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ECONOMIC SUSTAINABILITY IN THE REPUBLIC OF MOLDOVA

STRENGTHENING RESILIENCE AND DEVELOPING GREEN ENTREPRENEURSHIP

Romania 2025

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MONOGRAPH

The monograph was developed within the framework of Subprogram 030101, *"Strengthening the resilience, competitiveness, and sustainability of the economy of the Republic of Moldova in the context of the accession process to the European Union,"* through institutional funding.

Romania, 2025

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The monograph was recommended for publication by the Methodological Commission of NIER, AESM on March 11, 2025 (minutes report no. 1).

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DESCRIEREA CĂRȚII

ISBN

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INTRODUCTION

In the current context of the global economy, sustainable economic development represents one of the most pressing challenges facing society. Economic growth can no longer be analyzed solely through the lens of production and consumption expansion but must be integrated into a model that ensures a balance between development, environmental protection, and responsible resource use. Thus, green entrepreneurship, based on the principles of resilience and sustainability, becomes the main direction for building viable long-term economic systems.

Through this monograph, the authors aim to analyze the mechanisms and strategies through which the economy can become more sustainable, offering both a theoretical and practical framework on the main concepts associated with sustainable economic development. The study addresses multiple aspects, from the impact of fiscal and budgetary policies on the "green" economy to hazardous waste management and the implementation of circular business models.

The monograph is structured into seven chapters. Chapter 1 explores the fundamentals of sustainable economic development, including the relationships between resilience, sustainability, and the circular economy. It also analyzes different models of sustainable economic systems and the principles of the circular economy. Chapter 2 focuses on the mechanisms and strategies for promoting sustainable practices in entrepreneurship, examining the regulatory framework of the green economy, fiscal policy instruments, and their impact on sustainable development. Chapter 3 details circular business models, including their classification, defining characteristics, and an analysis of the relevant European regulatory framework. It also highlights the transition to a circular economy during the pandemic, emphasizing the European Commission's actions. Chapter 4 examines hazardous waste management in the Republic of Moldova, offering insights into the premises of the transition to a circular economy, its characteristics, and its environmental impact, as well as national strategies for managing toxic waste.

Chapter 5 presents examples of best practices in sustainable businesses in the Republic of Moldova, analyzing the opportunities and challenges of implementing circular business models and highlighting the barriers to their development. Chapter 6 addresses the sustainability of secondary raw materials, focusing on the recycling and reuse of waste such as used plastics, glass shards, cardboard, and metals. The technological processes and opportunities for their valorization are analyzed. Chapter 7 discusses waste management challenges and strategies, including their environmental impact and existing solutions for resource efficiency through green instruments such as RECP (Resource Efficiency and Cleaner Production).

The comprehensive approach to sustainability has allowed the authors to contribute to the development of economic aspects in the Republic of Moldova. In this context, the monograph addresses a highly relevant topic for the country's economic development: the transition to a sustainable and circular economy. In a global context where natural resources are intensively exploited, and the impact of economic activities on the environment is increasingly visible, the Republic of Moldova faces significant challenges in modernizing its economy. Therefore, an in-depth analysis of sustainable economic development mechanisms, strategies, and models is highly relevant for policymakers, the business environment, and civil society.

The authors have successfully highlighted the impact on economic and fiscal policies. Thus, the study underscores the role of budgetary-fiscal policies and economic instruments in stimulating the transition to a green economy. By analyzing the existing regulatory framework and the fiscal solutions applied in the Republic of Moldova, the study provides clear perspectives on how the state can encourage entrepreneurs and companies to adopt sustainable practices. Additionally, relevant European policies are evaluated, offering a best-practice model for aligning national legislation with international standards.

Another important element in ensuring economic sustainability is green entrepreneurship. The authors have successfully presented sustainable business models, emphasizing their benefits for entrepreneurs in the Republic of Moldova. By showcasing case studies and international best practices, the monograph serves as a valuable guide for those interested in developing businesses in line with circular economy principles. This aspect is essential for attracting green investments, reducing dependence on external resources, and increasing competitiveness in the international market.

An important issue related to efficient resource and waste management is also discussed by the authors. The study thoroughly analyzes the challenges and existing solutions in hazardous waste management and secondary raw materials. An economy based on resource reuse and recycling can significantly contribute to cost reduction, job creation, and minimizing negative environmental impacts.

The authors emphasize the necessity of adopting coherent environmental policies that ensure a balance between economic growth and natural resource protection. By highlighting European and international strategies, the study offers applicable solutions for integrating the Republic of Moldova into a global economic system that promotes resource efficiency and the reduction of ecological footprints.

Through its complex and multidimensional approach, the monograph makes an important contribution to understanding the transition process toward a sustainable economy in the Republic of Moldova. It provides both a

solid theoretical framework and practical solutions for optimizing resource use, reducing environmental impact, and stimulating green entrepreneurship. Given the economic and environmental challenges facing the country, this work becomes a valuable tool for researchers, policymakers, entrepreneurs, and all those interested in the sustainable development of the Republic of Moldova.

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Dear reader, this work provides a detailed perspective on the challenges and solutions related to sustainable economic development. In a context where pressures on natural resources and the environment are constantly increasing, adopting sustainable economic models becomes imperative. This study not only highlights relevant theoretical concepts but also analyzes their applicability in the context of the Republic of Moldova, offering practical solutions and recommendations for an effective transition to a more sustainable economy.

Chapter 1. SUSTAINABLE ECONOMIC DEVELOPMENT IN CONTEMPORARY REALITIES

1.1. Exponential approaches between resilience, sustainability and the circular economy

The concept of sustainability has been developed and refined over time by various scholars, each bringing a unique perspective on the balance between economic development, environmental protection, and social well-being. While initially, sustainability was seen as an ecological issue, recent research has demonstrated that it is a complex paradigm, involving economic, social, and technological aspects. Exponential technologies present opportunities to address sustainability challenges, but their growth must align with cultural shifts away from current neoliberal capitalist systems.

Interdisciplinary collaboration between technologists and humanists is essential to guide the direction of technology towards sustainable solutions. Fernandez-Solis, J. L. (2007) in Sustainability as the Force that Tames an Exponentialoid discusses sustainability as a force that tames an exponentialoid, emphasizing that sustainability involves complex processes, rather than isolated initiatives (Fernandez-Solis, 2007). This suggests that understanding exponential growth in different systems can improve approaches to effectively achieving sustainability. Leonhard, G., & Graf von Kospoth, C.-A. (2017) emphasize that sustainable technology should enhance the human experience, rather than forcing people to adapt to technological demand. In their studies on sustainable development, they advocate for a balance in which technology serves humanity, promoting a more humane approach to sustainability, rather than a purely exponential one (Leonhard, 2017). (Arinze, E. D. 2024) states that exponential approaches to sustainability involve harnessing technological advances and innovative practices to promote environmental sustainability. In the paper Unravelling Exponential Growth Dynamics: A Comprehensive Review, he emphasizes the importance of multidisciplinary cooperation and ethical standards to harness growth potential while ensuring ecological balance for current and future generations (Arinze, 2024). In the same context, Lian, M. (2024) specifically addresses exponential approaches to sustainability. It focuses on the impact of cleaner energy sources, high-tech firms, and economic expansion on ecological footprints, highlighting investments and policies directed towards sustainable development in the E7 and G7 countries. These exponential approaches to sustainability demonstrate that the economy, environment, and society are interconnected and must be managed responsibly. From ecological economics theory to modern innovations such as the circular economy and renewable technologies, the vision of the aforementioned

scholars outlines a future in which sustainability is no longer an option but a necessity (Lian, 2024).

In the specialized literature there are several conceptual approaches to the circular economy, starting from the 70s until today, most of them indicating as an explanation – a consumption and production model to eliminate waste. In this context, we present, first of all, the definition of the term circular economy, stated in several dictionaries.

In the French Agroecological Dictionary, the concept of circular economy is elucidated as ,,an economic model based on the fact that the quantity of available resources is limited .... aims at systematically reducing their use, unlike the currently dominant linear economy based on the following scheme: extraction, manufacture, consumption and disposal" (Dictionary, 2024). According to the Romanian-English-French Dictionary of Horticultural Termsz, the *circular economy "consists of an economy that produces zero waste, which means that a product or production process falls into two categories: either it has a biodegradable component, or a component with 100% recycling potential"* (Circulară, 2022).

According to modern literature, the term circular economy is defined by the wikipedia as "an economic system designed to be able to regenerate itself, thus guaranteeing its ecological sustainability". Thus, the term circular economy is also defined by the World Economic Forum on the Circular Economy as "an industrial system that is restorative or regenerative by intention and design. It replaces the concept of end-of-life with restoration, moves towards the use of renewable energy, eliminates the use of toxic chemicals, which affect reuse and return to the biosphere, and aims to eliminate waste through superior design of materials, products, systems and business models" (Circular Economy: Definition, Principles, Benefits and Barriers, 2018).

According to the definition given by the Ellen MacArthur Foundation, the circular economy is "an industrial economy that is restorative and regenerative by intention and design" (MacArthur, E., 2013). "The use of the word "restoration" is important because the circular economy is not only a preventive approach, reducing pollution, but also aims to repair previous damage by designing better systems within the industry entity itself" (Murray, Skene and Haynes, 2017). The definition given by Ellen MacArthur, integrates both environmental and economic advantages through the notion of regenerative performance, this model aiming to activate efficient flows of materials, energy, labor and information in order to restore natural and social capital. Materials are perceived as nutrients, divided into two categories by McDonough and Braungart (in Cradle to Cradle: Remaking the Way We Make Things) – biological representing materials designed to safely re-enter the biosphere and contribute to the restoration of natural capital (Lacatus, 2019).

1.2. Sustainable economic systems

In the last three decades, the exponential approach between resilience, sustainability and economic circularity occupies a place of major importance in research at the macro and micro economic levels, respectively and around businesses and organizations stimulating the need for responsibility, resistance and durability. Exponential approaches between resilience, sustainability and economic circularity refer to how these three concepts can support each other and develop in an accelerated way, having a significant impact on the global economy, the environment and society. Therefore, integrating sustainability and economic circularity into an exponential framework implies not only a paradigm shift in the way we produce and consume, but also a profound transformation of the entire economic system, with the aim of building a regenerative economy, more equitable and less harmful to the planet.

Studies conducted and examples of good practice identified over time demonstrate that integrating circularity into sustainability strategies can generate multiplicative benefits, accelerating the transition to a resilient and regenerative economic system, bringing lasting benefits in a more innovative and productive economy.

Economic resilience and the circular economy are two interconnected concepts, which contribute to the creation of a more sustainable, efficient and sustainable economic system. Therefore, the circular economy is not only a sustainable model but also an economic resilience strategy that contributes to reducing economic vulnerability, stimulating innovation and creating more robust and adaptable systems to economic crises. By adopting this strategic model, countries and companies can contribute to the establishment of more resilient, stable and sustainable economies in the long term. The interaction between economic resilience, sustainability and circularity is a multiplicative one due to the functional mechanisms that transform the vulnerabilities of linear systems into opportunities for adaptation and regeneration.

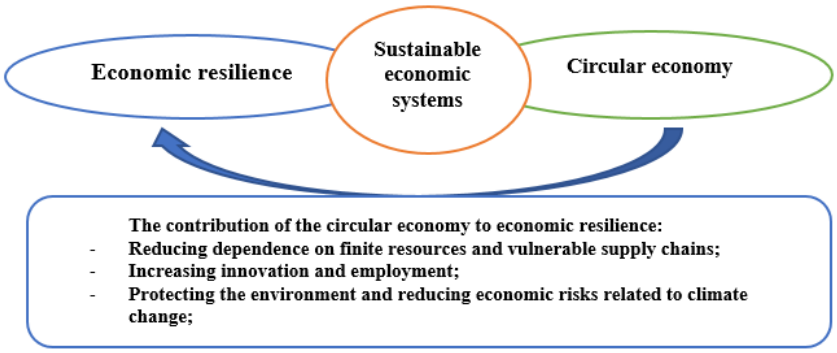

Figure 1. The relationship between resilience and the circular economy
Source: developed by the authors.

The in-depth study of the concept of circular economy from the perspective of sustainability has experienced an exponential development in recent years. The first approaches to the circular economy emerged as a reaction to the aspiration for sustainable growth in the context of the increasing pressure that production and consumption exert on the planet's resources and environment (CE, 2020). Thus, the concept of circular economy presents a new perspective on sustainable development. The roots of this perspective are found in the biosphere, where anything can become a resource for the next level of the food chain, in order to eliminate waste.

The multitude of research studies on the concept of circular economy has restructured the existence of the traditional linear approach (resource - commodity - waste) of resources, established since the origins of human activity and massively exploited in the contemporary world economy. The economic system of the linear model is formulated as (take-make-consume and throw away) aiming at the flow of resources and raw materials. According to researchers Kirchherr, Reike & Hekkert, the circular economy refers to the three "Rs": Reduction of materials and waste, Reuse of products or their component parts and Recycling of materials.

Therefore, the circular economy was initially based on three key principles, called “3Rs”: reduce - reuse - recycle, eventually transformed into “9Rs” (refuse, rethink, reduce, reuse, repair, refurbish, remanufactur, rethink purpose, recycle, recover), in which waste is a raw material. The process of waste production cannot be stopped completely, but each of us can adopt environmentally friendly behavior to have a positive impact.

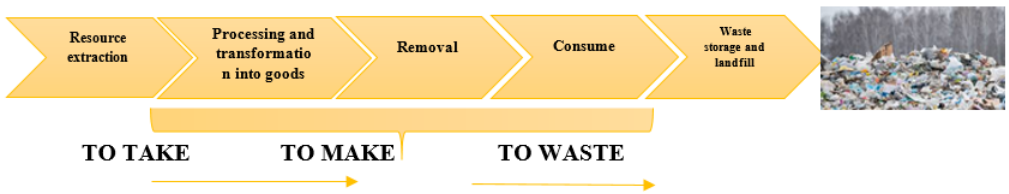

Figure 2. Traditional approach to the linear economic system
Source: developed by the authors.

Thus, we identify that in the specialized literature there are over a hundred definitions regarding the circular economy, concentrated around key concepts such as: sustainable development, the 4R framework (Reduce, Reuse, Recycle, Recover), the systemic approach (micro, meso, macro) and the waste hierarchy (Tîrțiu, 2018).

According to the above, the 4R guidelines are not a sufficient action to sustainably manage global waste, a new approach to waste management called "zero waste" is proposed (or at least to achieve 99% waste-free). To allow us

to lead a waste-free lifestyle, we must respect the 10-R method. In other words, "conscious consuming or conscious consumerism". Thus, the circular economy is an integrative model, based on eco-innovation characterized by the 10 R concept. The main elements of the 10R model are:

R1 - Refusal refers to making a product redundant by giving up the function it provides. For example, the option to refuse to use your own car in urban travel or in the daily commute to and from work, opting for public transport or a sharing service. This concept has generated disruptive business models, such as Uber, WeWork and, in general, the entire collaborative corporate ecosystem. Or another example from the hospitality industry - AirBnb or the model proposed by ByHours, which maximizes the use of unused accommodation capacity in hotels.

R2 - Rethinking refers to increasing the use of a product, for example, by sharing the product. We find it as a model in trends in the food industry, for example, in the collaborative approach aimed at reducing the use of single-use packaging and migrating to reusable packaging, in order to reduce the amount of waste.

R3 - Reduction refers to increasing the efficiency in the production or use of the product, consuming fewer natural resources. This is an example that we find in the automotive industry where the pressure to reduce fuel consumption has intensified innovation and the successful launch of electric models. It is a concept also used in the automation of production processes that lead to efficiency and reduced consumption of energy or raw materials. We find it in construction, in the concept of passive buildings, in the residential and office segments.

R4 - Reuse refers to any operation by which products or components that have not become waste are used again, for the same purpose for which they were designed. It is a model applied, for example, in equipping certain production units of various goods by purchasing second-hand equipment in good condition.

R5 - Repair refers to the reconditioning or maintenance of the defective product, so that it can be used with its original function. A model that we find applied from the clothing retail area, in the creative re-fashion approach, to the increasingly extensive use of 3D printing, which allows the repair of old things that no longer have spare parts available.

R6 - Remanufacturing refers to the restoration of an old product and its updating. The best application models can also be found in the automotive sector, where an appropriate basic design allows a diesel or gasoline car to be technically transformed into an electric car.

R7- Remanufacturing refers to the incorporation of parts of a discarded product into another product with the same function. Parts are recovered from

old laptops and computers to create refurbished products that can then be donated to schools.

R8 - Repurposing refers to the incorporation of a discarded product or parts of it into a new product with a different function. For example, paper, plastic, metal, wood and other materials left over from manufacturing processes can be reused to make various other objects, from furniture to packaging and containers or creative products, instead of ending up in the trash.

R9 - Recycling refers to any recovery operation by which waste is transformed into products, materials or substances to fulfill their original function or for other purposes. We find it in the recycling industry of electrical and electronic waste (WEEE), PET, glass and paper, etc.

R10 - Recovery refers to the incineration of materials and energy recovery. We see this model in the cement industry, where waste incineration is used in the manufacturing process or in the burning of non-recyclable materials to obtain energy. Other examples would be the use of windows to collect thermal energy or kinetic paving, which can be installed in metro stations to collect energy from people passing by.

The R10 circular economy strategies help reduce waste and optimize the use of resources, contributing to a more sustainable economic model. By applying these principles, companies and consumers can reduce their impact on the environment and create a more resilient and efficient economic system. Therefore, the R10 circular economy strategies are a set of 10 principles that help the transition from a linear economy ("extract-produce-consume-dispose") to a circular model, these strategies are classified according to the degree of intervention on products and resources, from waste prevention to recycling (TaxNews, 2022).

Circular economy	Short Curls	R0 Refuse	Avoiding the use of non-renewable materials and products with a negative impact on the environment.
		R1 Reduce	Reducing resource consumption through intelligent design and energy efficiency.
		R2 Reuse	Using a product for the same function, without major modifications.
	Medium Curls	R3 Repair	Extending the life of a product through repairs.
		R4 Renovate	Modernizing a product to make it functional and attractive again.
		R5 Remanufacture	Remaking a product using new and reusable components to bring it to a condition comparable to that of a new product.
		R6 Reuse	Using a product or its components for a function other than its original one.
Linear economy	Long Curls	R7 Recycle	Processing materials to transform them into raw materials for new products.
		R8 Recover Energy	Recovering energy from waste that cannot be reused or recycled.
		R9 Reintegrate	Ensuring the biodegradability and composability of products at the end of their life cycle.

Figure 3. The concept of circular economy strategies R10
Source: developed by the authors.

Short loops (R0-R3) start from the product design phase with the aim of reducing the consumption of material resources and increasing productivity. Reuse, repair, use of second-hand products by consumers are practices characteristic of short cycles. In these cases, consumers are encouraged to use resources more efficiently, and manufacturers to manufacture products that can be easily repaired or reused. Medium loops, which include reconditioning, remanufacturing, reorientation/reuse for other purposes (R4-R6), involve more complex interventions. In this case, used products are restored to a modern standard, parts from abandoned products are used to create new items with the same function, or used products or parts can be used to create new items with different functions.

Long loops (R7-R9) refer to recycling, energy recovery and re-use of materials. These processes involve extracting valuable substances from waste, often in the form of energy. Recovery is usually the last resort when other forms of waste management are not feasible. Examples include capturing waste heat for use in other processes or extracting valuable metals from electronic waste.

The circular thinking of the 10 Rs (R0-R9) emphasizes that a circular economy can only be achieved by integrating the behaviors of producers and consumers along local and global supply chains.

1.3. The circular economy model

Thus, an important starting point is the design of production processes, products and services. Products can be redesigned to be used for longer, repaired, upgraded, reworked or ultimately recycled, instead of being thrown away. Production processes can rely more on the reuse of products and raw materials, as well as on the regenerative capacity of natural resources, while innovative business models can create a new relationship between businesses and consumers.

In the same defined term, circular economy approaches exclude the concept of waste and usually involve innovation along the value chain, rather than relying exclusively on solutions at the end of a product's life cycle. For example, these approaches can include:

- reducing the amount of materials needed to provide a given service (light loading);
- extending the useful life of products (durability);
- reducing the use of energy and materials in the production and use phases (efficiency);
- reducing the use of hazardous or difficult-to-recycle materials in products and production processes (substitution);

- creating markets for secondary (recycled) raw materials (based on standards, public procurement, etc.);
- designing products that are easier to maintain, repair, upgrade, remanufacture or recycle (eco-design);
- developing the services that consumers need in this regard (maintenance/repair services, etc.);
- stimulating and supporting waste reduction and quality separation activities carried out by consumers;
- stimulating separation and collection systems that minimise the costs of recycling and reuse;
- facilitating the grouping of activities to prevent the transformation of by-products into waste (industrial symbiosis) and
- encouraging the expansion and improvement of consumer choice, through the rental, loan or exchange of services as an alternative to owning products, while protecting consumers' interests (in terms of costs, protection, information, contractual clauses, insurance issues, etc.).

The main phases of a circular economy model, simplistically illustrate the opportunities to reduce costs and dependence on natural resources, stimulate economic growth and employment, and limit waste and emissions harmful to the environment. The phases are interconnected, as materials can be used "in cascade", for example: industry exchanges by-products, products are refurbished or reprocessed, or consumers choose service-product systems. The goal is to minimize the resources that leave the circle, so that the system functions optimally. Conceptually, the circuit is reflected in the figure below, without negatively impacting economic development.

Figure 4. Phases of the circular economy model
Source: (Wistekmarket, 2022).

Based on the above, the circular economy is a model of production and consumption that involves reusing, repairing, recycling and renovating existing materials and products as much as possible, in order to extend their life cycle. Therefore, the development of the circular economy concept is influenced by the active involvement of all stakeholders (public authorities, the business environment, research institutes and non-governmental organizations). Thus, in order to understand the notion of circular economy, it is important to create the knowledge, values, attitudes and behavior that give rise to positive measures that aim to achieve the "zero waste" threshold as their central goal. Access to education for a circular economy can be ensured by any existing educational initiative in the field of environmental protection: energy conservation, waste management, education for biodiversity, climate change, etc.

According to the above, we deduce that the idea of circularity, or closing the economic loop, appears in 1976 in the report "The Potential to Substitute Human Labor for Energy" (Reday-Mulvey, 1977), presenting the vision of an economic loop in relation to the creation of new jobs, increasing economic completeness, saving resources and preventing waste.

A definition that is closer to our own understanding is the one proposed by the European Commission: "in a circular economy, the value of products and materials is maintained as much as possible; waste and resource use are minimized, and when a product reaches the end of its life, it is used again to create additional value; this can bring major economic benefits, contributing to innovation, economic growth and job creation."

Barriers to the transition to a circular economy. Implementing a sustainable circular economy requires efforts and collaboration between the private sector, the state and civil society to overcome the challenges inherent in any transition, related to, (Concurenței, 2024)*:*

- Regulations and policies: To facilitate the transition to a circular economy, it is necessary to implement appropriate policies and regulations that encourage businesses to adopt this concept. Differences in policies between countries can create inconsistencies and difficulties in the transition.
- Market inertia: Resistance to change, as well as the reluctance of some industries/businesses to adopt new circular practices, doubles government efforts to convince economic actors to adopt the circular economy. In addition, education and awareness of the population are necessary to create, at the national level, a culture of circularity
- Financing: Sustainable product design can be a challenge for businesses, not only financially, but also technically or functionally, to achieve products that meet consumer requirements. In transition, the initial value of investments may be higher and access to financing difficult.

- Extractive sector workforce: The circular economy may change the structure of the workforce. Extending the life of products, with the effect of reducing the demand for natural resources, may reduce the need for extractive sector workforce. Government involvement may be needed in managing issues in the extractive sector, with a possible solution to use new employment opportunities created in the recycling, repair, refurbishment and modernization sectors.
- Monitoring and evaluation: Monitoring the degree of implementation of the circular economy, assessing progress and the impact on society can be difficult, in the absence of adequate information/data on the evolution. Identifying progress indicators and implementing reporting procedures can be a challenge.

In this sense, we identify the need to adopt a circular economy model by the fact that the world's population is constantly growing, the supply of primary raw materials is limited. Some EU countries depend on others for raw materials. And their extraction leads to increased energy consumption and CO2 emissions.

The circular economy will have positive net benefits in the form of GDP growth and job creation, because the implementation of ambitious circular economy measures in Europe can lead to an increase in EU GDP by another 0.5% by 2030 and the creation of approximately 700,000 new jobs. At the same time, the opportunities of the circular economy are directly associated with both environmental protection. Likewise, consumers will have a more sustainable and innovative product that will increase the quality of life, but also save money in the long term.

Following the above, the circular economy emphasizes the recycling of waste but also the way in which products are made, so that the resulting waste is in the smallest possible quantity. Since 2015 there has been an action plan adopted by the European Union with a set of multi-sectoral measures related to waste, including waste from electrical and electronic equipment, end-of-life vehicles, wastewater and other measures that should lead EU member states to targets well established by the EC.

- ✔ For companies, the advantages of the circular economy concept are:
- ✔ Reduces pressure on resource consumption;
- ✔ Reduces the amount of waste and, implicitly, pollution;
- ✔ Reduces extraction/production costs for certain recyclable or reusable materials;
- ✔ Secures the supply of raw materials for certain companies that recycle or reuse;
- ✔ Reduces the amount of CO2 emitted. Currently, 45% of CO2 emissions are generated by the production of everyday materials;

- ✔ Creates new business opportunities in areas such as: collection, recycling, recovery, reuse and stimulates innovation;
- ✔ Improves the company's image: new generations emphasize environmental protection and conservation. A sustainable business is attractive to partners, banks and employees.

Circular economy and resilience are interconnected concepts that address sustainable development and adaptation to global change. In the literature, these two areas are studied in the context of their impact on the environment, economy and society. Here are some relevant sources and works in this field.

Table 1. Approach to interconnected concepts in the specialized literature

Concepts	Works	**Description**
Circular economy	**Georgios A. Tsiropoulos, George Y. Chan et al.** – "Circular Economy: A Critical Review of the Concept and its Applications".	This paper provides a critical review of the concept of circular economy, clarifying the differences between the circular economy and traditional economic models.
	Ken Webster – "The Circular Economy: A Wealth of Flows".	The author explores the different dimensions of the circular economy, including material and resource flows, and their impact on the environment and the economy.
	Lacy, P., & Rutqvist, J. – "Waste to Wealth: The Circular Economy Advantage".	The paper explores ways in which companies and economies can transform waste into economic value, providing a framework for implementing the circular economy in business.
	Ellen MacArthur Foundation	It frequently publishes reports and studies on the circular economy, including resources that help companies adopt circular economy models and improve sustainability.
Resilience	**Brian Walker et al.** –"Resilience Thinking: Sustaining Ecosystems and People in a Changing World".	This paper lays the foundations of resilience theory in ecological and economic systems, emphasizing the importance of maintaining a balance between adaptability and sustainability.
	Holling, C.S. „Resilience and Stability of Ecological Systems".	Although it focuses on ecology, this work is fundamental to understanding how economic and social systems can respond to change and crises.
	Peter W. Fröhlich & Martin Krüger - "Building Resilience in the Circular Economy: Key Challenges and Emerging Opportunities".	This paper explores how circular economy models can help improve the resilience of economies to global crises and climate change.
Sustainability	**Elkington, J. –** "Cannibals with Forks: The Triple Bottom Line of 21st Century Business".	In this paper, Elkington introduces the concept of the "triple bottom line" (TBL), which means that an organization's success should be evaluated not only in terms of financial profit, but also in terms of social and environmental impact. This is a central pillar of sustainability.

	UN Sustainable Development Goals (SDGs)	Within the United Nations, 17 Sustainable Development Goals are set that address economic, social and environmental challenges. Circular economies are considered a key tool for achieving many of these goals.
	Gillespie, A. – "Sustainability and the Political Economy of Development".	This paper explores how sustainability is approached from an economic and political perspective, providing a critical analysis of the relationship between economic development and environmental protection.
The link between the circular economy and resilience	**Circular Economy and Resilience: A Systematic Review**	This is a paper that analyzes how circular economy principles can contribute to creating more resilient economies, especially in the face of climate change and economic crises.
	Martin Haider & Timothée Parmentier - "Towards Circular Resilience: A Conceptual Framework".	This paper proposes a conceptual framework that combines the principles of the circular economy with strategies for increasing economic and ecological resilience.
The Interconnection between Circular Economy and Sustainability	**Bocken, N., Short, S., Rana, P., & Evans, S. –** "A Literature and Practice Review to Develop Sustainable Business Model Archetypes".	This paper addresses the development of sustainable business models that integrate circular economy principles, highlighting examples from various industries.
	Murray, A., Skene, K., & Haynes, K. – "The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context".	This paper investigates how the circular economy contributes to achieving sustainability goals, including discussions about the impact on the environment and natural resources.
	Geissdoerfer, M., Savaget, P., Bocken, N., & Hultink, E. – "The Circular Economy - A New Sustainability Paradigm?"	In this paper, the authors explore how circular economy principles can help promote sustainability, focusing on product life cycles and reducing negative environmental impacts.
	Reike, D., Vermeulen, W., & Witjes, S. – "The Circular Economy: New or Refurbished as the Basis for a Sustainable Business Model?".	The paper analyzes the intersection between the circular economy and sustainable business models, highlighting the ways in which they can help achieve a sustainable future, focusing on innovations in various economic sectors.
Public policies can support the transition to a circular economy and improve economic resilience	**European Commission – Circular Economy Action Plan**	The European Commission has adopted an action plan supporting the transition to a circular economy, with the aim of promoting sustainability and resilience in the current global context.
	OECD – The Circular Economy: A Review of the Policy Landscape	Provides an overview of how different governments and international organizations are implementing circular economy policies, with a focus on economic resilience.

Source: developed by the authors.

1.4. Resilience and sustainability

A general analysis of the concepts of economic resilience, circular economy and sustainability shows an inter-dimensional connection influenced by a wide range of factors that assess the capacity of existing economic mechanisms.

Thus, although sustainability and circular economy are related concepts, they have distinct meanings. Sustainability refers to the ability of a system or process to be maintained at a certain level over time. In the context of the environment, it means meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. Circular economy, on the other hand, is a concept in which the process of transition to a circular economy is closely linked to the reconsideration of unsustainable consumption and production patterns in order to identify future development opportunities.

Thus, the concept of economic resilience represents the capacity of the economic system to respond to socioeconomic changes that occur within the state. It is characterized by elasticity, that is, the ability to return to the initial state after an economic shock. Moreover, it is characterized by flexibility, persistence and the ability to transform (Modica and Reggiani, 2015). Spatial differences in economic resilience can be explained by a comprehensive set of factors that include economic diversification, participation in international trade, and the availability of human and social capital (Di Caro, 2017).

According to Martin & Sunley (2015), economic resilience can be approached from three perspectives, namely, first, the ability to recover from shocks, second to absorb shocks and third to anticipate them. The first perspective emphasizes the importance of the speed of recovery, the second emphasizes the stability of the system, its function and identity, while the third emphasizes the importance of the system's adaptability to new economic realities.

Economic resilience must be approached from the perspective of several indicators. Thus, it is not enough to consider only the production or the total level of welfare that has been created. It is important to also take into account the ability of the economy to retain jobs (Sensier et al, 2016).

Furthermore, the ability of countries to innovate is very much linked to their economic resilience, with more innovative states demonstrating a more pronounced economic resilience (Bristow and Healy, 2018).

Resilience, in the economic and ecological context, refers to the capacity of a system (be it ecological, economic or social) to adapt and recover from disturbances or crises. In the specialized literature, both organizational resilience and economy-wide resilience are discussed.

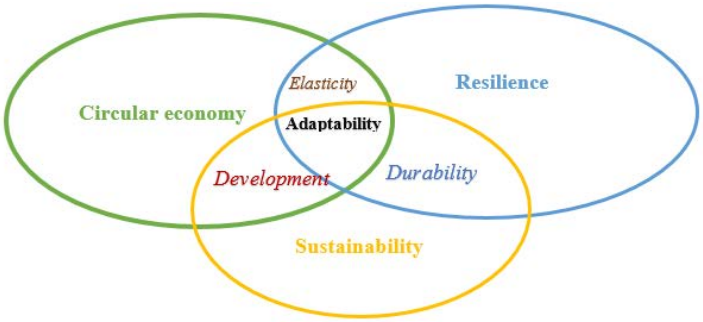

Figure 5. Interconnections of the dimensions addressed: circular economy, resilience and sustainability
Source: developed by the authors.

In essence, the interconnections between the circular economy, resilience and sustainability are fundamental to building a more sustainable and ecologically and economically balanced future. Each of these concepts plays a key role in how we manage natural resources, adapt to global change and ensure a long-term positive impact on the environment and society. Thus, the circular economy promotes a business and consumption model that minimizes waste and resource loss by recycling, reusing, repurposing and reducing materials at source. It encourages a closed economic system in which products and materials are used as much as possible before reaching the end of their useful life. The emphasis is on reducing the consumption of natural resources and extending the lifespan of products.

The circular economy offers a new approach to resource and waste management in the economy. By rearranging industrial processes and business models, resources can be optimally used and restored in a closed-loop system. This system aims to achieve an endless and self-sustaining flow of resources to create economic growth without generating waste, thus creating a state in which the economy and society can thrive using the resources provided by nature, while maintaining a constructive balance within the system.

In a broad sense, the circular economy is an important pillar of sustainability, as it encourages the efficient use of resources and protects the environment by reducing greenhouse gas emissions, reducing pollution and limiting the exploitation of finite natural resources.

Thus, the circular economy contributes to the resilience of economic and ecological systems by increasing the capacity to respond to disruptions (e.g. climate change, economic or resource supply crises) and by reducing dependence on linear supply chains, vulnerable to external shocks. By creating a system of recycling and reusing materials, the circular economy can contribute to increasing resilience, as it makes the economy less dependent on

external sources of raw materials and, at the same time, helps to reduce vulnerability to environmental change.

The link between resilience and sustainability is essential for sustainability, as to ensure a sustainable future, we must be able to cope with global changes and challenges. Resilient systems are better able to protect ecosystems and communities, while continuing to thrive in an unstable environment. Sustainability, on the other hand, focuses on finding a balance between economic, ecological and social needs, so that resources are used in a way that does not compromise the ability of future generations to meet their own needs. This concept encompasses environmental protection, economic prosperity and social justice. Sustainability is a key objective of the circular economy, as promoting a production and consumption model that reduces environmental impact, saves resources and minimises waste is a fundamental part of sustainable development.

These three concepts are interdependent and mutually supportive. The circular economy helps create a more sustainable system by reducing resource consumption and minimizing waste. Resilience allows for faster and more efficient adaptation to external changes, thus protecting economic and ecological systems. Ultimately, they all contribute to greater sustainability, ensuring a future in which resources are managed efficiently and the environment and societies are able to cope with global challenges.

Chapter 2. MECHANISMS AND STRATEGIES FOR PROMOTING SUSTAINABLE PRACTICES IN ENTREPRENEURSHIP

2.1. The regulatory framework for organizing sustainable practices

The need to transition from the traditional model of economic development to a "green economy" is a global trend that determines the sustainability of the development not only of national economies, but also of the entire planet, and the promotion of a "green economy" is the main and only correct path of development.

The problem of developing the economy in a new dimension, with an orientation towards environmental protection, arose at the end of the 19th century. Researchers realized even earlier that the continuation of the technical mode of production and maintaining the course of post-war economic development infringes on the right of future generations to a better existence. However, at the normative level, recognition of the problem came in 1972, when the first UN Conference on Development was organized in Stockholm, where eco-development was discussed.

