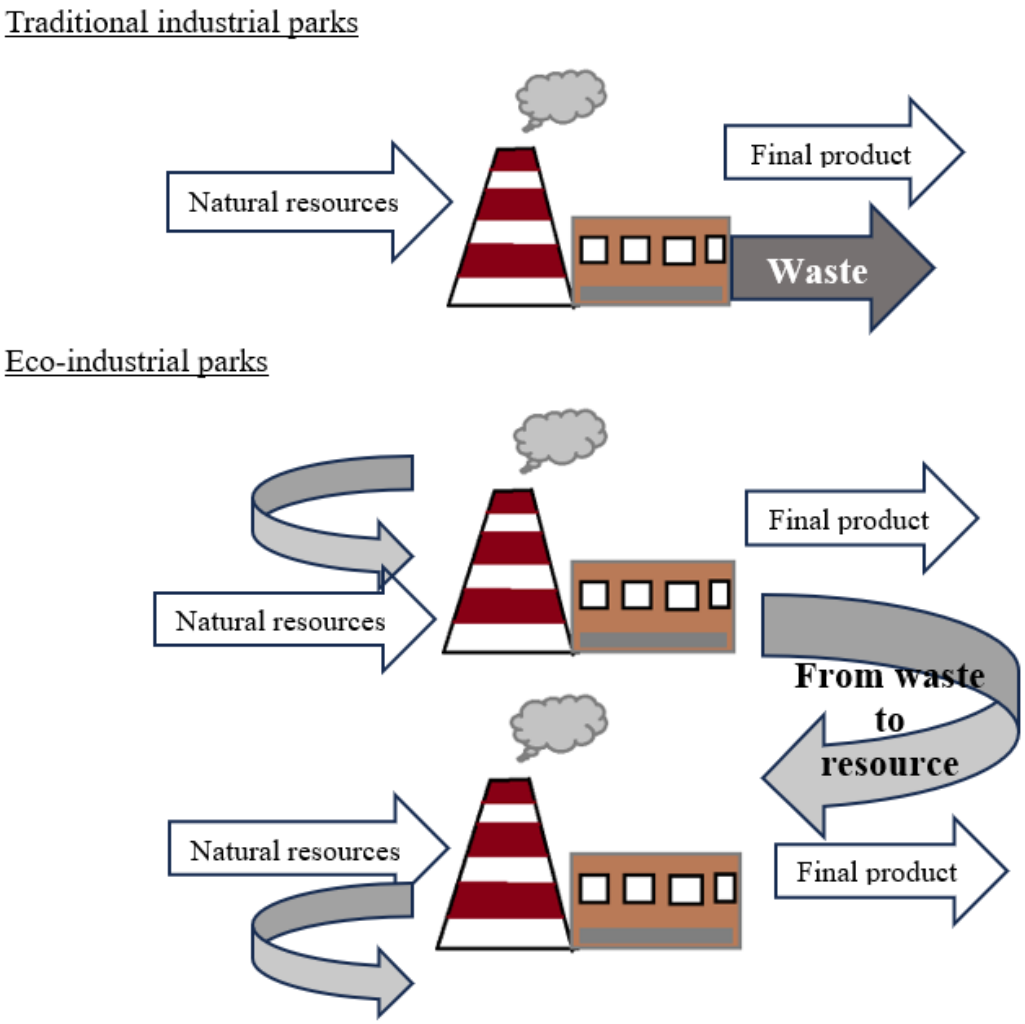


Figure 59 – Traditional vs. Eco-industrial parks

*Note: Compiled by the author according to the [132]

Despite the significant potential of eco-industrial parks as a tool for transitioning to a circular economy at the meso level, the results of in-depth interviews with representatives from the academic and business communities revealed several significant barriers to the practical implementation of such initiatives in Kazakhstan's agro-industrial sector.

Interview participants noted insufficient institutional coordination, low level of business involvement, lack of intersectoral interaction and limited digital infrastructure. These findings align with the data of Shi and Yu, which indicate that most international EIP projects have not achieved the expected results, primarily due to systemic and organizational issues. For the successful implementation of EIP in Kazakhstan, a comprehensive approach is necessary, encompassing both regulatory support and the active involvement of local stakeholders in the development and implementation of pilot initiatives [133].

Table 36 – Problems of implementing EIP and ways to overcome them (based on interviews and literature analysis)

Identified problem	Description	Recommendation
Weak institutional coordination	Lack of a single governmental body overseeing the implementation of the CE and EIP at the regional level	Creation of an interdepartmental coordination platform under the "Ministry of Agriculture of the Republic of Kazakhstan" and local akimats
Insufficient motivation and awareness of participants	Business does not realize the benefits of EIP and CE, and perceives them as an additional burden	Conducting information campaigns and practice-oriented seminars with demonstration of successful cases
Limitations of infrastructure	There are no mechanisms for exchanging data between enterprises and tracking circular flows	Development and implementation of a digital platform for monitoring, analysis and management of circular flows
Lack of financial incentives	Insufficient funding for pilot projects from the state and private sector	Introduction of tax incentives, subsidies, co-financing programs based on public-private-partnership
Distrust and weak culture of cooperation between enterprises	Companies are not willing to share resources and information	Creation of demonstration EIPs as "trust platforms" for building long-term interactions
Lack of trained personnel in CE	There is a lack of specialists with competencies in the CE and EIP management	Development of specialized educational programs and advanced training of personnel through, for example, the Atameken National Chamber of Entrepreneurs and universities
Note – Compiled by the author		

As can be seen from the Table 36, the launch and introduction of EIP in the agro-industrial complex of Kazakhstan must be multidisciplinary in nature, including institutional reforms, training and education, digitalization and incentive policies. Pilot projects launched in the high-potential regions can not only confirm the efficiency of the circular model, but also become the basis for scaling up the best practices throughout the country.

Next, one of the critical barriers to the transition to a circular economy in the agro-industrial complex at the meso level is the low level of awareness among both producers and consumers. Although interest in the topic of the CE is growing, the understanding of personal and institutional responsibility for environmental consequences remains fragmented.

As studies show, changing attitudes requires not only information but also the formation of new behavioral models that are supported by economic incentives and cultural attitudes. This is especially relevant for the agricultural sector, where the

behavior of consumers (including farmers, processors, buyers) is still focused on the linear logic of production and consumption [134].

The literature, survey and interview analysis showed that increased awareness and a change in attitude towards circularity are key prerequisites for a successful transition. Studies on the perception of the CE by different target groups emphasize that awareness alone and even a willingness to act are not enough. The transition requires a "profound shift in consumer behavior", which is also confirmed by the results of the present study. Representatives of government programs note the need for significant efforts to "pull strategy", which means actively working with businesses and explaining what opportunities the CE opens up. Such "involvement" should be aimed not only at producers, but also at consumers, forming their awareness of the role within the product life cycle. As experts emphasize, it is important to make consumers understand that they are present only at one stage, while the value of the product can remain after their use. In this regard, marketing campaigns, communication programs and information platforms are becoming effective tools at the meso level. Such initiatives allow for the formation of an attitude towards personal responsibility, demonstrating not only obligations, but also the benefits of participation in the circular model. This includes economic benefits, improved quality of life, participation in sustainable development. However, one of the main obstacles remains the "linear" way of thinking, which has been dominant for decades and permeates business models, logistics and consumer culture. Changing this paradigm requires a comprehensive communication strategy similar to successful public health campaigns such as anti-smoking campaigns. For example, a study by Kuipers et al. found that investments in mass media campaigns of around €540,000 (approximately 304 560 000 tenge) per month were associated with an increase in smoking cessation rates. This suggests that large-scale media projects targeting behavioral change can also be effective in the context of the CE [130-135].

Based on previous research and findings, an important direction is the implementation of marketing and communication strategies aimed at achieving specific goals. It can include following:

- Raising awareness through mass media campaigns, including television, radio, and social media platforms (such as Instagram, WhatsApp, Facebook, and TikTok).
- Conducting crowdsourcing competitions that involve citizens and businesses in generating ideas and solutions in the field of CE.
- Supporting initiatives at early and low stages, such as farmers' eco-cooperatives, with subsequent promotion of their experience at the national level.

— Launch of "consumer literacy" programs in the agro-industrial complex with an emphasis on the life cycle of products and the possibilities of reuse, recycling and biodegradation.

The meso-level recommendation thus shows that the strategy should provide for cross-sectoral cooperation between the state, business, and NGOs, focusing on awareness, the benefits of circularity, and the formation of collective responsibility for the life cycle of products. To systematize the recommendations at the meso-level, the following typology can be used [136, 137]:

Table 37 – Marketing and awareness-raising mechanisms at the meso level

Target group	Purpose of influence	Communication channels	Expected effect
Manufacturers and suppliers	Motivation for the implementation of CE, demonstration of benefits	Industry conferences, case studies, business media	Increased interest in the CE, launch of pilot projects
Businesses and clusters	Coordination of efforts within supply chains	Experience exchange platforms, round tables	Formation of collective initiatives
Marketers and product designers	Promotion of circular design and eco-packaging	Webinars, professional publications	Growth in the number of "green" solutions in products
Industry-level consumers	Increasing understanding of the role of CE	Targeted advertising, social networks, and packaging	Growth in demand for circular or eco products
NGOs, eco-initiatives	Support for educational programs	Joint projects, grants, and volunteering	Expanding audience reach, involvement
Government agencies	Coordination, support of campaigns, subsidies	Press releases, media plans, national strategies and policies	Legitimization of the CE
Note – Compiled by the author			

Recommendations for the development of a circular economy in the agro-industrial complex of Kazakhstan through digitalization

Effective use of digital technologies is becoming one of the key tools for achieving. Below are current technological solutions, their brief characteristics and recommendations for practical application in the context of the transition to CE.

1) Internet of Things (IoT) and the development of "smart farming" through mobile apps

The Internet of Things (IoT) in agriculture is advancing toward the development of complex "smart farm" systems, known as Smart Farming. These systems integrate mobile applications, sensor devices, and cloud platforms to efficiently manage all aspects of agricultural production. Mobile applications enable farmers to access real-time data, manage resources remotely, and automate processes based on data analytics.

The features and capabilities of smart farming mobile applications are detailed in the following Table 38:

Table 38 – The functionality of smart farming mobile applications

Functions of "Smart Farming"	How it works
Field condition monitoring	Involves collecting real-time data on soil moisture, nutrient levels, light intensity, and temperature using connected sensors installed in the field.
Irrigation management	Enables farmers to create optimized watering schedules, remotely control irrigation systems, and monitor overall water usage.
Animal health monitoring	Collecting data on livestock movement, body temperature, activity, and feeding through sensors and tags.
Notifications and recommendations	Receive automatic alerts about critical changes in the condition of plants or animals and personalized advice on corrective actions.
Planning of agricultural work	Preparation of planting, cultivation, harvesting schedules, and fertilizer use plans, taking into account weather data and soil analysis.
Note – Compiled by the author	

An approximate algorithm for the operation of a mobile application within the framework of a smart farm is as follows:

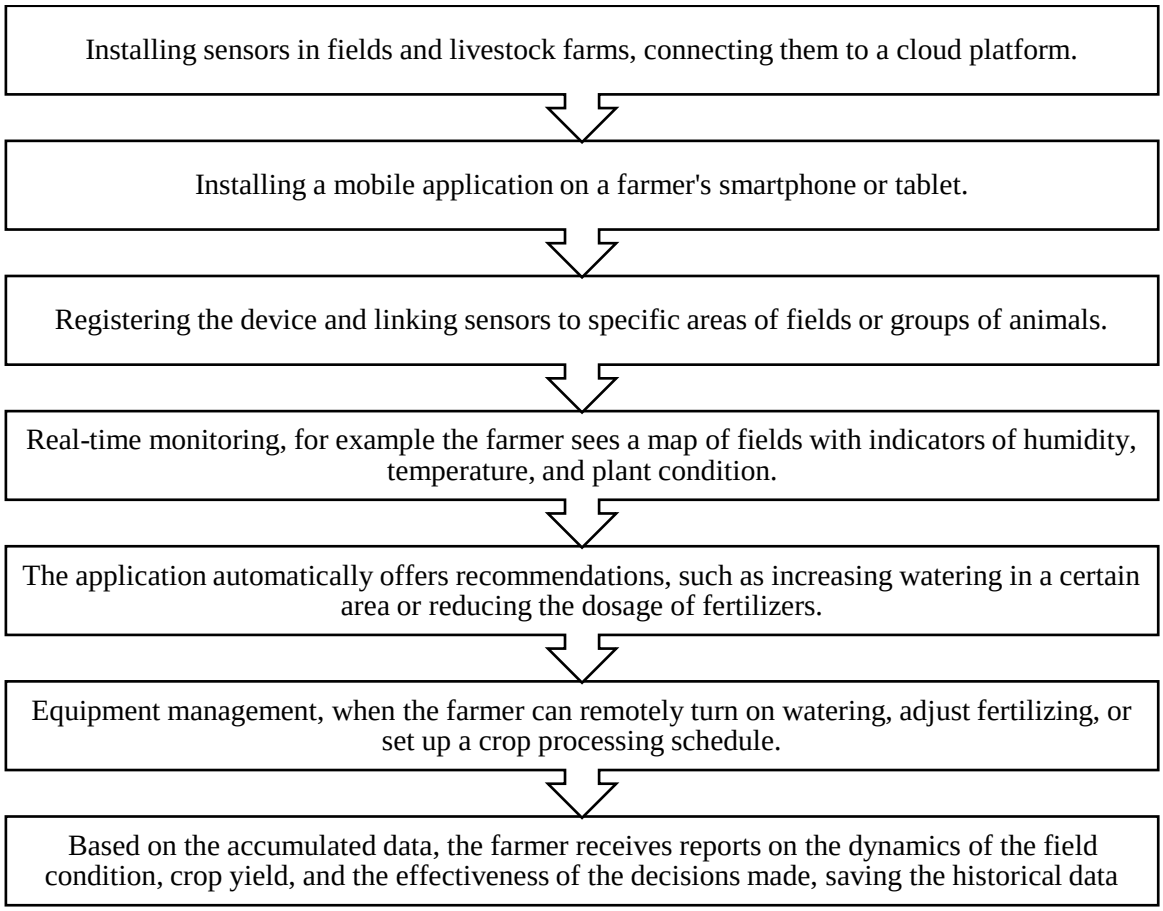


Figure 60 – Algorithm for using a Smart Farming application
*Note: Compiled by author

At the international level, platforms such as CropX, FarmLogs, and AgriWebb offer comprehensive mobile solutions for farm management. In Kazakhstan, there is potential to either develop local versions tailored to the country's unique climatic and economic conditions or adopt and adapt the most effective existing applications.