The transition process to the "green" economy and the stimulation of ecological businesses can be ensured through:

1) Access to financing;
2) Tax incentives;
3) Involvement of state institutions in promoting the green economy by creating support instruments;
4) Subsidies for producers, processors, exporters of ecological products;
5) Development of green marketing;
6) Awareness and promotion of green education.

To promote green practices in the entrepreneurial sector, support measures are needed to create facilitating conditions for the development of "green" businesses and to attract investors. Such conditions can be created through public policy instruments - by creating a facilitating regulatory framework, implementing various forms of state aid, financial support, subsidies, tax exemptions, etc.

The purpose of this research is to analyze the existing forms of support for the "green" economy as well as the instruments applied in other countries, to assess the impact of their implementation and to present the fiscal situation in the Republic of Moldova in terms of supporting "green" entrepreneurship.

A well-designed regulatory framework “can create conditions and incentives that drive green economic activity, remove barriers to green investment and regulate the most harmful forms of unsustainable behavior,

either by creating minimum standards or by completely banning certain activities" (UNEP, 2015).

The need to provide support for the development of "green" businesses is argued by the fact that governments have a limited amount of resources to directly finance green sectors. For these reasons, providing facilities for entrepreneurs concerned with carrying out sustainable activities could lead in the long term to strengthening the "green" entrepreneurship sector.

According to Law no. 139 of 15.06.2012 on state aid (Official Monitor no. 166-169a of 16.08.2012), there are the following forms of state aid:

1) subsidies and/or grants;
2) budgetary allocations;
3) cancellation or assumption of debts;
4) assumption of losses;
5) exemptions and/or reductions in the payment of taxes, fees and other mandatory payments;
6) deferrals, installments of the payment of taxes, fees and other mandatory payments;
7) waiver of income from state resources or resources of administrative-territorial units granted preferentially;
8) granting of loans on preferential terms;
9) investments of the supplier, if the rate of profit of these investments is lower than the normal one anticipated by a prudent private investor;
10) state guarantees, guarantees granted by public authorities/institutions and persons assimilated to public authorities, state/municipal enterprises and by commercial companies with full or majority public capital;
11) price reductions on goods and services provided, including the sale of movable and immovable property below market price.

According to art. 5 of Law no. 139 of 15.06.2012 on state aid (Official Monitor No. 166-169a of 16.08.2012) the areas in which state aid is granted are:

- remedying serious disturbances in the economy;
- training employees and creating new jobs;
- supporting SMEs;
- aid for research, development and innovation;
- environmental protection;
- aid granted to beneficiaries providing services of general economic interest;
- rescuing beneficiaries in difficulty;
- setting up businesses by women entrepreneurs;
- sectoral aid, depending on the sectors of activity of the national economy;
- aid for regional development.

In the context of this Law, it becomes relevant to analyze the possibilities of establishing tax incentives and to develop recommendations on the use of tax incentives for the greening of enterprises.

According to the current European policy in the field of state aid, several main requirements are imposed:

- State aid must be reduced, better targeted and with a lower potential to distort competition;
- A clear and precise economic approach is needed;
- Procedures must be more efficient and more predictable;
- The degree of transparency must be higher.

However, regardless of the social structure and objective, the introduction of economic incentives is a political decision for each country and cannot be taken literally.

Environmental problems put pressure on governments to find ways to reduce environmental damage while not hindering economic growth. Governments have a range of tools at their disposal, including regulations, information programmes, innovation policies, subsidies and environmental taxes. Environmental taxes in particular are a key element of this toolkit, helping to raise public revenues. Environmental taxes have also been used successfully to address a wide range of problems, including waste disposal, water pollution and air emissions.

2.2. Budgetary-fiscal policy instruments

Fiscal policy instruments provide for the collection of revenues and their expenditure. This includes payments and taxes, the elimination of harmful subsidies, subsidizing green sectors, allocation of funds, public investments in infrastructure, public procurement and other market mechanisms. In general, fiscal policy instruments are able to influence prices and are powerful instruments for influencing actors in the economic sector.

Taxes and duties. The main purpose of taxation and taxation is to collect revenues in the budget that will be used to cover the needs of society. At the same time, they represent an instrument for supporting certain sectors considered priority. Transferring the tax burden to socially harmful activities reduces their occurrence, and reducing the tax burden for socially purposed sectors contributes to their development. Thus, taxes can be established for environmentally harmful activities such as ecological taxes for the extraction of minerals, the use of non-renewable energy resources, the use of natural resources - water, forests, fauna, etc. At the same time, when introducing taxes and fees, it is important to take into account administrative costs, the impact on social competitiveness and on the population with modest incomes.

Subsidies for the development of green sectors. This instrument represents a non-refundable and non-taxable financial support granted from public funds to enterprises, conditioning their activity. Subsidies can be used to support investments made in the development of green sectors of the economy. Following the example of EU countries, subsidization can be used to stimulate the use of renewable energy. This mechanism is an effective way to encourage the transition to a "green" economy, but it also poses a risk to competitiveness. Therefore, it is necessary to gradually eliminate subsidies in sectors that form a mature and stable market.

Subsidies with a harmful effect. Subsidies are a form of preferential treatment of certain socio-economic sectors that manifest themselves through direct payments from governments to private actors, tax cuts, loans at preferential rates, the provision of state-owned goods and services and other support policy measures. In the Republic of Moldova, subsidies were mainly directed towards economic sectors with traditional activities.

The harmful effect of subsidies is visible in the field of agriculture, as they are perceived as anti-competitive instruments. For this reason, the application of subsidies is strictly regulated in most countries. Regulations limiting the negative impact of state support for agriculture have been adopted in the European Union and, recently, in the Republic of Moldova.

However, subsidies were originally conceived as a tool to support certain sectors. Their rational and correct use can contribute to the development of organic businesses in the Republic of Moldova. Starting with 2016, the Regulation on Subsidies to Agricultural Producers in the Republic of Moldova contains new measures that relate to the system of subsidies for organic farming.

Funding. Funding refers to the practice of allocating tax revenues for specific purposes and often represents a link between the use of taxation and subsidies. Such policies can be used to create facilities, such as green funds, designed to lend financing at lower rates for investments in green sectors. Revenues from green funds are intended to support the consumption of renewable energy, investment in green activities, such as the promotion of biomass as a renewable energy source, biogas installations, organic farming, energy-efficient products (electrical machinery, equipment and appliances) and environmentally friendly technologies. These funding allocations can reduce the flexibility of fiscal spending and need to be considered in the broader context of the existing fiscal space of the Republic of Moldova.

Special tax incentives for research and development targeting environmental innovation suffer from many of the same shortcomings as other measures that incentivise greening. These incentives have limited effects if they are used as the sole policy instrument for environmental innovation. For example, if a company has not invested in technology that reduces carbon

emissions, then applying tax incentives for innovation in technologies related to these emissions is pointless. If the technology can save the company money (for example, because it increases energy efficiency), then applying special tax incentives for research and development can provide an additional boost and help to alleviate the environmental problem.

Environmental taxes provide significant incentives for market-ready innovations. But even if all pollutants were taxed optimally, the long-term efforts needed to make big breakthroughs will still encounter some barriers – political and market uncertainty, access to capital, economies of scale. This suggests that general innovation policies cannot adequately address some of the specific environmental issues. Special tax incentives for research and development granted to environmentally oriented private firms could boost the innovation process, but not necessarily of a fundamental nature. In this regard, other policies besides tax are needed, such as public funding of fundamental research and development of advanced technologies.

The optimal approach is to have a strong environmental policy that combines taxation of environmentally harmful activities (proportional to the environmental damage) with broad innovation policies.

2.3. Specific fiscal instruments (product-related)

A component of the environmental policy portfolio are economic instruments related to products. Product instruments are those that regulate the sale and use of products, rather than those that address the environmental aspects of the production process.

There are four broad categories of economic instruments related to products:

Taxes on products. These include taxes levied on the sale of a product or group of products that have an impact on the environment. Taxes on products are introduced for environmental protection reasons, but also have the effect of generating revenue for the budget. Regardless of the initial motivation for the tax, it can have beneficial effects due to its influence on the behavior of producers and consumers.

Tax differentiation based on environmental factors. The structure of existing taxes can be adapted to environmental objectives by increasing tax rates on polluting goods and/or reducing tax rates on “green” goods. Generally, the aim is to achieve behavioural changes, in the form of a shift in production or consumption from unenvironmentally friendly goods to more environmentally friendly ones. Tax differentiation usually takes the form of a package of revenue-neutral tax changes, with increases in some tax rates and reductions in other taxes, so that the overall effect on revenue is quite small.

Refund schemes. These are commonly used to ensure high recovery rates for specific items that can be reused or recycled (e.g. beverage containers) or to encourage the return of end-of-life products or materials that would otherwise be hazardous or too expensive to dispose of as part of the general waste stream. A fee is charged when the product is sold, and then refunded in whole or in part when the good or its container is returned after use. Such arrangements may be mandatory or voluntarily instituted by manufacturers themselves, where the recovery of the items is sufficiently valuable (e.g. reusable print cartridges).

Extended Producer Responsibility (EPR). This implies that producers should be physically or financially liable for the social costs and environmental impacts of the finished product. EPR schemes take the form of legislative acts that establish a series of obligations for producers, including rules requiring producers to recycle products at the end of their life cycle. Producers - individually or collectively - can comply with these obligations by establishing measures that encourage a high rate of product return and recycling.

The applicability of these four types of instruments described can be analysed for each type of product that can be considered harmful to the environment.

The experience of some countries (OECD, 2015) indicates the range of products in which product-based economic instruments have been applied.:

- Taxes, refund schemes and REPs applicable to motor vehicles;
- Taxes on energy products, including fuels and household energy;
- Taxes on pesticides and fertilisers;
- Taxes, refund schemes and REPs applicable to products and packaging materials;
- Taxes, refund schemes and REPs applicable to products that may generate hazardous waste, such as batteries, used motor oils and certain electrical and electronic goods.

Some applications have been more successful than others, but it is certain that there is potential for the successful application of these tools to other areas that go beyond the products covered by the OECD experience.

2.4. The impact of applying fiscal instruments to stimulate the "green" economy

The application of product-based economic instruments is welcome in all areas where the instruments are capable of achieving behavioural changes with the desired environmental effects. For example, the justification for high taxes on fuels and household energy is that they should incentivise consumers to save energy, for example by choosing smaller, more fuel-efficient vehicles or by making more trips using public transport. Similarly, REP policies in the

field of product packaging are intended to discourage excessive packaging by making producers bear the waste management costs of product packaging.

The selection and design of product-based economic instruments must begin with a clear assessment of the environmental objectives of the policy and the behavioral changes that will be needed to achieve these objectives.

Within the existing model of application of product-based economic instruments, it can be seen that the instruments fall into two broad groups:

1. Instruments aimed at changing consumer purchasing behavior;
2. Instruments aimed at achieving changes in waste generation and waste management.

Effects on behaviour. Sales taxes have their main effects by changing the purchasing behaviour of consumers and the supply of products by firms.

Sales taxes on certain products can also be used to reduce the costs of waste management when waste packaging or end-of-life products are thrown away. High taxes can be used to discourage the sale of certain products that involve high end-of-life waste costs, such as polluting batteries, and to encourage consumers to choose alternative products (such as rechargeable batteries). However, two of the available instruments - refund schemes and REP - can target waste management issues that cannot be easily addressed by point-of-sale taxes. These two instruments can be used to achieve waste separation in a way that promotes reuse and recycling, which would allow for safer management of waste and environmentally hazardous materials.

Taxes on products are likely to be an effective way to stimulate consumer behavior change without excessive regulatory interference. However, product taxation cannot guarantee the extent of the behavioral response that will be achieved, as this depends on individual consumer decisions.

When it is essential that the policy ensures a certain environmental outcome, alternative regulatory approaches may be better. For example, taxes are unlikely to be a good choice if the goal is to discourage the use of hazardous products, such as asbestos. In these cases, a direct regulatory ban may be more appropriate.

Effect on tax revenues. A second significant motivation for using product-related economic instruments may be the revenues that could be raised. In particular, a product tax or levy would generate revenues that could be used for a specific purpose (e.g. an environmental fund) or as an additional contribution to the general government budget. Tax differentiation could be implemented in such a way that government revenues increase due to the taxation of harmful activities, while other tax rates remain unchanged. A revenue-neutral reform would also be possible, combining tax increases on some harmful goods, together with tax cuts on some “green” goods, to leave overall tax revenues – and therefore the tax burden – unchanged.

Impact on public budgets. The impact of product-based economic instruments on public budgets can be considerable. This is probably most significant in the case of instruments targeting waste management. Both deposit refund schemes and REP are intended to divert significant waste streams from the general publicly funded waste stream, thereby saving money on the collection and disposal of municipal waste. One of the factors that has made REP particularly attractive to policy makers is that it increases the prospect of achieving higher recycling volumes while reducing the financial burden on publicly funded waste management operations.

Effects on public administration. The resources required to administer and enforce taxes and product taxes can be quite high in relation to the revenues generated.

It is difficult to demonstrate the correlation between administrative costs and taxes on products associated with environmental protection. The existence of taxes on environmentally harmful products does not allow the calculation of administrative costs separately from other taxes existing in a tax system. However, the costs of administering environmentally related product taxes increase in proportion to the number of firms subject to these taxes: the more firms are involved, the greater the administrative burden.

Effects on businesses. A significant part of the costs associated with any taxation system are borne by taxpayers, who have to complete tax returns, keep accounting records, deal with audits and enforcement, etc. In the case of the REP instrument, the burden of operating the waste collection and disposal system is transferred to businesses. Where these businesses face international competitors that are not subject to the same policy instrument, the use of product-based economic instruments may have negative effects on the competitiveness of domestic businesses vis-à-vis these competitors. It is welcome that imported goods are subject to environmental taxes on the same basis as domestic production.

Product-related economic instruments can also create business opportunities in two main areas. First, as consumers move away from taxed polluting products, the market for greener alternatives will expand and demand for “green” products will increase. In order to create conditions for businesses and support them in producing alternative, green products, a phased introduction of tax measures is needed. This will give domestic firms the chance to invest in alternative products to meet the new consumer demand. In contrast, a sudden introduction of large tax incentives, especially in a context where there are doubts that they will be sustained over time, will lead to satisfying consumer demand from imports.

A second area where new business opportunities arise is when product-based tools are used for waste management. There is a need to start businesses in the field of waste recycling, especially for companies that provide waste

collection and processing services and for producers and users of recycled materials.

2.5. Tax solutions applied in the Republic of Moldova

In any contemporary state, there must be methods for monitoring the impact of man and his activities on nature. In the Republic of Moldova, two types of instruments are used to regulate the relations between man and nature:
1) Providing facilities for natural resource users

According to the current tax legislation in force in the Republic of Moldova, there are two forms of tax incentives with a pronounced environmental character. These refer to deductions for waste management and the elimination of polluting substances.

1. Art. 20 of the Fiscal Code provides for non-taxable sources of income with the following content gross income does not include letter) income obtained by individuals, with the exception of individual entrepreneurs and peasant households (farmers), from the handover of returnable packaging, residues and waste of paper, cardboard, rubber, plastic, glass (glass shards), used electric batteries, handed over separately or as component parts of a waste of electrical or electronic equipment (Fiscal Code, 1997);
2. Art. 24 refers to the deduction of expenses related to entrepreneurial activity and stipulates in points (12) and (13) the following:

(12) The deduction of payments for excessive disposal of polluting substances into the environment and excessive use of natural resources is not allowed.

(13) The deduction of residues, waste and natural perishability is allowed within the limits approved by the specialized authorities of the central public administration, together with the specialized institutions, with the approval of the Ministry of Finance, according to the manner established by the Government.

2) Restricting the exploitation of natural resources through taxes, fines and penalties

The national system of environmental taxes and fines includes the following types of payments:

Energy taxes - calculated and paid in the form of excise duties on fuels, regulated by the Fiscal Code of the Republic of Moldova, Title IV.

Transport taxes - include excise duties on motor vehicles, Fiscal Code of the Republic of Moldova, Title IV; road taxes (for cars registered in the Republic of Moldova and abroad), Fiscal Code of the Republic of Moldova, Title IX; parking fees, Fiscal Code of the Republic of Moldova, Title VII.

Pollution taxes. This fiscal instrument is provided for by the Law on Payment for Environmental Pollution, the Law on Production and Household Waste and includes a series of payments for various activities that may pollute the environment, namely:

- payment for emissions of pollutants into the atmospheric air from stationary sources;
- payment for discharges of pollutants with wastewater into water bodies and sewage systems;
- payment for the storage of production waste;
- tax on goods that, in the process of use, cause environmental pollution.

At the same time, the Fiscal Code of the Republic of Moldova, Title VIII, provides for resource use fees, namely:

a) water tax;
b) tax for carrying out geological prospecting;
c) tax for carrying out geological explorations;
d) tax for extracting useful minerals;
e) tax for using underground spaces for the purpose of constructing underground facilities, other than those intended for the extraction of useful minerals;
f) tax for operating underground structures for the purpose of carrying out entrepreneurial activity, other than those intended for the extraction of useful minerals;
g) tax for standing timber.

Failure to comply with environmental protection legislation and harmful and polluting activities are subject to fines under the Contravention Code of the Republic of Moldova, Chapter VII, Art. 86-87; Chapter IX, Art. 109-158; Chapter X, Art. 177 and under the Criminal Code, Art. 223-235 (Contravention Code RM, 2017).

In the Republic of Moldova, there are also other penalty mechanisms for environmental damage (MIRON, V., 2019). These are calculated based on the following legislative acts: Forestry Code; Law on Production and Household Waste; Law on Green Spaces of Urban and Rural Localities; Law on the Improvement of Degraded Lands by Afforestation; Law on Fish Stock, Fishing and Fish Farming; Law on the Plant Kingdom; Law on the Animal Kingdom.

When granting state support (fiscal aid) for the greening of enterprises, we recommend taking into account the following aspects:

• to identify sectors that have potential and are within the development perspectives of the regional economy;

• to take into account the relationship to social priorities: demography, quality of life, education, culture, environmental protection and other strategic development objectives of the country;

• to select financial resources to support projects considered priority and to analyze the feasibility of these investment projects in order to provide support strictly in accordance with real needs;

• to assess the impact of the facilities granted and their correlation with the investment recovery period;

• to reduce the share of state aid granted in the form of budget revenue waivers (exemptions, reductions, postponements) and to increase the share of facilities granted in the form of budget expenditures (entrepreneurship support funds, investments in modern technologies and equipment, financial guarantees and preferential loans);

• to eliminate the granting of individual aid and increase the number of measures granted through state aid schemes, transparent and open to all economic operators who wish to apply.

To be successful in promoting green practices, the Government of the Republic of Moldova should develop producer responsibility schemes, for example through the REP instrument, for the management of hazardous waste. These actions can be gradually achieved by maintaining environmental taxes for all types of packaging, tires, batteries, light bulbs and other harmful waste. Once the REP systems become fully operational, the taxes described could be eliminated.

There are types of products that should not be taxed, but could be prohibited or restricted by law. These include asbestos, products containing lead or other harmful substances, plastic packaging, chewing gum, etc. At the same time, it is recommended to apply an appropriate fiscal differentiation between products and activities that are more or less harmful to the environment.

The provision of tax incentives plays a very important role in addressing environmental challenges. Taxes and levies can be highly effective when they are properly designed, fairly levied and proportionate to the environmental damage. Revenues from taxing environmentally harmful activities and products can be used to help with fiscal consolidation or to reduce other tax rates.

The introduction of environmental taxes raises distributional or competitiveness issues, but these can be addressed through other policy instruments. Providing information, transparency and certainty is essential for public acceptance and the effectiveness of environmental taxation. Ultimately, taxes should be combined with other instruments to achieve the most effective environmental policy package.

In the Republic of Moldova, public authorities have begun to take measures to promote and support a transition to a “green” economy. This awareness is largely due to the commitments signed in order to join the EU community programs. However, there is a problem related to the responsibility

of each consumer and entrepreneur in relation to the impact of their activity on the environment. In this regard, the provision of fiscal and financial incentives would be effective solutions for educating a new society oriented towards environmental protection.

The use of both general and product-based fiscal incentives is a priority direction for the development of fiscal policies in the Republic of Moldova. The correct and balanced application of fiscal instruments can bring significant long-term benefits, contributing to the creation of a new economy – efficient, harmless and responsible.

Chapter 3. CLASSIFICATION AND CHARACTERISTICS OF CIRCULAR BUSINESS MODELS

3.1. Outlining the circular business typology

Just a few decades ago, people operated on the assumption that resources to extract or cultivate would always exist. Business models of the past were built around a concept that was called "take, produce, throw away."

Overconfidence in the constant availability of new resources and the idea that we could continuously manipulate nature to meet our needs led to resource depletion, large amounts of waste, and the throwing away of existing goods or resources before their full value was exhausted.

Thus, it becomes indispensable to change our behavior both in everyday life and in business, politics, and other areas. In addition to reducing the amount of waste and encouraging the recycling of paper and plastic, the need has arisen to fundamentally change business models. The question is, are there other ways to organize businesses and economies that take into account the idea that the earth's resources are limited? Can these businesses be profitable and sustainable at the same time? New models that will ensure economic sustainability must be designed to transform all the waste that companies and individuals produce into a valuable and productive resource that can be used again.

A successful transition to a circular economy could contribute to achieving the Sustainable Development Goals, the objectives of the Paris Climate Agreement, the ambitions of the European Green Deal and achieving carbon neutrality in Europe by 2050. Since the emergence of the circular economy as a major policy topic in Europe (EC, 2015, 2020a), interest in the potential of circular business models has grown strongly among policymakers, companies, entrepreneurs and other stakeholders. Over the years, more and more knowledge has become available on the opportunities for implementing circular business models, but also on the barriers and risks related to this implementation. However, as the research field has grown, so have the variations in definitions and typologies to explain circular business models. As a result, there is no clear and unique definition of the concept, but rather a variety of scientific interpretations (Perciun, et. at., 2022).

After the Ellen MacArthur Foundation, 2012, many important works have appeared that substantiated the basic concepts of the circular economy. (Ellen MacArthur Foundation, 2012). Among them is Accenture, 2014 which presented a large study on circular business models representing the conceptual framework of these models to which many authors still refer today (Accenture, 2014).

A conceptualization derived from the most important scientific works is presented by (Alhawari, O. et.al., 2021) who describe the circular economy "as a set of organizational planning processes for the creation, delivery of products, components and materials at the highest utility for customers and society, through the effective and efficient use of ecosystem, economic and product cycles by closing the loops for all related resource flows".

Important scientific studies that have addressed the development and implementation of business models in recent times are carried out by teams led by (Osterwalder, A., Pigneur, Y. and Tucci, C. L., 2005), (Moreno, De los Rios, Rowe, & Charnley, 2016), (Bocken, N. et. al., 2016), (Nußholz, J. L. K., 2017). In this paper we will refer to the works of these authors.

One of the fundamental works on which our study is based is the work of Osterwalder et al. who defined business models as "the rationale of how an organization creates, delivers, and captures economic, social, and other forms of value" (Osterwalder, 2005).

Table 2. Important indicator of waste management and economic development in EU

Country	GDP per capita	Value add (million EUR)	Municipal waste generation (per capita per year)	Recycling rate of municipal waste (%)	Recycling rate of packaging (%)	Recycling rate of bio waste (kg per capita)	Recycling rate of e-waste (%)
Austria	32147.6	2222.4	581.1	59.5	66.5	198.7	39.5
Belgium	30023.8	1915.2	451.3	53.6	78.4	96.4	32.5
Bulgaria	10981.0	267.6	525.7	22.8	57.2	8.8	68.3
Croatia	15085.7	407.2	386.5	15.6	55.5	7.9	63.0
Cyprus	23619.0	198.4	660.4	9.8	48.2	5.3	17.8
Czechia	21300.0	1109.2	340.9	16.9	67.8	15.0	33.6
Denmark	31990.5	1953.4	773.7	44.4	64.8	128.8	43.4
Estonia	17319.0	164.8	376.6	20.8	54.4	13.5	36.9
Finland	28919.0	1564.6	501.0	36.1	55.3	54.9	37.5
France	27219.0	14697.6	529.0	35.4	58.3	85.0	26.6
Germany	30485.7	28380.0	610.8	62.4	70.8	103.0	36.5
Greece	19981.0	1186.8	470.9	15.1	50.3	10.9	26.2
Hungary	16504.8	804.2	417.4	19.8	49.5	16.0	39.3
Ireland	38909.5	931.2	654.9	31.8	58.6	26.7	40.9
Italy	26247.6	14380.1	520.1	31.1	60.0	61.6	28.3
Latvia	14523.8	180.7	359.6	14.6	51.0	11.2	25.6
Lithuania	16481.0	241.2	421.6	19.7	54.2	34.5	36.9
Luxembourg	66395.2	253.9	694.2	45.3	63.6	129.7	35.9
Malta	22309.5	281.2	628.0	9.6	31.6	16.0	12.4
Netherlands	33852.4	3536.3	562.8	49.7	68.7	144.2	33.6
Poland	15481.0	2494.8	306.6	16.7	45.7	12.7	27.9
Portugal	20014.3	1233.3	475.1	20.7	52.6	49.8	32.9
Romania	12671.4	1685.4	318.6	7.2	46.8	10.4	18.3
Slovakia	17204.8	573.1	317.1	14.0	56.2	18.1	41.2
Slovenia	21357.1	238.2	470.0	31.5	59.5	28.3	27.9
Spain	23785.7	11464.7	533.1	31.1	59.0	81.6	25.6
Sweden	31628.6	3107.2	456.1	45.2	63.9	59.2	56.7
United Kingdom	28009.5	18176.4	531.1	33.2	56.7	60.4	32.5

Source: (Azwardi, A., Igamo, A. M., & Wijaya, W. A. 2023).

In Table 2, the countries with the highest average GDP are Luxembourg, Ireland, and the Netherlands. Statistical data on the volume of municipal waste per capita, countries that have the highest per capita waste generation are Denmark (773 kg/capita), Luxembourg (694 kg/capita) and Cyprus (660 kg/capita). This data already shows a correlation between GDP and the volume

of waste. Positive examples with respect to this indicator include the Czech Republic (340 kg/capita), Romania (318 kg/capita), and Poland (306 kg/capita). A very important indicator is also the recycling rate, which shows that although certain countries produce large amounts of waste, they also have high recycling rates by packaging waste by type of packaging such as, Belgium (78%), Netherlands (67%), and Denmark (65%), it can be seen from what is explained above that the indicator is not the only relevant one, according to Huysman et al., (2017) using indicators to measure the effectiveness of various possibilities for processing plastic waste in a circular economy. This measure takes into account the flow of plastic waste and its technical quality, and monitors consumption resources through Cumulative Exergy Extraction. Saidani et al., (2019) research is linked to the circular economy by highlighting the remaining 37 major challenges, such as effective uptake by industry. Moraga et al., (2019) provides a classification framework for categorizing circular economy indicators based on what (CE strategy) and how (environmental measurement). Howard et al., (2019) provides a framework for developing circular economy indicators related to the core objectives and principles of the circular economy.

The results display that the developed countries of the European Union generate more waste, but also provide except pointer of circular economy implementation. On the other hand, in order to achieve better results in the world's developing countries, more financial resources need to be invested in activities such as research and development, new technology development and innovation. It is also essential that environmental activists become more involved in activities that promote a circular economy (Sijtsema et al., 2020). Achieving these two goals of hers will improve the implementation of sustainable economic development in Member States (Azwardi, A., Igamo, A. M., & Wijaya, W. A., 2023).

3.2. Defining elements of business models

To describe a circular business model, it is necessary to identify what a business model is.

A business model is a conceptual tool that describes how business is done (Magretta, 2002). It rationalizes how an organization creates, delivers and captures value (Osterwalder, A., et.al., 2005). Authors concerned with describing business models (Bocken, N. M. P., et.al., 2014) (Osterwalder, et.al., 2010) (Richardson, J., 2008), dentify three main elements of them:

• value proposition: product or service offering and target customer – what value is offered and to whom?

• value creation and delivery: specific product or service characteristics and distribution channels – how is value delivered; resources, suppliers and partners?

• value capture: cost structure and revenue streams – how does the company generate value?

There are different types of business models, and they all outline the details of how an organization creates and delivers value and how it will make a profit. In the traditional business model card, the emphasis is on capturing economic value expressed in terms of turnover and profit (Teece, D. J., 2010), (Osterwalder, A., et.al., 2005) For sustainable business models, the idea of capturing value is broadened to include environmental and social value (Nußholz, J. L. K, 2017) (Bocken, N. M. P.,et.al., 2016).

A generally accepted way to structure a business model was developed by Osterwalder and his colleague Pigneur, who identified the elements on which a company creates value: the Business Model Canvas. This model is a perfect tool for developing new business models or for structuring existing ones (Osterwalder, A. and Pigneur, Y, 2010).

The Canvas model consists of 9 elements that describe the key factors of a business:

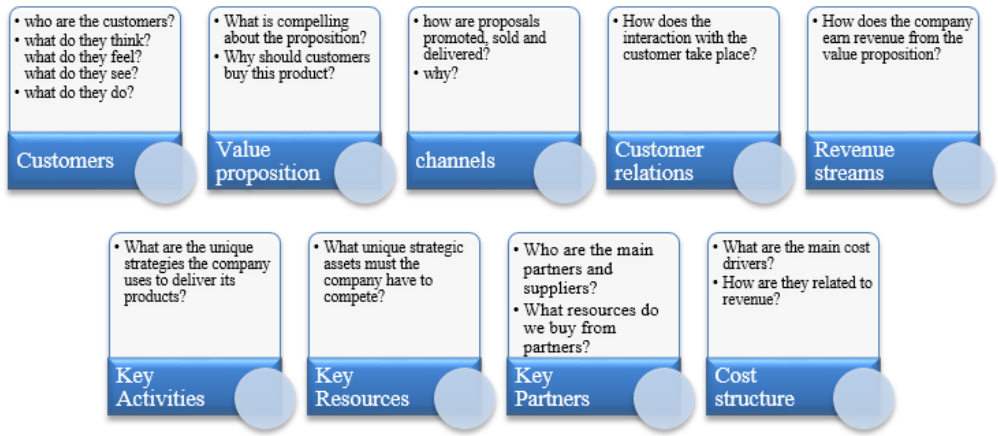

Figure 6. Business structuring model (Canvas Model)

Source: developed by the authors based on source (Osterwalder, et.al., 2010).

From the above, we conclude that in order to conduct a business, it is necessary to describe key elements, such as: customer and supplier segments, available resources and distribution channels, etc. All these elements can be grouped depending on their belonging to the proposition, creation and capture of value (see Figure 6). The demand for finite resources, such as natural gas, mineral resources, precious metals, quality soil and drinking water increases with the increase in the cost of obtaining them. The way in which companies

can contribute to mitigating the consequences of the increase in global demand for resources, as well as reducing current costs, is by adopting a more circular approach to production processes.

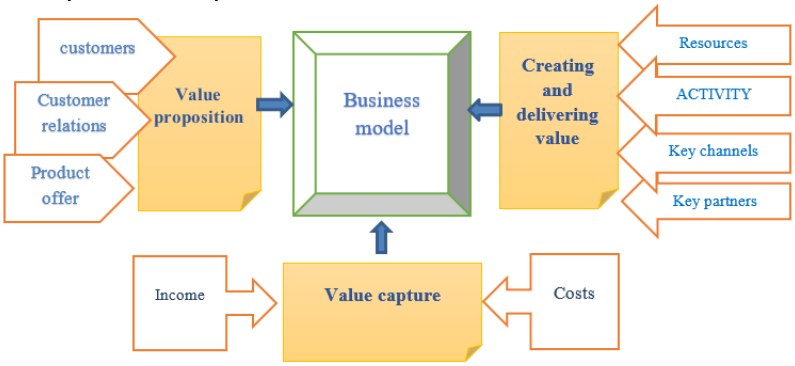

Figure 7. The elements of a business model through the lens of value
Source: developed by the authors.

The main difference between traditional and circular business models is that companies are starting to look at their businesses through a much broader lens. By evaluating the full potential life cycle of a raw material, companies are discovering ways to extract more value from previously unknown revenue streams while reducing their reliance on a constant flow of virgin raw materials.

Circular business models therefore involve a broader vision of business that is geared towards reducing, reusing, and recycling as much as possible.

In 2012, the Ellen MacArthur Foundation outlined the idea of the circular economy as a new business opportunity (Ellen MacArthur Foundation, 2012). This study has sparked a natural scientific interest in business models that can be effectively used in a circular economy. Thus, various studies have emerged that aimed to encourage entrepreneurs to adopt the concept of circularity in business (Accenture, 2014).

Over the years, various ways of classifying and dividing circular business models have emerged. For example, the British organization Forum for the Future, which specializes in identifying and solving sustainability challenges, has developed a guide with 10 business models that operate according to the principles of the circular economy. Also, the multinational company Accenture, which provides business support services worldwide, has outlined 5 circular business models that, in practical terms, are the most commonly used (UNGUR, C., 2022).

In scientific articles published in Scopus journals we find classifications of circular business models in (Moreno, M. et.al., 2016) (Bocken, N. et.al., 2016) (Bakker, C. et.al., 2014), systematization of these classifications was carried out by (Nußholz, 2017).

Table 3. Classification of circular business models based on the literature

Autori	Modele de afaceri circulare				
Moreno et al. (2016)			Circular consumables	Product Life Extension Product Value Extension Sharing Platforms	Resource value
Boken et al. (2016)	Encouraging sufficiency	Industrial symbiosis		Access and performance model Extending product life Extending product value	Access and Performance Model Product Life Extension Product Value Extension
Bakker et al. (2014)				Access Model Performance Model Hybrid Model Classic Long Life Model Gap Exploitation Model	
Life cicle stages	***extracting***	***Processing***	***Production***	Usage	***End of life cycle***

Source: Adapted from (Nußholz, J. L. K, 2017).

In April 2019, the OECD published one of the latest global policy documents in this area - *„Business Models for the Circular Economy: Opportunities and Challenges for Policy"* (Policy, 2019).

In our opinion, based on the OECD report, we consider it appropriate to divide circular business models into 5 categories (see figure):

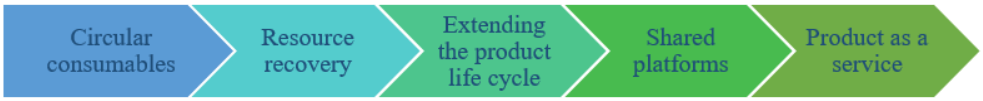

Figure 8. Types of circular models
Source: developed by the authors based on the literature studied.

3.3. Analysis of the European, regulatory and institutional framework related to the circular economy

In recent years, the circular economy has been an important strategic model for any country, but has been more strongly addressed by the countries of the European Union. Thus, the use of circular models has placed this approach at the heart of the EU development strategy, being supported by the European Structural and Investment Funds. The circular economy model

involves focusing on reducing the use of non-renewable resources and introducing innovative and sustainable elements in the consumption phase that respond to huge environmental challenges, such as resource scarcity, global warming and waste management (UNGUR C., 2022).

The first important step of the European Commission regarding the circular economy is the decision to withdraw its legislative proposal on waste and to present a new, more constructive package by the end of 2015 that would cover the entire economic cycle, not just waste reduction objectives. Thus, in December 2015, a "new era" of the European framework for the circular economy begins, represented by a set of well-defined measures, approved by the EU Member States. Meanwhile, a series of initiatives have emerged at the European level, such as:

- The European Circular Economy Stakeholder Platform facilitates the exchange of good practices between stakeholders and provides them with a database of good practices at European level.
- The European Cluster Collaboration Platform (ECCP) supports collaboration between thematic clusters in the EU as well as initiatives at international level.
- The Enterprise Europe Network includes around 600 organizations from over 60 countries to support SMEs in accessing financing opportunities for eco-innovation, energy and resource efficiency, etc.

These platforms encourage and also provide funding opportunities for organizations in the European Union regarding the circular economy.

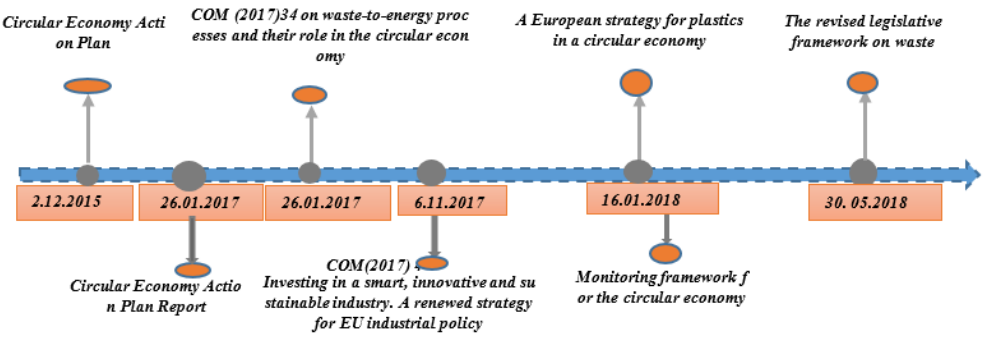

Figure 9. EU actions for the circular economy, 2015-2018
Source: compiled by the authors.

The regulatory policies related to the circular economy were proposed by the European Commission, with the adoption of the first Circular Economy Action Plan, which includes measures that will help to boost Europe's transition to a circular economy, boost global competitiveness, stimulate sustainable economic growth and create new jobs (OECD, 2019). This first EU plan for the circular economy: Communication: Closing the loop - an EU

action plan for the circular economy, - Brussels, 2.12.2015, COM(2015) 614 final. - sets out a concrete and ambitious action programme, with measures covering the whole cycle: from production and consumption to waste management and the market for secondary raw materials, and a revised legislative proposal on waste. This package, adopted by the Commission on 2 December 2015, includes legislative proposals on waste, with a series of long-term objectives in terms of reducing landfilling and increasing recycling and reuse. Thus, the circular economy package includes 54 measures to "close the loop" in the product life cycle - from production and consumption, to waste management and the secondary raw materials market. At the same time, it highlights five priority sectors where the transition should be accelerated, along the entire value chain:

- ✔ plastics,
- ✔ food waste,
- ✔ critical raw materials,
- ✔ construction and demolition,
- ✔ biomass and biomaterial.

The COM (2.12.2015) includes for the first time a definition of the circular economy as an economy “in which the value of products, materials and resources is maintained in the economy for as long as possible and the generation of waste is minimised”. At the same time, at the end of the COM communication (2.12.2015), a monitoring framework is proposed through the existence of a set of key indicators, which will reflect the main elements and progress made towards a more circular economy and the effectiveness of action at EU and national level. According to the communication: many relevant data already collected by Eurostat can form the basis for this monitoring. In addition, the Resource Efficiency Scoreboard and the Raw Materials Scoreboard contain relevant indicators and relevant analyses that will be particularly useful in tracking progress.

According to the COM communication (2.12.2015), in order to close the loop of product life cycles, it also included an Action Plan aimed at supporting the circular economy at every stage of the value chain: production, consumption, repair and manufacturing, waste management and secondary raw materials that are reintroduced into the economy. The EU is financially supporting this transition through the European Structural and Investment Funds, the Horizon 2020 programme, the European Fund for Strategic Investments (EFSI) and the LIFE programme. All 54 actions under the plan have been implemented or are in the process of being implemented.

According to the assessment of the European Commission presented in the impact assessment of the circular economy package (Report on the implementation of the Circular Economy Action Plan, COM

(2017)26.1.2017)), the following important actions are attributed:

i. The first action taken by the Commission concerned legal guarantees for consumer goods. On 9 December 2015, the Commission adopted a legislative proposal on online sales of goods. The proposal aims to strengthen the guarantees offered to consumers to better protect them against defective products and contributes to the durability and repairability of products. This prevents product waste and makes a significant contribution to the circular economy (EU, 2015).

ii. On 17 March 2016, the Commission proposed a Regulation that will create a genuine single market for fertilisers made from secondary raw materials (COM, 2016), (in particular recycled nutrients), thus turning waste management problems into economic opportunities. The draft Regulation provides rules for the free movement of all CE marked fertilising products throughout the EU, including organic fertilising products.

iii. The Commission has published a call for expressions of interest for "Innovation Agreements for a Circular Economy", which was open from 26 May to 15 September 2016. The call is a pilot approach to help innovators facing regulatory obstacles (UE, 2016);

iv. *Ecodesign for a more circular economy*. On 30 November 2016, under the Ecodesign Working Plan 2016-2019 (as part of the Clean Energy for All Europeans Package), the New Working Plan contributing to the EU's energy and climate objectives under the Paris Agreement was adopted, aiming to achieve energy savings comparable to the annual primary energy consumption of Sweden by 2030, by creating jobs and by stimulating innovation.

v. On 1 August 2016, the Commission established the EU Platform on Food Losses and Food Waste. It launched a stakeholder platform on food waste prevention, made progress in developing an EU methodology for measuring food waste and prepared EU-wide guidelines to facilitate food donations and the use of former food as animal feed. Therefore, necessary measures have been taken to achieve the commitment to meet the sustainable development goals of halving per capita food waste by 2030.

From the above, a number of key measures have been taken in areas such as food waste, eco-design, organic fertilisers, consumer product guarantees, innovation and investment. These initiatives are important for supporting the circular economy covering the entire value chain, from production to consumption, waste management and the use of secondary raw materials.

The Commission has adopted a Communication *on waste-to-energy processes and their role in the circular economy - Brussels, 26.1.2017, COM (2017)34 final.*

The main objective of the Communication is the energy recovery of waste used for the treatment of residual waste by (ensuring energy recovery from waste in the EU) supporting the objectives of the Circular Economy Action Plan and strictly following the waste hierarchy established by the EU (EU, COM, 2017). The main objectives are outlined in this document:

1. The position of the different waste-to-energy processes in the waste hierarchy and the implications of this position for public financial support are clarified.

Thus, according to the communication, the waste hierarchy is the cornerstone of EU waste policy and legislation and an essential element for the transition to a circular economy. The aim is to establish a priority order that minimises adverse environmental impacts and optimises the efficient use of resources in waste prevention and management operations. Waste-to-energy processes include very different waste treatment operations, ranging from 'disposal' and 'recovery' to 'recycling'.

The waste hierarchy and the protection human health and the environment are obligations, not options. Failure to comply with them leads to significant fines. Waste managers at the level of producers or holders of waste must take concrete steps to respect the waste hierarchy and the protection of human health and the environment when designing, implementing, verifying and reviewing the effectiveness of the waste management system within the community or organizations:

2. provide guidance to Member States on how they can better use economic and capacity instruments to avoid or address potential waste incineration overcapacity;

3. identifies the technologies and processes that currently have the greatest potential for optimizing energy and material production, taking into account the expected change in the materials entering waste-to-energy processes

Also, among the recommendations considered is that relating to the decrease in the volume of mixed waste, namely the increase in public support for energy recovery, due to separate collection obligations and more ambitious EU recycling targets. In this context, the stimulation of the use of BAT, the development of industrial parks and industrial symbiosis is also considered.

Communication: Investing in a smart, innovative and sustainable industry. A renewed EU industrial policy strategy, - Brussels, 6.11.2017, COM(2017) 479 final/2. The Communication proposes to strengthen the capacity of industry to adapt and innovate to the requirements, to facilitate investments in new digital technologies for a transition to a more circular and low-carbon economy. Stimulating the use of the technological base and adapting new business models that will favor future viability and a better functioning of the single market. The document includes a number of 27 critical raw materials important for the European economy. Thus, the strategy allows businesses to

create jobs and economic growth, protect regions and workers from industrial changes and to strengthen and protect Europe's leadership role, competitiveness and technological progress (EU, COM, 2017).

As regards the regulation of waste management at EU level, a series of legislative acts have been adopted. Therefore, the main waste directives are:

- Directive (EU) 2018/849 of 30 May 2018 amending Directive 2000/53/EC on end-of-life vehicles;
- Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators;
- Directive 2012/19/EU on waste electrical and electronic equipment;
- Directive (EU) 2018/850 of 30 May 2018 amending Directive 1999/31/EC on the landfill of waste;
- Directive (EU) 2018/851 of 30 May 2018 amending Directive 2008/98/EC on waste;
- Directive (EU) 2018/852 of 30 May 2018 amending Directive 94/62/EC on packaging and packaging waste.

The revised legislative framework on waste entered into force in July 2018. Thus, after amending Directive 2008/98/EC, the main objective of the new Directive 2018/851, according to art. 1, is to establish "measures to protect the environment and human health by preventing or reducing the generation of waste, the adverse effects of the generation and management of waste and by reducing the overall impact of resource use and increasing the efficiency of their use, which are essential elements for the transition to a circular economy and to ensure the long-term competitiveness of the Union."

In this Directive, art. 5 specifies the correct management of waste by "using economic instruments and other measures to provide incentives for the application of the waste hierarchy, or other appropriate instruments and measures." More details on the waste hierarchy approach are provided in the old Directive 2008/98/EC, art. 4 paragraph 1., ,,shall apply as an order of priority in the legislation and policy on waste prevention and management: (a) prevention; (b) preparation for re-use; (c) recycling; (d) other recovery operations, for example energy recovery; and (e) disposal.

Following the above, the revised legislative framework on waste under Directive 2018/851, in order to move to a European circular economy with a high degree of resource efficiency, Member States shall adopt the necessary measures to achieve the following objectives (EU., 2018):

Directive 2018/851, according to art.11 paragraph 2:

- separate collection of hazardous household waste (by the end of 2022), bio-waste (by the end of 2023), textiles (by the end of 2025).
- preparation for reuse and recycling of municipal waste shall be

increased to a minimum level of 55% by weight by 2025, respectively 60% by weight by 2030 and 65% by weight by 2035

- From 1 January 2027, Member States may consider municipal bio-waste entering aerobic or anaerobic treatment as recycled only if it has been collected separately or has been separated at source, in accordance with Article 22.
- landfilling of waste aimed at reducing landfill to a maximum of 10% of municipal waste by 2035;
- By 1 January 2025, Member States shall organise the separate collection of hazardous waste fractions from households, to ensure treatment and to guarantee that they do not contaminate other municipal waste streams.
- specific measures to combat food waste and marine litter, with the aim of achieving the United Nations Sustainable Development Goal of reducing food waste per capita by 50% worldwide, in the retail and consumer sectors, and reducing food losses in production and distribution chains by 2030

Directive 2018/852, according to art.6 paragraph 5:

- recycling of packaging waste by 31 December 2025 at the latest, a minimum of 65% by weight of all and a minimum of 70% by weight of packaging waste shall be recycled by 31 December 2030;
- recycling targets for certain packaging materials by 31 December 2025 at the latest, with regard to the recycling of the following specific materials contained in packaging waste: Paper and cardboard: 75%, Ferrous metals: 70%, Glass: 70%, Aluminum: 50%, Plastic: 50%, Wood: 25%.
- recycling targets for certain packaging materials, by December 31, 2030 at the latest: Paper and cardboard: 85%, Ferrous metals: 80%, Aluminum: 60%, Glass: 75%, Plastic: 55%, Wood: 30%.

During 2018, several actions related to the circular economy were carried out. Thus, the European Commission published the so-called Circular Economy Package. The first important action is the adoption of a European strategy on plastics: Communication: A European Strategy for Plastics in a Circular Economy Brussels, 16.1.2018, COM(2018) 28 final - this strategy lays the foundations for a new plastics economy, in which the design and production of plastics and plastic products fully meet the needs for reuse, repair and recycling, and in which more sustainable materials are developed and promoted.

This Strategy proposes concrete actions to turn the vision for a more circular plastics economy into reality. In this context, the strategy proposes a set of measures at EU level, such that by 2030 all plastic packaging should be

recyclable, thus contributing to the transition to a more circular economy. The strategy provides for actions to:

1. Improve the economics and quality of plastic recycling;
2. Reduce plastic waste and littering;
3. Drive investment and innovation towards circular solutions;
4. Scale up action globally.

According to this objective, the strategy contributes to "achieving the priority set by the Commission for an Energy Union with a modern, low-carbon and resource-efficient economy, and will make a tangible contribution to achieving the 2030 Sustainable Development Goals and to complying with the Paris Agreement". Through this approach, it should cover the entire value chain, which will encourage economic growth, job creation and innovation. Such an approach can also reaffirm European leadership in global solutions and help us achieve the transition to a circular and low-carbon economy, while providing citizens with a cleaner and safer environment.

The Communication notes that on Europe's external market, per capita consumption of plastics is growing rapidly, especially in Asia. Thus, plastics value chains span entire continents and plastic waste is traded internationally: in the EU, almost half of the plastic waste collected is sent abroad, where uncertainty remains about its treatment. And over 85% of exported plastic waste is currently sent to China, a situation that is set to change soon given China's decision to ban the import of certain types of plastic waste, creating opportunities for EU recycling businesses.

Also, an important moment is specified about the financing of research and innovation projects,, on better identification of contaminants and decontamination of plastic waste through the Horizon 2020 program,,. In this context, the European Structural and Investment Funds, in particular the Cohesion Funds, also contribute to the development of the EU's recycling capacity, including the recycling of plastics. Over EUR 5.5 billion was allocated for the period 2014-2020 to improve waste management. Thus, this is expected to lead in particular to an increase in waste recycling capacity of 5.8 million tonnes per year. The European Fund for Strategic Investments (EFSI) plays an important role by supporting greater integration of the value chain and projects for closed-loop recycling of plastics.

As part of the strategy, the Commission has launched several international fora and pledging campaigns to ensure that by 2025, ten million tonnes of recycled plastic are in new products on the EU market. This includes initiatives launched in international fora (such as the G7, G20, the United Nations and in the context of the MARPOL Convention) and regional maritime conventions; the International Ocean Governance Agenda for the Future of the Oceans includes actions against marine litter.

Another COMMUNICATION on the implementation of the Circular Economy Package: options for addressing the interface between chemicals, products and waste laws. *Strasbourg,16.1.2018 COM (2018)32 final*. The proposed framework aims to facilitate recycling and increase the use of secondary raw materials by limiting unnecessary constraints and facilitating the cross-border movement of secondary raw materials, so as to ensure that they can be easily traded across the EU. Another objective of the Communication is to replace chemicals of concern and, where this is not possible, to reduce their presence and improve their traceability.

COMMUNICATION on a monitoring framework for the circular economy. Strasbourg, 16.1.2018 COM (2018) 29 final. The Commission proposes an EU monitoring framework for the circular economy, consisting of a set of key indicators covering each stage of the product life cycle, at European and national level The range of indicators will be continuously updated on the dedicated website for the monitoring framework. This website includes tools to monitor progress and documents the methodologies for the indicators, data sources, definitions and publication standards, in particular food waste and green public procurement.

The monitoring framework consists of a set of 10 indicators grouped into four stages and aspects of the circular economy: (1) production and consumption, (2) waste management, (3) secondary raw materials and (4) competitiveness and innovation. The results of the monitoring framework should inform the setting of new priorities for achieving the long-term objective of the circular economy

In 2018, *the European Commission adopted other ambitious initiatives in the context of the Circular Economy Action Plan: the EU Directive on the reduction of the impact of certain plastic products on the environment*. Brussels, 28.5.2018 COM (2018) 340 final. The European Commission is proposing on 28 May 2018 for adoption a new directive that aims to reduce the impact of certain plastic products on the environment by implementing the EU Plastics Strategy, addressing the gaps identified in the existing legislation. The directive proposes key actions for specific single-use plastic items, taking into account consumer behavior as well as consumer needs and opportunities for businesses. Where alternatives are clearly available - both single-use and multi-use - restrictions are proposed. Other measures include appropriate labelling, awareness-raising, voluntary actions and the establishment of extended producer responsibility schemes that would also cover the costs of cleaning up litter.

EU Directive, on port reception facilities for the discharge of waste from ships, repealing Directive 2000/59/EC and amending Directive 2009/16/EC and Directive 2010/2010/65/EU Strasbourg, 16.1.2018 COM (2018) 33 final (EU, COM, 2018). Through the new directive adopted on 16

January 2018, Member States are invited to achieve a higher level of protection of the marine environment by reducing waste discharges at sea, as well as by improving the efficiency of maritime operations in ports, reducing administrative burdens and updating the regulatory framework. Thus, this directive contributes to the achievement of the objectives of the Marine Strategy Framework Directive, which aims to protect the marine environment and aims to achieve good environmental status in all EU marine waters by 2020. The directive therefore implements the provisions of the Waste Framework Directive through better waste management practices in ports, in line with the polluter pays principle and the EU waste hierarchy. The directive also aims to achieve the objective set out in the EU Circular Economy Strategy of reducing by 30% the amount of marine litter found on beaches and fishing gear lost at sea by 2020.

- ⇨ In 2019, the European Commission comes up with new important actions for the circular economy, the most important measures are:
- ⇨ March 4, 2019 – The European Commission adopted the 4th package of measures on the circular economy
- ⇨ March 12, 2019 – The European Commission published guidelines on best practices in extractive waste management;
- ⇨ June 20, 2019 – The European Council adopted the EU *strategic agenda 2019-2024, in which one of the priorities presented was to build a green, fair, social and climate-neutral Europe*;
- ⇨ December 11, 2019 – The European Commission, presented the European Green Deal, which sets out the roadmap towards achieving a climate-neutral circular economy, in which economic growth is decoupled from resource use.

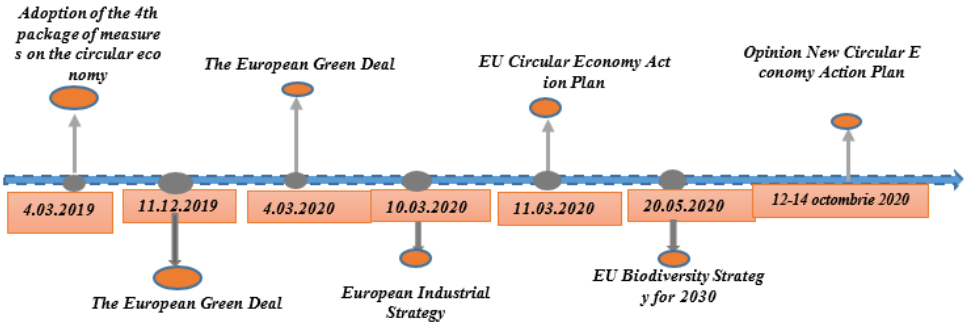

Figure 10. EU circular economy measures, 2019-2020
Source: developed by the authors.

Thus, on 4 March 2019, the European Commission presented a

comprehensive report on the implementation of the Circular Economy Action Plan to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

Report on the implementation of the Circular Economy Action Plan. Brussels, 4.3.2019 COM (2019) 190 final. The report presents the main results of the implementation of the Action Plan and outlines the future challenges of shaping the EU economy, creating a competitive advantage, paving the way towards a climate-neutral economy, where pressure on natural and freshwater resources and ecosystems is minimised. The report responds to the Council's request for "an annual written update on progress made in implementing the Action Plan", a request also echoed by the European Parliament.

The report presents the most important achievements in creating a more circular economy. The Commission defines the process of circularity as the adaptation of industrial processes. Design at the beginning of a product's life cycle helps to ensure the loop. Products and services designed in a circular way can minimise the use of resources and promote the reuse, recovery and recycling of materials in the future. The Commission has introduced circularity aspects (energy consumption and use of materials, waste prevention, recycling and reduction of hazardous chemicals) in Best Available Techniques Reference Documents (BREFs) under the Industrial Emissions Directive, making them reference standards for Member States when granting permits for industrial installations.

Circularity has also opened up new business opportunities, led to the emergence of new business models and developed new markets, both within and outside the EU. In 2016, circular activities such as repair, reuse or recycling generated an added value of almost €147 billion, while the value of investments was around €17.5 billion (EU, 2019). The report also highlights the importance of adopting the first EU-wide policy framework – the Strategy for Plastics in a Circular Economy, which sets out that by 2030, all plastic packaging placed on the EU market should be reusable or recyclable, and by 2025, 10 million tonnes of recycled plastics should be incorporated into new products.

The Report sets out tailored sets of measures, which are in the final stages of the legislative process on single-use plastic items and fishing gear, such as:

- measures to reduce the consumption of plastic food containers and beverage cups, as well as specific marking and labelling of certain products;
- the target of including 30% of recycled plastics in beverage bottles from 2030 and 25% for PET bottles from 2025, as well as the target of separate collection of 90% of plastic bottles by 2029, as well as the introduction of design requirements for the connection of caps to

bottles;

- measures aimed at reducing plastic waste from ships, such as the establishment of a flat rate fee for ship-source waste, etc.

The Commission proposes that EU countries invest in innovation and support the adaptation of the industrial base to accelerate the transition to a circular economy. In the period 2016-2020, the Commission has stepped up efforts in both directions, providing a total of over €10 billion in public funding for the transition.

Communication on the European Green Deal. Brussels, 11.12.2019 COM (2019)640 final. The European Commission proposes a European Green Deal for the countries of the European Union with the aim of: transforming the EU into a fair and prosperous society, with a modern, competitive and resource-efficient economy, with net-zero greenhouse gas emissions in 2050 and decoupling economic growth from resource use.

Achieving a circular and climate-neutral economy requires the full mobilisation of industry. It takes 25 years – a generation – to transform an industrial sector and all value chains. To achieve this goal by 2050, decisions and actions need to be taken by authorities in the next five years. An important step for the Commission is to adopt an EU industrial policy strategy in March 2020, which will stimulate the development of lead markets for climate-neutral and circular products both in the EU and beyond. These actions will prioritise the reduction and reuse of materials before recycling; promote new business models and set minimum requirements to prevent environmentally harmful products from entering the EU market.

The Commission aims to develop a regulatory framework for biodegradable and bioplastics by 2030, by implementing measures on single-use plastics. Accordingly, and incentive measures for businesses to offer consumers and give them the opportunity to choose reusable, durable and repairable products. A sustainable products policy is proposed to reduce waste. Particular attention must be paid to access to resources, which is also a strategic security issue for achieving the ambitious objective of the Green Deal proposed by the EU.

The Council of the European Union, on 4 October 2019, adopted several conclusions on the theme: "More circularity - the transition to a sustainable society" in which the following aspects are outlined:

- more ambitious efforts are needed to stimulate a systemic transition to a sustainable society;
- measures are required to promote circularity, systemically, across the entire value chain, including from the consumer perspective, in key sectors such as textiles, transport, food, as well as construction and demolition, including batteries and plastics;

- to extend the scope of ecodesign measures by including criteria on material efficiency, such as durability, repairability, recyclability and recycled content;

- to encourage the use of economic instruments (environmental taxes, green tax reforms and extended producer responsibility schemes) to promote the circular economy, more sustainable production and consumption patterns and better waste management (EU, 2019).

3.4. Transition to a circular economy during the pandemic – actions of the European Commission

The year 2020 is a year of tough challenges for the entire planet, shaped by the COVID-19 pandemic crisis, with negative economic and social impacts due to the isolation measures. However, it has revealed the vulnerability and dependence of the population on raw materials. Thus, the competent institutions must find the necessary measures to transform this crisis into an opportunity for an ecological restart and a sustainable society. Below we will present the actions of the European Commission in 2020 chronologically:

- 14 January 2020 - The European Commission presented the European Green Deal Investment Plan and the Just Transition Mechanism;
- 4 March 2020 - Public consultation on the European Green Deal, bringing together regions, local communities, civil society, businesses and schools. Proposal for a European Climate Law to ensure Europe's climate neutrality by 2050;
- 10 March 2020 - The European Industrial Strategy was adopted, a blueprint for an economy fit for the future.
- 11 March 2020 - Proposal for the EU Circular Economy Action Plan, focused on the sustainable use of resources;
- 20 May 2020 - Presentation of the EU Biodiversity Strategy for 2030, which aims to protect our planet's fragile natural resources;
- 8 July 2020 - Adoption of EU strategies on energy system integration and hydrogen to pave the way towards a fully decarbonised, more efficient and interconnected energy sector;
- 17 September 2020 - Presentation of the 2030 Climate Targets Plan.

The new Circular Economy Action Plan adopted on March 11, 2020 by the European Commission, is part of the main building blocks of the European Green Deal, a new European agenda for sustainable growth and an EU growth strategy to achieve climate neutrality by 2050.
Communication An Action Plan on the Circular Economy For a Cleaner and More Competitive Economy. Strasbourg, 11.3.2020 COM (2020)98 final. The

document proposes initiatives throughout the entire life cycle of products, targeting their design, promoting circular economy processes, encouraging sustainable consumption and aiming to ensure that the resources used in the EU economy are kept for as long as possible.

The Communication proposes the following objective: scaling up the circular economy from pioneers to mainstream economic players will make a decisive contribution to achieving climate neutrality by 2050 and decoupling economic growth from resource use, while ensuring the EU's long-term competitiveness and ensuring that no one is left behind. It also states that circular economy principles across the EU economy have the potential to increase EU GDP by 0.5% by 2030, creating around 700,000 new jobs. There are also clear economic arguments for individual companies: given that EU manufacturing companies spend on average around 40% on materials, closed-loop material management models can increase their profitability while protecting them from fluctuations in resource prices.

As regards the circular economy, the Commission will propose a legislative initiative on sustainable product policy. Priority will also be given to product groups identified in the context of value chains, such as electronics, ICT products and textiles, as well as furniture and high-impact intermediate products such as steel, cement and chemicals.

- ✔ Through the new plan, the Commission aims to: boost the circularity of industry in production processes by:
- ✔ assessing options for further promoting circularity in industrial processes, including integrating circular economy practices into future reference documents on best available techniques;
- ✔ facilitating industrial symbiosis by developing a reporting and certification system;
- ✔ supporting the sustainability and circularity of the bio-based sector by implementing the Bioeconomy Action Plan;
- ✔ promoting the use of digital technologies for tracking, tracing and mapping resources;
- ✔ promoting the uptake of green technologies through a robust verification system, by registering the EU Environmental Technology Verification Scheme as an EU certification mark.

At the same time, to promote longer product lifespans, the Commission is proposing a series of actions focused on sectors that use the most resources and where the potential for circularity is high (COM/98, 2020). Thus, the Commission is introducing concrete measures on

- ➢ electronics and ICT – the ‘Circularity Initiative for Electronics’ to deliver longer-lasting products and improve waste collection and

treatment;

- batteries and vehicles – a new regulatory framework for batteries to improve sustainability and boost the circularity potential of batteries, (this legislative proposal will build on the evaluation of the Batteries Directive and the work of the Battery Alliance);
- packaging – new mandatory requirements on what is allowed on the EU market, including reducing (excessive) packaging;
- plastics – new mandatory requirements for recycled content, with particular attention to both microplastics and bio-based and biodegradable plastics;
- textiles – a new EU Textiles Strategy to strengthen competitiveness and innovation in this sector and boost the EU textile reuse market;
- Construction and Buildings – a comprehensive Strategy for a Sustainable Built Environment promoting circularity principles in buildings;
- Food – a new legislative initiative on reuse, aiming to replace single-use packaging, tableware and cutlery with reusable products in food services.

At both European and national level, this provision focuses on avoiding waste production altogether and transforming it into high-quality secondary resources that benefit from a functioning market for secondary raw materials. The Commission will therefore examine the possibility of establishing a harmonised EU model for separate waste collection and labelling. The Action Plan also proposes a series of actions to minimise EU exports of waste and to tackle illegal shipments in this area.

The European Committee of the Regions has presented an Opinion on the new Circular Economy Action Plan to be adopted at the plenary session of 12-14 October 2020 In this document, the authors underline: the urgent need to accelerate the transition to a regenerative economic growth model, keeping resource consumption within planetary boundaries. This requires decoupling growth from resource use, developing towards a truly circular society and cooperation at all levels of governance and society. The document proposes to strengthen the local and regional pillar of the new Circular Economy Action Plan, to put cities and regions at the centre of attention.

According to Eurostat, the amount of waste generated annually by economic activities in the EU amounts to 2.5 billion tonnes, which is 5 tonnes per capita. Currently, there is no comprehensive set of legal and policy requirements to ensure that all products placed on the EU market are increasingly sustainable and meet circularity criteria, and the European Commission's new Circular Economy Action Plan (CEAP), presented on 11 March 2020, aims to do just that.

On June 15, 2020, the European Committee of the Regions launched the "Green Deal at Local Level" working group, consisting of 13 elected representatives at local and regional level, the group aims to transform the Green Deal into concrete projects and direct funding for cities and regions, so that the sustainable transition is achieved on the ground.

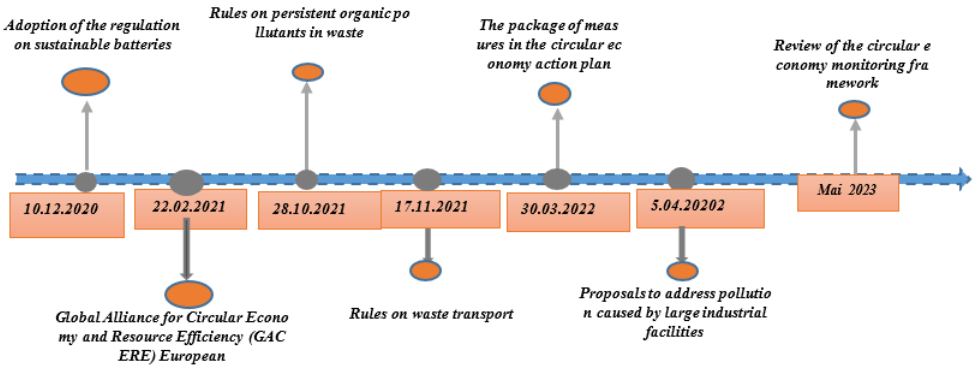

Figure 11. EU measures for the circular economy, 2020-2023
Source: developed by the authors.

Therefore, on 10 December 2020, the European Commission adopted a proposal for a new regulation on sustainable batteries. Since 2006, batteries and waste batteries have been regulated at EU level under the Batteries Directive (2006/66/EC). A modernisation of the framework is necessary due to changing socio-economic conditions, technological developments, markets and battery use. The demand for batteries is growing rapidly and is set to increase 14-fold by 2030. This is mainly driven by electric transport, making this market an increasingly strategic one at global level. Such an exponential global increase in demand for batteries will lead to an equivalent increase in demand for raw materials, hence the need to minimise their environmental impact.

With the Green Deal: Sustainable Batteries for a Circular and Climate-Neutral Economy Regulation, the European Commission proposes mandatory requirements for all batteries (i.e. industrial, automotive, electric vehicle and portable) placed on the EU market. Requirements such as the use of materials from responsible sources with restricted use of hazardous substances, minimum recycled content, carbon footprint, performance and durability and labelling, as well as meeting collection and recycling targets, are essential for the development of a more sustainable and competitive battery industry in Europe and around the world.

The measures proposed by the EU Commission will facilitate the achievement of climate neutrality by 2050. Better and more efficient batteries will make a key contribution to the electrification of road transport, which will significantly reduce its emissions, increase the use of electric vehicles and

facilitate a higher share of renewable sources in the EU's energy mix.

With this proposal, the Commission also aims to boost the circular economy of battery value chains and promote a more efficient use of resources, with the aim of minimising the environmental impact of batteries. From 1 July 2024, only rechargeable batteries for industrial and electric vehicles for which a carbon footprint declaration has been established may be placed on the market. To close the loop and keep the valuable materials used in batteries in the European economy for as long as possible, the Commission proposes to set new requirements and targets for the content of recycled materials and the collection, treatment and recycling of batteries at the end of their life. This would ensure that industrial, automotive or electric vehicle batteries are not lost to the economy after their useful life (POPA V., POPA N. , 2021).

To significantly improve the collection and recycling of portable batteries, the current collection rate of 45% should increase to 65% in 2025 and 70% in 2030, so that the materials from the batteries we use at home are not lost to the economy. Other batteries – industrial, automotive or electric vehicle – must be collected in their entirety. All collected batteries must be recycled and high levels of recovery must be achieved, in particular of valuable materials such as cobalt, lithium, nickel and lead. The proposed regulation defines a framework that will facilitate the reuse of batteries from electric vehicles so that they can have a second life, for example as stationary energy storage systems, or be integrated into electricity grids as energy resources.

On 22 February 2021, in the margins of the Fifth UN Environment Assembly, the European Union, in collaboration with the United Nations Environment Programme (UNEP) and in coordination with the United Nations Industrial Development Organization (UNIDO), launched the Global Alliance for Circular Economy and Resource Efficiency (GACERE). The Alliance is one of the outcomes of the EU Circular Economy Action Plan adopted by the European Commission in March 2020 as part of the European Green Deal, to support the development of international initiatives related to the transition to a circular economy, the promotion of resource efficiency and sustainable consumption and production.

Under the revised Waste Shipment Regulation, Brussels, 17.11.2021 COM(2021) 709 final the Commission delivers on the circular economy and zero pollution ambitions by proposing stricter rules on waste exports, a more efficient system for the circulation of waste as a resource and resolute action against waste trafficking. Waste exports to non-OECD countries will be restricted and only allowed if third countries are willing to receive certain waste and are able to manage it sustainably. Waste shipments to OECD countries will be monitored and may be suspended if they cause serious environmental problems in the country of destination. Under the proposal, all EU companies exporting waste outside the EU would have to ensure that the

facilities receiving their waste are independently audited to show that they manage this waste in an environmentally friendly way. The new rules also bring waste shipments into the digital age by introducing electronic document exchange.

The Waste Shipment Regulation further strengthens action against waste trafficking, one of the most serious forms of environmental crime, as illegal shipments can account for up to 30% of waste shipments worth €9.5 billion annually. Improving the efficiency and effectiveness of the enforcement regime includes setting up an EU Enforcement Group on Waste Shipments, empowering the European Anti-Fraud Office OLAF to support EU Member States' transnational investigations into waste trafficking and providing stricter rules on administrative sanctions.

On 30 March 2022, the European Commission presented a package of proposals on the European Green Deal to make sustainable products the norm in the EU, boost circular business models and empower consumers for the green transition. As announced in the Circular Economy Action Plan, the Commission proposed new rules to make almost all physical goods on the EU market more environmentally friendly, circular and energy efficient throughout their entire life cycle, from the design phase to daily use, reuse and end-of-life.

As part of this package, the EU Commission presented the EU Strategy for Sustainable and Circular Textiles. Brussels, 30.03.2022 COM (2022) 141 final. The strategy sets out the vision and concrete actions to ensure that, by 2030, textile products placed on the EU market are long-lasting and recyclable, made as much as possible from recycled fibres, free from hazardous substances and produced in a way that respects social and environmental rights. In a competitive, resilient and innovative textile sector, producers must take responsibility for their products throughout the value chain, including when they become waste. In this way, the circular textile ecosystem will flourish and be driven by sufficient capacities for innovative fibre-to-fibre recycling, while incineration and landfilling of textile waste must be minimised.

A third proposal aims to boost the internal market for construction products and ensure that the regulatory framework in place is fit for purpose for the built environment to achieve our sustainability and climate goals. Finally, the package includes a proposal for new rules to empower consumers in the green transition, so that consumers are better informed about the environmental sustainability of products and are better protected against greenwashing.

Thus, the EU Commission through this package presented tools to move to a truly circular economy in the EU: decoupled from energy and resource dependencies, more resilient to external shocks and respectful of nature and people's health. The proposals build on the success of existing EU ecodesign rules, which have brought remarkable reductions in the EU's energy

consumption and significant savings for consumers. In 2021 alone, existing ecodesign requirements saved consumers €120 billion. The rules have also led to 10% lower annual energy consumption of products in the sector. By 2030, the new framework could lead to primary energy savings of 132 mtoe, which corresponds to around 150 billion cubic metres of natural gas, almost equivalent to the EU's import of Russian gas.