2) Artificial intelligence (AI)

Artificial Intelligence (AI) is increasingly being used in agriculture today, both to automate data analysis, predict yields, and optimize resource use, as well as to improve the overall sustainability of agricultural systems. It is worth noting that AI technologies can process huge amounts of information from fields and farms, as well as production facilities. This allows them to recognize patterns and provide predictive recommendations tailored to the needs of individual farmers. Key functional capabilities of AI systems in agriculture include:

— Crop yield forecasting using satellite imagery, weather data, soil conditions and farming practices to provide accurate yield estimates.

— Diagnose plant diseases and detect pests using images taken by drones or smartphones, allowing for early detection of problems and recommendations for their elimination.

— Forecasting crop yields by analyzing satellite data, weather conditions, soil characteristics, and agricultural practices to accurately calculate expected yields.

— Identifying plant diseases and pests, such as automatically recognizing disease signs based on drone or smartphone images, and proposing control measures.

— Optimizing resource usage, such as calculating the minimal yet effective quantities of water, fertilizers, and pesticides required to maintain healthy crops with reduced losses.

— Predicting organic waste volumes and offering solutions for processing this waste into fertilizers, biofuels, or animal feed additives.

— Supporting decision-making by developing intelligent tools that recommend circular economy-based farming strategies.

Example of algorithm for using AI systems in agriculture:

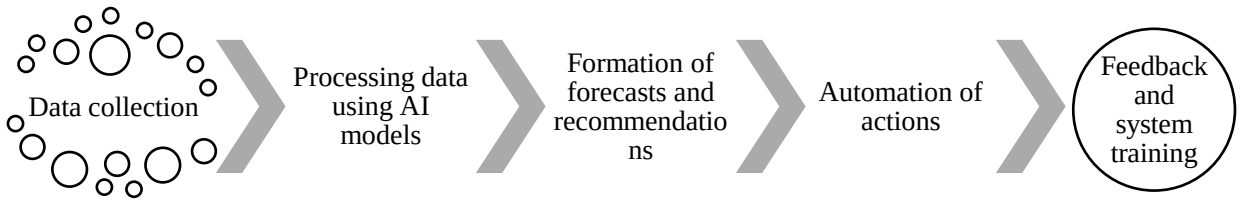


Figure 61 - Use of AI systems in the agro-industrial complex
*Note: Compiled by author

The integration of artificial intelligence (AI) systems within the agro-industrial complex relies on the systematic collection, processing, forecasting, and automation of management decisions. Firstly, data comes from a variety of sources, such as IoT sensors that monitor soil and microclimate conditions, weather stations with forecast information, and drones that record visual data on field conditions. This array of information is supplemented by historical records reflecting economic activity.

At the next stage, the collected data is processed using machine learning algorithms. Artificial intelligence analyzes many parameters to identify hidden patterns and trends. Using computer vision technology on different platforms helps to identify anomalies in plant development, allowing diseases or nutrient deficiencies to be detected at an early stage, even before external signs appear.

As a result of the analysis, forecasts are formed and recommendations are given. Such systems predict the expected level of yield, assess the risks of disease occurrence, and determine the need for additional farming measures. For instance, Plantix can analyze a photo of a plant and, within seconds, suggest treatments for any identified diseases, as well as preventive measures.

The next step involves automating agricultural tasks. Based on the recommendations received, precision farming systems can be implemented, such as automatic irrigation, fertilization, and the deployment of agricultural drones to target specific areas of the field. One example is the solution from Blue River Technology, which enables tractors to autonomously identify weeds and apply herbicides only where needed, thereby reducing the overall use of chemicals.

The final stage involves feedback and self-training of the system. AI analyzes the results of its forecasts alongside actual data regarding crop conditions, adjusting its models to improve future accuracy. Through this process, artificial intelligence gradually enhances its efficiency, promoting more sustainable and resource-saving agricultural practices within the framework of a circular economy.

Table 39 below presents examples of existing technologies to illustrate innovative AI-based solutions currently applied in the agro-industrial sector. The table outlines the area of application, the name of the technology, and a brief description of its functions. These solutions highlight the diverse potential of artificial intelligence to enhance agricultural productivity, support sustainable resource management, and advance circular economy principles within the agro-industrial complex.

Table 39 - Examples of existing AI technologies

Direction of application of AI	Name of technology	Description of functions

Diagnosis of plant diseases	Plantix [138]	A mobile application that automatically identifies plant diseases from photographs and provides recommendations for appropriate treatment.
Optimization of fertilizer and herbicide application	Blue River Technology [139]	Computer vision system for agricultural machinery: precise weed control without unnecessary chemical consumption.
Field state analytics	Prospera [140]	An AI-powered crop data analytics platform designed to enhance yield and optimize the use of resources.
Predicting disease risks	AgriPredict [141]	A system to warn farmers about potential pest and disease threats based on climate and agricultural data.
Automation of harvesting	Harvest CROO Robotics [142]	Robotic system with AI elements for automated harvesting of strawberries and other crops.
Livestock health monitoring	Connecterra (Ida platform) [143]	A platform that analyzes cow behavior and health, detects early signs of illness, and helps optimize feeding strategies.
Note - Compiled by the author		

3) Digital platforms for training and support of farmers

Since technology can be complex for small and medium farmers, a key component will be the development of educational platforms to help them adapt to new methods and tools [145].

For example, creating digital education platforms tailored for farmers. These could include online courses and interactive learning systems that provide practical knowledge on digital technologies, sustainable farming practices, and circular economy principles.

Next example is Decision Support Systems (DSS) – Offering structured guidelines for introducing integrated decision-support platforms that leverage AI and real-time field data to help farmers make informed choices quickly and effectively.

4) Integration with blockchain technologies to increase transparency and sustainability

Blockchain technology has the potential to significantly enhance digital solutions in agriculture by ensuring transparency and data security across the entire production and supply chain. By using blockchain to record and track each stage of agricultural production and processing, trust can be strengthened among consumers, investors, and regulatory bodies. This heightened transparency helps guarantee that resources are used responsibly and that environmental standards are being properly followed.

Additionally, the role of smart contracts should be taken into account. These automated agreements can streamline interactions among farmers, processors, and consumers, enabling more efficient and sustainable financial transactions and resource management. By minimizing the need for intermediaries, smart contracts also contribute to reducing transaction costs.

These recommendations can be addressed to key executive authorities - the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan and the Ministry of Digital Development, Innovation and Aerospace Industry of the Republic of Kazakhstan. In the future, its development and implementation are planned to be carried out through the proposed “National circular economy platform”, and possible inclusion in the plans of the state project "Digital Kazakhstan". For practical implementation, project documentation and guidelines can be transferred to the administration of akimats and to specialized ecology departments at the local level.

In order to fully realize the benefits of these digital and AI-driven solutions, it is crucial to advance Kazakhstan’s systemic shift toward a circular economy, thereby ensuring that resource use and waste generation are managed in a truly sustainable and accountable manner [145].

In conclusion, Chapter 3 presents a unified set of strategic and operational measures spanning both macro- and meso-levels to drive Kazakhstan’s transition to a circular economy. At the macro level, it calls for enshrining a dedicated “Roadmap model for the transition to a CE” with clear and measurable targets; mainstreaming circular-economy objectives into existing state economic programs; deploying targeted fiscal incentives - such as tax credits, grants, and low-interest financing; and establishing a “National circular economy platform” to ensure interministerial coordination, stakeholder engagement, data sharing, and rigorous progress monitoring.

At the meso level, the creation of eco-industrial parks is recommended for promoting efficient resource use, waste recycling, and the development of environmentally sustainable business models. Parks of this type can become key mechanisms for bringing together different sectors and stimulating the exchange of resources between companies, ultimately increasing productivity and reducing waste.

The use of digital technologies, including the Internet of Things (IoT), smart farming and artificial intelligence (AI), plays a key role in optimizing production processes and rational resource management. Digitalization makes it possible to monitor and regulate resource flows in real time, which helps improve recycling systems and their further distribution. This technological progress helps accelerate the transition to a circular economy model. In addition, the introduction of blockchain technologies opens the way to transparency and traceability at all stages of the supply chain, which ensures the sustainability of processes and strengthens trust between market participants.

In the agricultural sector, the use of digital educational platforms for farmers is of particular importance. Such platforms can provide comprehensive training in modern methods of sustainable agriculture, approaches to implementing the principles of a circular economy, as well as the effective use of innovative digital tools such as IoT and AI. The critical factor is equipping farmers with knowledge and access to technology. By doing this, Kazakhstan can establish a culture of innovation and environmental sustainability at the local level. This, in turn, will facilitate the transition to a circular economy.

For Kazakhstan, it is important to correctly adapt international experience taking into account local specifics when developing a circular economy model. The main components of success are the development of effective financial support instruments, promotion of waste recycling initiatives, creation of eco-industrial parks, and introduction of advanced technologies. An equally significant aspect is the involvement of all stakeholders, as well as the integration of environmental priorities into the state's strategic plans.

Successfully implementing these recommendations will enable Kazakhstan to speed up its transition to a circular economy, enhance resource use efficiency, and establish a sustainable economic model that addresses contemporary environmental and economic challenges.

CONCLUSION

1. The study of the theoretical foundations of the circular economy highlights its crucial role in promoting sustainable development, especially in the face of population growth, depletion of natural resources, and environmental degradation. The concept of the circular economy seeks to replace the traditional linear model of resource consumption, characterized by the “take, produce, throw away” approach, with a closed-loop system. This new model emphasizes the principles of reduction, reuse, recycling, and the restoration of natural systems. The development of the circular economy model relies on strategies such as the 3R-9R framework, the implementation of industrial ecology principles, extending product lifecycles, and enhancing resource efficiency.

2. Government regulation plays a decisive role in creating conditions for the transition to a circular economy. Various instruments of influence are used at the macro, meso and micro levels, including administrative and legal measures, economic incentives, regulatory control, subsidies, taxation, investments in green technologies and the development of waste recycling infrastructure. Direct (administrative) and indirect (economic) methods of regulation should be used comprehensively to achieve a balance between stimulating innovation and environmental protection. In addition, mechanisms for information support and the formation of environmental responsibility among all participants in economic processes are of great importance.

3. An analysis of international experience shows that the transition to a circular economy is most successful in high-income countries due to comprehensive public policies, systemic support for innovation and the active participation of all economic actors. In countries such as Germany, Japan, Sweden and the UK, the circular economy is integrated into national development strategies, supported by legislation, financial mechanisms and incentive measures. The development of eco-industrial parks, the introduction of waste recycling technologies, the use of renewable energy sources and support for closed production cycles have become the basis for their successful transition to a new economic model. In middle-income countries such as China, Brazil and Mexico, reforms towards a circular economy are at an early stage, often implemented in individual sectors and accompanied by the active development of industrial symbioses and local initiatives. In lower-income countries, the transition to a circular economy is just beginning and requires significant institutional support, investment in infrastructure and the development of a regulatory framework. In general, international experience shows that a successful transition to a circular economy requires a comprehensive approach at all levels of governance, investments in innovative technologies, the development of a system of state support, as well as raising awareness among businesses and society about the benefits of the circular model.

4. Studying the transition to a circular economy requires an integrated, interdisciplinary approach. This approach combines a cross-disciplinary framework that weaves together economic, environmental, and social analyses; employs

systems thinking alongside comparative, indicator-based, and statistical methods; and conducts layered evaluations at macro, meso, and micro scales to fully capture transformations across national, regional, sectoral, and enterprise contexts.

5. An analysis of current legislation and strategic documents in Kazakhstan shows that circular economy issues are gradually being integrated into the national sustainable development agenda, though they remain in the early stages of implementation. Key policy frameworks—such as the "Concept of the Transition of the Republic of Kazakhstan to a Green Economy," the "Environmental Code," and the "Strategic Development Plan of the Republic of Kazakhstan until 2025"—already include measures aimed at improving resource efficiency, minimizing waste, and supporting the use of renewable energy. However, the legislative and institutional framework still approaches the circular economy in a fragmented way, with a predominant emphasis on waste management and energy conservation rather than a comprehensive, system-wide strategy. There is a lack of comprehensive approaches to regulating closed production cycles, stimulating recycling, promoting extended producer responsibility models, and supporting new business models based on circularity principles. Additionally, there is inadequate coordination among different economic sectors and levels of government in implementing circular initiatives.

6. The results of the regression analysis indicate that, despite the sufficiently high coefficient of determination and the overall statistical significance of the regression model, the individual coefficients of all variables were not statistically significant, even at the 10% level. Consequently, the initial hypothesis that the volume of current expenditures on waste management has a statistically significant and positive effect on the level of waste recycling and reuse in Kazakhstan is rejected. The findings suggest that current waste management costs are not sufficiently correlated with the actual volume of recycling and reuse activities. This highlights the need to revise waste management strategies and introduce additional measures aimed at stimulating effective circular practices beyond merely increasing operational expenditures.

7. A population survey, which involved 3448 respondents and conducted using the PLS-SEM method, revealed that awareness of the circular economy (CE) and external factors, such as government support, significantly influence citizens' pro-circular behavior. The study also found a close relationship between the population's behavior and the concept of resource sharing, which can enhance the active implementation of CE principles. The next phase of the research involved interviews with 54 experts from various sectors, including business, government, financial institutions, and academic organizations. The results indicated that while most respondents acknowledge the importance of CE principles, the level of their implementation varies. This suggests that there are existing barriers and obstacles to effectively applying the CE, including differences in perception and understanding of these principles.

8. Barriers to the transition to a circular economy (CE) were identified through expert interviews with 15 professionals in the agro-industrial complex. Representatives from the civil service emphasized the need for state support and subsidies. Scientists highlighted the importance of educational and research initiatives, while practitioners expressed concerns about circular technologies' high initial costs and long payback periods. Recommendations for the transition to a circular economy were developed based on the research results, including statistical analysis of the Kazakhstani data, analysis of legislation, regression analysis, population survey, and expert interviews. These recommendations cover both the macro and meso levels, aimed at increasing the effectiveness of the application of circular economy principles in the country's agro-industrial complex.

9. At the macro level, the main directions of state policy for implementing the circular economy in Kazakhstan have been defined: the development of a national circular economy roadmap and the integration of CE principles into key economic development programs of the country. Also, establishing a National Circular Economy Platform (QazaqCircular Hub) to coordinate stakeholders, share best practices, and monitor progress was proposed.

10. At the meso level, a range of initiatives has been put forward to spur circular business models within agro-industrial regions and sectors. These include developing eco-industrial clusters, setting up dedicated recycling centers, and fostering cooperatives focused on waste recovery. Also, it was recommended to deploy precision-farming methods, IoT-enabled smart-agriculture solutions, blockchain platforms, and AI-driven systems to maximize resource efficiency, increase productivity, and support the agricultural sector’s shift toward a bioeconomy.

11. The transition to a circular economy model in the agro-industrial complex of Kazakhstan plays a strategically significant role, contributing to strengthening the sustainability of this industry, reducing waste volumes, improving the environmental situation, and opening up new economic prospects for farmers and processing enterprises.

12. The transition to a circular economy is based on a combination of integrated theories and interdisciplinary approaches. Its implementation requires coordinated regulation at various levels, the use of international best practices, and the introduction of targeted incentives. Essential steps along this path include the creation of a national platform, developing eco-parks, constructing recycling infrastructure, and actively implementing digital technologies such as the Internet of Things, blockchain, and artificial intelligence. Following these directions, it is possible to use resources more efficiently, eliminate legal and information barriers, and ensure sustainable economic growth.

REFERENCES

1. World Commission on Environment and Development. Our Common Future. Oxford University Press. – 1987. URL: https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

2. Pearce D. W., Turner R. K. Economics of Natural Resources and the Environment [Electronic resource] / D. W. Pearce, R. K. Turner. — ResearchGate, 2010. — URL: https://www.researchgate.net/publication/31662420_Economics_of_natural_resources_and_the_environment_DW_Pearce_RK_Turner

3. United Nations Conference on Sustainable Development, Rio+20 [Electronic resource]. — United Nations, 2012. — URL: https://sustainabledevelopment.un.org/rio20

4. United Nations. The Future We Want: Outcome document [Electronic resource]. — United Nations, 2012. — URL: https://sustainabledevelopment.un.org/futurewewant.html

5. Ellen MacArthur Foundation. Introduction to the Circular Economy [Electronic resource]. — EMF, 2015. — URL: https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview#:~:text=A%20circular%20economy%20decouples%20economic,loss%2C%20waste%2C%20and%20pollution

6. European Commission. Circular Economy Action Plan: For a Cleaner and More Competitive Europe [Electronic resource]. — EC, 2014. — URL: https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf

7. UNECE. Circular Economy: Understanding the Concept in Order to Develop a Plan for Further Actions (Information Note) [Electronic resource]. — UNECE, June 2020. — URL: https://unece.org/fileadmin/DAM/trade/SCTCS_2020/BackgroundNote_CircularEconomy_Rus.pdf

8. World Economic Forum. Annual Meeting 2019: Meeting Overview [Electronic resource]. — WEF, 2019. — URL: https://www3.weforum.org/docs/WEF_AM19_Meeting_Overview.pdf

9. Ellen MacArthur Foundation. Towards the Circular Economy, Vol. 1: An Economic and Business Rationale for an Accelerated Transition [Electronic resource]. — EMF, 2013. — URL: https://ellenmacarthurfoundation.org/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an

10. UNEP. Green Economy Initiative: Linkages to Sustainable Consumption and Production [Electronic resource]. — UNEP, 2009. — URL: http://www.unep.fr/scp/marrakech/pdf/SCP-GE%20Workshop%20presentation%20Steven%20Stone.pdf

11. UNEP. The Green Economy: Pathways to Sustainable Development and Poverty Eradication [Electronic resource]. — UNEP, 2011. — URL: http://old.ecocongress.info/5_congr/docs/doklad.pdf

12. UNCTAD. The Green Economy: Trade and Sustainable Development Implications [Electronic resource]. — UNCTAD, 2010. — URL: http://unctad.org/en/docs/ditcted20102_en.pdf

13. Green Economy Coalition. The 5 Principles of Green Economy [Electronic resource]. — GEC, 2015. — URL: https://www.greeneconomycoalition.org/news-and-resources/the-5-principles-of-green-economy

14. International Chamber of Commerce. Comments on the UNEP Draft Green Economy Report [Electronic resource], p. 7. — ICC, 2011. — URL: https://www.icc-portugal.com/images/publicacoes/documentos_gratuitos/Ambiente_Energia/ICC_comments_on_the_UNEP_draft_Green_Economy_Report_(2011).pdf

15. Rao T. Building an Equitable Green Economy – What Will It Take? [Electronic resource]. — Danish Group 92, Forum for Sustainable Development, 2012. — URL: http://www.92grp.dk/files/fokus-og-nyheder/07-TARA.pdf

16. Kirchherr J., Reike D., Hekkert M. Barriers to the Circular Economy: Evidence from the European Union // Journal of Cleaner Production. 2017. Vol. 167. P. 114–122. — DOI: 10.1016/j.jclepro.2017.11.064. — URL: https://www.sciencedirect.com/science/article/pii/S0959652617302835 (accessed 28.04.2025).

17. Ghisellini P., Cialani C., Ulgiati S. A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems // Journal of Cleaner Production. 2016. Vol. 114. P. 11–32. — DOI: 10.1016/j.jclepro.2015.09.007. — URL: https://www.sciencedirect.com/science/article/pii/S0959652615012287 (accessed 28.04.2025).

18. Ellen MacArthur Foundation. Towards the Circular Economy. Vol. 2: Opportunities for the Consumer Goods Sector [Electronic resource]. — EMF, 2012. — URL: https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

19. Murray A., Skene K., Haynes K. The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context // Journal of Business Ethics. 2017. Vol. 140, no. 3. P. 369–380. — DOI: 10.1007/s10551-015-2693-2. — URL: https://link.springer.com/content/pdf/10.1007/s10551-015-2693-2.pdf (accessed 28.04.2025).

20. Geissdoerfer M., Savaget P., Bocken N. M. P., Hultink E. J. The Circular Economy – A New Sustainability Paradigm? // Journal of Cleaner Production. 2017. Vol. 143. P. 757–768. — DOI: 10.1016/j.jclepro.2016.12.048. — URL: https://www.sciencedirect.com/science/article/pii/S0959652618311867 (accessed 28.04.2025).

21. WRAP. What is a Circular Economy? [Electronic resource]. — WRAP, 2004. — URL: https://wrap.org.uk/

22. Yuan Z., Bi J., Moriguichi Y. The Circular Economy: A New Development Strategy in China // Journal of Industrial Ecology. 2008. Special Issue. — URL: https://www.researchgate.net/publication/229618832_The_Circular_Economy_A_New_Development_Strategy_in_China

23. Wen C. F., Zhao Y. L., Liang R. Z. Recycle of Low Chemical Potential Substances // Resources, Conservation and Recycling. 2007. Vol. 51, no. 2. P. 475–486. — DOI: 10.1016/j.resconrec.2006.10.011. — URL: https://www.sciencedirect.com/science/article/abs/pii/S0921344906002527

24. Tukker A. et al. Four Systems Perspectives on Circular Economy Research: How to Make CE Real? // Journal of Cleaner Production. 2015. Vol. 115. P. 1–12. — DOI: 10.1016/j.jclepro.2013.12.048. — URL: https://www.sciencedirect.com/science/article/abs/pii/S0959652613008135 (accessed 28.04.2025).

25. Guryeva M. A. The Concept of the Circular Economy as a Universal Model of Green Growth [Electronic resource]. — Economics magazine, 2019. — URL: https://1economic.ru/lib/40990

26. Geng Y. et al. Implementing Sustainable Development in China: Solving the Belt and Road Dilemma Through a Circular Economy // Sustainable Development. 2010. Vol. 15, no. 3. P. A6–A15. — DOI: 10.3843/SusDev.15.3:A6. — URL: https://www.tandfonline.com/doi/abs/10.3843/SusDev.15.3%3A6

27. Zhu Q., Geng Y., Sarkis J. A Review of Circular Economy Research in China: The Road Ahead // Journal of Cleaner Production. 2007. Vol. 31. P. 1–15. — URL: https://www.sciencedirect.com/science/article/abs/pii/S0959652606002411

28. Su B., Heshmati A., Geng Y., Yu X. A Review of the Circular Economy in China: Moving from Rhetoric to Implementation // Journal of Cleaner Production. 2013. Vol. 42. P. 215–227. — DOI: 10.1016/j.jclepro.2012.11.020. — URL: https://www.sciencedirect.com/science/article/abs/pii/S0959652612006117?via%3Dihub

29. European Environment Agency. Circular Economy in Europe: Developing the Knowledge Base [Electronic resource]. — EEA, 2016. — URL: https://www.socialistsanddemocrats.eu/sites/default/files/Circular%20economy%20in%20Europe.pdf

30. José Potting, Marko Hekkert, Ernst Worrell and Aldert Hanemaaijer. PBL Netherlands Environmental Assessment Agency. Measuring Innovation in Product Chains: Towards a Circular Economy (Potting et al.) [Electronic resource]. — PBL, 2017. — URL: https://www.pbl.nl/sites/default/files/downloads/pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf

31. Fonseca L. M. et al. Assessment of Circular Economy Within Portuguese Organizations: Drivers, Barriers, and Performance Indicators // Journal of Manufacturing Technology Management. 2018. Vol. 29, no. 6. P. 1008–1029. — URL:

https://www.researchgate.net/publication/325971435_Assessment_of_Circular_Economy_within_Portuguese_Organizations

32. OECD. The Role of National Governments in Supporting the Transition to a Circular Economy [Electronic resource]. — OECD, 2019. — URL: https://www.oecd-ilibrary.org/sites/724e5c45-en/index.html?itemId=/content/component/724e5c45-en#section-d1e22491

33. Torgautov B., Zhanabayev A., Tleuken A., Turkyilmaz A., Borucki C., Karaca F. Performance assessment of construction companies for the circular economy: a balanced scorecard approach // Sustainable Production and Consumption. – 2022. – Vol. 33. – P. 991–1004. – DOI: 10.1016/j.spc.2022.08.021

34. Tokazhanov G., Galiyev O., Lukyanenko A., Nauyryzbay A., Ismagulov R., Durdyev S. Circularity assessment tool development for construction projects in emerging economies // Journal of Cleaner Production. – 2022. – Vol. 362. – P. 132293. – DOI: 10.1016/j.jclepro.2022.132293

35. Sansyzbayeva G., Temerbulatova Z., Zhidebekkyzy A., Ashirbekova L. Evaluating the transition to green economy in Kazakhstan: a synthetic control approach // Journal of International Studies. – 2020. – V. 13, № 1. – p. 324–341. – DOI: 10.14254/2071-8330.2020/13-1/21

36. Mukhtarova K.S., Trifilova A.A., Zhidebekkyzy A. Commercialization of Green Technologies: an Exploratory Literature Review // Journal of International Studies. – 2016. – V. 9, № 3. – p. 75–87. – DOI: 10.14254/2071-8330.2016/9-3/6

37. Smagulov A., Zhatkanbaev Y., Tumbai J., Abdikul Sh., Muratbekova K., Agymbay A. The impact of the environmental crisis on the purchasing power of consumers // E3S Web of Conferences. – 2020. – Vol. 159. – Art. 03005. – P. 1–9. – DOI: 10.1051/e3sconf/202015903005.