On 5 April 2022, the European Commission adopted proposals for revised EU measures to address pollution from large industrial installations *to address pollution caused by large industrial facilities***.** The Industrial Emissions Directive aims to achieve a high level of protection of human health and the environment as a whole by reducing harmful industrial emissions across the EU. The revised Industrial Emissions Directive has the following objectives:

- Ensure full and consistent implementation of the IED in Member States, with stricter permit controls on emissions to air and water;
- Increase investment in new, cleaner technologies, taking into account energy use, resource efficiency and water reuse, while avoiding the lock-in of outdated technologies;
- Support more sustainable growth in sectors that are essential for building a clean, low-carbon and circular economy;
- Cover additional intensive agricultural and industrial activities, ensuring that sectors with significant potential for high resource use or pollution also reduce environmental damage at source, by applying best available techniques;
- Establish an Innovation Centre for Industrial Transformation and Emissions (INCITE);
- Integrate the previously separate requirements for abatement and decarbonization, so that future investments in pollution control better take into account greenhouse gas emissions, resource efficiency and water reuse.
- Improve data transparency and public access to environmental information by making permit summaries available online and providing more opportunities for public participation in the establishment and review of permits.

The revision of the Industrial Emissions Directive provides a framework for the operation of industrial installations in the EU that is in line with the European Green Deal and the Zero Pollution Action Plan .

On 30 November 2022, the Commission proposed a revision of the Packaging and Packaging Waste Directive. This revision contributes to the objective of the European Green Deal and the new Circular Economy Action Plan to ensure that "all packaging on the EU market is reusable or recyclable

in an economically viable way by 2030". It will also contribute to the commitment of the 2018 Plastics Strategy to ensure that by 2030 all plastic packaging placed on the market can be reused or recycled in a cost-effective way". This revision aims to: prevent the generation of packaging waste by reducing it in quantity and promoting reuse and refilling; ensure that all packaging on the EU market is recyclable in an economically viable way by 2030; to increase the use of recycled plastics in packaging, thus enabling high-quality recycling ("closed loop") and the replacement of virgin materials.

It is therefore important to monitor progress towards a circular economy and its direct and indirect benefits. This allows the EU and national authorities to assess whether policies are effective and to identify best practices. The European Commission, in 2023, revised the circular economy monitoring framework, previously adopted in 2018. The revision adds new indicators on:

- material footprint and resource productivity - to monitor material efficiency;
- consumption footprint - to monitor whether EU consumption is within planetary boundaries.

The research proposes a theoretical and critical approach to recent circular economy legislation, such as: Circular Economy Action Plan, Circular Economy Package, Monitoring Plan, European Green Deal, etc. Therefore, all these measures and legislative actions offered by the EU focus on solving the problems that exacerbate the environment and climate. Because climate change is a global challenge that requires a global response and the EU is determined to contribute to increasing the level of ambition at the global level and provides an example in this regard. In this context, EU countries have approved the objective of achieving climate neutrality by 2050, in accordance with the Paris Agreement. In this regard, the EU has established ambitious measures and targets to reduce greenhouse gas emissions for key sectors of its economy. Over the past two years, the EU has recognised the need to establish an enabling framework to ensure a cost-effective, balanced and socially equitable transition to climate neutrality, taking into account different national circumstances. EU leaders have underlined the significant economic, societal and technological opportunities that the transition to climate neutrality will bring.

Chapter 4. HAZARDOUS WASTE MANAGEMENT IN THE REPUBLIC OF MOLDOVA

4.1. Identifying the prerequisites for the transition to a circular economy in the national economy

The challenge of sustainable development is to identify the optimal interaction between the economic, human, environmental and technological systems in a dynamic and flexible process of functioning. Sustainability must be applied to all subsystems that make up the dimensions of sustainable development, i.e. starting from energy, agriculture, industry and up to investments, human settlements and biodiversity. The concept of sustainable development requires that environmental protection be harmonized with economic and social development. In these conditions, the connection between the need for economic, social development and environmental protection is essential.

Under EU law, the rational use of natural resources was one of the first environmental concerns underlying the first European Treaties. The Roadmap to a Resource Efficient Europe (COM (2011)0571) is one of the key initiatives of the 7th Environment Action Programme (EAP). One of the main objectives is to unlock the EU's economic potential for more productivity with fewer resources, towards a circular economy. In addition, the recent Circular Economy Package includes measures that will help to boost the EU's transition to a circular economy by increasing recycling and reuse, while also boosting global competitiveness, promoting sustainable economic growth and creating new jobs.

Specific policies address the different elements of the circular economy paradigm. In the case of resource efficiency, these include the Roadmap to a Resource Efficient Europe and the Roadmap for moving to a low-carbon economy (EU Strategy, 2050).

In this context, the European Union, through the Resource Efficiency Roadmap, takes into account the progress made under the 2005 Thematic Strategy on the Sustainable Use of Natural Resources (COM (2005)0670) and the EU Sustainable Development Strategy and establishes a framework for planning and implementing further actions. It also defines the structural and technological changes needed by 2050, including intermediate targets to be achieved by 2020. It proposes ways to increase resource productivity and decouple economic growth from resource use and its environmental impact. (EU, 2020)

Sustainable development and the promotion of the green economy are development priorities for the Republic of Moldova as well. They are found in the main policy documents of the Government, in particular in the National

Development Strategy Moldova 2030, the Energy Strategy–2030, the SME Sector Development Strategy for 2012-2020, the Roadmap for Improving Competitiveness, the Agricultural Development Strategy 2013–2020, the Environmental Strategy 2014–2023, the Program for Promoting the Green Economy in the Republic of Moldova for 2018-2020. They are also part of the commitments of the Republic of Moldova to the country's development partners abroad. The Association Agreement with the European Union expressly aims to ensure sustainable development and promote the green economy in the Republic of Moldova. By signing the Agreement, the Republic of Moldova commits to harmonizing national legislation with European legislation and ensuring the integration of environmental protection provisions, through rational use of resources and energy efficiency, eco-labeling, eco-innovations, in all sectors of the national economy and social life.

To achieve the objectives of promoting the principles of the green economy, environmental management in enterprises, and eco-friendly products and services, the Ministry of Economy and Infrastructure and The Entrepreneurship Development Organization (ODA) developed the SME Greening Program (approved by the Government in November 2019), and the launch of its practical implementation began in the first half of 2020 and was presented at the Launching Conference of the SME Greening Program, on June 3, 2020.

Thus, Greening SMEs provides informational support, consultancy and mentoring, environmental training and education. Through this program - Greening Economies in the Eastern Partnership Countries (EaP GREEN), the Organization for Economic Cooperation and Development published in 2018 the Environmental Policy Tool for Greening SMEs in the EU Eastern Partnership countries, which presents policy recommendations for the Republic of Moldova. As a result, within the Inter-Ministerial Working Group for the Promotion of Sustainable Development and the "Green" Economy, the Program for the Promotion of the "Green" Economy in the Republic of Moldova for 2018-2020 and the Action Plan for its implementation were developed. ODA is in the process of implementing several projects in this area where SMEs will practice this component or contribute to greening or implement this circular sustainable economic model in their activity. A separate compartment is reserved for non-reimbursable financing of SME greening actions and the development of access and expansion capacities on international markets.

At the same time, in the process of promoting the green economy, the Ministry of Economy and Infrastructure has joined international programs and platforms in the field of green economy, such as the EU Program "Greening the Economy in the Eastern Neighborhood", the Eastern Partnership (EaP GREEN Programme (2014-2017), the Green Industry Platform, the UNIDO

Country Program (launched in 2019), participates in the GREEN Action Program, OECD and, in partnership with the Ministry of Agriculture, Regional Development and Environment, is the coordinator and beneficiary of the EU Action - EU4Environment - European Union for the Environment (2019-2022).

4.2. Toxic waste management

In the Republic of Moldova, the problem of toxic waste management is very acute, given the socio-economic aspects related to the transition to a market economy. Over the past two decades, the Republic of Moldova has undergone important transformations in the national economy: privatization and/or bankruptcy of large industrial enterprises, change in the spectrum of economic units, with the prevalence of small and medium-sized enterprises, implementation of efficient and cost-effective technologies, application of new chemicals, etc. Thus, waste is one of the main sources of environmental pollution, as well as contributing to the phenomenon of climate change, which affects the health and quality of life of the population. Insufficient development of a functional waste management system is also an impediment to the economic development of localities.

In the context of these realities, a major risk problem for the health of the environment and the population in the Republic of Moldova is generated by toxic waste, which is mixed with household waste and then thrown into landfills. Unfortunately, in the Republic of Moldova, waste management is based on the linear model (collection-transportation-storage) but not on the circular one.

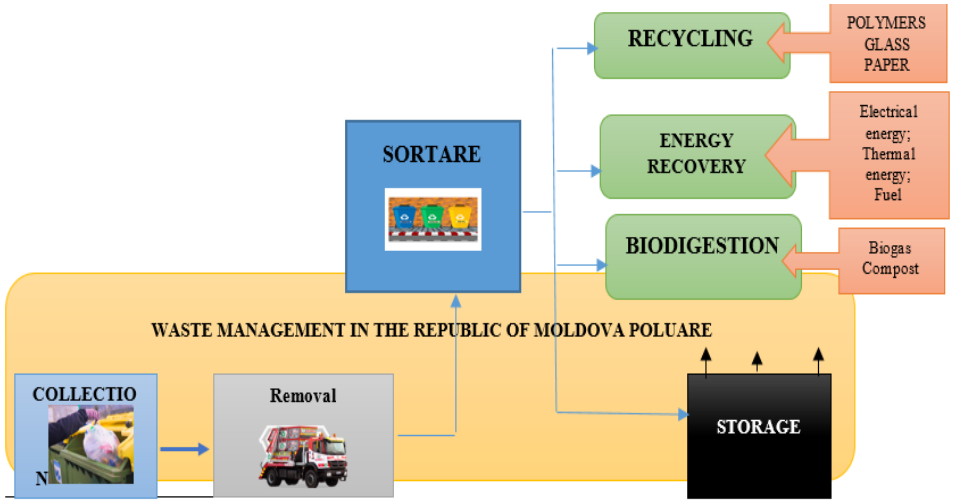

Figure 12. Linear waste management model in the Republic of Moldova
Source: developed by the authors.

Within the linear model - landfills are:
- Sources of long-term water and soil pollution;
- Contribute to climate change;
- Missed opportunities for resource reuse and job creation;
- Irrational land use.

In this study, we provide a comprehensive analysis of the reality of toxic waste management in the Republic of Moldova and propose a transition from a linear model to a circular model, as provided for by the EU.

The main provision of the Waste Management Strategy in the Republic of Moldova for 2013-2027 involves – Development of integrated waste management systems according to EU standards, based on the regional approach and territorial division of the country into 8 waste management regions:

Region 1 – Cantemir, Cahul, Taraclia, Comrat.
Region 2 – Leova, Cimișlia, Basarabeasca.
Region 3 – Căușeni, Ștefan Vodă.
Region 4 – Strășeni, Ialoveni, Hâncești, Criuleni, Cocieri, Anenii Noi.
Region 5 – Ungheni, Nisporeni, Călărași.
Region 6 – Șoldănești, Rezina, Telenești, Orhei.
Region 7 – Drochia, Râșcani, Glodeni, Florești, Fălești, Sîngerei, Soroca.
Region 8 – Briceni, Ocnita, Edineți, Dondușeni.

The roles and responsibilities of central and local authorities in relation to hazardous waste would be as follows:
1. Creating and implementing relevant legislation in line with the transposition of EU directives and the environmental acquis;
2. Creating a national reporting and data system for hazardous waste;
3. Raising awareness among hazardous waste producers;
4. Raising awareness among the general public about the impact of hazardous waste on health and the environment;
5. Providing economic and financial incentives for the development of appropriate hazardous waste management and for the creation of a market for hazardous waste management services.
6. Managing those hazardous wastes for which producers or holders do not exist or cannot be identified, such as historical waste.

The Ministry of Environment issues permits to enterprises carrying out waste management activities.

Regulatory framework for the implementation of international conventions on hazardous waste:

- *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal:* At the national level, the provisions of the Basel Convention were transposed by the Decision

of the Government of the Republic of Moldova No. 637 of May 27, 2003, which approved the Regulation on the Control of Transboundary Movements of Wastes and Their Disposal, which establishes the mechanism for implementing the provisions of the Basel Convention, intended to ensure compliance with the requirements regarding environmental safety in the export, transit and disposal of waste.

- *Stockholm Convention on Persistent Organic Pollutants: At the national level, the provisions of the Convention were partially reflected in the Decision of the Government of the Republic of Moldova No. 1155 of October 20, 2004,* on the approval of the National Strategy on the reduction and elimination of persistent organic pollutants (POPs) and the National Implementation Plan of the Stockholm Convention, with about a third of the stocks of pesticides contaminated with POPs being destroyed (1293 tons) and 18660 units of old electrical capacitors containing PCBs being eliminated, with a total weight of 934 tons. The problem of reducing POPs that are formed as by-products following unforeseen industrial activities (PCDD/PCDF, HCB and PCB) was prioritized for its resolution during the period 2010-2015.

The main objectives of current EU waste policy are to prevent waste generation and to promote reuse, recycling and recovery from an environmental perspective. Waste is increasingly seen as a source of valuable raw materials for industry, with approaches such as reuse, recycling and energy recovery, regulation of packaging waste, end-of-life vehicles, waste electrical and electronic equipment, biodegradable waste and tyres being applied. European policy focuses in particular on activities to separate biodegradable waste from landfills, and recycling and recovery are increasing, which contributes to preventing environmental pollution and reducing greenhouse gas emissions.

4.3. Characteristics of hazardous waste. Properties

Hazardous waste is harmful to human health and the biological environment. Industrial activities use artificially processed chemicals as well as various heavy metals extracted from the underground that did not exist or did not present an appreciable amount in the natural biosphere, where living organisms were conceived or evolved. Thus, waste containing chemicals and / or excessive heavy metal content can be dangerous to living things. Industrial activity that has made our lives more comfortable and better produces hazardous waste that poses a degree of risk to both our lives and the environment (JICA, Report, 2019).

Examples of hazardous waste:: hospital waste, pharmaceutical, medicinal and veterinary components, biocides, solvents, halogenated organic substances used as solvents, cyanides, hydrocarbon/water emulsions, substances containing PCBs or PCTs, polychlorinated dibenzofurans, polychlorinated dibenzo-para-dioxins, tars, paints, resins, plasticizers, adhesives, unidentified chemicals whose effects on humans or the environment are unknown (e.g. laboratory residues), explosives, etc. All of these are listed in specific lists. The handling and treatment of this type of waste is carried out only by economic agents that meet the necessary conditions and keep strict records, based on an authorization (EU, 2000)

Technically, hazardous waste can be defined from three points of view:

1. The type of waste that presents one of the hazardous properties in certain processes OR the waste that contains one of the constituents included in the list that have hazardous properties;
2. Components of different types of waste that give the waste the possibility of being hazardous when they have a certain degree of hazard;
3. Properties that can make the waste hazardous.

In the Figure below we present the basic concept for hazardous waste from the European Waste Catalogue (EWC) which encompasses the three points of view.

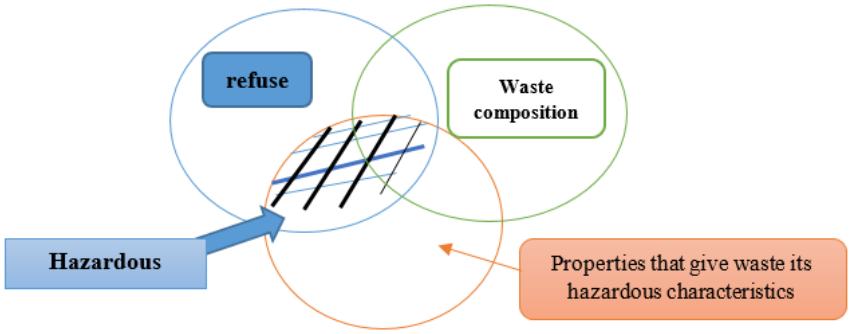

Figure 13. The concept of hazardous (toxic) waste
Source: (JICA, Report, 2019)

The risk of hazardous waste to human health and the environment cannot be assessed solely in terms of the hazardous nature of the waste. The risk can be characterised and assessed through the following three components:

1. The degree of hazard of the waste (including: volume, concentration, extent, etc.);

2. The exposure pathway through which the hazardous substance passes from the source to the receptor (including geographical and hydrogeological setting, etc.);

3. The condition of the receptor. Thus, it is important to know this data and information for assessing the risk posed by the production, storage and disposal of hazardous waste.

According to Law No. 209 of 29.07.2016 on waste, **hazardous waste is any waste that** presents one or more of the hazardous properties specified in Annex No. 3 of the law. Therefore, According to Art. 7 of Law No. 209 of 29.07.2016 on waste, the list of waste, including hazardous waste, is developed and periodically updated by the Ministry of Environment and approved by the Government. Thus, in the case of a type of waste that falls, according to the List of Waste, under two different codes, depending on the possible presence of hazardous characteristics (codes marked with an asterisk), the classification as non-hazardous waste is carried out by the producers and holders of such waste only on the basis of an analysis of the origin, tests, analysis reports and other relevant documents.

If the Ministry of Environment finds, based on laboratory analyses or feasibility studies, that a waste classified in the list of waste as hazardous does not present any of the properties specified in Annex No. 3 of the Waste Law, it shall be considered as non-hazardous. At the same time, it is prohibited to reclassify hazardous waste as non-hazardous waste by diluting or mixing it in order to reduce the initial concentrations of hazardous substances to a level lower than the level required for a waste to be defined as hazardous.

According to the National Bureau of Statistics (NBS), (NBS, the methodological indicators for completing the statistical report form No. 1 - toxic waste are completed annually by production units, combines, enterprises, industrial and agricultural units where toxic waste is accumulated, stored, used or neutralized (liquidated). Within the framework of this report, toxic waste enterprises are those wastes that contain substances that are particularly harmful to the health of citizens and nature. All toxic wastes containing harmful substances, including toxic products that have become unusable during storage or transportation and that cannot be used according to their intended purpose (for example, pesticides that have become unusable and prohibited), are subject to registration.

According to the degree of action on the human body, harmful substances are divided into four categories:

- Category I—extremely harmful substances;
- Category II—very harmful substances;
- Category III—moderately harmful substances;
- Category IV—slightly harmful substances.

The categories of harmfulness of toxic waste, the chemical content and the physical characterization of industrial toxic waste are determined by laboratory analyses in enterprises, scientific research institutions with the involvement of specialists from institutions and subdivisions for

environmental protection or specialists from territorial sanitary-epidemiological stations. When determining the chemical content of waste, the percentage content of toxic substances in dry mass is calculated.

CLASSIFICATION OF HAZARDOUS HOSPITAL WASTE:

1.1. anatomo-pathological waste and anatomical parts (unit of measurement — kg) — biopsy material resulting from surgery and obstetrics, anatomical parts resulting from autopsy laboratories, animal corpses resulting from research activities;

1.2. infectious waste (unit of measurement — kg) — waste containing or having come into contact with blood or other biological fluids, as well as viruses, bacteria, parasites and toxins of microorganisms (syringes, needles, catheters, gloves, probes, dressings, dialysis membranes, used laboratory materials);

1.3. chemical and pharmaceutical waste (unit of measurement — kg) — waste including expired serums and vaccines, expired medicines, reagents and substances used in laboratories, disinfectants;

1.4. Radioactive waste (units of measurement: solid — Bg/kg, liquid — Bg/I, gaseous — Bg/m3(Bg — Begurell)) — solid, liquid and gaseous waste resulting from medical, diagnostic and treatment nuclear activities, which contain radioactive materials.

Hazardous waste properties: HP1 "Explosive", HP2 "Oxidizing", HP3 "Flammable", HP4 "Irritant - skin irritation and eye damage". HP5 "Specific target organ toxicity (STOT)/aspiration toxicity", HP6, "Acute toxicity", HP7 "Carcinogenic", HP8 "Corrosive", HP9 "Infectious", HP10 "Toxic for reproduction", HP11 "Mutagenic", HHP13 "Sensitizing", P12, "Emission of an acutely toxic gas", HP14 "Ecotoxic", HP15 "Waste capable of developing one of the hazardous properties mentioned above, which the original waste does not directly exhibit".

Table 4. Properties of waste that make it hazardous in the EU

Symbol	Property
H1	"Explosives": substances and preparations which may explode under the effect of a spark or which are more sensitive to shock or friction than dinitrobenzene.
H2	"Oxidizing": substances and preparations which produce strongly exothermic reactions in contact with other substances, especially flammable substances.
H-3A	"Highly flammable": • liquid substances and preparations which have a flash point below 21 °C (including extremely flammable liquids) • substances and preparations which may become hot and then ignite in contact with air at ambient temperature without the application of additional energy • solid substances and preparations which may ignite readily after rapid contact with a source of ignition and which continue to burn or consume after the source of ignition has been removed • gaseous substances and preparations which are flammable in air at normal pressure • substances and preparations which, in contact with water or moist air, emit highly flammable gases in dangerous quantities.
H3-B	"Flammable": liquid substances and preparations which have a flash point equal to or greater than 21 °C and less than or equal to 55 °C.
H4	"Irritants": non-corrosive substances and preparations which, through immediate, prolonged or repeated contact with the skin or mucous membranes, may cause inflammation.
H5	"Harmful": substances and preparations which, if inhaled or ingested or if they penetrate the skin, may constitute limited risks to health.
H6	"Toxic": substances and preparations (including very toxic substances and preparations) which, if inhaled or ingested or if they penetrate the skin, may cause serious, acute or chronic damage to health and may even be fatal.
H7	"Carcinogens": substances and preparations which, if inhaled or ingested or if they penetrate the skin, may induce cancer or increase its incidence.
H8	"Corrosive": substances and preparations which may destroy living tissue on contact with them.
H9	"Infectious": substances containing viable microorganisms or their toxins that are known to cause disease in humans or other living organisms.
H10	"Teratogens": substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce non-hereditary congenital malformations or increase their incidence.
H11	"Mutagenic": substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce hereditary genetic defects or increase their incidence.
H12	Substances and preparations which emit toxic or very toxic gases in contact with water, air or an acid.
H13	Substances and preparations capable by any means, after storage, of producing another substance (e.g. leachate) which possesses any of the characteristics listed above.
H14	"Ecotoxic": substances and preparations which present or may present immediate or delayed risks to one or more sectors of the environment.

Source: (UE, 2000).

4.4. Toxic waste management analyses and statistics

Hazardous/toxic waste management is one of the difficult problems that need to be solved in the Republic of Moldova. According to the latest statistical data provided by the National Bureau of Statistics, in 2019, the total amount of hazardous/toxic waste generated amounted to 10,484 tons, an increase of 1.7 times compared to 2014 (6,223 tons), and compared to 2001 this trend is decreasing by 12% (11,879 tons). However, the trend of aggravating the waste problem in the Republic of Moldova, especially hazardous waste, is generated by the faulty way in which various stages of waste processing are currently solved.

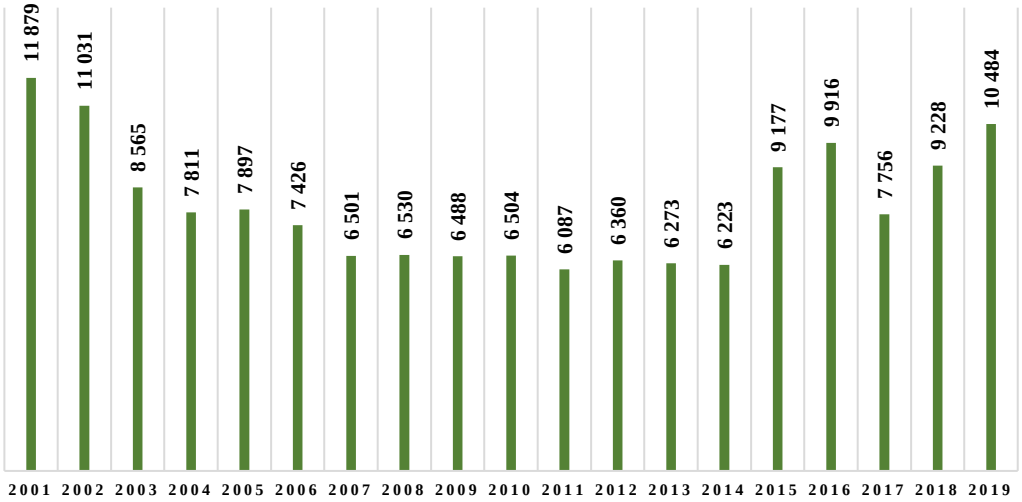

Figure 14. Toxic/hazardous waste at the end of the year in the Republic of Moldova, 2001-2019, tons

Source: developed by the authors based on data from statistica.md

Hazardous waste management in the Republic of Moldova is carried out through the following methods: recycling, neutralization, export for final disposal and storage. Thus, according to statistical data, waste generation fluctuates annually, and the amount of waste generated and managed is increasing. In 2019, a total amount of 4747 thousand tons of toxic waste was managed. The most toxic waste managed in the period 2001-2018 was recorded in 2017 with a quantity of 6857 tons. Of which a large part, about 4254 thousand tons, is represented by generated waste.

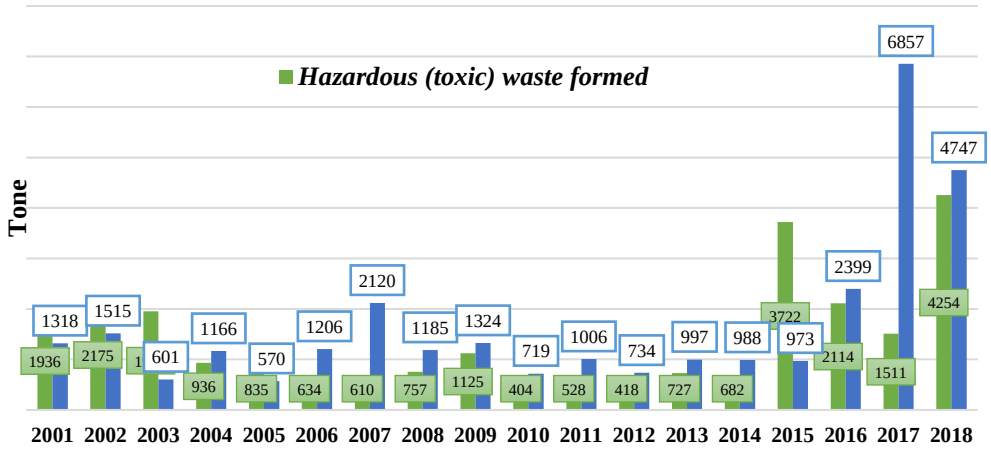

Figure 15. Toxic/hazardous waste generated and treated annually in the Republic of Moldova during 2001-2018

Source: developed by the authors based on data from statistica.md

There are several waste processing enterprises operating in the Republic of Moldova and information on the volumes of recycled waste is not subject to statistical records. Thus, the records of toxic waste are carried out based on the form "F-1 Toxic Waste". Therefore, the number of enterprises reporting the generation of toxic waste is increasing from 43.7 thousand enterprises in 2009 to 55.9 thousand enterprises in 2019 and the quantities of accumulated waste are increasing. The method of managing this category of waste is recycling. Of the amount of toxic waste, only 4570 tons were recycled in 2019, 5 times more than in 2014 (854 tons).

The stock of hazardous waste is the amount of hazardous waste awaiting treatment or disposal. Hazardous waste is normally stored prior to treatment or disposal. Some of the hazardous waste cannot be treated, disposed of or exported during the year in which it is generated. At the end of the year, this amount of hazardous waste will contribute to the stock of hazardous waste that must be treated or exported for disposal for subsequent years.

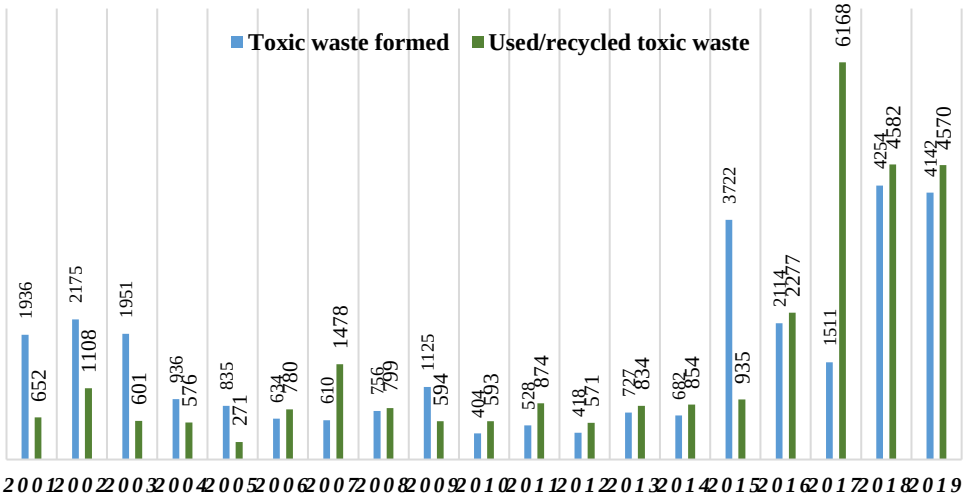

Figure 16. Toxic/hazardous waste in the Republic of Moldova, 2001-2019, tons
Source: developed by the authors based on data from statistica.md

In principle, the sum of the quantities of hazardous waste to be: (Recycling + Incineration + Landfill + Other disposal) should be equal to the quantity of "Hazardous waste treated or disposed of during the year". However, as there may be double counting due to secondary quantities of waste (e.g. incineration residues that are stored in the landfill), the sum may be higher than the quantities to be managed.

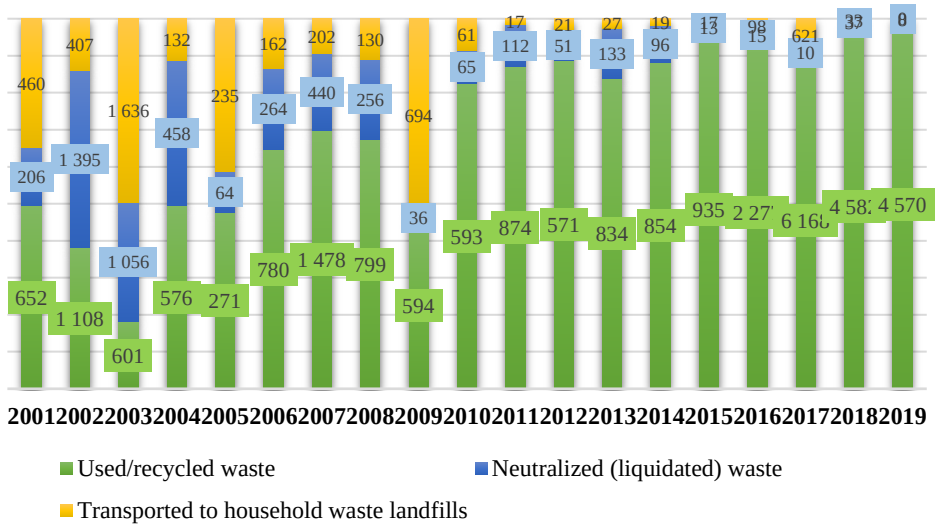

Figure 17. Hazardous waste treatment by treatment type at national level, 2001-2019, tons
Source: developed by the authors based on data from statistica.md

According to the data presented by the NBS, it is noted that until 2009, most of the toxic waste was transported to landfills or was liquidated. Since 2010, the situation has been improving, most of the toxic waste was recycled 90%. Thus, in 2019, 4570 tons of waste were recycled, and 8 tons of toxic waste were liquidated.

The majority of toxic waste existing on the territory of the Republic of Moldova was attributed in 2008 to 2014 to the Southern region of the republic, after which from 20015-2018 it belonged to the Central region. At the regional level, in 2019 the toxic waste stock belonged to the Northern region of the Republic of Moldova, with 2890.40 tons, followed by the Central region with 2236.80 tons and the Southern region with 1732.10 tons.

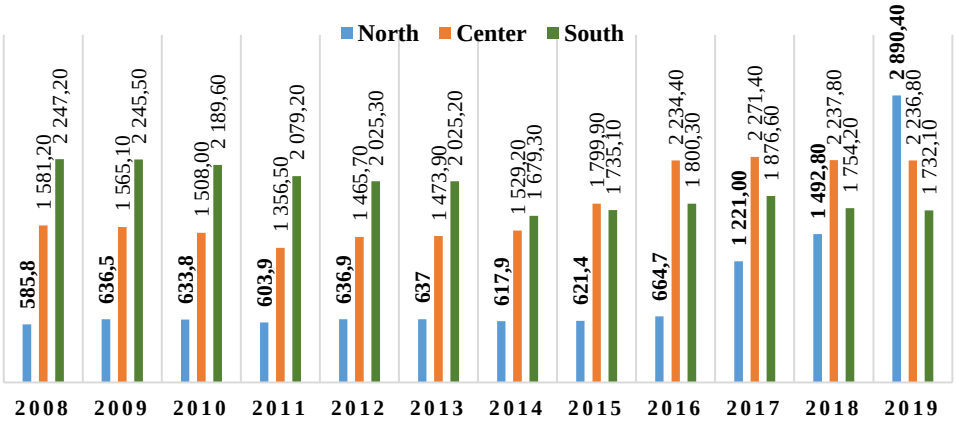

Figure 18. Existence of hazardous waste by region at the end of the year, during 2008-2019, tons

Source: developed by the authors based on data from statistica.md

In 2019, most toxic waste is accumulated in Chisinau municipality with a share of 54%, followed by Balti municipality with a share of 44% and a percentage is sold to ATU Gagauzia. Therefore, 3549.80 tons were recorded in Chisinau in 2019, an increase of 1.8 times compared to 2008. Public administrations have the responsibility to organize waste collection and disposal systems, thus establishing appropriate fees, ensuring the financing of these activities. Specialized services in waste collection and disposal exist in municipalities and in all district centers. Municipal waste management is carried out in an organized manner, through these services, which work on a contract basis with individual generators, but this system covers only 60-90% of all municipal waste generators in the urban area.

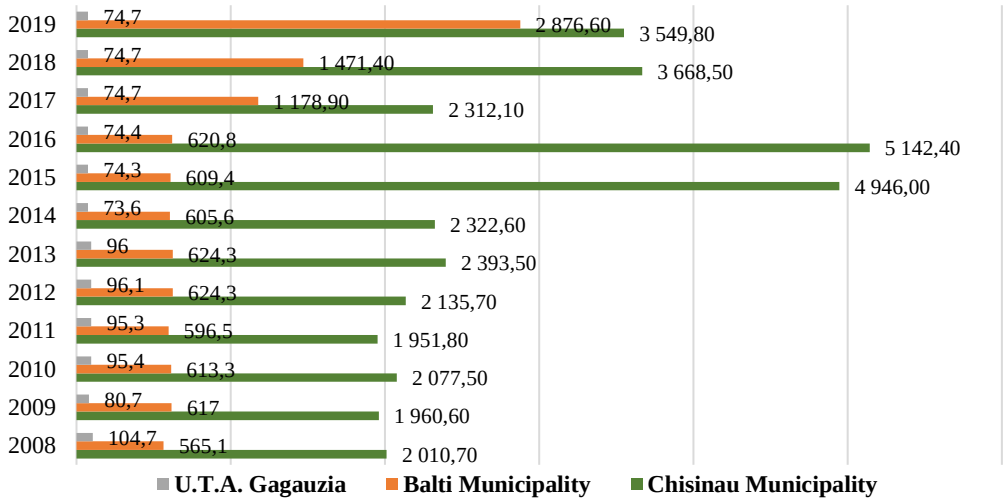

Figure 19. Existence of hazardous waste by region in the Republic of Moldova, 2008-2019, tons

Source: developed by the authors based on data from statistica.md

Analyzing the series of statistical data on the sanitation of localities, there is a slow increase, on average approximately 3.6%, in the volume of waste during the period 2017-2019, in the case of rural localities, the generation trends are increasing on average by 30%, and in the case of urban localities the increase is more modest at 1.3%.