38. Sansyzbayeva G., Ashirbekova L., Nurgaliyeva K., Ametova Z., Asanova A. Realities and prospects of using green technologies in Kazakhstan // E3S Web of Conferences. – 2020. – Vol. 159. – Art. 07002. – DOI: 10.1051/e3sconf/202015907002

39. Diyar S., Akparova A., Toktabayev A., Tyutunnikova M. Green Economy – Innovation-Based Development of Kazakhstan // Procedia – Social and Behavioral Sciences. – 2014. – Vol. 140. – P. 695–699. – DOI: 10.1016/j.sbspro.2014.04.497

40. Mahmood M., Orazalin N. Green governance and sustainability reporting in Kazakhstan's oil, gas and mining sector: Evidence from a former USSR emerging economy // Journal of Cleaner Production. – 2017. – Vol. 164. – P. 389–397. – DOI: 10.1016/j.jclepro.2017.06.203

41. Abuov Y., Seisenbayev N., Lee W. CO_2 storage potential in sedimentary basins of Kazakhstan // International Journal of Greenhouse Gas Control. – 2020. – Vol. 103. – P. 103186. – DOI: 10.1016/j.ijggc.2020.103186

42. Alikhanova A., Kakimzhan A., Mukhanov A., Rojas-Solórzano L. Design of a bus shelter based on green energy technologies for extreme weather conditions in Nur-Sultan, Kazakhstan // Sustainable Energy Technologies and Assessments. – 2019. – Vol. 36. – Art. 100544. – P. 1–7. – DOI: 10.1016/j.seta.2019.100544

43. Akhanova G., Nadeem A., Kim J.R., Azhar S. A multi-criteria decision-making framework for building sustainability assessment in Kazakhstan //

Sustainable Cities and Society. – 2020. – Vol. 52. – Article 101842. – DOI: 10.1016/j.scs.2019.101842

44. Karatayev M., Clarke M., Salnikov V., Bekseitova R., Nizamova M. Monitoring climate change, drought conditions and wheat production in Eurasia: the case study of Kazakhstan // Heliyon. – 2022. – Vol. 8, No. 1. – P. e08660. – DOI: 10.1016/j.heliyon.2021.e08660

45. Islam G., Darbayeva E., Rymbayev Z., Dikhanbayeva D., Rojas L. Switching-off conventional lighting system and turning-on LED lamps in Kazakhstan: a techno-economic assessment // Sustainable Cities and Society. – 2019. – Vol. 51. – Article 101790. – DOI: 10.1016/j.scs.2019.101790

46. Biakhmetov B., You S., Dostiyarov A. Sustainable waste management and circular economy // Low Carbon Stabilization and Solidification of Hazardous Wastes / Eds. D.C.W. Tsang, L. Wang. – Amsterdam: Elsevier, 2021. – P. 545–554. – DOI: 10.1016/B978-0-12-824004-5.00032-3

47. Kazhmuratova A., Akhmetkaliyeva S., Boltaeva A., Moldabekova A. Introduction of environmental innovations in the Republic of Kazakhstan // E3S Web of Conferences. – 2020. – Vol. 159. – Article 01005. – DOI: 10.1051/e3sconf/202015901005

48. Bator, F. M. (1958). The Anatomy of Market Failure. The Quarterly Journal of Economics, 72(3), 351–379. https://courses.cit.cornell.edu/econ335/out/bator_qje.pdf

49. Stiglitz J. E. Economics and the Public Purpose: monograph / J. E. Stiglitz. – New York : W. W. Norton, 1996. – 224 p.

50. Musgrave R. A., Musgrave P. B. Public Finance in Theory and Practice: 5th ed. / R. A. Musgrave, P. B. Musgrave. – New York : McGraw-Hill, 1989.

51. OECD. Aligning Policies for a Low-Carbon Economy: Policy Toolkit / Organisation for Economic Co-operation and Development; International Energy Agency; Nuclear Energy Agency; International Transport Forum. – Paris : OECD Publishing, 2015.

52. European Commission. A New Circular Economy Action Plan for a cleaner and more competitive Europe: COM/2020/98 final / European Commission. – Brussels: European Commission, 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN

53. North D. C. Institutions, Institutional Change and Economic Performance: monograph / D. C. North. – Cambridge; New York : Cambridge University Press, 1990. – 152 p.

54. World Bank Country Classifications by Income Level: 2022–2023 [Electronic resource]. — https://blogs.worldbank.org/opendata/new-world-bank-country-classifications-income-level-2022-2023

55. Zhidebekkyzy A., Kalmakova D., Amangeldiyeva B. Implementation of circular economy principles across countries // Central Asian Economic Review. 2021;(6):43-62. https://doi.org/10.52821/2789-4401-2021-6-43-62

56. Schnurer H. German Waste Legislation and Sustainable Development [Electronic resource]. — BMU, 2018. — URL:

https://www.bmuv.de/fileadmin/bmu-import/files/pdfs/allgemein/application/pdf/entwicklung_abfallrecht_uk.pdf

57. Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). German Waste Management 2018 [Electronic resource]. — BMU, 2018. — URL: https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/abfallwirtschaft_2018_en_bf.pdf

58. Nelles M. et al. Waste Hierarchy in Practice: Foundational Concepts [Electronic resource]. — Elsevier, 2016. — URL: https://reader.elsevier.com/reader/sd/pii/S1878029616300901?token=196122CA5C942A82275E61CC5CE7E35FEB40C941EDA69DCB149A10BED9FA1127B12E8CC1D6D0BA5D86228A8064A67580

59. Ministry of the Environment, Government of Japan. Environmental Legislation in Japan [Electronic resource]. — MOEJ, 2023. — URL: https://www.env.go.jp/

60. Avfall Sverige AB. Swedish Waste Management 2018 [Electronic resource]. — Avfall Sverige, 2018. — URL: https://www.avfallsverige.se/fileadmin/user_upload/Publikationer/SAH_2019_EN.pdf

61. Government Offices of Sweden. Circular Economy – Strategy for the Transition in Sweden [Electronic resource]. — Regeringen, 2020. — URL: https://www.government.se/4ad42c/contentassets/d5ab250cf59a47b38feb8239eca1f6ab/circular-economy--strategy-for-the-transition-in-sweden

62. United Kingdom. Clean Growth Strategy: Executive Summary [Electronic resource]. — UK Government, 2018. — URL: https://www.gov.uk/government/publications/clean-growth-strategy/clean-growth-strategy-executive-summary

63. Clausen A., Garcia Lopez C., Kriipsalu M., Pretz T. MSW Management in Estonia: Current Situation and Future Potential for Energy Recovery from Sustainable Sources [Electronic resource]. — WTERT, 2017. — URL: https://www.wtert.net/paper/3972/Current-state-of-Waste-Management-in-Estonia.html

64. OECD. Environmental Performance Reviews: Estonia 2017 [Electronic resource]. — OECD, 2017. — URL: https://www.oecd-ilibrary.org/sites/9789264268241-11-en/index.html?itemId=/content/component/9789264268241-11-en

65. Statistics Estonia. Waste and Circular Economy 2020 [Electronic resource]. — Statistics Estonia, 2020. — URL: https://www.stat.ee/en/find-statistics/statistics-theme/environment/waste-and-circular-economy

66. Eurostat. Municipal Waste Generation, 2007 and 2017 (kg per inhabitant) [Electronic resource]. — Eurostat, 2018. — URL: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Municipal_waste_generation,_2007_and_2017_(kg_per_inhabitant)_world20.png (accessed 28.04.2025).

67. Broom D. South Korea Once Recycled 2 % of Its Food Waste. Now It Recycles 95 % [Electronic resource]. — WEF Agenda, 2019. — URL: https://www.weforum.org/agenda/2019/04/south-korea-recycling-food-waste/ (accessed 28.04.2025).

68. Fondazione Symbola. 100 Italian Circular Economy Stories [Electronic resource]. — Symbola, 2021. — URL: https://corporate.enel.it/en/stories/a/2021/12/100-italian-circular-economy-stories (accessed 28.04.2025).

69. Thomson Reuters Practical Law. Environmental Law and Practice in Italy: Overview [Electronic resource]. — Practical Law, 2021. — URL: https://uk.practicallaw.thomsonreuters.com/1-503-2608 (accessed 28.04.2025).

70. People's Republic of China. Circular Economy Promotion Law No 4, 29 August 2008 [Electronic resource]. — URL: https://ppp.worldbank.org/public-private-partnership/sites/ppp.worldbank.org/files/documents/China_CircularEconomyLawEnglish.pdf (accessed 28.04.2025).

71. Feng K. E. & Lam C.-Y. A. An Overview of Circular Economy in China: How the Current Challenges Shape the Plans for the Future // The Chinese Economy. 2021. P. 1–18. — DOI: 10.1080/10971475.2021.1875156.

72. Li W. & Lin W. Circular Economy Policies in China // Anbumozhi V. & Kim J. (eds.). Towards a Circular Economy: Corporate Management and Policy Pathways. — ERIA Research Project Report 2014-44, Jakarta: ERIA, 2016. P. 95–111.

73. Dezan Shira & Associates. China's Circular Economy: Understanding the New Five Year Plan [Electronic resource]. — 2021. — URL: https://www.china-briefing.com/news/chinas-circular-economy-understanding-the-new-five-year-plan/ (accessed 28.04.2025).

74. Russian Federation. Industry Development Strategy for Processing, Disposal and Neutralization of Production and Consumption Waste to 2030 [Electronic resource]. — URL: https://docs.cntd.ru/document/556353696 (accessed 28.04.2025).

75. Fedotkina O., Gorbashko E., Vatolkina N. Circular Economy in Russia: Drivers and Barriers for Waste Management Development // Sustainability. 2019. Vol. 11.

76. Koroleva E. B. Cirkulyarnaia ekonomika na urovne goroda [Circular Economy at the City Level] // Collection of Articles, South-Eastern Finland – Russia Programme 2014–2020. — St. Petersburg, 2021. P. 53.

77. Mexico. General Law for the Prevention and Integral Management of Wastes [Electronic resource]. — 2003. — URL: https://www.global-regulation.com/translation/mexico/560306/general-law-for-the-prevention-and-integral-management-of-wastes.html (accessed 28.04.2025).

78. Brazil. National Solid Waste Policy (Law 12.305/2010) [Electronic resource]. — WIEGO, 2010. — URL: https://www.wiego.org/sites/default/files/resources/files/Pereira-Brazilian-Waste-Policy.pdf (accessed 28.04.2025).

79. Lovón-Canchumani G., Veiga L., Araujo M. Circular Economy in Brazil: A Review and Potentialities in Three Economic Sectors. Research Report, 2016. — URL: https://www.researchgate.net/publication/342644665_Circular_Economy_in_Brazil_a_review_and_potentialities_in_three_economic_sectors_Research_Report (accessed 28.04.2025).

80. CNI (Confederação Nacional da Indústria). Circular Economy: Strategic Path for Brazilian Industry [Electronic resource]. — Brasília, 2020. — URL: https://static.portaldaindustria.com.br/media/filer_public/3a/a6/3aa67ad0-4e7c-46c8-8b10-0c6d097f35cf/circular_economy_-_interativo.pdf (accessed 28.04.2025).

81. Malaysia. National Plan for Sustainable Consumption and Production 2016–2030 [Electronic resource]. — SWITCH-Asia, 2016. — URL: https://www.switch-asia.eu/resource/the-national-scp-blueprint/ (accessed 28.04.2025).

82. MIDA. Circular Economy: Where Are We Now and How Do We Even Begin? [Electronic resource]. — May 2021. — URL: https://www.mida.gov.my/circular-economy-where-are-we-now-and-how-do-we-even-begin/ (accessed 28.04.2025).

83. Practical Law. Environmental Law and Practice in Turkey: Overview [Electronic resource]. — Thomson Reuters, 2022. — URL: https://uk.practicallaw.thomsonreuters.com/7-522-2040 (accessed 28.04.2025).

84. UNECE. Environmental Performance Reviews: Moldova [Electronic resource]. — UNECE, 2015. — URL:endregion=https://unece.org/fileadmin/DAM/env/epr/epr_studies/moldova.pdf (accessed 28.04.2025).

85. OECD/EAP. Green Economy Country Pilot: Moldova [Electronic resource]. — OECD, 2015. — URL: https://www.oecd.org/environment/outreach/EI-country-pilot-Moldova-en.pdf (accessed 28.04.2025).

86. UNECE. Desk Study: Statistics on Sustainable Development and Environmental Sustainability in Eastern Europe, Caucasus and Central Asia [Electronic resource]. — UNECE, 2013. — URL: https://unece.org/fileadmin/DAM/stats/documents/ece/ces/ge.33/2013/mtg4/Desk_study_RU.pdf (accessed 28.04.2025).

87. Shpak N., Kuzmin O., Melnyk O., Ruda M., Sroka W. Implementation of a Circular Economy in Ukraine: The Context of European Integration // Resources. 2020. Vol. 9, no. 8. Art. 96. — DOI: 10.3390/resources9080096. — URL: https://www.mdpi.com/2079-9276/9/8/96 (accessed 28.04.2025).

88. ODB Brussels. Innovative Uzbekistan Project [Electronic resource]. — ODB, 2020. — URL: https://by.odb-office.eu/razviccio-patencyjalu-arhanizacyj_/innovative-uzbekistan (accessed 28.04.2025).

89. IAEA. Fourth National Report of Tajikistan for the Sixth Review Meeting [Electronic resource]. — IAEA, 2017. — URL:

https://www.iaea.org/sites/default/files/national_report_of_tajikistan_for_the_6th_review_meeting_-_english.pdf (accessed 28.04.2025).

90. UNECE. Environmental Performance Reviews: Tajikistan (3rd cycle) [Electronic resource]. — UNECE, 2017. — URL: https://www.greengrowthknowledge.org/sites/default/files/downloads/resource/UNECE%20Environmental%20Performance%20Reviews_Tajikistan%202017%20%283rd%20cycle%29.pdf (accessed 28.04.2025).

91. City of Bishkek & EBRD. Bishkek Solid Waste Management Project: ESIA Addendum [Electronic resource]. — EBRD, 2016. — URL: file:///C:/Users/ZenBook/Downloads/Bishkek%20SWP%20ESIA%20Adden_Final_9%2011%202016.pdf (accessed 28.04.2025).

92. National Statistical Committee of the Kyrgyz Republic. Open Data: Environment 2016–2020 [Electronic resource]. — NSC KR, 2020. — URL: http://www.stat.kg/en/opendata/category/137/?is_green (accessed 28.04.2025).

93. Bhamra A., Patel S. C., Singh T. India Green Economy Barometer 2018 [Electronic resource]. — Devalt, 2018. — URL: https://www.devalt.org/images/L2_ProjectPdfs/GreenEconomyBarometer.pdf (accessed 28.04.2025).

94. Statista. Waste Management in India: Statistics & Facts [Electronic resource]. — Statista, 2021. — URL: https://www.statista.com/topics/5586/waste-management-india/#dossierKeyfigures (accessed 28.04.2025).

95. ClearIAS. Environmental Laws in India [Electronic resource]. — URL: https://www.clearias.com/environmental-laws-india/ (accessed 28.04.2025).

96. UNEP/SACEP. Environmental Legislation and Institutions in Pakistan [Electronic resource]. — UNEP, 2001. — URL: http://www.sacep.org/pdf/Reports-Technical/2001-UNEP-SACEP-Law-Handbook-Pakistan.pdf (accessed 28.04.2025).

97. U.S. Commercial Service. Pakistan Country Commercial Guide: Waste Management [Electronic resource]. — URL: https://www.trade.gov/country-commercial-guides/pakistan-waste-management (accessed 28.04.2025).

98. Asia-Europe Foundation. Waste Management in Indonesia and Jakarta: Background Paper [Electronic resource]. — ASEF, 2022. — URL: https://asef.org/wp-content/uploads/2022/01/ASEFSU23_Background-Paper_Waste-Management-in-Indonesia-and-Jakarta.pdf (accessed 28.04.2025).

99. Practical Law. Environmental Law and Practice in Indonesia: Overview [Electronic resource]. — Thomson Reuters, 2023. — URL: https://uk.practicallaw.thomsonreuters.com/Document/I135fe76420af11ed9f24ec7b211d8087 (accessed 28.04.2025).

100. Ghisellini P., Cialani C., Ulgiati S. A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems // Journal of Cleaner Production. — 2016. Vol. 114. P. 11–32. — DOI:10.1016/j.jclepro.2015.09.007;

101. Kirchherr J., Reike D., Hekkert M. Conceptualizing the circular economy: An analysis of 114 definitions [Electronic resource]. — 2017. — SSRN. — DOI:10.2139/ssrn.3037579

102. Ellen MacArthur Foundation. Delivering the circular economy: A toolkit for policymakers [Electronic resource]. — 2015. — URL: https://ellenmacarthurfoundation.org/publications/delivering-the-circular-economy-a-toolkit-for-policymakers

103. Geissdoerfer M., Savaget P., Bocken N. M. P., Hultink E. J. The circular economy – a new sustainability paradigm? // Journal of Cleaner Production. — 2017. Vol. 143. P. 757–768. — DOI:10.1016/j.jclepro.2016.12.048

104. Bocken N. M. P., Short S. W., Rana P., Evans S. Product design and business model strategies for a circular economy // Journal of Industrial and Production Engineering. — 2016. Vol. 33, no. 5. P. 308–320. — DOI:10.1080/21681015.2016.1172124

105. Murray A., Skene K., Haynes K. The circular economy: An interdisciplinary exploration of the concept and application in a global context // Journal of Business Ethics. — 2017. Vol. 140. P. 369–380. — DOI:10.1007/s10551-015-2693-2

106. Ellen MacArthur Foundation. Towards the circular economy: Accelerating the scale-up across global supply chains (Vol. 3) [Electronic resource]. — 2015. — URL: https://ellenmacarthurfoundation.org/publications/towards-the-circular-economy-accelerating-the-scale-up-across-global-supply-chains-2014

107. Carbon Trust. Footprinting guide: Carbon footprint [Electronic resource]. — 2008. — URL: https://www.carbontrust.com/resources/guides/carbon-footprinting

108. International Organization for Standardization. ISO 14040:2006 Environmental management — Life cycle assessment — Principles and framework. — Geneva: ISO; 2006

109. Bocken N. M. P., de Pauw I., Bakker C., van der Grinten B. Business models for sustainability // Oxford Research Encyclopedia of Environmental Science [Electronic resource]. — 2023. — DOI:10.1093/acrefore/9780199389414.013.842

110. Jangabulova A. K., Salykhbaeva A. T. Formation and Development of the Legal Foundations of Environmental Policy of the Republic of Kazakhstan // Law and Ecology. — 2025. — No. 1. — P. 10–18.

111. Adilet ZAN. Legal Information System of the Republic of Kazakhstan [Electronic resource]. — URL: https://adilet.zan.kz

112. Baideldinov D. L., Kuratov S. G. Legal Problems of Reforming Environmental Legislation of the Republic of Kazakhstan / D. L. Baideldinov, S. G. Kuratov. – Almaty: Ecological Society “Green Salvation”; Almaty: XXI Century Foundation, 1998. – 104 p.

113. Environmental Code of the Republic of Kazakhstan [Electronic resource] // Zakonodatel’nyy akt RK. — No. 400-VI. — 2 January 2021 // URL: https://adilet.zan.kz/eng/docs/K2100000400

114. Government of the Republic of Kazakhstan. Ministry of Ecology and natural resources of the Republic of Kazakhstan // — URL: https://www.gov.kz/memleket/entities/ecogeo?lang=en

115. Strategy for Achieving Carbon Neutrality by 2060 [Electronic resource] : Decree of the President of the Republic of Kazakhstan of 02.02.2023 No 121 / President of the Republic of Kazakhstan. – Available at: https://adilet.zan.kz/rus/docs/U2300000121

116. Bapiev K. Kazakhstan Changed Its Strategy for Transitioning to a Green Economy [Electronic resource] / K. Bapiev. – 20 June 2024. – Available at: https://kz.kursiv.media/2024-06-20/print1039-green/?utm_source

117. Decree of the Government of the Republic of Kazakhstan No. 910 of 31 October 2024 "On Approval of the Concept for the Development of Ecological Culture 'Taza Kazakhstan' for 2024–2029" [Electronic resource] / Government of the Republic of Kazakhstan. – IPS "Adilet". – Available at: https://adilet.zan.kz/rus/docs/P2400000910

118. President of the Republic of Kazakhstan. Decree No. 577 of 30 May 2013 "On the Concept for the Transition of the Republic of Kazakhstan to a Green Economy" [Electronic resource] / President of the Republic of Kazakhstan. – IPS "Adilet". – Available at: https://adilet.zan.kz/rus/docs/U1300000577

119. President of the Republic of Kazakhstan. Decree No. 636 of 15 February 2018 "On Approval of the National Development Plan of the Republic of Kazakhstan to 2025 and on Repeal of Certain Decrees of the President of the Republic of Kazakhstan" [Electronic resource] / President of the Republic of Kazakhstan. – IPS "Adilet". – Available at: https://adilet.zan.kz/rus/docs/U1800000636

120. Association "KazWaste" // [Electronic resource]. — 2013. — URL: https://kaz-waste.kz/

121. European Environment Agency, Italian Institute for Environmental Protection and Research (ISPRA). Bellagio Declaration on Circular Economy Monitoring Principles // [Electronic resource]. — 2020. — URL: https://www.isprambiente.gov.it/en/archive/news-and-other-events/ispra-news/2021/03/bellagio-declaration

122. United Nations Economic Commission for Europe. Guidelines for Measuring Circular Economy: A Simplified Framework for National-Level Monitoring // [Electronic resource]. — 2023. — URL: https://unece.org/sites/default/files/2024-02/ECECESSTAT20235_WEB.pdf

123. National Bureau of Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan // [Electronic resource]. — URL: https://stat.gov.kz/

124. Zhidebekkyzy, A., Temerbulatova, Z., Amangeldiyeva, B. A., & Sakhariyeva, A. (2023). Towards a Circular Economy: an Analysis of Kazakhstani case. // Journal of Economic Research, Business Administration, 143(1), 16–32. https://doi.org/10.26577/be.2023.v143.i1.02

125. Zhidebekkyzy, A., Moldabekova, A., Amangeldiyeva, B., & Streimikis, J. (2022). Assessment of factors influencing pro-circular behavior of a population. // Economics and Sociology, 15(3), 202-215. Scopus procentile - 92, Q1. doi:10.14254/2071-789X.2022/15-3/12.

126. Zhidebekkyzy, A., Moldabekova, A., Amangeldiyeva, B., & Šanova, P. (2023). Transition to a circular economy: Exploring stakeholder perspectives in Kazakhstan // Journal of International Studies, 16(3), 144-158. doi:10.14254/2071-8330.2023/16-3/8

127. Ministry of the Environment and Climate Change, Finland. Strategic Programme to Promote a Circular Economy [Electronic resource]. — 2021. — URL: https://ym.fi/en/strategic-programme-to-promote-a-circular-economy

128. Government of Finland. Government Resolution on the Strategic Programme for Circular Economy, 8 April 2021 [Electronic resource]. — 2021. — URL: https://ym.fi/documents/1410903/42733297/Government%20resolution%20on%20the%20Strategic%20Programme%20for%20Circular%20Economy%208.4.2021.pdf/309aa929-a36f-d565-99f8-fa565050e22e/Government%20resolution%20on%20the%20Strategic%20Programme%20for%20Circular%20Economy%208.4.2021.pdf

129. Science of the Total Environment [Electronic resource]. — 2018. — DOI: 10.1007/s11356-018-1390-y — URL: https://link.springer.com/article/10.1007/s11356-018-1390-y

130. HAL Open Science. Circular Economy Metrics for Industrial Symbiosis // [Electronic resource]. — 2019. — URL: https://hal.science/hal-02166722/

131. Journal of Cleaner Production // [Electronic resource]. — 2004. — URL: https://www.sciencedirect.com/science/article/abs/pii/S0959652604000873

132. Journal of Industrial Ecology // [Electronic resource]. — 2019. — DOI: 10.1111/jiec.12749 — URL: https://onlinelibrary.wiley.com/doi/10.1111/jiec.12749

133. Journal of Cleaner Production // [Electronic resource]. — 2011. — URL: https://www.sciencedirect.com/science/article/abs/pii/S0959652611000059

134. MDC Sustainability. Assessing National Circular Economy Performance // [Electronic resource]. — 2018. — URL: https://www.mdpi.com/2071-1050/10/12/4545

135. MDC Sustainability. Governance Models for Circular Economy // [Electronic resource]. — 2014. — URL: https://www.mdpi.com/2071-1050/6/9/6325

136. Bocken N.M.P. et al. Business Model Innovation in a Circular Economy: Conceptualization and Cases // [Electronic resource]. — 2017. — URL: https://d1wqtxts1xzle7.cloudfront.net/52085507/Business_Model_Innovation_in_a_Circular_20170309-10330-13ng4rp-libre.pdf?1489055372&response-content-disposition=inline%3B+filename%3DBusiness_Model_Innovation_in_a_Circular.pdf

137. Braithwaite D. et al. Tobacco Retailer Density and Youth Smoking Initiation // Tobacco Control. — 2018. Vol. 27, no. 4. P. 455–461. // [Electronic resource] — URL: https://tobaccocontrol.bmj.com/content/27/4/455

138. Plantix // [Electronic resource]. — URL: https://plantix.net

139. Blue River Technology // [Electronic resource]. — URL: https://bluerivertechnology.com

140. Prospera // [Electronic resource]. — URL: https://www.prospera.ag
141. AgriPredict // [Electronic resource]. — URL: https://agripredict.com
142. Harvest CROO Robotics // [Electronic resource]. — URL: https://harvestcroorobotics.com
143. Connecterra (Ida platform) // [Electronic resource]. — URL: https://www.connecterra.io/ida
144. Zhidebekkyzy, A., & Amangeldiyeva, B. (2025). The Influence of Economic and Environmental Factors on the Adoption of Responsible Production Standards. Eurasian Journal of Economic and Business Studies, 69(1), 97–110. https://doi.org/10.47703/ejebs.v69i1.477
145. Kalmakova, D. T., Moldabekova, A. T., & Amangeldiyeva, B. A. (2023). Decoupling economy from natural resources consumption and environmental pressure: analysis of Kazakhstani case. Journal of Economic Research &Amp; Business Administration, 145(3), 57–73. https://doi.org/10.26577/be.2023.v145.i3.06

Appendix A

Most cited papers on circular economy

Applied filters: Years ("from 2000 to 2024"), Keyword ("circular economy"), Branch of knowledge ("Business, Management and Accounting Economics", "Econometrics and Finance"). Total - 8,539 documents found.