Table 5. Top 15 districts with the most toxic waste in the Republic of Moldova, tons

Top	Raionul	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	Ialoveni	651,2	655,6	573,5	459,6	454,1	462,1	768,4	1 040,00	1 473,60	1 473,60	1 473,40	**1 472,00**
2	Căușeni	1 195,80	1 196,20	1 196,40	1 196,20	1 093,40	1 093,40	1 053,20	1 053,20	1 053,20	1 053,20	1 053,20	**1 053,20**
3	Orhei	383,4	360,3	384,6	363,4	363,5	363,6	362,5	362,9	363,2	363,6	363,9	**364,2**
4	Cahul	218,2	217,8	217,8	217,8	217,8	217,8	219,1	219,5	226,5	229,1	234,9	**243**
5	Taraclia	475	475	434,5	362	351,2	351,2	166,4	163,1	190	187,1	170,5	**172**
6	Leova	234,7	235,2	235	235	247,1	247	173,6	199,4	199,4	199,5	199,5	**161,7**
7	Hâncești	105,2	105,3	107,9	108,2	108,9	108,9	107,5	105,2	105,9	139,8	106,8	**103,7**
8	Telenești	101,2	101,2	101,2	101,2	101,2	101,2	101,2	101,2	101,2	101,2	101,2	**101,2**
9	Călărași	199,3	199,3	199,3	199,3	199,3	199,3	67	67	67	67	67	**67**
10	Cimișlia	97,4	98,3	98,7	60,4	60,7	60,7	61,1	62	61,8	61,9	61,4	**63,9**
11	Nisporeni	50	51,2	51,2	61	176	176	61,1	61,1	61,1	61,1	61,1	**61,2**
12	Anenii Noi	80,7	80,7	80,7	52,8	52,8	52,8	52,8	52,8	52,8	52,8	52,8	**52,8**
13	Basarabeasca	26,1	23	7,2	7,8	55,1	55,1	5,9	37,9	69,4	145,8	34,7	**38,3**
14	Dondușeni	15,7	14,2	17,8	4,1	9,9	9,9	10	9,5	16	9,6	10	**9,9**
15	Strășeni	8,7	9,3	8,6	9	7,6	7,6	7,7	7,9	7,9	7,9	7,9	**7,6**

Source: developed by the authors based on data from statistica.md

In total, in 2020, 187 specialized services in waste collection and disposal are organized and operating (53 services in the urban sector and 134 services in the rural sector), respectively, 296 rural localities benefit from municipal waste collection services. The most toxic waste accumulated at the district level is reflected in the table below (Popa. V. et. al., 2021).

4.5. The process of managing toxic waste management at the national level

The process of managing toxic waste at the national level is regulated by the waste legislation - Law No. 209 of 2016 on waste, stipulated in art. 3. The waste hierarchy and its application. It presents a hierarchy of waste management: it starts with prevention, followed by preparation for reuse, recycling and recovery and ends with disposal. The legislation aims to prevent waste generation to the greatest extent possible, use the generated waste as a resource and minimize the amount of waste that reaches landfills (see Fig. 20).

According to the Waste Law, the application of the waste hierarchy is provided for in paragraph (1), its compliance is mandatory for all subjects involved in waste management, ensuring the prevention of waste generation and the efficient and effective management of waste, so as to reduce their negative effects on the environment.

The waste hierarchy, as presented below, applies as an order of priorities in waste prevention and management legislation and policy:

a) prevention;
b) preparation for reuse;
c) recycling;
d) other recovery operations, including energy recovery;
e) disposal.

Within recycling we must distinguish between:

– Upgrading: converting low-value materials into valuable products;
– Declare: converting valuable products into low-value raw materials.

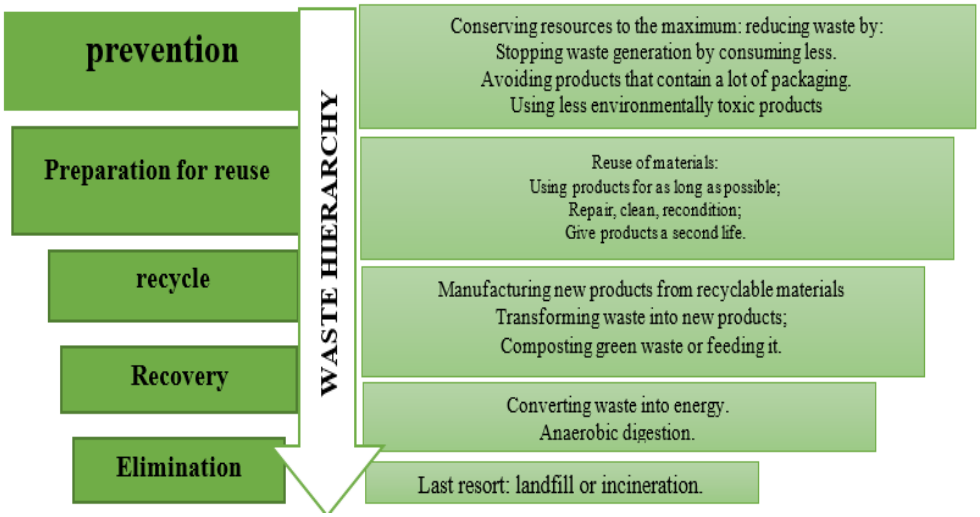

Figure 20. Waste hierarchy
Source: developed by the authors based on Law 209 of 2016.

The process of managing toxic waste involves the collection, transport, recovery and disposal of waste, including the supervision of these operations and the subsequent maintenance of disposal sites, including actions taken by a trader or broker. Some of this waste can be recycled (solvents, oil). Others must be stored in specially designated hazardous waste sites (Popa, V., 2021).

Figure 21. Toxic/Hazardous Waste Management Process
Source: developed by the authors.

In accordance with the National Waste Management Strategy and the Regional Waste Management Plans, local authorities must carry out investment programs that include stages of implementing an integrated management system: Prevention, Collection and Selective Collection, Recovery and Recycling, Treatment and Disposal, in parallel with the closure of non-compliant landfills.

The circular model has the following approaches:

- Non-renewable natural resources are exhaustible;
- Pollution and climate change have a negative impact on renewable natural resources, which leads to changes in living conditions;
- Pollution has an impact on health and quality of life;
- Creation of job opportunities.

a. Hazardous waste collection

Among the waste that is collected and managed separately, a very important category is that of hazardous waste, such as packaging containing residues of hazardous substances or contaminated with hazardous substances, metal packaging containing a solid porous matrix formed by hazardous materials (e.g. asbestos), including empty pressure storage containers, absorbents, filter materials (including oil filters not elsewhere specified), polishing materials and protective clothing contaminated with hazardous substances, paints, inks, adhesives and resins containing hazardous substances; batteries and accumulators containing lead, mercury, Ni-Cd, alkaline or unsorted batteries and accumulators containing these batteries, solvents, acids, alkalis, oils and fats, other than edible ones, detergents containing hazardous substances, pressurized gas cylinders (including halon) containing hazardous substances, wood waste containing hazardous substances, pesticides, paint and varnish waste containing organic solvents or other hazardous substances.

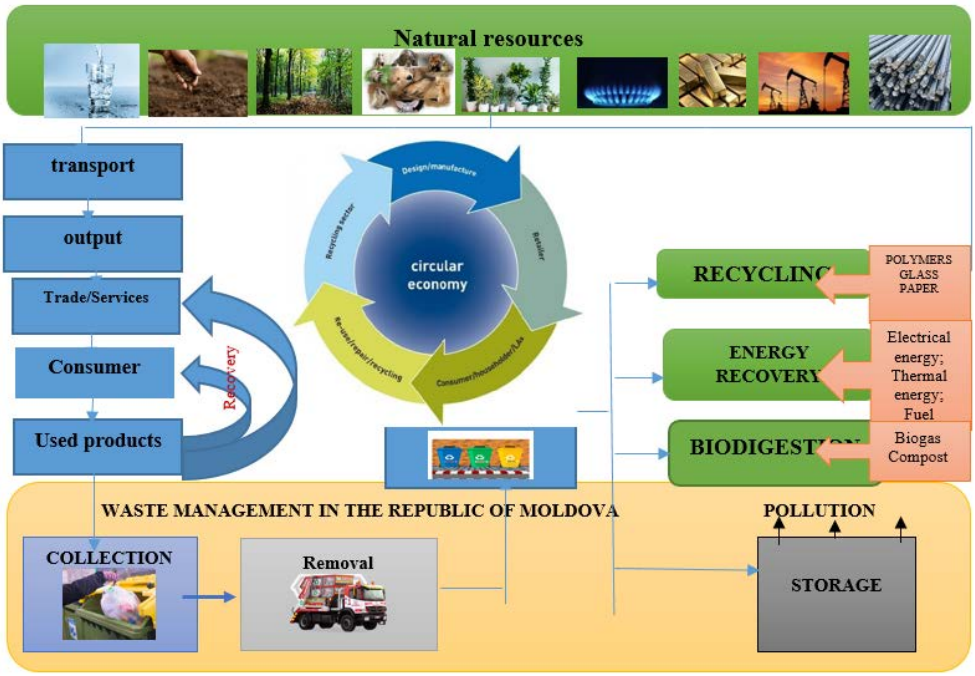

Figure 22. Waste management in the circular economy (toxic/hazardous)
Source: developed by the authors.

Hazardous waste producers and enterprises managing hazardous waste ensure that, during collection, transportation and temporary storage, they are packaged and labeled in accordance with the requirements for the classification, labeling and packaging of substances and mixtures, approved by the Government, and with international treaties to which the Republic of Moldova is a party, indicating the degree of toxicity, the full name of the waste, its state of aggregation, color, odor, flammable and explosive properties, type of packaging, name of the technological process from which they resulted, special requirements for behavior under normal conditions and in exceptional situations, address of the enterprise or organization where they were produced (Law no.209, 2016).

Hazardous waste producers, as well as units and enterprises specialized in the collection and transport of hazardous waste or acting as hazardous waste agents or brokers, shall keep a chronological record of the quantity, nature and origin of the waste, the destination, the frequency of collection, the means of transport and the method of treatment.

In the Republic of Moldova there are very few and limited facilities dedicated to the treatment and storage of hazardous waste. In general, no company has developed a specialized transport service for hazardous waste generators.

The environmental permit for waste management is issued by the Environmental Agency, for the conduct of waste management activities, which include the collection, transport, treatment, disposal by storage of waste.

Waste collection companies appear to be in general, private companies and are more likely to be LLCs, production cooperatives, private institutions, etc., i.e. local rather than national organizations. Most of the existing collection companies in the Republic of Moldova are mainly engaged in the collection and transport of municipal waste. Some of these collection agents collect waste from the commercial and industrial sectors, garden waste, as well as construction and demolition waste. These agents claim that they do not collect any hazardous waste. There are also waste recycling organizations that collect waste from generators, some of which collect hazardous waste, most notably used oils, car batteries and, to a lesser extent, solvents. There are very few service providers for hazardous waste management in the Republic of Moldova. Those that do exist generally offer waste collection but their transport capacity is limited. No dedicated hazardous waste transporters have been identified to provide collection. The remainder of hazardous waste is transported by waste generators. However, more than 80% of all hazardous waste is stored or dumped, and this generally occurs at or very close to the hazardous waste generation site, requiring minimal transportation.

b. Hazardous waste packaging

It is necessary that toxic waste be packaged in strict accordance with legal standards and provisions, using packaging bags, containers and warning symbols specific to toxic waste and then placed in special disposable packaging boxes or containers. Hazardous waste resulting from medical activity is packaged and labeled in compliance with the conditions of the Sanitary Regulation and in accordance with national legislation on the classification, labeling and packaging of substances and mixtures and in accordance with international treaties to which the Republic of Moldova is a party, the packaging being indicated (Decision no. 696, 2018):

- toxicity level;
- full name of the waste;
- their state of aggregation;
- color, odor, flammable and explosive properties;
- type of packaging;
- name of the technological process from which they resulted;
- special requirements for behavior under normal conditions and in exceptional situations;
- address of the enterprise or organization where they were produced.

According to the Sanitary Regulation on the management of waste resulting from medical activity, the packaging in which separate collection is carried out and which comes into direct contact with hazardous waste resulting

from medical activity is disposable and is disposed of together with the contents. Sharps, anatomopathological and infectious waste, identified with codes 18 01 01, 18 01 02 and 18 01 03 in the List of Waste and the annex to this Sanitary Regulation are packaged in yellow bags. For the separate collection of infectious waste that does not contain sharp objects, cardboard boxes with yellow polyethylene bags or polyethylene bags marked with yellow should be used. Bags for the storage of hazardous/infectious medical waste must meet the following conditions:

- be made of high-density plastic, with high mechanical resistance;
- close easily and securely;
- the thickness of the plastic from which the bag is made must be between 50-70 μm,
- the heat seals must be continuous, resistant and must not allow liquid to leak.

For the packaging of waste resulting from medical activity, it is prohibited to use other categories of packaging that do not present documents confirming the conformity of the product for the intended use (certificates, reports), including for the chemical composition of the material from which the packaging is made, marking, in accordance with Law No. 209 of 29 July 2016 and these Sanitary Regulations. Therefore, only the use of packaging that meets the requirements of Art. 55 para. (3) of Law No. 209 of 29 July 2016 on waste and these Sanitary Regulations is permitted.

c. Temporary storage of hazardous waste

In accordance with Law No. 209 of 29 July 2016, art. 16, the requirements for waste disposal aim to comply with procedures to prevent or reduce the negative environmental effects that waste disposal activities may have during the entire life cycle of the landfill, which includes the design, construction, operation and closure of the landfill. Waste disposal activities are carried out in accordance with the Waste Law and the Regulation on Waste Disposal, approved by the Government.

The design and construction of landfills, as well as the operation of landfill engineering systems, are carried out in accordance with building codes and environmental permitting acts.

Depending on the nature of the waste, landfills are classified into the following categories:

a) hazardous waste landfills;

b) non-hazardous waste landfills;

c) inert waste landfills.

The following wastes are not accepted for landfilling:

a) liquid waste;

b) explosive, corrosive, oxidizing, highly flammable or flammable wastes, as defined in Annex No. 3;

c) hazardous medical waste or other hazardous clinical waste from medical or veterinary facilities with HP9 property, as defined in Annex No. 3;

d) all types of used tires, whole or cut, except tires used as construction materials;

e) any other type of waste that does not meet the requirements of the Waste Landfill Regulation.

Waste disposal is permitted only in the case of holding an environmental permit for waste management, issued in accordance with the provisions of art. 25. Therefore, the landfill operator is responsible for the maintenance, supervision, monitoring and post-closure control of the landfill and is obliged to:

1) when operating the landfill, ensure the establishment of a system of technological self-monitoring and self-monitoring of the quality of environmental factors and bear its costs;

2) report within the SIA MD as follows:

a) annually – on the types and quantities of waste disposed of;

b) semi-annually – on the data recorded following the monitoring of the landfill, in order to demonstrate compliance with the provisions of the environmental permit for waste management, as well as to demonstrate the status of the implementation of the measures in the compliance program; and

c) no later than 12 hours after the finding, within the monitoring program, on any negative ecological effects;

3) to establish a fund for the closure and post-closure follow-up of the landfill, which will serve as proof of the financial guarantee necessary to remedy construction deficiencies or those that have arisen during operation or for compensation in the event of accidents caused by the landfill activity.

The closure of a landfill is carried out according to the procedures established in the Regulation on waste disposal (Law no.209, 2016).

d. Transportation of hazardous waste

The transportation of hazardous waste to the place of treatment or disposal is carried out in compliance with the provisions on environmental protection and public health stipulated in art.4 of Law no. 209 of 29 July 2016 on waste.

Specialized transport operators for urban waste transport must be authorized by the environmental protection authorities, after notification of the transport activity. In the case of intercity or international transport of hazardous waste, the road transport operator must hold a transport license for dangerous goods, issued in the order established by the Licensing Chamber. The Transportutri Agency monitors the compliance by transport agents with the provisions and requirements of the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), as well as issues ADR aggregation certificate forms.

e. Hazardous waste treatment

The main treatment methods are separate collection and recycling, physical and chemical treatment, incineration and landfilling. Currently, only a small part of this waste stream (car batteries, used oil, mobile phone batteries) is collected separately and then recycled.

The processes and methods used for the treatment and disposal of hazardous waste must not endanger public health and the environment and must comply with the following requirements:

a) does not pose a danger to water, air, soil, fauna or vegetation;

b) does not have a negative impact on the health of the population in neighboring residential areas;

c) does not produce noise pollution and unpleasant odors;

d) does not affect landscapes or protected areas.

When choosing the treatment method, the type of waste, environmental and safety factors, technological capacities and the provisions of Law no. 209 of July 29, 2016 on waste are taken into account.

Hazardous waste treatment can be:

- outsourced treatment - by handing over, based on the service contract, to authorized economic operators, in accordance with art. 25 of Law no. 209 of July 29, 2016 on waste.
- Internal treatment - medical and sanitary institutions equipped with waste shredding equipment and their own thermal decontamination facilities can treat sharps and infectious waste.

Producers and holders of hazardous waste may export these wastes for treatment or final disposal only to countries that have ratified the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, to which the Republic of Moldova acceded by Parliament Decision No. 1599-XIII of March 10, 1998, and that have adequate technology and agree to carry out such operations.

The transfer of waste from the Republic of Moldova to other countries is carried out only with the approval of the notification for export or transit by the competent authorities designated by the importing country, in compliance with the provisions of the regulations on waste transfers. The records of notifications for export, import or transit are carried out by the Environmental Agency through SIA MD.

Reuse and recycling of waste

(1) In order to comply with the provisions of this law and ensure a high level of resource efficiency, the following state policy objectives are established:

a) by 2018 – the introduction of separate collection systems for paper, glass, metals and plastics in compliance with art. 13 paragraph (6);

b) by 2020 – the preparation for reuse and recycling of waste, such as, at least, paper, glass, metals and plastics from household products and, possibly,

from other sources, to the extent that these waste streams are similar to waste from household consumption, shall be increased to a minimum level of 30% of the total mass;

c) by 2020 – preparation for reuse and other material recovery operations, including backfilling operations, which use waste to replace other substances, non-hazardous waste from construction and demolition activities, with the exception of natural geological materials, shall be increased to a minimum level of 55% of the total mass.

(2) The national waste management programme approved by the Government shall contain appropriate measures to promote:

a) the reuse of products and preparation for reuse activities, in particular through measures to stimulate the creation of repair and reuse networks and by supporting them, through the use of economic instruments and criteria relating to public procurement, through quantitative objectives established by normative acts approved by the Government;

b) high-quality recycling and the introduction, for this purpose, of separate waste collection systems, where this is technically, economically and environmentally feasible, and these systems comply with the quality standards established for the relevant recycling sectors.

(3) In order to achieve the objectives of the state policy provided for in paragraph (1), local public administration authorities, initial waste producers and waste holders shall be obliged to:

a) starting from the date of entry into force of this law, ensure the initiation of activities for the introduction of separate collection systems in accordance with paragraph (1) letter a);

b) carry out waste reuse and recycling activities in accordance with the objectives specified in paragraph (1) letters b) and c).

(4) Every three years, the central environmental body of the public administration, in collaboration with the other authorities involved in waste management, shall submit to the Government reports on the status of achievement of the objectives, in accordance with art. 36. In the event of failure to achieve the objectives, this report shall include the reasons for the respective failure and the measures that the authorities involved shall initiate in order to achieve the objectives.

Waste recycling is not possible without selective collection at source, which is an essential condition for maximizing waste recovery. Waste recycling generates additional income for companies, especially when it comes to waste paper, cardboard, plastic, metal, wood, rare metals, glass, etc. Essential aspects in generating benefits and opportunities:

- Appropriate selection at source.
- Efficient collection and storage system (compactors reduce the volume of waste collected and allow for lower transportation

costs).

- Collaboration with authorized organizations for waste transportation and recycling.
- Use of high-performance recycling technologies.
- Knowledge of the properties and values of waste.

Most of the toxic products can be recycled from products of various industries: *packaging, glass, metal, batteries, tires and plastics, used oil, paper and cardboard; electrical and electronic equipment, wood; construction and demolition waste*.

- *Metals are materials* that can be recycled at a rate of 90-95% if they are collected selectively. Some metals, such as aluminum, can be recycled indefinitely. Recycling metals reduces energy consumption by 70% compared to producing a completely new element.

- *Paper and cardboard recycling.* Almost any type of paper and cardboard can be recycled. Recycling technology can remove inks, staples, staples, and glue used to bind books, but not oil. Therefore, paper and cardboard stained with oil or food cannot be recycled. In addition, waxed, laminated, or plastic-coated papers (glossy magazine covers), napkins, or other used paper sanitary products cannot be recycled. Milk and juice cartons are recycled separately. Cardboard can be recycled many times, but not infinitely. That's why it's good to avoid packaging as much as possible, even paper packaging.

- *Glass recycling.* Glass can be recycled by melting indefinitely, without losing its properties. Also, recycling costs are lower than those of producing glass from raw materials, thus saving energy. Colored glass can only be produced in the same color. Therefore, colorless glass is more valuable, as it can be reused for many purposes. Heat-resistant glass, such as Jena dishes, is not recycled with ordinary glass, because it affects the melting process.

Thus, it is important that waste is recycled; it is necessary that it be correctly identified, then sorted and deposited by the consumer in a separate container with the specific waste specification.

f. Hazardous waste disposal

The legislation of the Republic of Moldova provides for several methods of final disposal of hazardous waste, depending on the category of waste:

a) Incineration - anatomopathological waste (human fragments and organs, including blood and preserved blood containers); chemical waste consisting of or containing hazardous substances; cytotoxic and cytostatic drugs. Emissions into air and water from medical waste incineration facilities must not exceed the emission limit values established by environmental legislation and international treaties to which the Republic of Moldova is a party. Sedimentary residues from cleaning boilers, filters, channels and chimneys of incineration

facilities, being very dangerous, must be disposed of in special places designated for the burial of hazardous waste.

b) Storage - waste whose collection and disposal are subject to special measures regarding the prevention of infections; sharp waste. These are stored in the authorized hazardous waste landfill, after mandatory treatment.

In accordance with waste legislation, units and enterprises authorized under Article 25 for waste disposal activities have the following obligations:

a) to ensure the complete disposal of the waste entrusted to them;

b) to use the best available technologies that do not involve excessive costs;

c) to locate and equip the waste disposal facility in an appropriate space and under appropriate conditions, with the consent of the competent authorities, in accordance with Article 24;

d) to introduce into the disposal facility only the waste permitted by the competent authorities referred to in Article 24 and to comply with the disposal technology approved by them.

Waste disposal outside authorized areas for this purpose is prohibited. In the Republic of Moldova, the import of waste and residues of any nature, in raw and processed form for the purpose of temporary accumulation, recovery or disposal by any method, is prohibited, with the exception of the categories of waste presented in Annex No. 7 to the Law on Waste, intended for use as secondary raw material at existing domestic enterprises.

4.5. Identifying problems related to waste management in the Republic of Moldova

Despite the above, the authors set the goal of the study to develop a general questionnaire on identifying the prerequisites for transitioning to a circular economy in the Republic of Moldova, in order to identify problems related to waste management in the Republic of Moldova, focusing on hazardous waste. The purpose of the study is to provide an overview of the problems related to waste management and toxic waste, the level of knowledge regarding the degree of toxicity of these wastes and the danger to health and the environment. The data collected and analyzed in the study provide a clear vision of the existing situation regarding toxic waste in the Republic of Moldova, as well as the existing obstacles to collecting this waste properly. The results of the empirical study present a number of important aspects regarding the management of hazardous waste in the Republic of Moldova by individuals between the ages of 14 and over 60, predominantly from the Center region. Each of the target groups considers that the most dangerous toxic wastes are: batteries, lamps, expired medicines, detergents, engine oil, etc. Thus, according to the data collected from respondents and presented in Fig.

1, it is observed that the top 5 hazardous wastes used in households are batteries (85%), expired medicines (65.5%), detergents (57.2%), lamps (57%) and paint (55%).

Question

1. What do you think are the most dangerous (toxic) wastes in your household?

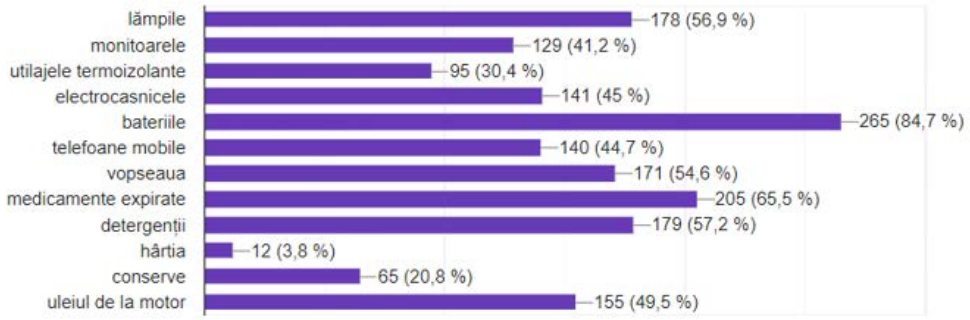

Figure 23. Most hazardous household waste (%)

A gratifying fact is that 90.5% of respondents use economical/ecological LED light bulbs in their households and 75.8% of respondents know about the ECO symbols found on packaging and various electronic equipment, 10.2% of respondents have not heard of them, 11.1% do not know about these symbols and 5% are not interested.

Question

2. Do you use energy-saving/ecological light bulbs (LED bulbs) in your household?

3. Are you aware of the ECO symbols found on packaging and various equipment?

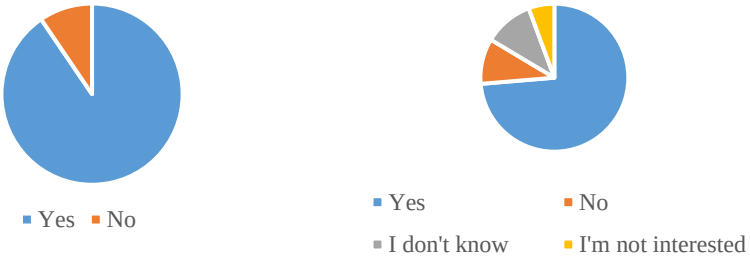

Figure 24. ECO symbols on packaging and equipment (%)

However, in the present study, respondents continue to keep toxic waste in their households and it is thrown away mixed with other waste in the landfill, thus 82% of respondents indicated that there is a problem with toxic waste in their locality. And, 15% of respondents are unaware of the existence of this problem.

Question

1. Do you think there is a problem with toxic waste in your locality?

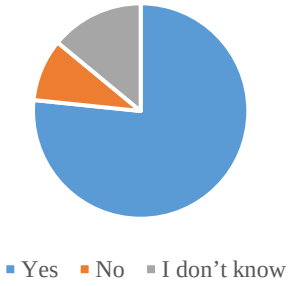

Figure 25. The problem of toxic waste in the locality

According to the data resulting from the study and presented in Fig. 4, 70% of respondents do not know where hazardous waste is collected, 18% of respondents approximately know and 12% know where waste is collected in the locality.

Question

1. Do you know where hazardous waste is taken/collected in your locality?

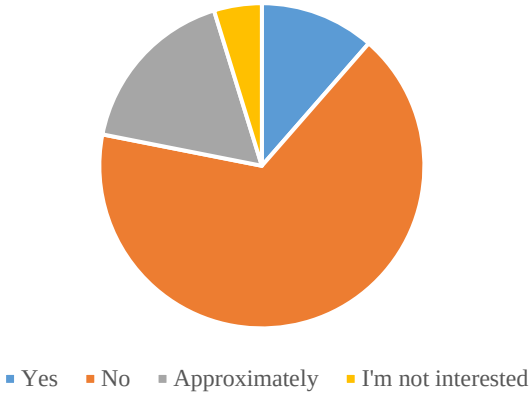

Figure 26. Hazardous waste collection (%)

As we can see from Figure 3, 53% of respondents do not know about the existence of toxic waste collection points in the locality, 33% do not even know about these points and 14% of respondents know about the existence of separate toxic waste collection points.

Question

1. Are there separate hazardous waste collection points in your locality?

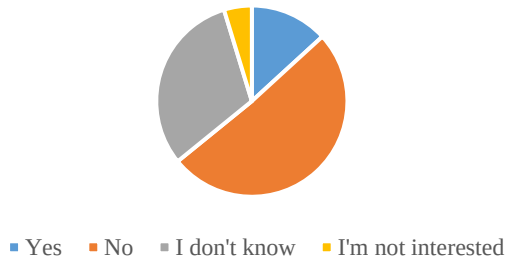

Figure 27. Separate collection points for hazardous waste (%)

The most important reason for not collecting toxic waste separately, according to respondents, would be: lack of collection points (81.5%), lack of dumpsters (59.4%), insufficient information (52.4%), lack of motivation of the population (51.4%) and other reasons, shown in Figure 31.

Question

1. What do you think – why is hazardous waste not collected separately? You can choose more than one answer:

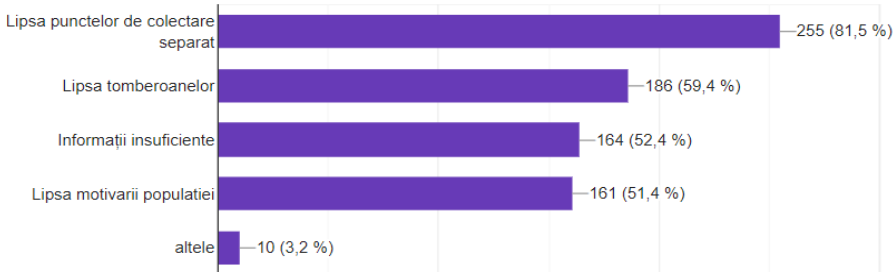

Figure 28. Separate collection of hazardous waste (%)

At the same time, as shown in Fig. 5, 49.4% of respondents have not heard of the existence of toxic waste storage facilities in the locality. Respectively, 28.5% of respondents have not heard of any waste storage facilities, and 14.7% of respondents know about the existence of toxic waste storage facilities in the locality.

Question

1. Do you think there are facilities for storing toxic waste in your locality?

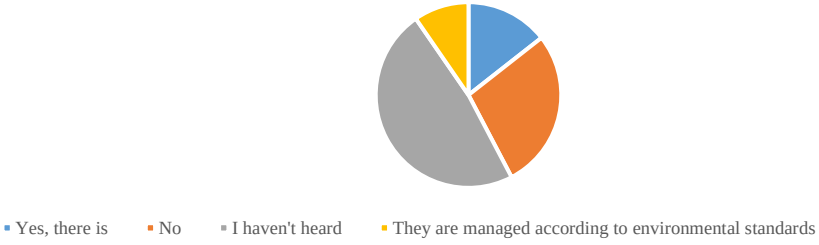

Figure 29. Hazardous waste storage facilities (%)

At the same time, the study data according to fig. 6, show a low level of trust of respondents in the authorized institutions, thus, 7.6% of respondents do not know which institution is responsible for the correct management of waste. Therefore, the majority of respondents 68.5% consider that the Inspectorate for Environmental Protection is the institution responsible for waste management, followed by the Environmental Agency (66.9%), the City Hall (59.6%), the Ministry of Environment (43%), the Local Government (33.8%), the Government (30.3%).

Question

1. Which institutions do you think are responsible for hazardous waste management?

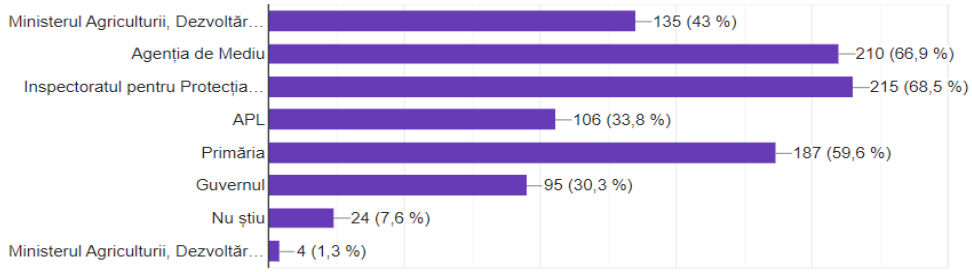

Figure 30. Institutions responsible for hazardous waste management (%)

Unfortunately, 64% of respondents have not heard of or 28.7% are unaware of the existence of companies or enterprises that carry out toxic waste management activities in their locality. Only 7.3% of respondents indicated that they know of the existence of enterprises that carry out toxic waste management activities in their locality.

Question

1. Are there any businesses/companies that carry out toxic waste management activities in your locality?

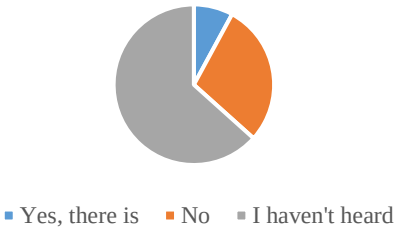

Figure 31. Existence of enterprises/companies carrying out toxic waste management activities (%)

Therefore, respondents indicated a poor appreciation of the actions regarding the recycling of toxic waste and there is no good collaboration and

open communication between the central authority, local authorities, sanitation workers, collectors, recyclers and the business environment. Thus, 47.9% of respondents indicated that no actions are taken, only 1% of respondents indicated that enough actions are taken by the state. In this chapter, the study data show a very low credibility and appreciation of the population in relation to the result of the actions taken by the competent public authorities in the field of toxic waste, fig. 32.

Question

1. Rate from 1 to 5 to what extent the state is taking enough action regarding the recycling of hazardous (toxic) waste, where 1 – No action is taken, 5 – enough action is taken.

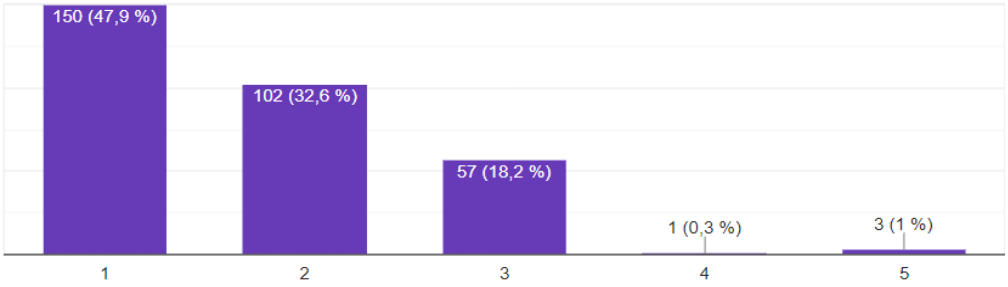

Figure 32. State actions regarding recycling (%)

According to the results presented in Fig. 33, it is evident that there is a lack of activities and projects in the field of selective collection and recycling of hazardous waste in the localities of the Republic of Moldova. Therefore, 42.7% of respondents do not know about the existence of recycling projects in the locality, 41.4% do not know about the existence of projects, and 16% know about some activities and projects for recycling waste.