Authors	Title	Brief summary	Methodology	Citations (Scopus)
Geissdoerfer M., Savaget P., Bocken N. M. P., Hultink E. J.	"The Circular Economy – A new sustainability paradigm?"	Investigates the circular economy as an emerging sustainability framework and its relation to sustainable development.	Conceptual analysis and case studies.	4909
Kirchherr J., Reike D., Hekkert M.	"Conceptualizing the circular economy: An analysis of 114 definitions"	Synthesizes 114 definitions to clarify the scope and principles of the circular economy.	Literature review and content analysis.	4825
Ghisellini P., Cialani C., Ulgiati S.	"A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems"	Reviews circular economy features and perspectives, outlining drivers and barriers to implementation.	Systematic literature review.	4089
Korhonen J., Honkasalo A., Seppälä J.	"Circular economy: the concept and its limitations"	Critically examines conceptual strengths and limitations of the circular economy.	Conceptual critique.	2449
A. Murray, Keith R. Skene, Kathryn Haynes	"The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context"	The circular economy concept emphasizes redesigning processes and cycling materials, but has limitations in addressing the social dimension of sustainable development.	Literature review approach.	2060
Lieder M., Rashid A.	"Towards circular economy implementation: a comprehensive review in context of manufacturing industry"	Assesses barriers, enablers, and strategies for implementing circular economy in manufacturing.	Comprehensive review.	1897
Tukker A.	"Product services for a resource-efficient and circular economy - A review"	Shows a fourfold increase in PSS research since 2000, highlights their role in resource efficiency and CE, and identifies key success factors and B2C adoption barriers.	Systematic literature review.	1414

Reike, D., Vermeulen, W. J. V., & Witjes, S.	"The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options"	Identifies three historical phases of the circular economy, exposes conceptual controversies around resource-value retention, unifies divergent views into a 10R typology, and argues for prioritizing shorter-loop options (e.g., remanufacturing) to advance circularity.	Qualitative conceptual study: critical literature and historical review of CE evolution.	1196
Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., & Hekkert, M.	"Barriers to the Circular Economy: Evidence from the European Union (EU)"	Reveals that cultural and market barrier - particularly low consumer awareness and hesitant company culture - are perceived as the main obstacles to CE in the EU, while technological barriers rank low on the list.	Mixed-methods large-N study: an online survey of 208 CE professionals across EU member states, complemented by 47 in-depth expert interviews.	1166
Genovese, A., Acquaye, A. A., Figueroa, A., & Koh, S. C. L.	"Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications"	Compares traditional and circular production systems in chemical and food industries, showing that circular integration reduces lifecycle emissions, enhances waste recovery, decreases virgin resource use, and improves carbon visibility	Comparative multiple-case study; direct, indirect, and total lifecycle emissions were quantified.	1060
Su B., Heshmati A., Geng Y., Yu X.	"A review of the circular economy in China: moving from rhetoric to implementation"	Reviews China's circular economy policies, achievements, and challenges from 2000 to 2012.	Policy analysis and literature review.	1044
Govindan, K., & Hasanagic, M.	"A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective"	Synthesizes global evidence on the drivers and barriers to circular-economy adoption in supply chains, proposing a multi-stakeholder framework that emphasizes the crucial role of government in promoting CE practices through laws, policies, and governance.	Systematic literature review: screening and coding of peer-reviewed studies on CE in supply chains. classification of identified drivers, barriers, and practices.	1039
Note - Compiled by the author				

Appendix B

Comparative analysis of state measures for supporting and developing circular economy across countries

№	Country	Legislative framework, state programs, strategic documents	Successful cases on CE
	High-income group		
1	**Sweden**	– National strategy for the transition to a circular economy, July 2020 – The New Comprehensive Plan for Umeå Municipality (2018) – Swedish government's letter of December 2015, "Politics for sustainable businesses" – Waste Incineration for the Future, 2019	Wrights Recycling Machinery Ltd - manufacturing the cable stripping machinery, granulators and shredders for waste, etc. NIVUS GmbH - developer, manufacturer and supplier of measurement systems for the water industry. Weda AB - Elleta Group - specialised in underwater cleaning solutions with automatic and semi automatic robots. IKEA - Continuously working to expand the use of both renewable and recyclable materials Developed materials made entirely from recycled wood and recycled PET bottles
2	**Germany**	– Enregiewende – Germany's transition to low-carbon energy – Circular Economy Act (2012) – Resource efficiency program ProgRess I (2012) – Climate Action Program 2020 (2014) – Resource efficiency program ProgRess II (2016) – Climate Action Plan 2050 (2016) [BEROC, 2018] – Circular Economy Initiative Deutschland (CEID) 2019 – Circular Economy Roadmap for Germany	Rhinopaq - provides reusable shipping packaging boxes made of polypropylene, which can be reused up to 20 times. RadiciGroup - Renycle® is a product obtained from recycled nylon 6, a highly valued material because of its excellent resistance, dyeability, softness and versatility. ReNewTex - Circular Economy for Textiles Van Werven Plastics Recyling - specialises in creating high-quality raw materials from post-consumer hard plastics, collected from construction waste, industrial waste and municipal recycling centres
3	**Great Britain**	– Resources and waste strategy for England (2018) – 25 Year Environment Plan (last update in 2019, first published in 2018) – Clean Growth Strategy (2017, updated in 2018)	Good Club - is the online Zero Waste store. They deliver groceries in reusable delivery boxes and reusable product containers which they collect from customers' homes. CauliBox - helps businesses and customers ditch disposable food packaging via their digitally-enabled reusable solutions A Good Thing - A non-profit organisation making it easy for businesses who care to donate unused items to amazing local charities.
4	**Estonia**	– Circular economy conference (2018,2019,2021) – Estonian Circular economy strategic document and action plan (2021) – Strategy «Estonia 2035»	Ragn-Sells - collects, treats and recycles waste and residual products from businesses, organisations and households. Rohepakend - home-grown alternative to plastic food packaging: a food wrap made from donated cloth, pine resin from Estonian forests and beeswax

5	**South Korea**	– Framework Act on Resource Circulation (FARC) 2016 – Waste management Act (1986) – Act on resource saving and recycling promotion (1992) – Act on encouragement of purchasing Green Products (2004) – Act on resource circulation of electrical, electronic equipment and vehicles (2008) – First Master Plan on Resource Circulation (Resource Circulation – Plan) 2018–2027 – The Master Plan on Resource – Development (2020–2029)	Granutech-Saturn Systems - offers a diversified line of recycling equipment systems that can be easily integrated into a single processing facility. From shredders to granulators to powederizers and refiner mills - to auto crushers and etc KB Corporation - working on the Recycling Activities for the battery scraps & electronic scrap in Korea such as lead-acid batteries from auto & industrial, all different kinds of rechargeable batteries like NiCd, NiMH and Li-ion batteries Samsung - Samsung's Galaxy Upcycling program
6	**Japan**	-The Public Cleansing Act (1954) was the first attempt to regulate the collection and disposal of waste for sanitation. -The Basic Environment Act (1993) is the main document regulating the waste management sector. -Basic Act on Establishing a Sound Material-Cycle Society	"Mottainai" culture ("don't throw away until it's completely used"). 63% of all paper is recycled, the rest is incinerated using advanced plasma gasification technology. 85% of plastic bottles are recycled (plan to reach 100% by 2030).
7	**Italy**	Circular Economy Package Implementation (2020) Legislative Decree No. 116/2020 National Strategy for Circular Economy (2022) Green Public Procurement (GPP)	Aquafil — production of ECONYL fibres from recycled nets and carpets Novamont — biodegradable plastics from agricultural waste Hera Group — recycling of household waste and biogas production Comieco — recycling of paper packaging
	Upper-middle-income group		
8	**Russia**	– Fundamentals of state policy in the field of environmental development of the Russian Federation for the period up to 2030 – National project "Ecology" (2018) – International Conference "Cyclical Economy as a Context for Innovation in the 21st Century" (2015)	Sberbank - ESG- direction (ESG = (Environmental) + (Social) + (Governance)) Polymetal - Gold mining company MTS – telecommunications company Sibur – Petrochemistry company
9	**Mexico**	– National Programs for the Prevention – and Integral Management of Waste – National – Vision Towards Sustainable Management: Zero Waste (2019) – National Strategy for Sustainable Production and – Consumption (2012) – The Low Carbon and Circular Economy Business Action in Mexico	Heineken N.V.(beer) - production waste and unused secondary resources are transferred to neighboring enterprises for reuse Hellmann's mayonnaise - sold in packaging made from 95% recycled PET plastic
10	**Brazil**	– REDE Candonga Initiatives (2020) – National Solid Waste Policy (Law No. 12,305/2010) – Incentive – Program for Alternative Electricity Sources (PROINFA) was created by Law No. 10,438/2002 – The National Water Resources Policy (Law Bill (PLS) No. 58 of 2016)	Rede Asta - has created an online platform to support a network of artisans, to recover materials from corporate and urban waste. Natura - By sourcing materials from biodiversity assets — defined as the many valuable natural assets offered by the rainforest 'biome' — the cosmetics company has importantly demonstrated a threefold benefit through harvesting fruits,

		– New Forest Code (Law No. 12,651/2012)	compared to the typically linear extraction of timber
11	**Malaysia**	– National Plan for Sustainable – Consumption and Production – Waste Eco Park (WEP)	Sphera - creates a safer, more sustainable and productive world. Sphera is the largest global provider of Integrated Risk Management software and information services with a focus on Environmental, Health Safety & Sustainability (EHS&S). Landustrie Sneek BV - field of water and wastewater management.
12	**China**	– Guidance of the State Council on Promoting the Development of Circular Economy"2005 – Circular Economy Promotion Law 2008/2009 – 11th Five-Year Plan – Development Plan for the Circular Economy in the 14th Five Year Plan Period[1] – China's inaugural Circular Economy Roadmap	Telecom – recycles used mobile phones. Guigang – Eco-Industrial Park. Fushan village – the case of an integrated ecological Farm.
13	**Moldova**	– Law on Wastes (1997), – Law on Natural Resources (1997), – Law on Air Protection (1997)	UNDP Moldova Initiatives: Programmes to support plastic and paper recycling among small and medium enterprises. Startups have emerged that recycle textiles and recyclable materials to produce eco-friendly materials (for example, eco-friendly home goods).
14	**Turkey**	-Environment Law (1983), -Waste Management Regulation, -Control of Air Pollution, – Control of Soil Contamination	87% of household waste is buried in landfills. Programs are being implemented to combat plastic pollution and increase the level of waste recycling. Hazardous and non-hazardous industrial waste - recycling increased by 68% and 30% respectively. Enterprises producing >1000 kg of hazardous waste per month are required to obtain a temporary storage license.
	Lower-middle-income group		
15	**Tajikistan**	– Law No. 44 On Production and Consumption Waste of 2002. – Law No. 1002 "On the Management of Radioactive – waste "2013 – Law No. 705 "On Environmental Information" 2011 – Law No. 760 "On Environmental Protection" 2011 – "Concept of environmental protection in the Republic of Tajikistan", approved by the Government of the Republic of Tajikistan on December 31, 2008 (No. 645) – National Concept for Rehabilitation of Uranium Ore Processing Waste Tailings for 2014–2024. – National Development Strategy of the Republic of Tajikistan for the period up to 2030 (2016)	Project "Candied fruits" - Production and sale of candied fruits. Ecoplast - A startup for recycling plastic bottles: it produces paving slabs from used PET bottles, has a patented technology and a mobile application for informing about separate waste collection in Tajikistan. Aprelevka (a joint venture of Tajik-Canadian + Spirit) - Builds a plant in Guliston for recycling various waste (including mining tailings) with a capacity of up to 100 tons per day, where modern technologies make it possible to extract valuable raw materials - gold and silver.

		– In 2016, Tajikistan joined the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal 1989.	
16	**Uzbekistan**	– Law of the Republic of Uzbekistan On Waste (2002) – RI strategy for solid waste management in RI for the period 2019-2028 – Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 787 "On measures to further improve the efficiency of work in the field of household waste management" (2018) – Resolution of the President of the Republic of Uzbekistan dated No. P-3730 "On measures to further improve the system for handling household waste" (2018) – Decree of the President of RU No. PP-2916 "On measures to radically improve and develop the waste management system for 2017-2021" (2017) – Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 295 "On approval of the Regulation on the procedure for the implementation of state accounting and control in the field of waste management" (2014)	"Ecotrans" - Bicycle rental service centers. They are located in crowded places and near the metro along the cities of Tashkent. Users can take bicycles from one center and return to another, which is convenient for them. Bicycles have a device. Consumers can use a dedicated app for payment and security. "Green Roofs" - The aim of the project is to green roofs, create recreation areas and sports on the roofs of residential buildings and business centers. Green roofs are the elimination of the heat island problem in large cities with gas pollution and smog.
17	**India**	– The Forest Conservation Act, 1980 – The Environment (Protection) Act 1986 – The Wildlife Protection Act, 1972 – Air (Prevention and Control of Pollution) Act, 1981 – Air and The Indian Forest Act, 1927 and Water (Prevention and Control of Pollution) Act, 1974. – National Environmental Policy, 2006	Binbag Recycling - Binbag leverages technology to collect and recycle e-waste in the formal channels. Namo eWaste Management - extraction of metals from e-waste and separating the hazardous content present from the waste. Saahas - works with bulk waste generators such as businesses, residential complexes, educational institutions, hotels, etc. The discarded waste is further molded into different products like roofing sheets, clipboards, stationary, upcycled textile products, etc.
18	**Ukraine**	– Sustainable Development Strategy "Ukraine - 2020" (January 2015) – Energy Strategy of Ukraine - 2035, – Small and Medium Business Development Strategies - 2020, – State target program for the development of the agricultural sector - 2020, – changes are made to the Environmental Strategy - 2020, – work has begun on the Low-Carbon Development Strategy - 2050 and the Industrial Complex Development Strategy - 2025	Neo-Eco Ukraine - Processes construction and industrial waste into new construction and eco-materials, and consults enterprises on creating cyclical technological chains. Offices in Kyiv and Nikolaev. Re:inventex - Pilot project for mechanical processing of textile waste (post-industrial and pre-sale), includes collection, sorting and reuse of fibers to create new materials. S.Lab - Startup-winner of Green Alley Award 2023, develops 100% biodegradable packaging from mushroom mycelium and hemp stems instead of polystyrene foam.
19	**Kyrgyz Republic**	Law of the Kyrgyz Republic on Environmental Protection 1999 Law of the Kyrgyz Republic on Production and Consumption Wastes 2001.	Kumtor Gold Company LLC - completely recycles scrap metal, waste oil and wood through local suppliers, effectively managing household, industrial and hazardous waste.

		– The program for the development of a green economy in the Kyrgyz Republic for 2019-2023 – The concept of environmental safety of the Kyrgyz Republic 2007. – The procedure for handling production and consumption waste in the Kyrgyz Republic in 2015 – Sustainable Development Goals 2030 in Waste Management – State Program on Sustainable Waste and Secondary Resources Management for 2019-2023	Tire Recycling Pilot Plant (branch of Kumtor Gold Company) - in Tokmok, it is completing the pilot phase of a plant for recycling used car tires into rubber crumb for construction and industrial needs. Tazar - a digital platform connecting residents and waste collectors, with an interactive map of collection points and a bonus system for responsible sorting.
20	**Pakistan**	-Pakistan Environmental Protection Ordinance (1983) -National Environmental Quality Standards, -Environmental Samples Rules, -National Biosafety Rules	TrashIt is a Pakistani startup that focuses on composting organic waste for home and business use. KSBL Circular Plastic Institute (CPI) – an academic and practical center at the Karachi School of Business & Leadership that researches methods for the reuse of plastics and implements pilot projects on collection and recycling Engro Foundation – Circular Plastics Program: collects and recycles PET waste for the production of building blocks and paving slabs, funding research on closed-loop plastics in the country.
21	**Indonesia**	-Environmental Law (2009) -Omnibus Law (2020)	Waste management mainly involves unorganized incineration and landfill. The government has started working on the transition to a circular system for plastics (in partnership with Norway). Some environmental taxes are applied (on the extraction of natural resources, the use of water, fuel, etc.).
Note – compiled by authors			

Appendix C

Expert survey

1. **Assess the overall level of implementation of circular economy principles in Kazakhstan, where 1 is a low level, 5 is a high level.**

Increasing the efficiency of product use: reusing a product that performs its original function (reuse)	1	2	3	4	5
Recycling (recycle)	1	2	3	4	5
Remanufacturing and upgrading of a product (remanufacture): repairing and servicing a product, changing product parameters, using parts of an obsolete product in a new product	1	2	3	4	5
Consuming fewer natural resources and materials in the production of goods (reduce)	1	2	3	4	5
Transferring a product to the category of excess. Refusing a product (refuse)	1	2	3	4	5
Transferring the functions of a product to another product (repurpose)	1	2	3	4	5

2. **Assess the level of readiness of your business/industry to implement the circular economy, where 1 is low and 5 is high.**

Efficient use of raw materials and environmentally friendly materials	1	2	3	4	5
Efficient use of production facilities, materials, human resources	1	2	3	4	5
Reduction of resource consumption in the production of goods	1	2	3	4	5
Reduction of waste in the production and consumption process	1	2	3	4	5
Minimization of environmental pollution	1	2	3	4	5
Availability of reverse logistics, extension of product service life, reuse of components	1	2	3	4	5
Development of eco-design of the product, using the principles of the circular economy at the product design stage	1	2	3	4	5
Level of personnel competence in green technologies	1	2	3	4	5
Availability of corporate environmental culture	1	2	3	4	5
Application of digital technologies for more efficient use of resources	1	2	3	4	5
Use of renewable energy sources and renewable materials	1	2	3	4	5

3. **Assess the level of readiness of state and financial institutions for the development of a circular economy in Kazakhstan, where 1 is a low level, 5 is a high level**

State support for circular business models	1	2	3	4	5
Investment in eco-projects	1	2	3	4	5
Development of innovative projects on green technologies	1	2	3	4	5
Development of “green” finance and socially responsible investment	1	2	3	4	5
Legal and regulatory support for the development of a circular economy	1	2	3	4	5
Development of infrastructure in populated areas for efficient waste disposal	1	2	3	4	5
Recycling of household waste and ensuring its environmentally friendly disposal	1	2	3	4	5

Recycling and reuse of industrial waste	1	2	3	4	5

4. **Assess the level of readiness of science and education, public institutions for the formation and development of a circular economy, where 1 is a low level, 5 is a high level.**

Training of personnel in the circular economy (eco-industry, etc.)	1	2	3	4	5
Updating the content/competence of educational programs	1	2	3	4	5
Development of R&D in green technologies	1	2	3	4	5
Development of public initiatives, NGOs and other organizations on environmental issues, green technologies, etc.	1	2	3	4	5
Application of the CE principles in the university/educational institution itself	1	2	3	4	5

5. **Assess the level of formation and development of a circular society in Kazakhstan, where 1 is a low level, 5 is a high level.**

Level of development of “green” consumption	1	2	3	4	5
Level of awareness of the population about the circular economy	1	2	3	4	5
Repair and reuse of products (second-hand market, repair of household appliances)	1	2	3	4	5
Level of waste sorting by the population	1	2	3	4	5
Reduction of consumption or refusal of excesses in favor of the environment	1	2	3	4	5
Level of development of shared consumption (rent, car sharing, etc.)	1	2	3	4	5

6. **Your suggestions and recommendations for the development of a circular economy in Kazakhstan:**

_____

_____

7. **Please indicate your area of activity:**

1. Business and industry
2. Science and education
3. Government structures
4. NGOs, international organizations
5. Other

8. **Number of employees in the organization**

1. Up to 10
2. 10-50
3. 51-100
4. 101-250
5. More than 250

9. **Your position:**

CEO/Manager
Head of Department
Employee

10. **If you wish to participate in an expert interview on the development of the circular economy in Kazakhstan, please leave your contact information**

Thank you for participating in the expert survey!

Appendix D

Expert interview

1. General information

1. What area do you work in? (agricultural sector, science, public administration, education, etc.)
2. What is your position? (manager, specialist, analyst, etc.)
3. What is the size of the organization you work for?

Block 2. Awareness of the circular economy

4. How familiar are you with the concept of a circular economy?
5. How do you rate the level of awareness of the agro-industrial complex about the importance of recycling and waste reduction?
6. How actively are representatives of the agro-industrial complex interested in the implementation of circular approaches?

Block 3. Barriers to the transition to a circular economy

7. What are the main barriers to the implementation of circular economy principles in the agro-industrial complex?
   - — Lack of government support
   - — Lack of funding
   - — Lack of knowledge and information
   - — Technical and technological barriers
   - — Cultural and social barriers
   - — Lack of a legislative framework
   - — Low level of institutional coordination
8. Which barrier do you consider the most significant?
9. What specific examples of difficulties in implementing circular approaches in the agro-industrial complex can you give?

Block 4. Opportunities for the transition to a circular economy

10. What measures could contribute to the development of a circular economy in the agro-industrial complex?
11. How do you assess the impact of the following measures on the development of a circular economy?
    - • Strengthening government funding (subsidies, grants)
    - • Training and professional development in the circular economy
    - • Implementation of innovative technologies
    - • Development of waste recycling infrastructure
12. What steps, in your opinion, will most effectively accelerate the transition to a circular economy in the agro-industrial complex of Kazakhstan?

Block 5. Implementation of CE practices in the agro-industrial complex

13. How actively are waste recycling and resource reuse practices being implemented in the agro-industrial complex?
14. What role can educational and scientific institutions play in the development of a circular economy in the agro-industrial complex?

Thank you for participating in the expert interview!

Appendix E

Population survey

Please rate your level of agreement with the statements below on a scale of 1 to 5, where 1 means completely agree, 2 means partially agree, 3 means it is difficult to say whether I agree or disagree, 4 means partially disagree, and 5 means completely disagree.

A. Level of awareness/knowledge.

I know more about recycling than the average person	1	2	3	4	5
I know how to choose products and packages that reduce waste	1	2	3	4	5
I understand eco-labels on packaging	1	2	3	4	5
I know what a “circular economy”/”closed-loop economy” is	1	2	3	4	5
I am familiar with the principles of a circular economy, such as: reuse, recycle, reduce consumption, etc.	1	2	3	4	5

B. “Eco-friendly”, ecological consciousness

I am concerned about the deterioration of the environment	1	2	3	4	5
It is important to me that the products I use do not harm the environment	1	2	3	4	5
I think about how to improve the quality of the environment	1	2	3	4	5
I would call myself an environmentally responsible person	1	2	3	4	5
The meaning of the Kazakh words “obal bolady”, “nandy baspa”, “ysyrap zhasama”, etc. is very important to me	1	2	3	4	5

C. Ecological behavior

I always buy organic food	1	2	3	4	5
I always try to buy energy-efficient products and appliances (for example, high-efficiency light bulbs to save energy)	1	2	3	4	5
I always sort waste	1	2	3	4	5
I am always ready to donate money for the environment	1	2	3	4	5
I am always ready to buy used goods: clothes	1	2	3	4	5
I am ready to buy used goods: household appliances	1	2	3	4	5
I am always ready to participate in environmental protests, actions	1	2	3	4	5
I try to reduce consumption where possible	1	2	3	4	5
I try to repair, if possible, rather than buy new	1	2	3	4	5

D. External factors

I am ready to hand over old clothes/old household appliances/cars if in return there is a discount on a new product, tax breaks/coupons or other incentives	1	2	3	4	5
I am ready to buy a product at a higher price if the manufacturer guarantees recycling after use	1	2	3	4	5
I am ready to sort garbage if there are sorting containers for separate waste near my home	1	2	3	4	5
I will sort my waste if the state takes coercive measures (fines, punishments, etc.)	1	2	3	4	5

How do you feel about sharing/using services on the following items? Rate your level of support on a scale of 1 to 5, where 1 - fully support, 2 - partially support, 3 - hard to say, 4 - partially do not support, 5 - do not support at all.

Rent of real estate (housing, apartments)	1	2	3	4	5
Rent of vehicles	1	2	3	4	5
Rent of electric scooters/bicycles	1	2	3	4	5
Rent of a work place for a certain period of time	1	2	3	4	5
Freelance work (remote short-term work with different clients)	1	2	3	4	5
Educational services (courses, seminars)	1	2	3	4	5
Food (food exchange)	1	2	3	4	5
Books (book exchange)					
Clothes (second-hand stores, social stores)	1	2	3	4	5
Rent of household appliances, furniture, goods	1	2	3	4	5
Money (loans)	1	2	3	4	5
Crowdfunding (raising funds for ideas, business, creative and charitable projects)	1	2	3	4	5
Carpooling (fellow travelers travel together in one car and share expenses)	1	2	3	4	5

How many categories do you sort your waste into?

1. I don't sort at all
2. 2 categories
3. 3 categories
4. 4 categories
5. More than 5 categories
6. I don't know

What types of waste do you sort at home? (select all that apply)

1. paper and cardboard,
2. packaging materials
3. plastic packaging
4. children's toys
5. metal
6. packaging, cans
7. glass
8. glasses, bottles
9. organic waste
10. old things such as clothes, shoes
11. hazardous waste (e.g. batteries, mercury lamps)
12. none of the above

How is waste disposed of in your community (select all that apply)?