Question

1. Do you know of any hazardous waste recycling activities or projects in your locality?

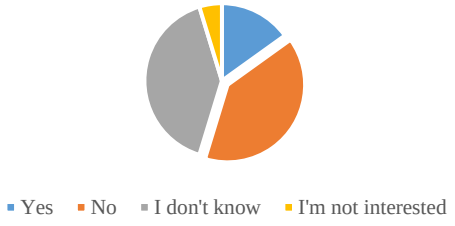

Figure 33. Toxic waste recycling activities or projects (%)

Therefore, a major problem related to the correct management of toxic waste, identified as a result of this study, is the lack of WEEE collection points (used

batteries, cells, used accumulators) at the national level, being accessible to the population. Thus, 80.2% of respondents indicated that they had not seen or that there were no special containers for collecting used batteries, cells and used accumulators near their home or in the locality. Only 12.1% of respondents indicated the existence of such containers. The most well-known special collection containers near their home or locality, according to the respondents' answers, are: in the nearby store (9%); in the Linella supermarket chains (7%), the Green Box (5.7%), followed by BATEREC containers and PECO Rompetrol stations (5.4%) and Volta stores (3.2%).

Question

1. Is there a special container for collecting used batteries, cells and accumulators near your home or in your locality? (You can choose more than one answer)

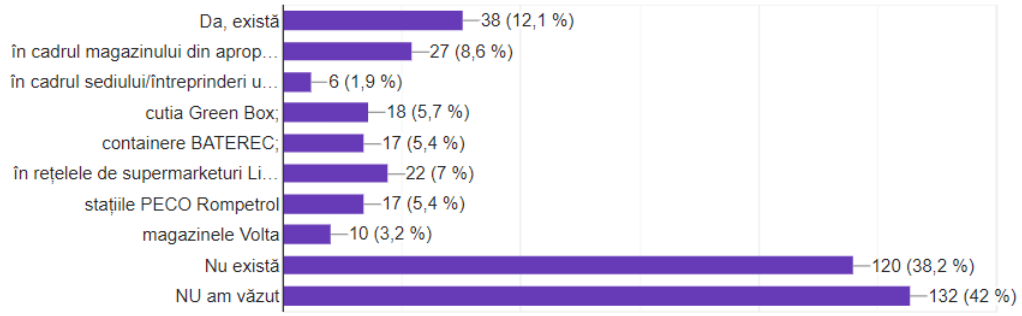

Figure 34. Existence of special WEEE collection container (%)

When asked which toxic materials do you think can be recycled, 34.4% of respondents answered all toxic materials. However, the Top 5 answers were: fax paper and napkins (33.8%), wax paper (31.5%), ceramic materials (26.3%), magnets (23.4%), packaging of toxic materials-paint (22.1%).

Question

1. Which toxic materials do you think can be recycled? (You can choose more than one answer)

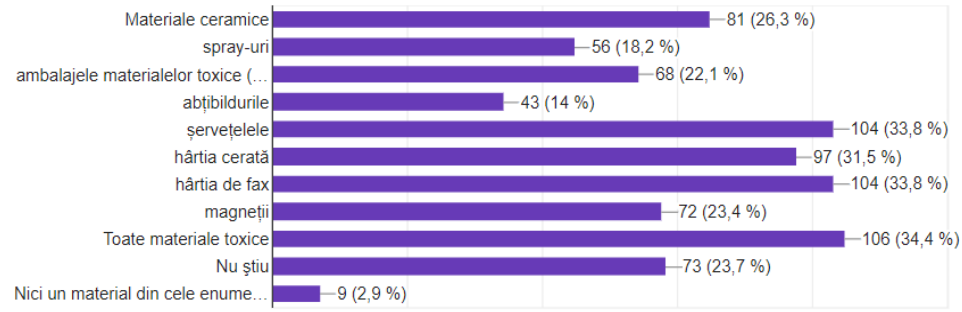

Figure 35. Toxic materials recycled (%)

Hazardous waste in the Republic of Moldova is generally stored and buried in landfills. There are cases where waste from factories/plants is often buried in the factory's own land or disposed of together with non-hazardous waste at off-site landfills. Thus, rudimentary reduction of the volume of hazardous waste is attempted, such as sludge dewatering as a pre-treatment before on-site storage and disposal. However, at present, uniform separation of non-hazardous and hazardous waste is not sufficient. (Separation of hazardous waste is the first step in the 3R activities.) According to the OECD report on "Progress towards achieving basic levels of cleaner production capacity in Central and Eastern European Countries/Newly Independent States (CEEC/NIS)". In general, the 3Rs (Reduce, Reuse, Recycle) are not used in the Republic of Moldova.

Therefore, a large volume of hazardous substances, which are not identified as hazardous substances, are discharged together with wastewater and blast furnace gases (missing hazardous waste). Thus, it is necessary that the legal framework be well strengthened, which will ensure the provision of pollution control equipment and the aforementioned missed waste will be collected and identified as hazardous waste. At the moment in the Republic of Moldova, there are no standards for the collection, transport, recycling, treatment and disposal of hazardous waste. There is also an obvious lack of facilities, and in these conditions, awareness of the proper management of hazardous waste is not well perceived by the plants/factories generating hazardous waste. As for the consumer, it is important:

- Limit the use of hazardous products through rational and responsible consumption;
- Try ecological alternatives to common detergents;
- Products in good condition, but that you no longer use, should be reused (sale, donation);
- Defective products can be repaired and subsequently reused;
- Waste is thrown into specially arranged places;
- We sort waste and send it for recycling;
- Replace regular batteries with rechargeable batteries/accumulators;
- Return expired or no longer needed medications to the pharmacy;
- Use water-based paint, not solvents,
- Waste management services are paid for in the same way as any service or goods, etc.

All these activities lead to changing consumer behavior and more efficient management of hazardous waste. Therefore, local public authorities must also participate in the decision-making process by:

- Working groups;
- Public consultation meetings;

- Approval of draft decisions,

➢ To provide expertise and consultancy, through:
  - Development of project proposals;
  - Participation in the conceptualization process of the hazardous waste and municipal waste management model;
  - Organization of study visits and exchange of experiences.

➢ And to provide communication and information services to citizens.

Following what the authors presented in the study, the following general conclusions can be drawn:

- The national regulatory framework in the field of waste management is under development;
- Ineffective enforcement mechanisms;
- Management, including waste storage at local level unclear;
- Application of unecological solutions (uncontrolled disposal or incineration, mixing with other products or selling as such, etc.).
- Lack of transparency when reporting waste produced.
- The small quantities currently reported and collected do not provide adequate incentives for the cement industry to invest in measures necessary for waste treatment and recycling.
- Lack of companies specialized in waste collection, transport/pre-treatment.
- LPA: lack of holistic vision regarding waste management;
- LPA: tariffs below ensuring efficiency;
- Population: irresponsible consumption and unwillingness to pay for services.

Therefore, hazardous waste management is insufficiently controlled in the Republic of Moldova. The appropriate flow of hazardous/toxic waste is not established. Possible private activities in this area do not have the necessary information on the volume of hazardous waste that should be treated and disposed of properly, so that costs and fees cannot be accurately estimated. There is still a need to establish the legal and regulatory framework for recycling and waste treatment in accordance with EU requirements.

Thus, for the efficient management of toxic/hazardous waste, we come up with the following recommendations:

- Harmonization of the regulatory and legislative framework related to the Waste Law according to European legislation;
- Population: rational consumption, collected and separated waste, paid services;
- LPA: integration into the regional waste management system, sorting/incineration stations, regional landfills;
- CSO: pro-activism in the decision-making process and policy monitoring.

Hazardous waste management is a complex subject with many components. There is no perfect model that can be applied in every situation, but the EU has firm principles on which its approach to waste management is based that can be applied in the Republic of Moldova.

Chapter 5. MODELS OF GOOD PRACTICES OF SUSTAINABLE BUSINESS IN THE REPUBLIC OF MOLDOVA

5.1. Opportunities for implementing circular business

For the Republic of Moldova, one of the recommended circular business models is the Circular Suppliers business model, which is based on replacing traditional material and energy inputs used in the production process with renewable, recoverable or biodegradable ones.

The Circular Suppliers model assumes that a business can become more circular if it reorients itself from the use of limited resources, towards those whose value can be re-exploited in new production cycles. For example, by using a renewable energy source or a recycled and reused raw material from other production cycles in the production process.

The chosen model does not refer to all stages of the life cycle of a product, but only to the production phase. It should be noted that most of the circular business models that have been described in the specialized literature refer to the product use stage (see fig 40).

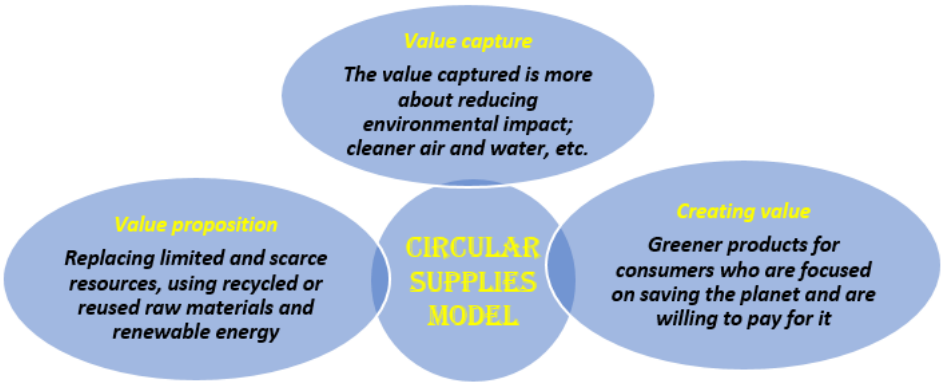

Figure 36. Description of the Circular Supplies model from the perspective of value creation, proposition and capture
Source: developed by the authors.

One of the main factors for companies adopting the Circular Supplies model is reducing their environmental impact. In line with this model, they become sustainable and can attract consumers who demand harmless and less polluting technologies and who are willing to pay more for environmentally friendly products.

Adopting this model is particularly important for businesses that have a strong environmental impact or for those that face limited or depleted raw materials. Even though the transition to a circular business model involves

risks and costs, reducing the environmental impact and the reputation of a "green producer" are the positive effects of this transition that are becoming increasingly important for consumers.

The philosophy behind the CS model is often called Cradle to Cradle. This concept is the opposite of cradle to grave, where materials incorporated into products end their lives in incinerators or landfills. Instead, these materials become inputs into the manufacture of new products. In this context, a parallel is often drawn with natural systems, where the death of an organism results in the transfer of nutrients to other organisms. Cradle-to-cradle is now also an official certification system, with around 500 certified products. An example of a company selling C2C certified products is Tarkett, a global flooring manufacturer. Other examples include Advance Nonwoven, a Danish insulation material manufacturer, and Green Packaging, an American food packaging manufacturer.

The implementation of the circular supply business model has implications for various aspects of a firm's operations. This model influences the conceptualization of product design and manufacturing process, and also relates to product branding and potential distribution channels. Successful implementation requires that certain conditions be met. First, there must be sufficient market demand and willingness to pay for green products. This condition may differ by country; consumers in developing countries may have limited ability to pay for products that are relatively expensive. Second, the bio-based, renewable or recovered material inputs that are adopted must be good substitutes for traditional materials. They must also be sufficiently available and affordable. Firms are unlikely to adopt the circular supply business model if it significantly increases their cost of doing business or risk profile.

5.2. International practice of implementing the CS business model

There are many examples of companies adopting a CS model. Any business that uses residues from one production process (either their own or another company's) as a raw material for another process operates on a circular basis.

Finland is the country that is striving to create the most advanced circular economy in the world. The world's first circular economy development plan was launched in Finland in September 2016. Since then, nine EU countries have followed Finland's example and developed similar action plans. Finland also hosted the first event dedicated to the world's best solutions in this area - the World Circular Economy Forum 2017. This forum gave impetus to international cooperation in the field of transforming the global economy.

At the current stage, the most innovative business and consumption models are implemented in Finland. For example, tractors that are no longer functional and cannot be repaired are disassembled so that the good parts can be reused. Old roofs are transformed into raw material for asphalt, coffee grounds are used as soil for growing mushrooms. Some Finnish restaurants prepare dishes from liquidated food products that are given to them for free. Retail chains use special apps to sell food products at discounts near the end of their expiration date.

In Finland, circularity principles are also used in the textile industry. For example, the company Remake Ecodesign recycles second-hand clothes to mass-produce new clothing collections. The company Globe Hope produces clothes and accessories from discarded textiles, such as used military uniforms, old sails and textile promotional materials. Pilot projects have also been launched in Finland, in which new fibers and yarns are extracted from used clothes and other textile waste, and then new fabrics are produced.

The company Sulapac, thanks to biochemistry specialists, has managed to create packaging and cutlery from biodegradable materials, which can be processed through industrial composting. Thus, many cosmetics brands, such as Chanel or Stora Enzo, use Sulapac packaging and thus contribute to the gradual replacement of plastic and the reduction of its quantity on the planet.

Sulapac produces biodegradable, wood-based, plastic-free containers, which manufacturers can use with already available equipment, which means that no significant investments are needed.

Figure 37. products from natural raw materials
Source: (Sulapac).

Another highly successful Finnish company on a mission to accelerate the shift towards a sustainable future by reimagining plastics is *Woodly*, which produces flexible cellulose-based packaging.

Figure 38. Products obtained by the Woodly process
Sursa: *(Woodly).*

The United States of America, which is one of the main promoters of saving the planet, is recording successes in the area ofcircular business. Here are some examples.

Ford Motor Company is an American automobile corporation founded in 1903 by Henry Ford and is among the largest automobile manufacturers in the world.

Ford CEO Bill Ford promotes the idea that a business can be successful by making good products, but also by making the world a better place at the same time: "We see no conflict between business objectives and social and environmental needs." (Ford).

Ford has set sustainability goals to use only recycled and renewable plastics in their vehicles. Thus, by 2030, they will completely abandon single-use plastic. At the same time, the company plans to use 100% renewable energy, from local sources, for all their products globally by 2035 (Ford Sustainability, 2020).

Most of the metals used by Ford Motor Company are recycled, but the most notable example of "closed-loop recycling" is the return of high-value aluminum scrap to raw material suppliers to make new sheet metal for Ford's F-Series trucks.

At the same time, back in 2000, Ford was the first automaker to start using plant-based materials in its manufacturing process. These materials capture carbon, reducing the impact of global warming and reducing energy requirements for processing. Many of them are waste products from the agricultural industry, thus achieving the goals of the circular economy. The company's specialists are also studying the possibility of using tomato skins, bamboo, agave fiber, dandelion roots, algae and coffee husks in the production of cars. Ford's goal by 2025 is to use 20% of sustainable materials in the manufacturing process.

By using recycled materials, the company keeps waste out of landfills, uses fewer natural resources and uses less energy. Therefore, we can consider

Ford Motor Company as a good example of successfully adopting the circular CS model in its business that allows it to produce responsibly without impacting performance.

Apple is one of the largest companies in the world that manufactures and sells consumer electronics, computer software and online services. Apple is deeply concerned about environmental issues and the need to protect them, therefore it takes all possible measures to ensure that their activity is based on renewable, reused and recycled resources.

So, knowing that manufacturing processes rely on electricity, which causes the highest carbon emissions, Apple has set a goal of using green energy throughout its supply chain. Since 2015, Apple's Supplier Clean Energy Program has helped Apple transition to renewable energy, whether from solar, wind, or other renewable sources. A big part of this achievement was the transition in 2018 to 100% renewable electricity in all Apple retail stores and data centers. Apple's goal is for all of its products to be powered by 100% renewable energy by 2030 (Apple, 2030).

Another aspect of Apple's CS model is its use of recycled aluminum in its devices. Since many Apple products use aluminum as a raw material, the company has developed its own 100% recycled aluminum alloy that can be reused indefinitely, maintaining its performance and durability. And when new mined aluminum is needed in the manufacturing process, Apple works with its suppliers to obtain aluminum that is smelted primarily with low-carbon electricity sources, such as hydroelectricity, thereby reducing carbon emissions. Using this model, Apple has been able to reduce its carbon emissions associated with aluminum by 72% since 2015 (Apple, 2030).

In Romania, in 2012, a project was implemented to produce renewable energy (electricity and heat) in cogeneration, using organic substrate (vegetables and, subsequently, organic waste) in the area of Filipeștii de Pădure, Prahova County. The project involved an investment of approximately 5 million Euros and was developed and fully financed by Genesis Biopartner (Biopartner, 2024). The project aims to develop three priority areas in Romania: energy, agriculture and environmental protection. The biogas-based cogeneration plant is suitable for any industrial consumer that uses thermal energy (hot water, technological steam, hot air).

The first beneficiary of the company is the ***CrisTim Sausage Factory***. The partnership between Genesis Biopartner and CrisTim was built by identifying common objectives, which provide advantages to both partners.

Source: (Biopartner, 2024).

For Genesis Biopartner, the partnership consists of capitalizing on the thermal energy produced in cogeneration, while CrisTim benefits from the decrease in the cost of producing thermal energy, as well as from more efficient management of waste resulting from meat processing.

5.3. Green business in the Republic of Moldova

In the Republic of Moldova, green businesses still have small shares in the entire economy, but more and more attempts can be found to implement elements of circularity and innovative business models. Below we will present examples of companies from the Republic of Moldova that implement green or circular business models.

In 2019, Orange Moldova launched the institutional Orange Green program through which it aims to reach zero carbon emissions by 2040. The proposed deadline is 10 years shorter than that of other global operators in the field. To achieve this goal, Orange Moldova follows strict energy efficiency policies, increases the consumption of renewable energy, develops the circular economy and invests in carbon capture solutions to reduce waste emissions.

Source: (Orange, 2024).

In the trend of contributing to preserving/saving the planet, Orange Moldova is based on the idea: "A small gesture for us, a big gesture for the planet". Thus, with small steps, Orange Moldova wants to achieve the proposed objective and, in this regard, takes the following actions:

• collecting old phones for recycling and reuse;
• giving up printing information brochures for customers;
• putting eco-friendly accessories on sale for customers;
• implementing electronic billing;
• reducing by 50% the amount of cardboard and plastic used in packaging SIM cards.

In 2020, Orange Moldova managed to reduce by 20% the electricity consumption consumed by Orange base stations in the country, compared to 2018 (Orange, 2024).

Uniqa Wall Systems is a Moldovan-Dutch company based in Stefan Voda, which implements new technologies and innovations in the field of construction in Moldova.

Starting with 2016, the company brought to the Republic of Moldova a new business model, which involves the prefabrication of building panels in factory conditions and their assembly in the field, to create a new type of housing — energy-efficient. Based on this technology, a turnkey house can be built within three months from materials patented in the Netherlands, at much lower costs than houses made of traditional materials (Uniqa, 2024).

Source: (Uniqa, 2024).

Uniqa is concerned about the environment, therefore it does not produce construction waste, carefully selects suppliers who operate with the same values using sustainable and eco-friendly materials. In this way, Uniqa's business fits into the *CS circular business model.*

A relevant example of the implementation of circular business models in the Republic of Moldova is the Chisinau Paper Factory Candelux-Com. The company's field of activity is the acquisition and recycling of paper waste and the production of toilet paper and table napkins. Candelux-Com currently

recycles over 70% of the total waste paper collected nationally, being the most important recycler of paper-based waste (Candelux, 2024).

Candelux-Com collects waste paper from all waste paper generators (chain stores, state-owned enterprises, libraries, printing houses, etc.) and from authorized waste paper collectors, having collaborative relationships with important suppliers of recyclable waste paper from the Republic of Moldova and Romania. Thus, Candelux-Com uses waste paper collected from suppliers as raw material for the products it manufactures, which represents a circular business model, namely CS. On the other hand, the company, being the largest paper recycler in the Republic of Moldova, falls within the circular business model Resource Recovery, with the mission of transforming waste into resources.

Source: (Candelux, 2023).

Through its activity, the Candelux-Com Paper Mill provides a good example of a profitable circular business in the Republic of Moldova, demonstrating that by utilizing reusable materials, the forest fund can be saved and the environment can be protected.

The **Eveco construction company** is another one of the ecological businesses in the Republic of Moldova. The company is based in Comrat and deals with the construction of ecological houses from 100% natural materials, the raw materials used being wood and straw.

Eveco's construction model is based on the "Cradle to Cradle" concept and involves the use of renewable materials, of local origin and which leave a minimal footprint on the ecology, before they end up back in nature.

Source: (EVECO, 2023).

Another significant advantage is the low cost and short construction time of straw houses built by Eveco. Thus, 1 m2 costs about 400-500 euros, which is significantly less than the cost of a house made of traditional materials. The construction time of a 100 m2 turnkey house is about 5 months. In addition, ecological houses are energy-efficient, fire and earthquake resistant, healthy and well soundproofed.

Functional properties are determined by the physical properties of the material that can confer some distinctive features to the material in operation or use. They are also characterized by the properties of the material to have resistance to water and temperature, that is, to natural factors. Functional properties are also characterized by the mechanical, physico-chemical and diological properties of the material.

a. b.

Figure 39. a. glass mineral wool; b. basalt mineral wool

Source: (EVECO, 2023).

Energy saving - thermal insulation. The main characteristic of basalt mineral wool products is the low value of the thermal conductivity coefficient (for temperatures of 4-10°C, depending on the assortment λ= 0.036 - 0.040 W/mK). The lower this value is, the lower the heat transfer between the interior and exterior of the home will be. The whole family will enjoy the reduction in costs for heating the home. Mechanical resistance and stability. The density of mineral wool products is in the range of 30 - 160 Kg/mc. The density increases

with the binder content and pressing during the production of the products, being a distinct characteristic of the product assortments. The density determines the specific mechanical characteristics of the wool products that are generally used in thermal and sound insulation under static loads. The easily trafficable and rigid products support static loads of up to 10,000 N/m2.

Behavior towards water. Mineral wool is hydrophobic, does not absorb water and does not react chemically with it. The hydrophobicity of the products is achieved by applying hydrophobic substances. Mineral wool products, due to their fibrous and porous structure with open pores, exhibit the phenomenon of temporary water retention depending on the assortment and the way the product comes into contact with water. The retained water is easily removed.

Diversified areas of use. The properties of basalt mineral wool products recommend them as excellent thermal and sound-insulating materials, in a very wide range of applications: fireproof and sound-absorbing insulation, insulation in civil constructions (exterior and interior walls, floors, attic roofs and terraces), industrial constructions made of reinforced concrete or metal, refrigeration installations, industrial installations at high temperatures, thermal and/or sound insulation in household appliances, motor vehicles, seagoing vessels, pipe and duct insulation.

Ergonomic properties are characterized by the particularities and convenience of exploitation during use. They are also characterized by the hygienic properties that characterize the material as a hygienic-sanitary one.

Comfort. Product with a fibrous structure, made of fine, elastic fibers, with an open structure, basalt mineral wool ensures good air circulation, a property that leads to ensuring a pleasant climate in the home. Products made of basalt mineral wool are easy to use and are compatible with common construction materials. The use of basalt mineral wool products has a number of advantages over other insulating materials: easy cutting, application on flat or curved surfaces, dimensional stability, the remains can be used to isolate niches or other spaces that are difficult to access

The harmlessness properties are reflected in the sound, thermal capacity and fire safety of the material.

Noise protection. Basalt mineral wool is a very good sound insulator (in the frequency range 250÷6000 Hz), depending on the product type and thickness. The fibrous structure and porosity of 90-96% of mineral wool products ensure very good sound absorption properties. A 200 mm layer of felt leads to noise attenuation by 42 dB (10 dB corresponds to a halving of the sound intensity).

Fire safety - reaction to fire. Classified in Euro fire reaction class A1, basalt mineral wool is a non-combustible product. Thus, basalt mineral wool products do not sustain fire and do not emit harmful gases under the action of fire. In the temperature range -50°C....+250°C (binder volatilization

temperature), basalt mineral wool products retain their thermal insulation properties, elasticity and mechanical resistance within convenient limits. The range of use can go up to 1000°C, at temperatures above this value the phenomenon of fiber destruction occurs.

Health and environment. Mineral wool has a vitreous-amorphous structure, does not contain crystallized material under asbestos-type formations, is not harmful to health, does not pollute the environment, does not release gases under the action of fire and does not emit hazardous substances. Durability properties are characterized by the term of exploitation.

Durability. The long-term reduction in thickness reported to a period of 10 years is maximum 2.5 mm. Being a basalt rock product, it is chemically and biologically inert: it is not attacked by alkalis or acids, does not corrode and is not corroded, does not contain water-soluble salts, the hydrolytic stability is remarkable, it is not attacked by fungi and microorganisms, does not constitute food for insects or rodents, does not rot.

Currently, the portfolio of the enterprise "*Chisinau Glass Factory*" includes about 300 varieties of bottles and jars for packaging. The enterprise has a design department that can afford to embody any shape and size of packaging. This allows the enterprise to win over as many customers as possible and to be able to fulfill their most exclusive wishes. The assortment is divided into two categories: an assortment of standard bottles and jars and an assortment of truly exclusive bottles and jars that feature high techniques and special aesthetic values that give them the opportunity to be classified as works of art. This is due not only to the new technologies implemented within the enterprise but also to the high level of qualification of the workers.

Source: (Glass, 2023)

For building materials, such consumer properties as: functional properties, ergonomic properties, hygienic properties, harmless properties, aesthetic properties, durability properties are characteristic.

It is worth noting that in the Republic of Moldova there are companies that operate responsibly, thinking not only about the profit they can obtain

today, but also about the benefits they can bring to future generations through the efficient use of resources and the reduction of environmental pollution.

5.4. Barriers to developing a circular business model

The importance and benefits of the circular economy have been discussed many times at the highest levels. Companies have realized that there are advantages of circular business models such as: saving material costs, creating competitive advantages and accessing new markets. At the same time, there are barriers and challenges that small and medium-sized enterprises may face in their process of adopting circular business models. Among these are: high costs, the need for specific technical skills, incomplete legislative basis, etc.

To detail the challenges that arise in the transition to circularity in business, we will group these impediments into several categories:

1. *High costs.* Starting a circular business requires higher financial investments than a linear business, as there are also costs of managing a reverse logistics network. In addition, it is difficult to estimate what the payback period will be in relation to the higher costs related to raw materials, production, human resources. And in the case of a business transition to an ecological model, there will be a number of additional costs, such as:
    - costs related to technological innovation
    - ecological resources (energy, raw materials) which are more expensive
    - development of human resources skills
    - marketing costs, especially for "educating" the consumer, etc.
2. *Lack of support mechanisms from the state.* First of all, it is about the lack of effective legislation in the field, especially regarding the establishment of fiscal and administrative facilities.
3. *Insufficient information and previous experience.* Because circular business is a new field, but very necessary for current economic systems, there is not yet a sufficient information base on the opportunities, legislation, technologies, etc. in this field. In addition, there are not yet enough success stories and mass experiences from which business people could draw inspiration.
4. *The organizational culture of the company.* The values, way of thinking, habits and attitude of the company's managers and employees play a very important role in the implementation of circular business practices. In order to be successful, all employees need to be followers of the same circular philosophy.

5. *Insufficient "green" education of the consumer.* Customers are slowly becoming aware of the benefits of ecological products and are not willing to pay more for them. Thus, demand is not so motivating for small entrepreneurs to change their business model towards a sustainable (circular) direction.
6. *Lack of technologies.* Implementing circular business models requires the use of innovative technologies to ensure production and consumption. Design, sharing, recycling, etc. technologies are needed, as well as competent employees who could manage them. The integration of new technologies is expensive and prevents SMEs from transforming their linear business model into a circular one.
7. *Insufficient resources and partners.* To run a circular business, renewable, recyclable, reused resources are needed. To ensure the production process with ecological raw materials, suppliers of such resources are needed. The lack of renewable energy producers, recyclers and waste collectors affects the value chain of products or services.

5.5. Opportunities for implementing circular business models in Moldova

Knowing the impediments and challenges that may arise in the process of implementing a circular business model helps to develop mechanisms to support such businesses.

Policies to support circular businesses in the Republic of Moldova

Supporting the Republic of Moldova's transition to a circular economy through the greening of SMEs is provided for in *national strategic documents* (Decision No 592, 2019):

1) Environmental Strategy for 2014-2023 and the Action Plan for its Implementation (Government Decision No. 301/2014), with an emphasis on environmental protection, sustainable development, the development of the "green" economy and the integration of climate change adaptation principles in all sectors of the national economy;

2) Low-Emission Development Strategy of the Republic of Moldova until 2030 and the Action Plan for its Implementation (Government Decision No. 1470/2016);

3) National Energy Efficiency Program 2011-2020 (Government Decision No. 833/2011);

4) Energy Strategy of the Republic of Moldova until 2030 (Government Decision No. 102/2013);

5) Waste Management Strategy in the Republic of Moldova for 2013-2027 (Government Decision No. 248/2013);

6) Water Supply and Sanitation Strategy (2014-2028) (Government Decision No. 199/2014).

Financial support mechanisms

1) from the state budget

National strategic documents aimed at supporting and promoting the "green" economy have spurred the creation of various support mechanisms in this area. The most important support for the development of "green" technologies and businesses is financial. Thus, in 2019, the *SME Greening* Program was developed in our country (Decision No.592, 2019). The program is implemented by the Organization for the Development of the Small and Medium Enterprises Sector (ODA) in order to promote, support and develop the capacities of SMEs to adopt greening practices in production and service provision processes. Within this Program, SMEs benefit from information materials, consultancy, support services and training on greening production and service provision processes. After informational support, SMEs receive financial support in the form of a grant for the implementation of greening actions.

According to the SME Greening Program, for 3 years the state allocates 60 million lei for energy and resource efficiency; circular economy; eco-innovation: creating business opportunities by integrating "green" and circular business models.

At the end of 2021, the Agency for Energy Efficiency launched the project "Clean Technology Innovation Programme for SMEs and Start-ups in the Republic of Moldova", financed by the Global Environment Facility (GEF) in collaboration with the United Nations Industrial Development Organization (UNIDO).

The objective of the project is to promote and support renewable energy technologies in the Republic of Moldova by piloting an Entrepreneurial Accelerator, which will lead to the development of entrepreneurship, job creation and positive impact on the environment.

For the period 2021-2023, the project activities include the development of a set of tools for public authorities, the business environment and end consumers on energy efficiency and renewable energy, as well as recommendations for financing projects in this field.

2) from financial organizations

There are opportunities in the Republic of Moldova to finance green businesses through various lending instruments at commercial banks. We will describe three such instruments below:

1) *Green Economy Financing Facility (GEFF) Program in Moldova*, available through Moldova Agroindbank (MAIB)

Under MAIB, individuals and legal entities can apply for investments in the “green” economy under the Green Economy Financing Facility (GEFF)

associated with the European Bank for Reconstruction and Development (EBRD). The loans granted by MAIB through this program aim to support investments in energy efficiency, renewable energy and water saving. Under this program, loans of up to 5 million euros can be obtained, over a 4-year term, with a grace period of 12 months. Beneficiaries of financing can use the money for investments in climate change mitigation and adaptation technologies and services.

2) *EcoCredit from ProCredit Bank*

ProCredit Bank was one of the first commercial banks in the Republic of Moldova to offer small and medium-sized enterprises "green" loans for investments in energy efficiency, renewable energy, and other environmentally friendly activities. The EcoCredit service for business clients was launched by ProCredit Bank in 2013 with the aim of increasing the performance and competitiveness of businesses, as well as reducing their dependence on traditional energy sources that are expensive. Thus, entrepreneurs can access a loan to run a circular business based on existing circular business models.

3) *EU4Business-EBRD Credit Line*

The EU4Business-EBRD Credit Line is a joint initiative of the European Union and the European Bank for Reconstruction and Development (EBRD) to help SMEs in the Republic of Moldova finance investments that allow them to take advantage of the opportunities presented by the Deep and Comprehensive Free Trade Agreement (DCFTA).

The financing mechanism proposed by the EU4Business-EBRD Line provides up to EUR 3 million in the form of loans and leasing financing, provided through the local partner institution in the Republic of Moldova. A repayment incentive of up to 15% is offered for these loans.

Other tools to support circular businesses

In addition to policy documents and financial offers, there are other tools to support circular businesses in our country. One of these tools is the Green Technology Selector (GTS) implemented by the European Bank for Reconstruction and Development (EBRD). GTS is an innovative tool that allows companies and individuals who want to invest in energy efficiency or renewable energy to choose their products online from a wide list of the best available technologies. Currently, there are over 60 sellers and suppliers of green technologies on the Moldovan market that are included in the Green Technology Selector (GTS) lists. These sellers and suppliers have listed over 600 products including: photovoltaic panels, building insulation materials, LED lighting, heat pumps, industrial processing equipment, drip irrigation systems, as well as technologies for sustainable land management and rainwater harvesting.

Another tool to support circular businesses is renewable energy. In the Republic of Moldova, there is significant technical potential for renewable energy sources, such as wind, solar (photovoltaic), hydroelectric and biogas (based on biomass). The use of these sources would bring major benefits to the economy and the environment, but there is also the problem of balancing the national electricity system. That is, when planning to increase the share of renewable sources, the state must take into account the security of balancing the national electricity system at affordable costs for end consumers.

In the Republic of Moldova, various mechanisms have been developed to support SMEs in the field of renewable energy production and use. Among them are customs and fiscal incentives, namely: reduced customs duties on imports, VAT exemption for installation works and other contributions regarding renewable energy projects. Another mechanism made available to investors in renewable energy is the "Fixed Tariff" support scheme, which guarantees a fixed payment for each unit of electricity produced and delivered to the grid from renewable sources. The mechanism provides for non-discriminatory connection to the grid, priority supply and the obligation of the central supplier to purchase all electricity generated from renewable sources for 15 years, at a guaranteed tariff. This means that anyone who wants to invest in a green technology has the guarantee that the investment amount will be recovered.

In recent decades, there has been a growing interest in researching innovative business models in the context of the circular economy. Businesses are faced with the need to reorient their business towards the use of renewable, recyclable and reusable materials. Adopting circular approaches in business has become more than just a fashion that adds value to a company's image. It is often a legal requirement in countries that adopt the circular path of conducting economic activities.

The research we conducted in this study allowed us to discover that there are also some obstacles or disadvantages to the implementation of circular business models. Among these, we can mention aspects related to consumer education and producer responsibility. The most important step towards circularity is to learn to think differently, to see good materials to reuse in everything, to build from the start taking into account the impact on the environment. Therefore, the applicability of new business models focused on circularity depends largely on awareness and change in consumer behavior.

Another barrier to implementing circular business models is investment costs. In order to replace traditional energy resources with renewable ones, it is necessary to invest in equipment such as photovoltaic systems, wind installations, etc. These investments are very large and have a much longer recovery period (return investment) than in the case of investments in traditional energies. In this context, we return to changing the way of thinking,

namely focusing on the environmental impact and not on the investment recovery period.

Another contradictory element is the use of recyclable raw materials, which sometimes leads to a reduction in the product's lifespan and therefore increases the amount of waste. For example, boots with soles made from recyclable materials wear out faster and thus the consumer is forced to buy a new pair, which contradicts the idea of repair or reduction of consumption. It is important to use raw materials rationally, choosing the most sustainable one, but also to track waste.

Another example in this regard are biodegradable straws that are composed of paper or bio-based polylactic acid (PLA). Paper straws use wood and water resources to manufacture, while PLA straws require a certain temperature and humidity to decompose. For countries that do not have available facilities for PLA recycling, PLA products will be treated as general waste and will result in linear production.

The above cases demonstrate that the effect of the CSM depends on the policies and conditions of countries and regions. Next, we have developed a series of recommendations for the Republic of Moldova that would support the adoption of the Circular Suppliers business model and the transition to a circular economy.

The development of businesses based on circular models can bring major benefits to the economy if some legislative adjustments are made. More financial support mechanisms are needed, as businesses based on the circularity of resources require large investments. According to the study conducted by the Energy Efficiency Agency of the Republic of Moldova, a solar photovoltaic installation with a power of 45.60 kWp becomes profitable from the 9th year of operation (AEE, 2021). This demonstrates that in addition to the high costs, investment in renewable energy production also has a fairly long payback period. For these reasons, entrepreneurs need support through advantageous credit lines, grants, tax breaks. These would reduce the investment costs of entrepreneurs and offer consumers more affordable products and services.

The steps taken by national authorities in recent years, aimed at supporting the green economy, are favorable for the development of circular businesses. However, an acute problem remains the lack of information at both the consumer and producer levels. Consumers do not know the consequences of their behavior, they do not have information on waste recycling and they do not know which responsible producers are using circular business models.

Producers, in turn, lack adequate communication and sufficient exchange of information between market players. The use of broad communication channels, such as digital platforms, well promoted and known by all actors involved, would facilitate market operations, connect material

suppliers, producers and consumers. This would improve competition and optimize market prices (Ungur C., 2021).

Another recommendation for consumer education and information would be to introduce information on the benefits of using renewable, recyclable or reusable resources into the single digital platform. Potential customers should have access to a register of opportunities available in the event of switching to this type of resources.

Chapter 6. THE SUSTAINABILITY OF SECONDARY RAW MATERIALS

6.1. Purchase of used plastic items

Procurements are carried out both within production and commercial enterprises to ensure and maintain the continuity of technological and commercial processes: in production enterprises, raw materials are purchased for the production of goods, and in commercial enterprises, goods are purchased to replenish stocks for sale.

The organization and implementation of the procurement of polymer waste at economic units for recycling and production of new plastic items involves establishing relations with a large number of suppliers and negotiating with them the terms of delivery of goods, quality, price and conditions for the return of the assortment during the term of the contract, ensuring the conditions for their reception, storage and preservation.

Currently, all successful organizations consider procurement to be an activity of essential strategic importance (Baily P., 2024).

The role and contribution of purchasing have grown steadily over the last half of the last century, with the last few years seeing even greater interest in the activity.

As attention to purchasing increases, activities in this area tend to be more strategic, focusing more on aspects such as negotiating long-term relationships, improving suppliers, and reducing total costs, rather than on the routine operations of ordering goods and replenishing inventories.

In recent years, more attention has been paid to creating “reciprocal” relationships between suppliers and buyers, beyond the simple exchanges that were once common. Thus, the emphasis is on actions taken together to achieve a satisfactory outcome.

The purchase of goods from purchasing and production enterprises involves compliance with a series of requirements that can ultimately ensure the efficiency of the economic unit. Thus, we mention the following objectives of the purchase:

- To supply the organization with a constant flow of materials and services necessary to meet its needs;

- To ensure the continuity of supply by maintaining effective relationships with existing supply sources and by developing relationships with other sources, either as alternatives or to meet current or planned needs;

- To purchase efficiently and economically, obtaining, through ethical means, the best price-quality ratio for each monetary unit spent;

- To size, based on technical and economic documentation, the specific

consumption of materials for the entire manufacturing structure; technical and economic substantiation of the plan and programs;

- To manage stocks in such a way as to provide the highest possible level of service to users, at the lowest cost;
- To choose the material resources that best meet the needs of the enterprise;
- To test the credibility of the selected suppliers;
- To develop material insurance policies;
- To issue orders and conclude economic contracts;
- To monitor and control the implementation of material insurance contracts;
- To receive quantitatively and qualitatively material resources;

Specific objectives include:

- To select the best suppliers on the market, in order to purchase high-quality goods at advantageous prices;
- To contribute to the effective design of new products by defining optimal technical parameters. This means not only obtaining an attractive product, but also a product that incorporates those services and raw materials that can be purchased cost-effectively, and this implies that these services and raw materials must be attractive to the suppliers who manufacture or deliver them;
- To protect the company's cost structure by avoiding additional expenses for the goods purchased. These unnecessary expenses could result from defining too strict technical parameters for the goods to be purchased, from purchasing high-priced goods when alternative goods would be acceptable;
- To maintain a fair balance between quality and value by purchasing goods or raw materials with the best price-quality ratio;
- To negotiate effectively, in order to collaborate with suppliers who will seek to obtain mutual advantages through superior economic performance (Baily P., 2024).

Main tasks of the acquisition

1. Request for quotation/offer, price/quality comparison::

Depending on the value of the goods to be purchased, several suppliers should be asked to submit their offers by the specified date. Price announcements and catalogues can also be considered as offers. However, their reliability must be checked. In principle, all offers can be improved.

The request for and receipt of the offer generally does not entail any obligations for the purchaser. The offer can be accepted or not, without any reason. It is also possible for potential suppliers to be compensated for a detailed offer. This is the case if the offer is linked to the transfer of special know-how. This belongs to the paying customer in this case.

A good purchaser knows the market and the suppliers. If he therefore chooses judiciously, in a specific case 3 or 4 or even 5 different suppliers, he receives enough offers to obtain the appropriate know-how or the chance of a particularly advantageous price.

All offers are first compared from a general technical point of view. It must be checked whether the offered goods meet the requirements; the required quantity can be delivered within the required time; the validity period of the offer, etc.

After the technical check, the price/quality comparison follows. There are factors that can increase the price such as: packaging, transport, storage, weighing, financing, taxes, VAT, customs duties.

2. negotiation:

Always involves two parties: a seller and a buyer or a supplier and a consumer. Negotiations take place in several stages: initiation of the negotiation process, organization of the negotiations, actual conduct of the negotiations.

3. placing the order:

In commercial enterprises, orders are generally placed in writing. Each order must contain the following elements: administrative part; contractual partners (addresses); type of contract, date; subject of the contract, quantity, units; delivery conditions; price; delivery date, shipping and payment conditions, signature

4. order tracking and execution

Important orders are tracked by good buyers. Among other things, this means visiting the supplier to check whether the order is being carried out as planned

Whether or not to carry out a control on the goods after delivery depends on the goods themselves and the agreements agreed between the two parties. In general, the quality control is carried out at the supplier. Moreover, the goods have certainly been controlled quantitatively and qualitatively upon shipment.

In the market economy, a broader notion that also includes purchases is procurement.

Procurement has a wider scope, including, along with purchasing, activities of identifying needs, evaluating and selecting suppliers, negotiating delivery conditions, effectively bringing material resources to the enterprise, etc.

Technical and material insurance, although in most cases it is considered similar to procurement, has a wider scope, including both procurement and the activity of completing the need for material resources from own sources (products manufactured for internal consumption).

From the definitions presented, it follows that the term technical-material insurance covers a wider range of activities, including supply, transportation and inventory management.

The recovery of plastics from secondary raw materials (used plastic articles) consists of subjecting the polymer material to a phase transformation process, in order to confer the same or a new use value, after previously bringing the residual content of impurities to values at which, uniformly dispersed in the polymer, it behaves as a filler material.

The technological stages of the reintroduction of plastics from used objects into the production circuit, as a source of raw materials, are: collection, preliminary sorting, compaction, shredding, sorting, washing, addition and regeneration.

1. Collection.

The collection of secondary polymeric raw materials from industrial consumers (industrial, construction, transport, trade, public catering units), or individuals, can be collected selectively (separately), or mixed with household waste.

The fixed means strictly necessary for a collection point to operate profitably are: means of transport, shredding-compaction equipment, storage containers.

Establishing the pricing system is an important link in increasing the degree of public interest and in maintaining the profitability of collection-recovery units within stimulating limits.

2. Compaction.

Compaction aims to increase the density of secondary polymeric raw materials (used plastic items) by reducing the volume and is carried out in order to reduce the number of transport equipment and storage spaces necessary for their circulation.

The reduction of the volume of hollow bodies, especially of large ones (canisters, barrels, trays, plates, shuttles) is mainly achieved by cutting. Grinding allows a reduction of the volume of used plastic articles by about 50.0%.

Pressing is the most widely used method for compacting films, products with a cellular structure, or hollow bodies with small dimensions. The volume is reduced by about 80%.

3. Shredding.

Reducing the size of used plastic items (hollow bodies, bottles, containers) increases the efficiency of the decontamination process by allowing the cleaning of used polymer that has formed corners and bent edges. It is done by rough cutting on collection platforms and by shredding.

During grinding, the degraded superficial layer is removed and the polymer is "dry cleaned", that is, the detachment of adhering impurities due to

the hardness different from that of the polymer support.

4. Separation.

Used plastic items for industrial or household use are characterized by a certain degree of contamination, consisting of materials that have contributed either to increasing the use value (stoppers, labels, paints, printing inks), or of materials specific to the field of use or the collection site (food waste, gravel, sand, chemicals, etc.).

Separation takes place in equipment whose operation is based on the difference between the mechanical, thermal, electrical, optical, etc. properties of the materials in contact, a criterion that determines the division of separators into mechanical, pneumatic, thermal, chemical, magnetic, electrical, gravitational, etc.

4.1. Mechanical separators.

They operate based on the difference between the mechanical properties (rigidity, nature of deformation, etc.) of plastics and those of the materials with which they are impregnated.

The lower rigidity of PO films (polyolefin heat-shrinkable films) compared to that of paper allows the hooks of a rotor, moving above a conveyor belt, on which the shredded mixture formed by the 2 materials is deposited, to collect the PO pieces very easily. The paper remains on the conveyor belt, any traces hanging from the rotor being removed in the next separation phase carried out in a cyclone.

Replacing rotor 2 in the separator described above with conveyor belts with hooks, connected in series, which move at increasing speeds from the first to the last, increases the separation efficiency. The belt with the lowest speed separates coarsely, the one with the medium speed normally, and the last one, which has the highest speed of movement, completes the process. The PO pieces are concentrated on the belt with the highest speed.

4.2. Pneumatic separators.

They are effective in separating materials with a lower density than used plastic articles. They are sometimes also used for separating plastic mixtures into components. They are based on the principle of differential entrainment of material particles in an air stream, the gliding speed of the particles depending on their size and density.

In the pneumatic separator, one of the types widespread in the secondary polymer raw material regeneration industry, separation is achieved by discharging used plastic articles (SMPl) onto the discharge pipe of a fan. The air discharged by it will send the mixture into a separation hopper. Heavy particles (PVC, ABS, stones, etc.) will fall into the collection funnel located below the outlet of the discharge pipe, and light ones (PO, expanded PS, paper, etc.) will be collected in the funnel near the far wall of the hopper.

4.3. Wet separators:

They perform separation by immersing the mixture in a liquid with a different density than that of the constituent particles. Particles with a density lower than that of the immersion liquid will rise to its surface, while all others will sink. The efficiency of wet separation depends on the degree of wetting of the surface of the particles in the mixture by the immersion liquid, the shape of the particles, the precision with which the density of the immersion liquid is maintained constant, the degree of de-icing of the mixture subjected to separation.

The efficiency of separation by the wet method is greatly improved if the immersion medium is in a dynamic regime, ensured by the use of pulsations (pulsation separators), bubbling of a gas (flotation separators), etc.

The forces that arise, as a result of the pulsations of the immersion liquid in a pulsation separator, determine the passage of heavy components through the sieve that feeds the deposition space. The light components are taken up by the pulsating current and discharged through an overflow. The water used as the separation medium can be recirculated.

4.4. Thermal separators (hot or cold).

They are used, in particular, for removing plastics from used plastic items such as metallized sheet, textile polymer laminates, electrical cables or from heterogeneous mixtures, formed from materials that differ only in thermal properties.

The most widespread hot separators are those formed by a heated cylinder, which, rolling over a conveyor belt on which the mixture to be separated is deposited, collects the plastics that melt at the temperature of the cylinder. The efficiency of the separation is limited by the fact that all plastics that have a higher melting temperature remain on the belt.

The heat provided by the infrared radiation separator causes the recovery of the highly elastic deformation of the macromolecules produced during the processing of the polymer melt and therefore the strong contraction of the bottle upon cooling, at which point the label comes off very easily.

The same phenomenon is the basis for the separation of the plastic insulation from the metal conductors of used electrical cables. The heat generated during shredding heats the polymer sheath, which causes the relaxation of the macromolecular chains and therefore its detachment, which begins when the cable pieces have dimensions of 20-50 mm and is finalized at 0.4-6 mm.

4.5. Chemical separators.

Separation based on the difference in chemical properties is one of the few possibilities to remove secondary polymers from used electrical cables, or layered polymer materials, by polymer type, at a purity level of 100%, with the chemical structure unaffected by the separation process.

The operation of chemical separators is based on the swelling or dissolution of the polymer (extraction) upon contact with a solvent (or a mixture of solvents).

The swelling of the polymer facilitates the separation from the metal conductor. Pressing the mixture on the holes of a suitable die, or centrifugation, finalizes the separation and performs the separation. Chemical separation by swelling is advantageous in that it allows the recovery of the polymer with its initial composition.

The use of solvent mixtures is preferred because the dissolution time is much shorter.

4.6. Electric separators:

They operate on the principle of different electrostatic charging, depending on the electrical properties, of the particles in the mixture to be separated, when passing through an electric field produced by 2 electrodes connected to a voltage of 30-70 KV, which ionizes the gases in the field. For this reason, some will be attracted to the surface of the drum of the electric separator from where they will be separated by scraping, and others will fall freely into the collection funnel.

5. Washing.

It is carried out in one or more stages depending on the degree of contamination of the used plastic items, and the impurities that must be removed, namely: pre-washing, washing and rinsing.

5.1. Pre-washing aims to remove coarse impurities that can damage the active parts of the shredding equipment and soften strongly adhering contamination.

5.2. Washing. The way the washing process proceeds depends on the impurities present and is controlled by the following parameters: the degree of shredding of the used plastic items; the nature of the washing medium; the value of the ratio between the volume of the washing liquid and that of the material being washed; the working temperature and pressure; the amount of turbulence in the washing medium.

The most commonly used washing baths are cylindrical or oval, vertical or horizontal, with one or two paddle, propeller or screw agitators, with continuous or discontinuous operation.

5.3. Rinsing is an important phase of the washing process, contributing both to the removal of the washing solution and to the additional elimination of impurities.

6. Drying. After washing, 70% of the weight of the washing solution remains mechanically entrained on the surface of the washed material. Its removal is achieved by: free and mechanical squeezing and, where appropriate, by drying .

By drying, the residual moisture content reaches 0.1-0.5% and will be greatly reduced by degassing the melt during granulation of the secondary polymer raw material, or/and during processing into a finished product.

The most commonly used dryers are pneumatic, cyclone type or horizontal ovens.

7. Regeneration - represents the only form of recycling in which the polymer undergoes a new phase transformation, in order to confer the same or a new use value, and when the quality of the secondary polymer can be improved by modification and/or processing on high-efficiency degassing - filtering, plasticizing - homogenizing equipment.

7.1. The melt processing of secondary polymers generally follows the laws encountered in primary ones, regarding the additivity processes. In this process, a molten mass is obtained consisting of the main binder (the plastic mass obtained from used plastic items), lubricants, stabilizers, fillers, plasticizers, stabilizers, etc.

7.2 The homogeneity criterion in melt processing machines is the magnitude of the transverse shear, which determines the exchange of material between the different moving layers. The value of the degree of homogenization depends on the type of processing machine used for regeneration.

7.3 Degassing is indispensable for the regeneration of secondary polymers and is imposed by the need to eliminate volatile elements resulting from the evaporation of moisture remaining from the drying process, the decomposition of residual organic impurities, paints not removed from the polymer surface during purification, even the decomposition of the polymer due to active degradation species formed during life.

Degassing of polymer melts is achieved by building one or more degassing zones on the homogenization equipment, which takes place through a diffusion process (long process) or boiling (short process).

7.4. Melt filtration is the final phase in the efforts to remove impurities from secondary polymer raw materials. It is carried out using filtering devices located in the extruder head. The main part of these devices is a sieve or a sieve package, through which the material melt is forced to pass, before reaching the profiling head.

7.5 Possibilities of using regenerated plastic materials.

The reintroduction of regenerated polymers into the production circuit has major implications for the rational use of national resources (oil, wood, metal, etc.) and takes into account, first of all, market characteristics (interest for certain products correlated with those related to the quality of regenerated polymers). One of the major effects of reintroducing these materials into the production circuit is the saving of national oil resources by saving the consumption of primary polymer.

The physical-mechanical properties will have performance values only through special, costly efforts.

For these reasons, the processing of regenerated polymers into finished or semi-finished products will bypass those directions that result in products such as:

– food packaging and all products whose use is conditioned by food approvals;

– thin-walled products;

– pipes for liquids under pressure, products with a high bending modulus, or resistant to light, etc.

Regenerated polymers can be successfully used to make medium and heavy injected products, where the residual content of impurities does not endanger the clogging of injection channels: products used in agriculture, construction, household use, etc. All drainage pipes, films, etc., made by extrusion from primary polymers, which are used in fields that exclude the above, can be replaced with those made from secondary polymers. PVC carpets can be made from regenerated PVC deposited on a textile support. Bottles for packaging non-food products (chemicals, etc.) can be made from PVC or PE, from used bottles.

A particularly wide area in which regenerated polymers can be used is that of construction materials, as substitutes for wood, metal, cement, given that the products obtained from them can have an appearance similar to those obtained from these types of materials, their use being accompanied by a series of advantages such as: durability, corrosion resistance, abrasion, low weight.

7.6. Regeneration of the main secondary polymers

As mentioned, the high-tonnage polymers found as secondary materials are: PELD and PEHD, PVC, PS, and ABS used to make, in principle, the following types of products:

– PE and PP: foils and films used as packaging and in agriculture;

– PVC-P: foils, electrical cables, synthetic leather;

– PVC-U: pipes, tubes, joints, etc.;

– PS: expanded products, automotive parts;

Table 6. Plastics from used objects as a source of raw materials

Material / Recycling symbol	Material properties	Product applications	Products containing recycled material
1	2	3	4
PET /PETE/PETP/ Polietilen tereftalat 	Clarity (transparency), resistant, durable, solid, gas and moisture barrier, retains carbonation, heat resistant	Plastic bottles for soft drinks, water, juice, beer, soda, ketchup and oil. Jars for peanut butter, pickles, jelly and jam. Film and trays for baked foods, straps and food and non-food containers.	Fibers, bags for storing and transporting clothing, foil and sheets, food and beverage containers, carpets, straps (bands, webbing), bottles (bottles, flasks), down jackets, foil for soil retention, filters. Notes: For recycling PET containers: - they must be washed and flattened; labels can be left on, but not caps (seals on the caps); - bottles from petroleum products (e.g. motor oil), pesticides or herbicides are not allowed to be recycled.
HDPE Polietilena de mare (înaltă) densitate 	Good moisture barrier properties, stiffness, strength, durability, chemical resistance, gas permeable, easy to process and easy to form (work).	Bottles for milk, water, juice, cosmetics, shampoo, liquid dishwashing and laundry detergent, bleach, yogurt and margarine containers, cereal boxes, meat, shopping carts, bags, sacks and sacks.	Colored bottles (bottles, flasks) of liquid dishwashing and laundry detergent, fabric softener, shampoo, motor oil and clear bottles (bottles, flasks) for milk and water; pipes, baskets, baskets, flower pots, garden borders, foil and boards, garbage cans (recycling), plastic furniture (chairs, benches), dog houses, lumber products (plastic + wood composite), picnic table, mailbox, fences, containers, compost bins, granules. Remarks: Chemical resistance makes it good for household packaging and industrial chemicals such as detergents and bleaches. Bottle (bottle) with pigment (dye) has better resistance to cracking than bottles without pigment (dye).
PVC /V/ Policlorura de vinil 	Versatility, clarity (transparency), easy to mix, strong, durable, resistant to grease, oil and chemicals, stable flow characteristics and electrical properties.	Transparent packaging for food and non-food products, tubes for medicines, insulation, wires and cables, foil and boards, construction industry products such as pipes, fittings, tiles, conveyor belts and windows; bottles (bottles, vials), blood bags, synthetic leather products.	Packaging, bonding for removable sheets, flooring, panels (cassettes), panelling, gutters, foil and tiles, mats, doormats, resilient flooring, tray (support), cassettes and CDs, electrical boxes, cable insulation, traffic signals, garden hose, mobile house edging, detergent bottles (bottles, flasks), dishes, windows; tiles, installation items (pipes, fittings), speed bumps, covers (channels) for industrial access roads.

LDPE Polietilena de mică (joasă) densitate 	Easy to process, resistant, durable, flexible, easy to glue (hot), moisture barrier.	Food bags for bread and frozen products, bags for clothes boxes, compressed bottles for honey, mustard. It is also used to produce flexible caps and is used in electrical wire and cable applications. Fibers, carpets, furniture, food pans and trays, pipes and drains.	Transport covers, garbage cans, furniture, foil and boards, compost containers, bottles (bottles, flasks) for natural lemon juice, mustard boxes, plastic-wood items (fence timber, etc.).
PP Polipropilena 	Tough, durable, heat, chemical, grease and oil resistant, moisture barrier. High melting point makes the products resistant to filling with hot liquids.	Ketchup bottles, yogurt and margarine/butter containers, tubes, medicine bottles, textile applications such as carpets, twine, cord, rope (rope, cordage), rigid shuttles and automotive components.	Car battery cases, light signals, battery cables, broom brushes, ice scrapers, oil funnels, bicycle racks, rakes, tie-down straps, granules, plates, trays, yogurt containers, syrups.
PS Polistiren 	Versatile, insulating, clear (transparent), easy to shape, relatively low melting point.	Protective packaging, containers, lids, glasses, bottles (bottles, flasks) and trays, CD cases, food serving applications, meat display trays, egg containers, bowls, knives.	Thermometers, light switches, thermal insulation, egg containers, ventilation holes, trays, rulers, frames, packaging, cups, plates (bowls), expanded glasses, various utensils (tools).
Al. PC /Acrylic/ABS/ Mixed plastic / Polyester and polyester fibers (PBT, PCTA, PCTG, PETG) / Nylon and Nylon fibers (PA 6, /ABS/ Plastic 6.6, 11, 12, 6.10, 6.12) / Polyurethane /... 	It depends on the material or combination of materials.	Three or five gallon reusable water bottles for lemon juice and ketchup.	Bottles (bottles, flasks), for food and juices, syrup, plastic-wood applications. Notes: The indications of these symbols are used when a material other than the 6 types presented above is used or is made of more than one of the materials presented above or is used in a combination of layers of materials.

Source: (Rusu M. 1989).

Plastic waste brought to processing units is generally contaminated with foreign materials. Foreign materials, such as food, cause wear and tear on granulators and other equipment used in sorting and recycling these materials.

It presents difficulties both in terms of sorting them into categories according to density and in terms of applying recovery technologies, which are

not fully developed and thus the products obtained are of a lower quality than those made directly from raw materials. For 1 ton of recovered polyethylene, 8t of oil are saved and 6000 m2 of non-transparent film or 3000 packaging containers can be manufactured. Plastic.

The largest part of the production of plastic materials is made up of PE, PVC, PP and PS. In the field of packaging, the types of plastic materials PE and PP are mainly used.

Plastic waste is classified according to its useful life, into:

- Short useful life (less than two years): packaging for textile, food and even chemical products (if they are not toxic), films, foils, bags, bottles, boxes
- Medium useful life (2-10 years): special packaging, syringes, special bottles, household items, car parts
- Long useful life (over 10 years): pipes, appliance casings, household items, cables, machine parts

6.2. Organizing the process of purchasing shards of glass

The most important reasons why glass is recycled are the following:

• Recycling glass requires less energy than manufacturing it.

• Reducing costs related to household waste. 8% of this can be recovered by recycling glass.

• For every ton of remelted glass waste, 1.2 tons of raw materials are saved, thus helping to protect the environment.

Glass recycling is the process of transforming glass waste into reusable products. Depending on the final purpose, the glass is separated by color.

Recycling at the state enterprise "Chisinau Glass Factory" is done for common or simple glass, which can be of the following types by color:

The most common types of packaging are of the following colors:

• colorless glass;

• green glass;

• brown glass.

The glass to be reused is first crushed or transformed into granules with rounded edges and corners.

"The Chisinau Glass Factory" has a very high production potential, judging by the volume of production or the number of partners it supplies with packaging. Due to the fact that glass is 100% recyclable, the factory is interested in this fact.

Due to its ecological and hygienic properties, glass is successfully used by manufacturers as a packaging material. Glass pieces melt faster than sand, so when factories use broken glass, they can lower the temperature in the melting furnace, using less energy. Using broken glass instead of natural ingredients helps us save natural resources.

Not all types of glass can be recycled in the melting furnace. Only some sources of glass can be recycled, but others have different alternative uses. In addition to melting, glass is also used as a filler for concrete and asphalt, which will give them greater resistance. Therefore, it is important for buyers to know the types of glass for recycling and their areas of use.

The procurement process at the State Enterprise "Chisinau Glass Factory" consists of the following:

Study of procurement sources and discussion and negotiation with them

The procurement sources identified by the State Enterprise "Chisinau Glass Factory" are the following:

- shards from the production process waste
- shards purchased from partners who purchase packaging produced by the "Chisinau Glass Factory"
- household shards collected by enterprises and individuals from the population from household waste
- packaging from food producers that requires recycling,
- etc.

Reception of glass waste

Waste – called glass shards are purchased at the enterprise “Chisinau Glass Factory” from all working partners. The reception process is carried out by the purchasing department consisting of the following staff: head of the purchasing department, warehouse manager, porters. During the reception of glass shards, only the quantitative value is checked according to the weighing results. The qualitative value is assessed organoleptically without laboratory determinations to determine the content of impurities. The percentage of impurities is established at the enterprise, which is 2%.

Storage

The storage of glass shards is done in the open air and does not require special rooms and conditions. It is unloaded directly onto the raw material platform and transported as close as possible to the moving line that transports the shards to the furnace.

Figure 40. The method of storing glass waste at the Chisinau Glass Factory
Source: (Glass,2023).

Recycling

Glass shards are recycled at 99%, which means that the process is one of the most economical. Before recycling, the shards are sorted by color because the glass production process also includes secondary raw materials that act as catalysts, opacifiers or dyes that must be introduced as needed. Sorting before recycling is also done to remove impurities of an organic nature or other materials.

Identifying the sources of purchasing glass shards is a very important factor for the "Chisinau Glass Factory" enterprise because the shards are a good source that contributes to the economy of energy resources, that is, financial sources.

Household glass products, from which glass shards are most often obtained, are shaped by the following processes: blowing, pressing, pressing-blowing, centrifuging, drawing, etc.

Each way of shaping glass products has specific properties:

- the nature of the surface – smooth, rough, with low gloss, glossy.
- the shape of the product – simple, complicated, geometric, fantasy.
- the nature of the upper and lower diameter in the article.
- the thickness of the walls – large, small and the differentiation of thickness in the same article.
- specific features – the method of marking, the method of decoration, etc.

Glass products shaped by various processes are distinguished by the following organoleptic characteristics:

Blow-blown products

- thin walls and low weight;
- have a smooth, glossy surface;
- have inhomogeneous wall thickness, the bottom being, as a rule, thicker;
- are diverse in shape, size and complicity;
- have a high degree of transparency;
- colored glass products are characterized by intense coloration;

Pressed products

- have walls with increased thickness (over 2-3 mm) and increased weight;
- less smooth surface, with reduced gloss;
- the thickness of the walls and the bottom in the article are approximately equal;
- have the decoration formed from the matrix and is less embossed, indistinct, the facets deeper;
- have simple shapes, with small depth and with the inner surface of a cylindrical, prismatic or narrowed shape at the bottom, the lower

diameter being smaller or equal to the upper one;
- products pressed in the matrix, have traces from the union of the component parts of the matrices (burrs) on the outer surface;
- have reduced transparency;
- marking is done in less observable places (dorsal side) simultaneously with shaping;
- colored glass products have pale, less intense colors, but never undergo the superposition of
colored glass;
- have a smaller assortment

Blow-molded products:

- have the same appearance characteristics as pressed items except for the shape; the shape being complicated, with a well-relieved neck, usually narrowed (bottles, jars, decanters) and with an upper diameter smaller than the lower one.

For easier identification of the types of glass, the product characteristics of the main 4 types of glass are presented below:

Common glass is characterized by:
- Medium gloss;
- Good transparency (except for the opaque one);
- It is colorless, but may appear greenish, blue or faintly violet shades;
- It is often colored in various colors.

Crystal glass is characterized by:

- Increased gloss compared to that of common glass;
- The degree of transparency and the coefficient of refraction of light are higher;
- It is colorless (rarely colored), without color shades;
- The sound produced when struck with a wooden stick is long, melodious and crystalline;
- Crystal shards, compared to those made of common glass, are heavier;
- The thickness of the walls of crystal shards is usually about 4 mm and more (10-12 mm);
- The "diamond polishing" decoration is more often applied to crystal items;

Sital glass is characterized by:

- Glossy surface;
- White color (similar to that of porcelain), but can also be colored;
- The walls of sital glass shards are thicker, but the items are comparatively lighter;
- More often the products have a flat shape and are obtained by pressing;
- Crystal glass shards have increased resistance to sudden temperature changes (from 20-800 ºC).

- Keeps the temperature of the dishes for a longer time;
- The most common decorations are: decals and painting.
- Borosilicate glass is characterized by:
- Reduced gloss;
- Reduced transparency;
- Colorless or with a yellowish-white tint;
- The thickness of the walls in the glass shards is increased;
- Increased weight;
- Borate glass products are usually produced by pressing and have increased heat resistance;
- As a rule, these items are without decorative effects.

Ever since man first discovered glass, he noticed that the reaction is reversible. That is, at high temperatures, glass from the solid state passes into the liquid state. At first, the Egyptians used this method to decorate glass items by heating and superimposing several layers of glass. Later, when glass became a packaging material widely used in the food and non-food industries due to its harmlessness and resistance to bases, acids and salts. The raw material used in the manufacture of glass is very cheap and available, and that is why it was the basis for the recycling and repurposing of glass. The greatest impetus came with the sanitation and ecological operations that have recently concerned the entire globe. In Europe, this problem has been paramount for a very long time, especially since glass waste is recycled at 98%. Several objectives were established in the bachelor's thesis, including the commodity characteristics of glass.

For the production of glass, primary raw materials are used, which give the vast majority of properties, including vitrifiers, fluxes and stabilizers, as well as secondary raw materials, which include fining agents, opacifiers, decolorants and dyes.

The technological process of obtaining glass items includes four major phases: obtaining the glass mass, shaping, annealing and finishing.

Knowledge of the properties of glass is important, because they determine the quality, assortment and use value of glass items. The most important physical properties are: specific mass, thermal, optical and electrical properties. The mechanical properties of glass are: hardness, elasticity, fragility, resistance. Chemical properties show us the behavior of glass under the action of chemical agents (acids, bases, salts) and atmospheric agents (air humidity, gases in the atmosphere).

Recycling of production waste is one of the factors that is also carried out by the enterprise studied as the object of research in the bachelor's thesis. Because the enterprise Glass Factory in Chisinau is one with a large working capacity and the percentage of production waste is high. Glass shards being 100% recyclable are a source of saving energy resources because they melt at

a lower temperature than the raw materials when forming the glass mass. Due to the properties of packaging for food and non-food products, the process of their reuse is no more than 30 times. It would seem that this is a very long time, but if we analyze the partners of the enterprise we see that most of them are producers of soft drinks or low-alcohol drinks that in a short period of time may require their recycling.

The procurement activity within the artisanal enterprises that existed during the Middle Ages was of major importance, but it was not separate and did not have a special specialization from the rest of the activities, it was usually handled by the owner of the enterprise, which has not changed over the years. At the current stage, within the enterprises, procurement, supply, materials management and logistics departments have become main compartments and their importance is increasing from year to year. In our country, procurement activities are carried out at the level in various fields. The regulatory framework allows this. Studying the issue of the recovery and recycling of glass waste, we find that in the Republic of Moldova no one has the courage to start a campaign for the collection of separate waste that would lead to a decrease in the volume of household and production waste. I propose that the State Enterprise Glass Factory in Chisinau come up with the initiative in question and be the first to invest in this area.

6.3. Possibilities for reusing purchased cardboard waste

Paper is everywhere: in stores, in every room of every home, in company offices, on sidewalks, piled up in landfills alongside other waste. Every day, each of us touches at least one piece of paper. Paper is also the most common waste, originating from almost all fields of activity and, therefore, has the largest share in total waste worldwide. The paper industry contributes a quarter of all industrial wood consumption, which comes from both natural forests and commercial plantations. Large areas of untouched natural forests can still be found in many places in the world, but they are threatened by logging and deforestation. Wherever natural forests are cut down, ecosystems are severely affected, but when tropical forests are cut down, the damage is irreversible. The ecosystems of these forests cannot cope with sudden exposure to environmental conditions, as happens when there are no more trees, and the animals also disappear, sometimes forever. For an area to be cleared, infrastructure such as roads and accommodation is needed. Once a road has penetrated a previously unexploited forest, the path is open to other interested parties, so loggers are followed by farmers and livestock farmers.

The paper industry often claims that it plants more trees than it cuts. This may be true in many cases, but where fast-growing conifers are planted where an old-growth forest once grew, an introduced species replaces a forest rich in

diversity and life. This can harm the local ecology, increasing soil acidity, destroying aquatic species and threatening the existence of other native species such as birds, mammals, plants and even other trees. Another important aspect is that while young trees – the planted ones – absorb carbon more quickly, old trees store vast amounts, helping to reduce greenhouse gases in the atmosphere. Furthermore, when a tree is cut down, it will release much of the stored carbon back into the atmosphere. Annually, paper products contribute at least 35% of the wood consumption in commercial plantations. The papermaking process uses a large amount of water, which eventually returns to the environment. In many cases, the water is returned directly to rivers or the sea, and thus the toxins resulting from this process enter nature and the food chain.

Wood residues, chemicals used to break down the fibers, and bleaching agents are all pollutants that must be treated before they are discharged. The production of cellulose also consumes energy, and paper is indirectly responsible for air pollution because some processes emit gases directly into the atmosphere, directly contributing to acid rain. By recycling paper, we contribute enormously to reducing pollution and saving exhaustible natural resources. It takes 70% less energy to produce paper from recycled fibers than from natural fibers.

It has been calculated that one ton of recycled paper saves:

- 15 trees
- 2.5 barrels of oil
- 4132 KwH (enough to heat a home for 6 months)
- 2.26m³ of waste storage space
- 26,497.88 liters of water
- 26.8 kg of air pollutants.

The raw material used in the manufacture of paper and cardboard is classified as follows:

Cellulose – has several physical and chemical properties that are formed depending on the method of production. The most popular methods are considered to be the acid sulfite and alkaline sulfate methods. The acid method involves boiling the wood pulp in a solution of sulfuric anhydride or potassium disulfite, as a result of which gray-colored sulfite cellulose is obtained, which is treated with bleaches to be bleached. The alkaline method involves boiling the wood pulp with sodium sulfide. The physical and mechanical indices of the cellulose obtained by this method are higher, but it cannot be used to obtain the whitest grades of paper because it is allowed to use raw materials with mold, defects and broken tree branches and waste from the wood processing industry.

Hemicellulose – is easier to obtain than cellulose. It is obtained more by the alkaline method. Paper made from hemicellulose has lower properties but the degree of whiteness is higher due to boiling in a sodium carbonate

solution.

Wood pulp – is the cheapest fibrous semi-finished product used in the manufacture of paper. Three types of wood pulp are produced: white, brown and chemical. White wood pulp is made from coniferous wood varieties. The wood used must have minimal defects and is processed by mechanical methods. With the help of abrasive discs, the fibers are dispersed from the surface of the wood without changing the chemical composition and are subjected to bleaching. This raw material is used to obtain paper with a shorter shelf life.