1. take it to landfills
2. burn it at special plants
3. sort and recycle
4. do nothing, residents take out their garbage themselves
5. I don't know

Are there eco-points for waste collection for recycling in your region/city and do you use them? (1 answer)

1. Yes, there are, and I use them.
2. Yes, there are, but I don't use them.
3. No, but I would like to use them.
4. No, and I wouldn't like to use them.
5. I don't know

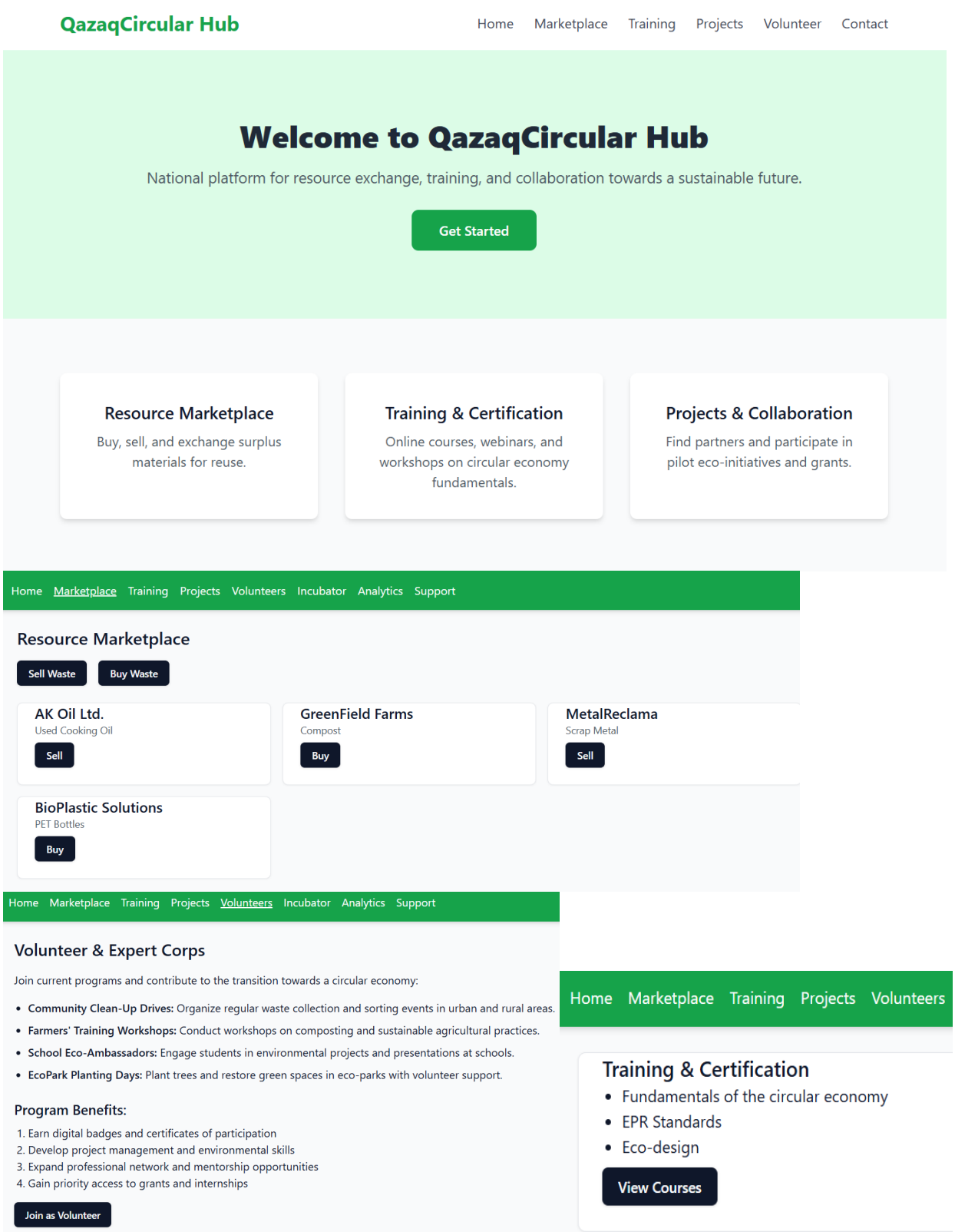
Appendix F

Online platforms for promoting the circular economy and their features

№	Website	Features
1	MyWaste.ie	An Irish platform for regional waste management offices from the Department for Climate Action. Helps citizens and businesses find options for the proper disposal and recycling of different types of waste.
2	ShareWaste.com	A community for sharing food waste: users post what organic scraps they are willing to donate for composting or feeding worms/animals, and a map shows the nearest "receivers".
3	Freecycle.org	Freecycle Network is a private, non-profit organization. Their mission is to develop a global culture of sharing, reduce waste, conserve resources, and reduce landfill pressure while providing community benefits to members.
4	OLIO	A mobile app for exchanging surplus food and goods: users post things they no longer need and find neighbours willing to accept them, reducing waste.
5	Circular Berlin	A non-profit organisation in Berlin promoting CE through research, initiatives and projects in the fields of urban planning, product design, textiles and the bioeconomy.
6	Czech Circular Hotspot	A Czech public-private partnership platform for sharing resources and experiences, aiming to create a society of rational and efficient use of natural resources.
7	RecycleNation.com	A US-based technology platform for finding recycling centers. Provides an interactive widget and API for personalized search, as well as mobile apps for iOS and Android.
8	PACE (Platform for Accelerating the Circular Economy)	A global UN-like platform: brings together governments, businesses and NGOs to accelerate the transition to the CE through research, tools and coalitions of leaders.
9	ENEA Platform for Industrial Symbiosis	Italian online business platform: allows businesses to find partners to exchange leftover materials, energy and services, creating symbiosis and reducing disposal costs.
10	TerraCycle Mission	Collaborates with businesses, authorities and individuals, organising special programmes and collections for the recycling of hard-to-recycle materials in various sectors.
11	Craigslist	Classifieds: The "Free & For Sale" section allows you to donate and find goods, materials and equipment for reuse or recycling for free.
12	Ambition4Circularity	AFEP (French Enterprise Association): evaluates the commitment of major French corporations to implement the seven principles of the CE, publishes transparent reports and lobbies the interests of participants with the authorities.
13	CER Sustainable Business Network Slovenia	A large network of sustainable businesses in Slovenia: helps companies of all sizes implement climate-neutral and resource-saving practices through training, consulting and joint projects.
14	Circular Communities Scotland	An association of charities and social enterprises in Scotland. Supports a recycling and repair network, advocates for its members and helps to expand the sector through interaction with authorities and the community.
Note: Compiled by the author		

Appendix G

Example of the platform



Appendix H

02-13-04-379 от 08.05.2025

«ӘЛ-ФАРАБИ АТЫНДАҒЫ ҚАЗАҚ ҰЛТТЫҚ УНИВЕРСИТЕТІ»
КОММЕРЦИЯЛЫҚ ЕМЕС АКЦИОНЕРЛІК ҚОҒАМЫ

НЕКОММЕРЧЕСКОЕ АКЦИОНЕРНОЕ ОБЩЕСТВО
«КАЗАХСКИЙ НАЦИОНАЛЬНЫЙ УНИВЕРСИТЕТ ИМЕНИ АЛЬ-ФАРАБИ»

NON-PROFIT JOINT-STOCK COMPANY
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Әл-Фараби атындағы ҚазҰУ
«8D041– Бизнес және басқару»
кадрларды даярлау бағыты бойынша
диссертациялық кеңеске

АНЫҚТАМА

Осы анықтама Амангелдиева Бірғаным Асқарқызының келесі ғылыми жобаларда кіші ғылыми қызметкер ретінде жұмыс істегенін растайды:

1. ЖТН AP09259851 «Қазақстанда циркулярлы экономиканы дамыту: әлеуеті, үдерістері, келешегі» (2021–2023);
2. ЖТН AP19576593 «Қазақстандық кәсіпорындардағы жауапты өндіріс ТДМ-12 қол жеткізу құралы ретінде: әлеуетін бағалау және даму перспективалары» (2023–2025). Жобалардың жетекшісі: PhD, қауымдастырылған профессор Жидебекқызы А.

Аталған жобалар ҚР Ғылым және жоғары білім министрлігі Ғылым комитетінің ғылыми және (немесе) ғылыми-техникалық жобалар бойынша іргелі және қолданбалы ғылыми зерттеулерді гранттық қаржыландыру шеңберінде жүзеге асырылды.
Анықтама сұраныс бойынша берілді.

Ғылыми және инновациялық қызмет жөніндегі департамент директорының орынбасары **Рысмагамбетова А.А.**

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Уникальный код:	E5719527D8964167
Короткая ссылка:	https://short.kaznu.kz/vfPQkn
	Электрондық құжатты тексеру үшін: https://odo.kaznu.kz/verify мекен-жайына өтіп, қажетті жолдарды толтырыңыз. Электрондық құжаттың көшірмесін тексеру үшін қысқа сілтемеге өтіңіз немесе

02-13-04-379 от 08.05.2025

	QR код арқылы оқыңыз. Бұл құжат, «Электрондық құжат және электрондық цифрлық қолтаңба туралы» Қазақстан Республикасының 2003 жылғы 7 қаңтарда шыққан Заңының 7-бабының 1-тармағына сәйкес, қағаз құжатпен тең дәрежелі болып табылады. / Для проверки электронного документа перейдите по адресу: https://odo.kaznu.kz/verify и заполните необходимые поля. Для проверки копии электронного документа перейдите по короткой ссылке или считайте QR код. Данный документ согласно пункту 1 статьи 7 ЗРК от 7 января 2003 года «Об электронном документе и электронной цифровой подписи» равнозначен документу на бумажном носителе.

Appendix I

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ZHANASSYL

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Әл-Фараби атындағы ҚазҰУ
«8D041– Бизнес және басқару»
кадрларды даярлау бағыты бойынша
диссертациялық кеңеске

Ғылыми зерттеу нәтижелерін енгізу
АКТІСІ

Осы хат арқылы, докторант Амангельдиева Бірғаным Асқарқызының **«State regulation of the circular economy's development in the Republic of Kazakhstan»** («Қазақстан Республикасында циркулярлы экономиканың дамуын мемлекеттік реттеу») тақырыбындағы диссертациялық зерттеу шеңберінде алынған ғылыми-зерттеу нәтижелері **«ZHANASSYL» ЖШС**-нің өндірістік қызметі үшін өзекті және тәжірибелік маңызы бар екенін растаймыз.

Зерттеу нәтижесінде әзірленген ұсыныстар циркулярлы экономика қағидаттары мен заманауи технологияларды өндірістік процестерге енгізуге, операциялық шығындарды азайтуға, экологиялық жауапкершілікті арттыруға, сондай-ақ нарықтағы бәсекелестік артықшылықтарды нығайтуға бағытталған. Сондай-ақ, диссертациялық жұмыстың нәтижелері мен ұсыныстары кәсіпорынды дамыту жоспарында ескерілуі мүмкін.

Аталған ғылыми ұсыныстарды қолдану өндірістік қалдықтарды қайта өңдеу үлесін арттыруға және тұрақты өсу үшін жаңа мүмкіндіктер жасауға ықпал етеді.

«ZHANASSYL» ЖШС
Бас директоры **Данабеков Б.Ш.**

Күні: 24.04.2025
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Appendix J

АЛМАТЫ ҚАЛАСЫН ДАМЫТУ ОРТАЛЫҒЫ АКЦИОНЕРЛІК ҚОҒАМЫ
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www.almatydc.kz

шыг./исх. № 10-10/275
«25» апреля 2025 ж./г.

В диссертационный совет по направлению подготовки кадров «8D041 – Бизнес и управление», КазНУ имени аль-Фараби

АКТ
о практическом применении результатов диссертационного исследования

Настоящим подтверждаем, что результаты диссертационного исследования Амангельдиевой Б.А. на тему «State regulation of the circular economy's development in the Republic of Kazakhstan» («Государственное регулирование развития циркулярной экономики в Республике Казахстан») представляют интерес для АО «Центр развития города Алматы», учредителем которого выступает КГУ «Управление экономики города Алматы». Представленные материалы обладают аналитической и прикладной ценностью в контексте исследований, проводимых Центром.

Основные положения и выводы диссертации были использованы в работе центра при подготовке предложений по вопросам устойчивого развития и циркулярной экономики по г. Алматы. Полученные рекомендации способствуют углублению понимания механизмов государственного регулирования, а также могут быть учтены в дальнейшем при формировании экспертных заключений, стратегических инициатив и межведомственных программ в рамках устойчивого городского планирования.

Результаты исследования могут быть востребованы и в перспективе — при разработке подходов к рациональному управлению ресурсами, внедрению инновационных экологических решений, а также при реализации городских инициатив в области циркулярной экономики и устойчивого развития.

Заместитель Председателя Правления **Ж. Габдуллина**

Казахстан Республикасы Алматы қаласы Акционерлік қоғамы Центр развития города Алматы Акционерное общество город Алматы Республика Казахстан