Brown wood pulp is obtained from coniferous wood that has been steamed. This further facilitates the process of dispersing the fibers from each other more easily. Longer fibers are obtained from such wood and the color is brownish yellow. It is used more in the production of cardboard and packaging paper. Chemical wood pulp is obtained as a result of processing coniferous or deciduous wood with sodium sulfate solutions or other substances. After chemical treatment, the wood is steamed and then dispersed. The result is a flexible mass with long fibers without a brown color. This type of semi-finished product has good mechanical properties and often replaces cellulose in the composition. It is widely used in the manufacture of cardboard, printing paper, for newspapers and newsstands, in various types of fine paper and in the case of use in types of white paper it is bleached.

Textile fiber pulp – is obtained from textile waste made from natural flax or cotton fibers. These types of fibers are usually longer than wood cellulose. The ratio of fiber length to thickness is a very important index for fibers used in high-quality paper. . Textile fibers form higher consumer properties in paper than those used in obtaining paper for money, documents, for writing, for linear drawing, for copies and other types of paper and also for obtaining cardboard.

Waste paper – represents used paper and production waste. The process is based on shredding and friction to disperse it in a water solution. In the case of paper with a higher glue content, the mass is heated to 700C and the printing ink and other dirt are removed with acidic or sodium chemical solutions. After boiling, the pulp is subjected to the bleaching process.

Regarding paper, recycling is not a new concept because to obtain certain types of paper, fibers recovered from old paper, textiles or cardboard must be used. In different forms, paper occupies approximately 41% of the total household waste we produce. Paper can be reused (by recycling) approximately six times. Each time paper is recycled, the individual cellulose fibers shorten, affecting its strength (something important for paper production, not for cardboard). If the paper is contaminated with oils, grease, paint, etc., it becomes non-recyclable. So it is very important what kind of paper we put in the recycling container, but also keeping it away from sources

of contamination. Ventilated spaces, away from the sun, moisture and dust are preferable. There are three types of paper that can be recycled directly:

• quality paper (school notebooks, copier paper, envelopes, typing paper, computer paper),

• newsprint

• cardboard.

Waste paper - represents paper and cardboard items that have lost their functional properties, being physically worn out, such as: newspapers, books, journals, boxes, notebooks and archival paper. Waste paper represents a valuable secondary raw material for obtaining paper, cardboard, bituminous cardboard, asphalt cardboard and other types of soft roofing. The advantage of processing waste paper is to obtain valuable paper items with a lower production cost in comparison, if wood and cellulose are used for their production. The sources of supply of waste paper are diverse and each of them differs from each other, depending on the nature of their purchase, for example, from commercial enterprises you can purchase especially packaging in the form of cardboard boxes and boxes, wrapping paper, paper bags, paper bags left over from unpacking goods.

Waste paper of various qualities and inhomogeneity is purchased from the population: newspapers, books, notebooks, boxes, etc.

Figure 41. Unsorted waste paper

Source: Eestivanapaber (2023).

Waste paper collected directly from the population and from various commercial and manufacturing enterprises is called unsorted. It cannot be used for industrial purposes, since it has an enormous content of impurities and is not sufficiently homogeneous in terms of its quality indicators. Waste paper processed at purchasing enterprises and sorted into appropriate grades (brands), packaged by pressing and marked, as provided for in the reference standards, is called sorted and only in this way can it be supplied to industrial enterprises.

Figure 42. Sorted and baled paper and cardboard
Source: SC DIREN EXIM SRL (2023).

In the process of processing waste paper, excess impurities are removed, as well as unconditioned paper and cardboard. From books and notebooks, cardboard covers, artificial leather, as well as clips, fabrics, etc. are removed. Archive waste paper is removed from metal and textile impurities. Paper bags are cleaned of products that may remain in them in small quantities.

Unsorted waste paper purchased from specialized organizations, after its processing and sorting is supplied to waste paper processing plants.

Sorted waste paper must meet the requirements of the reference standard GOST 10700-97, according to which it is classified into three grades depending on its quality:

- A – high quality;
- B – medium quality;
- C – low quality.

In turn, these groups, depending on the collection source and color, are classified into the following grades:

MS - 1A - represents industrial waste obtained from the production of white paper (except newspapers) - paper for printing houses, for notes, drawings, etc.

MS - 2A - represents industrial waste obtained from the production of all categories of white paper or in the form of pieces of paper lined on the edges with black, red, or other colored lines. This assortment is represented by waste from the production of: paper for printing, for drawings, for diagrams, etc.

MS - 3A – represents industrial waste obtained from the production of brown sulfate cellulose paper, namely from the production of: paper for packaging, for electrical insulation, for seals, for paper bags, paper that serves as a base for glue strips, etc.

MS - 4A – includes water-permeable paper bags (not impregnated with bitumen or other substances of the respective category).

MS - 5B – industrial waste obtained from the production of corrugated cardboard as well as consumer waste in the form of paper and cardboard used in its manufacture.

MS - 6B – industrial and consumer waste in the form of cardboard of all types (except that used for insulation and in the footwear industry) of black-

and-white or colored color.

MS - 7B – includes books, journals, brochures, leaflets, catalogs, notebooks, used notebooks and other items from the printing industry, as well as items made of white paper written in a single color or in different colors, without covers, printed on white pulp paper.

MS - 8C – this group includes industrial waste from the newsprint industry, as well as consumer waste in the form of newspapers.

MS - 9C – this group includes: tubes, spools, plugs (without coatings or impregnations) made of paper.

MS - 10C – this group includes paper articles obtained by molding cellulose mass.

MS - 11C – includes industrial and consumer waste of paper and cardboard impregnated and coated with special substances: wet-resistant, bituminous, laminated paper, as well as bags made from the above-mentioned paper.

MS - 12C – includes industrial and consumer waste of black or brown paper and cardboard.

MS - 13C – this group includes cardboard of various colors, except for black or brown.

Depending on the fibrous content, sorted waste paper can be classified into 2 large groups: paper and cardboard, which in turn are classified into 12 brands (quality grades): from HM-1 to KM-12 (HM – represents the brand of paper, and KM represents the grades of processed waste paper).

HS – 1 – represents industrial waste (pieces, paper shreds) of white color, clean, unwritten, obtained 100% from white cellulose.

HM – 2 – industrial waste of white color, clean, obtained from cellulose pulp and wood.

HM – 3 – industrial paper waste, obtained both from HM – 2 brand waste paper and from cellulose pulp, but which are not included in the groups mentioned above, for example, newspapers that have not been used.

HM – 4 – white paper for books and journals, collected in the form of old or new books, journals, brochures, leaflets, catalogues and other printed matter, published on white paper. This category of waste does not include book covers made of cardboard. In addition to the above, this group also includes: blotters, drawing paper, notebooks, white paper obtained from archived documents, as well as stationery, written with typographic text on typewriters. Archived documents, before being collected, must be cleaned of pins, clips, as well as cardboard covers.

HM – 5 – colored paper, except for black and brown, unwritten or written, with ink or pencil.

HM – 6 – paper used for packaging goods and other types of brown paper and also paper bags.

HM – 7 – paper for wrapping, packaging of sulphate cellulose and other semi-finished products, obtained after unpacking industrial goods from commercial enterprises and other organizations. This also includes black and brown paper obtained from books and journals.

HM – 8 – this group includes unitary or complex bags left after unpacking food products, seeds, industrial items, kaolin, gypsum, chalk and washing powder.

Paper bags soaked in bitumen, in which cement, mineral fertilizers and other chemical products were stored, can be collected and purchased only by mutual agreement with the buyers.

KM – 9 – this group of waste paper includes industrial cardboard waste of different colors, in the form of pieces and tears.

KM – 10 – this is how corrugated cardboard packaging and also compact cardboard are marked.

KM – 11 – this group includes unpackaged cardboard boxes soaked in film-forming substances such as varnishes and bitumens.

KM – 12 – this marking is applied to insulators not soaked with paraffin, without the presence of threads on their surface, as well as paper ropes.

The grade and quality mark of the waste paper must be indicated in the sales contract concluded between the purchasers and the enterprises processing it.

If the enterprises processing the waste paper produce paper or other articles of the same type, for which their brand does not matter, then they purchase the paper and cardboard, which they use without preliminary sorting.

The paper made from recycled waste is used in the manufacture of corrugated cardboard, micro-corrugated cardboard, cardboard and toilet paper. The purchased cardboard is recycled only into cardboard and the unconditioned one is used to obtain alternative fuel.

The waste is collected in a warehouse called a waste paper warehouse where the paper is sorted. Depending on the quality of the cellulose product to be manufactured, the sorted paper is used according to recipes, in different proportions, as raw material.

The equipment used to transform recycled paper into cellulose raw material, used in the manufacture of cardboards are:

1. Hydropulper – is a mixer with a mechanical agitator in which paper and cardboard waste is introduced mixed with a quantity of industrial water in a proportion of 80% water, 20% waste which, by rotation by a rotor in the mixer tank, is defibrillated;

2. Double-disk disintegrators – are defibrillation equipment that continues the disintegrating process by sectioning the paper fiber with metal disks;

3. Conical mill – is a machine that grinds paper fiber and transforms it into a paper pulp suspended in water;

4. The actual cardboard drawing machine – is a machine that, with the help of cylindrical screens and a flannel, captures the paper fiber from the water and forms elementary layers of paper;

5. Cardboard dryer – are 2-4 storey buildings in which there are clamps for holding cardboard sheets for natural drying using natural air currents;

6. Calender – is a machine consisting of two metal rollers through which the dried cardboard sheet is passed in order to finish the sheet surfaces.

Table 7. Characteristics of quality marks of waste paper and cardboard

Group	Brand	Content
A (superior quality)	MS-1A	Industrial waste obtained from the production of white paper (except for newspaper), printing paper, note paper, drawing paper, and other types of white paper.
	MS-2A	Industrial waste obtained from the production of all categories of white paper in the form of pieces of paper lined on the edges with black, red, or other colored lines. This assortment is represented by waste from the production of: printing paper, drawing paper, diagram paper, etc.
	MS-3A	Industrial waste obtained from the production of brown sulfate cellulose paper, namely from the production of: packaging paper, electrical insulation paper, seals, paper bags, paper serving as a base for glue strips, etc.
	MS-4A	Water-permeable paper bags (not impregnated with bitumen or other substances of the respective category).
B (average quality)	MS-5B	Industrial waste obtained from the production of corrugated cardboard as well as consumer waste in the form of paper and cardboard used in its manufacture.
	MS-6B	Industrial and consumer waste in the form of cardboard of all types (except that used for insulation and in the footwear industry) of black-white or colored color.
	MS-7B	Books, journals, brochures, leaflets, catalogs, notebooks, used notebooks and other items from the printing industry, as well as items made of white paper written in a single color or in different colors, without covers, printed on white pulp paper.
C (low quality)	MS-8C	Industrial wastes from the newsprint industry, as well as consumer wastes in the form of newspapers.
	MS-9C	Paper tubes, bobbins, stoppers (without coatings or impregnations).
	MS-10C	Paper articles obtained by molding cellulose mass.
	MS-11C	Industrial and consumer wastes of paper and cardboard impregnated and covered with special substances: moisture-resistant, bituminous,
	MS-12C	laminated paper and also bags obtained from the above-mentioned paper. Industrial and consumer waste of black or brown paper and cardboard
	MS-13C	Cardboard of various colors, except black or brown.

Source: ГОСТ 10700-97 (2002).

Today, all successful organizations consider procurement to be a strategically essential activity. However, not all economic entities believe that procurement is a function that would be best performed by a specialized department, and there are those who believe that it would be more appropriate for this activity to be carried out as close as possible to the point where the purchased goods and services are needed. However, it could be said that most large organizations call on the services of a dedicated team of procurement and supply specialists.

The role and contribution of procurement have grown steadily in the last half of the twentieth century, with an even greater intensification of interest in the activity in question in the last few years.

Not all enterprises attach the same importance to procurement. This depends on the share of total expenses incurred for the purchase of raw materials and supplies in the total expenses of the enterprise.

The technological storage process is composed of a series of operations that include:

• Unloading cardboard waste from means of transport;
• Transportation of cardboard waste to reception rooms;
• Reception of cardboard waste;
• Distribution of cardboard waste to storage locations, sorting of goods depending on the storage location;
• Transportation of cardboard waste to storage locations, storage of cardboard waste;
• Transportation of goods to production locations;
• Transportation of goods to shipping locations;
• Organizing the shipment of goods by various means of transport.

The procurement activity is carried out in accordance with the requirements of the legislation in force: Law on the Sale of Goods No. 134-XIII of 03.06.1994, Law on Internal Trade No. 749-XIII of 23.02.1996 and the order on the approval of the standard form of primary document with special regime "Act of procurement of goods" No. 130 of 30.09.2010.

According to these regulatory documents, managers are aware that the uninterrupted operation of enterprises is largely conditioned by the timely supply and creation of stocks of goods, including cardboard waste, in the required quantity and size.

The starting point and the main problem on which the concern of the enterprise administration for the proper organization of the collection and supply of cardboard waste is based is the development of consumption norms and standards.

Knowing the consumption and stock norms, the next stage in the field of supply is determining the supply requirements to fulfill the tasks set out in the business plan, investment plan and other sections of the socio-economic plan.

After determining the quantity of cardboard waste required for collection and supply, the enterprise proceeds to the next stage, namely the conclusion of economic purchase and sale-purchase contracts - if the purchase is made from legal entities or individuals registered with the State Registration Chamber (Annex 3 and 4) or the procurement act - in the case of collecting cardboard waste from individuals who do not practice entrepreneurial activity.

It should also be noted that in the procurement process, the following objectives are also taken into account:

- the procurement of goods, including cardboard waste, is carried out within the established deadlines that the enterprise needs;
- in its activity it constantly monitors the evolution of the goods market, including cardboard waste;
- establishes the procurement methods;
- develops procurement programs;
- establishes the rules for controlling the supplied cardboard waste;

In the process of purchasing cardboard waste, the company's managers fulfill the following conditions:

- They purchase cardboard waste at the lowest possible price, but at the same time take into account its quality conditions;
- They correctly manage cardboard waste stocks, which are purchased in small quantities, preliminarily calculating the service coefficient as the ratio between the quantities of cardboard requested by buyers and the quantities supplied, or as the ratio between the number of satisfied requests and the total number of requests.

Cardboard waste is purchased through buyers, directly from the population.

The buyer is appointed by the commercial director. The buyer performs the function of purchasing cardboard waste in the territory and assumes full responsibility for the monetary and material values transferred to the management of the company.

The purchaser has means of transport for transporting cardboard waste from the point of purchase to the enterprise's warehouse.

The purchaser purchases cardboard waste from the population against the cash received from the enterprise, after which he delivers the goods purchased from the population to the enterprise's warehouse every 3-5 days. In case of non-purchase of the goods, the purchaser returns all the funds received to the enterprise's cash register.

This form of purchase involves the conclusion of a purchase agreement between the purchaser and individuals. The records of transactions carried out by the purchaser are recorded in the management, movement and storage reports of cardboard waste under the management of the purchaser, which confirm the quantity and price of the goods purchased from the population.

Analysis of the procedure for quantitative and qualitative reception of cardboard waste within the enterprise. The procedure for receiving cardboard waste is organized to ensure the quality of the purchased product. The person who receives cardboard waste knows the requirements for the quality of the purchased product and acquaints the persons involved in the collection with it. The receiver also informs the persons involved in the collection about the collection rules.

Reception of cardboard waste is carried out by quantity and quality, and is carried out in accordance with the Regulation on the reception of goods according to quantity and quality in the Republic of Moldova, Government Decision No. 1068 of 20.10.2000 and in accordance with GOST 8047-93 Paper and cardboard. Acceptance rules. Sampling for determining medium quality.

When receiving cardboard waste in quantity, the manager studies a number of important documents: the purchase contract, the sales contract, the contract notes that provide for deliveries, the shipping or transport bill, the documents that refer strictly to the cardboard received.

The quantitative reception of cardboard waste must establish the quantity, that is, its mass, which is most often determined in kilograms.

The quantity check is done either for the entire quantity (if a small batch of cardboard waste was brought to the enterprise), or on a sample (if the batch of cardboard waste is large). In the case of sample check, the quantities indicated in the standards or agreed upon between the parties must be respected; quantities smaller than these are not allowed.

If the cardboard waste is received packaged, then the quantity is determined based on the net mass of a packaging unit, which mass will be extended to the total number of packages forming the batch. If the packages are damaged, the verification is carried out in full, mentioning this in the report. In this case, the company manager describes the type of packaging, the packaging method and the type of defect observed.

The qualitative reception of cardboard waste aims to assess the quality according to organoleptic indicators: color, length, density, degree of impurities, surface, sort, etc. In order to reduce the subjectivity of assessing the quality of cardboard waste through organoleptic indicators, the personnel ensuring the reception of cardboard waste possess a high degree of professional competence and know the peculiarities of its quality.

The qualitative reception of cardboard waste involves carrying out measurements, analyses and tests that are carried out according to an established methodology to specify the level at which its quality characteristics are found at a given time. The qualitative reception of cardboard waste involves achieving the following objectives:

- establishing the correspondence between the real quality of cardboard waste and the quality prescribed in the normative-technical documents;

- establishing the extent to which the quality of the received cardboard waste meets the requirements of the beneficiaries.

Characteristics of storage conditions, preliminary processing, and storage of cardboard waste within the enterprise.

Cardboard waste storage is carried out in accordance with GOST 7691. The process of storing cardboard waste includes a range of operations. We will recall the main ones:

♦ Determining the necessary areas for storing various goods, as well as cardboard waste;

♦ Developing a system for placing cardboard waste in storage spaces depending on the order of inputs and outputs (deliveries);

♦ Determining the procedures and techniques for placing cardboard waste in storage locations (in stacks, on pallets, in containers, on racks, etc.);

♦ Ensuring optimal storage conditions (temperature, humidity, degree of illumination, ventilation, sanitary and hygienic regime, etc.);

♦ Insect control and deratization (extermination of rodents);

♦ Continuous and systematic control of the quality of cardboard waste;

♦ Determining natural losses in the storage process and taking measures to reduce them.

There are certain technical and regulatory conditions that determine the maximum storage capacity and the maximum quantity of cardboard waste stored.

The necessary measures for optimal storage of cardboard waste:

♦ Ensuring hygienic and sanitary conditions;

♦ Systematic control of cardboard waste;

♦ Control of storage conditions (temperature and humidity);

♦ Checking the stacks.

For the proper organization of cardboard waste storage, certain stable conditions are required: temperature, relative air humidity, optimal sanitary and hygienic regime.

When storing and arranging cardboard waste, it is necessary to observe the rules of safety technology. The appearance and durability of the packaging, the degree of mechanization of work in the warehouse are taken into account. Racks are installed at a distance of 10-15 cm from the wall and 0.5-1 m from heating systems and sewer pipes, the room is well ventilated, without natural lighting. Well-packed cardboard waste is stored at an air temperature of +23ºC ± 1ºC and an air humidity of 50% ± 2%.

Workers of the commercial production enterprise must strictly observe the conditions for storing cardboard waste, not to allow a decrease in its quality or to cause other losses of the normed goods, respectively, perishable goods.

When the optimal storage regime for cardboard waste is not observed, 2 types of perishability are detected:

- normal
- abnormal.

Normalized perishability occurs during transportation, storage, and preparation for production.

Figure 43. Products from recycled waste
Source: (Karton, 2023)

There are established norms for the transition of cardboard waste to losses if it has been oversaturated with water, or burned following the outbreak of fires. These norms are established depending on the volume of goods circulation.

Non-standard perishables appear due to their incorrect storage. In all these cases, reports are drawn up.

6.4. Technology and technical support for metal recycling

Currently, only 3% of the cans on the market are recycled, and over 10,000 tons of high-purity aluminum end up in the trash. In Europe, the recovery rate of this waste varies between 40 and 70% and even more in Switzerland and the Scandinavian countries. The European average per capita of aluminum waste is 175 kilograms, with Greece and Finland recording rates lower than 100 kilograms per capita. Ireland and France exceed the level of 200 kilograms. In the next seven years, Romania must reach the point of recycling 50% of the amount of aluminum placed on the market. To meet the necessary consumption, approximately 350 million aluminum cans are produced annually in Romania and another 100 million cans are imported. Aluminum, the most precious recyclable material. Because recycling one ton of material saves at least $265 in electricity, oil, gas and coal. The energy saved by recycling a regular bottle will keep a 100W light bulb on for four hours.

By recycling a single aluminum can, we save the energy consumed by a television for three hours and that of a 100 W light bulb that can stay lit for 20 hours. To raise awareness about the importance of aluminum recycling, Europeans built the Verona Arena from 40 tons of aluminum and the Padua Cathedral from 60 tons.

"The smelting of aluminum requires 95% less energy than the primary production of the metal. This metal increases our standard of living and with its help, a wide variety of products are made available to us. Used for food packaging, it can be transported in large quantities over long distances. The ore from which aluminum is obtained is bauxite, and current reserves of bauxite are sufficient for another 400 years,". A television can operate for three hours and a 100 W light bulb can operate for 20 hours with the energy saved by recycling a single aluminum can. Aluminum is the most valuable recyclable material, ten times more valuable than steel.

1. The purpose of recycling ferrous metal alloys and sources

On our planet with finite resources, any piece of metal thrown away at random after "consumption" is practically lost forever. It is worth meditating on this. But beyond the philosophical aspect, there is also an economic one: the recovery of used metal (as well as other waste) brings income. Or it should bring. Among the waste collection activities, the greatest interest for collection companies is represented by ferrous and non-ferrous materials, which are also in demand for export.

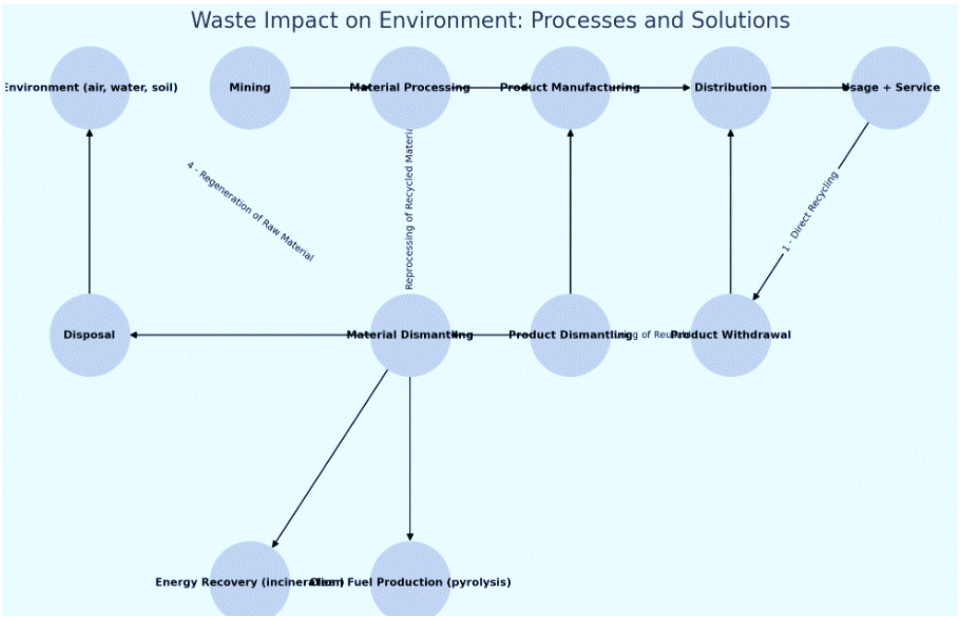

Figure 44. Closing the life cycle of a product

Source: developed by the authors

Some researchers argue that environmental friendliness should be measured in energy units. It is all the better if we consume as little energy as possible to manufacture a product. This notion has led to the so-called "Life Cycle Analysis" / assessment of LCA approaches. LCA (or assessment) is a method in which the energy and raw material consumption, the various types of emissions and other important factors related to a specific product are measured, analyzed and summed over the entire life cycle from an ecological point of view. All manufactured products sooner or later develop defects, age or simply become useless, rudimentary. In the case of cars, their withdrawal from the market (user) generally occurs when they no longer meet the technical and ecological conditions for being in circulation or in the event of serious damage to the car. This period of use (life) depends on the country and model. The degree of product recovery can be divided into: total reuse of the product, its reconditioning and recovery of certain components and materials.

"Recycling" is the most commonly used term for recovering products and reusing or decomposing them to some extent. As a result, there are many levels at which a product can be "recycled" (decomposed) in order to be repurposed on the second-hand market. The terminology used for each of these levels differs from one literature to another, but the most important strategies for extending the life cycle (recycling) of a product are the following: reuse (through repair), remanufacturing/reconditioning (including inspection, reconditioning, parts recovery and technical upgrade) and material recycling.

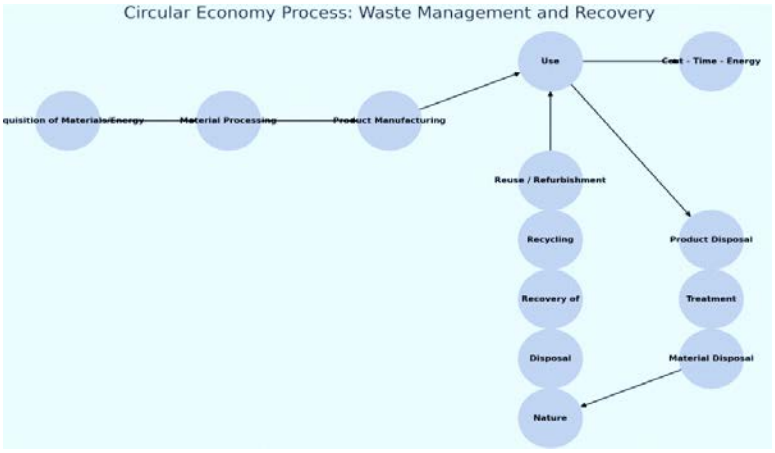

Figure 45. Processes that occur during the life cycle of a product
Source: developed by the authors

Developing a recycling strategy is a complex process that is partly characterized by an assessment of opportunities, resulting in rational decisions and partly an adaptation to phenomena that occur in the context of the process and also in the process. In figure 58 the most important processes during the

life cycle of a product are also represented.

Material recycling

Involves recovering the material content of the product so that it can be used again for other purposes. The distinction between reuse and recycling is not always clear due to their interchangeability, but in the case above the term recycling refers strictly to recycling-recovery of materials. This is the most common process:

• Only the materials are retained, all geometric details are lost

• Allows for (cheap) destructive disassembly

In the electronics industry, material recycling is in many cases carried out with the aim of recovering valuable materials (e.g. gold, platinum).

The term recycling is often used for all activities that accompany the product, product components or the constituent material of the product in a new cycle of use. A distinction is often made between primary recycling where the material is transformed into a product at the same value level as in the first cycle (e.g. glass containers reused in a new bottling) and secondary recycling where the material is reused in different applications of lower value level (e.g. plastic waste used as filler in a composite material). Secondary recycling is easier to do than primary recycling. For example, polyurethane foam in modern car seats can be recycled into covering materials (carpet), but not back into polyurethane foam in a new seat. Similarly, various plastics can be used as composite materials in construction. Somehow this degradation of the material will cause problems and people will reflect on the continuity of recycling. Also in industry and education much attention is given to the recycling of materials in which the geometry of the product (and the associated value) is destroyed and only the constituent material is led into a new cycle of use. For the recycling of materials, the following 3 stages are usually considered:

1. Material separation
2. Sorting
3. Reprocessing

This can be done depending on the place of origin as follows:

- own waste (“process scrap”), also called internal waste (“internal scrap”). It results from different stages of steel production, casting or forging (solidified steel in tundishes and networks, in holes, in ladles, incomplete or defective ingots, etc.) and represents ~3.4-6.6% of liquid steel production;

- machining waste (“post-production scrap”) resulting from the transformation into finished products from hot or cold rolled semi-finished products, from cast or forged parts;

- recovered waste (“post depreciation scrap”) from machinery, mechanisms, installations, at the end of their operating life.

Sources of ferrous waste and sectors that supply ferrous waste

Recovered ferrous waste comes from two main sources:

- the industrial sector, through the scrapping of equipment, machines, aggregates, installations, metal structures, motor vehicles, rolling stock, ships, etc.;

- the private sector (collections), through the scrapping of household objects and appliances, metal household waste (packaging, etc.).

Own waste, in most cases, is consumed in the same place where it was generated. Machining waste and recovered waste constitute the group of collected (purchased) waste and are usually sold.

Own waste is generated by technological processes in:

- the blast furnace sector (slag, slag, cast iron slag);

- steelmaking sector (solidified steel in tundishes and networks, in holes, in ladles, incomplete or defective ingots, etc.);

- rolling mill sector (slags, defective rolled products, etc.).

Machining waste comes from the manufacturing industry and includes:

- slags from metallurgical processing units (pipe, wire, wire products, etc. factories);

- waste resulting from the processing of rolled products by cutting, etc.

- waste resulting from mechanical processing operations of metallurgical products by stamping, drawing, drilling, cutting, etc.

Recovered waste comes from the following main sources:

- the industrial sector, through the scrapping of equipment, machines, aggregates, installations, metal constructions, vehicles, rolling stock, ships, etc.;

- the private sector (collections), through the scrapping of household objects and appliances, metallic household waste (packaging, etc.).

The fields that provide ferrous waste are very diverse:

• household waste

- roofs, grilles and metal fences

- metal supplies (nails, springs, plates, hinges, locks, etc.)

- toys

- tools

- tools

• obsolete equipment

- large-sized (refrigerators, freezers, washing machines or dishwashers, dryers, cookers-stoves, gas stoves, air conditioners, heating systems, etc.)

- small-sized: (lamps, kitchen equipment, etc.)

• waste from means of transport

- cars

- trucks

- buses

- tractors

• waste from other sustainable uses
- aviation
- naval sector
- railway sector
- oil and gas product transport pipelines
- pipelines, sewer covers
• construction waste
- machinery
- strength elements (profiles, reinforced concrete)
- metal bridges (beams, platforms)
- road elements (railings, traffic signs)
• containers (packaging)
- food and beverage boxes
- industrial product packaging (boxes, barrels).

According to the recommendations of the European reference system, the following scrap qualities are recommended for waste used in the production of steel in an electric arc furnace:

Table 8. Recommended waste qualities for waste used in steel production in an electric arc furnace

• medium pieces:	dimensions max.1100x600x600mm thickness min. 10mm density min. 1.4 t/m3
• light pieces:	dimensions max.600x600x600mm thickness min. 6mm density min. 1.2 t/m3
• small pieces:	dimensions max.200x200x200mm thickness min. 10mm density min. 1.5 t/m3
• tubular materials:	length max.600mm diameter max. 500mm volumetric mass min. 0.8 t/m3 lengths of max.1100mm are allowed in a proportion of max.10% of the batch mass
• metal shavings:	dimensiunea max.150x150x150mm grosime min. 5mm masa volumică min 0,9 t/m^3
• small turnings:	chip length max.200mm density min 0.9 t/m3 pieces of steel, cast iron or non-ferrous alloys are not allowed
• small packages:	dimensions max.800x500x500mm density min. 1.2 t/m3
• briquetted turnings:	minimum mass 2kg/piece min volumetric mass 3t/m3

Source: (Vtorion, 2022).

Ferrous waste preparation.

Waste preparation represents the set of processes and technological operations by which they are processed to be brought to the quality conditions required by the user.

The choice of preparation operations is determined by the origin (composition, quality, etc.) and destination of the waste (type of steel used for its production, processing aggregate, etc.).

Waste preparation comprises two stages:

- primary processing;
- secondary processing.

The primary processing operations to which metallic waste is subjected consist of:

- detection of radioactive contamination;
- pyrotechnic control;
- sorting according to physical properties;
- selection according to chemical properties;
- dimensional preparation.

Secondary processing operations consist of:

- purification by chemical, thermal or other methods in order to reduce the content of harmful elements and recover useful elements.

Primary processing operations to which metal waste is subjected

1. Detection of radioactive contamination. The need to complete this stage in the flow of preparation operations results from the fact that the risk of radioactive contamination of metal waste coming from various sources increases every year.

One of the methods proposed for carrying out this control was experimented at Thyssen Stahl–Sonnenberg and then extended to all steel units in the European Union. It involves controlling the loads in the means of transport, either statically (when vehicles loaded with waste are stopped) or dynamically (when road or rail transport means are moving slowly) using gates designed to detect radioactive contamination, fig.1. The dynamic method allows the location of the radioactive source to be detected along the longitudinal axis of the vehicle.

In order to detect waste that may present an explosion hazard, metal waste is subjected to pyrotechnic control. This is carried out by pyrotechnic controllers. Waste from ammunition (projectiles, mines, grenades, etc. which must be without warheads), shrapnel, weapon barrels, tanks are analyzed. Some parts, components, consumer items that may have various liquids inside also pose a risk of explosion: containers, taps, closed valve-type parts, pipes with flattened ends, boxes, barrels, flasks, massive metallurgical bodies (sluices, etc.).

2. After examination for radioactive contamination and pyrotechnic control, metal waste and scrap iron are subjected to sorting.

Sorting can be carried out according to:

- chemical characteristics;
- physical and mechanical characteristics.

The most difficult problems in sorting according to chemical properties are posed by ferrous waste contaminated with non-ferrous metals, non-metallic impurities, explosives, coatings, separation of cast iron from steels, etc.

After separating metallic waste from non-metallic waste, sorting involves separating ferrous waste from non-ferrous fractions (or components). In the next stage, ferrous waste is sorted into non-alloyed, alloyed and doubtful waste.

Sorting operations according to chemical composition differ depending on the source of the waste. If properly stored, own (internal) waste, collected at the forming site, does not require sorting. Those from the processing industry (machining waste) are delivered sorted (unalloyed and alloyed, by steel grades), but sometimes they can be mixed. In the latter case, sorting is difficult or impossible, the alloying elements are lost or must be eliminated by additional metallurgical processes, if the steels to be processed do not contain them.

Sorting operations are carried out by qualified operators, based on visual observations or by using appropriate equipment.

Selection according to physical and mechanical characteristics takes into account color, weight, hardness, sound, appearance of the crack. Sorting may also take into account the external appearance, shape and origin of the piece.

By weight, ferrous waste can be sorted into:

- heavy scrap iron, intended for cutting (with flame or scissors);
- light scrap iron for pressing, baling;
- turnings and stampings for shredding, briquetting.

Waste sorting can be carried out more easily after fragmenting mixed waste on shredding equipment with high-performance automated means.

The shredded waste, transported on a belt, is inspected with the help of a video camera, when passing through a brightly lit area. The image taken and transmitted by it is analyzed based on colors. The results of the analysis determine the operation in one direction or another of a simple sorting mechanism. The results of experimental tests carried out on shredded waste coming from an electric motor have demonstrated the efficiency of the system through the separation efficiency of pieces rich in Cu (with a reddish color different from that of ferrous metal pieces) which can reach the maximum, tending towards 100%.

In many cases, the size and composition under which the waste is presented, require dismantling as the first operation. The operation can be performed manually (with low productivity), by cutting or breaking.

After dismantling, sorting and classification, the actual waste preparation operations follow.

Dimensional preparation of metal waste (scrap iron)

Dimensional preparation by cutting long or flat pieces of waste is carried out in order to obtain dimensions that allow either easier handling or to adapt the dimensions to the needs imposed by their use. Cutting can be done with an oxy-acetylene flame or with scissors.

Cutting with an oxy-acetylene flame is recommended for large waste, with thicknesses and strengths higher than those allowed for cutting with guillotine scissors. The operation requires a lot of labor and high oxygen consumption and has low productivity (5-8t/year and shift).

Cutting with alligator shears has higher productivity, 30 - 50 t/shift (depending on the machine) with a continuous feed of waste of regular shapes (bars, concrete steel, light and medium profiles, thin pipes, etc.) and short lengths, so that they can be handled manually.

Guillotine shearing can be grouped into several classes depending on the cutting force, which varies from 3000 to 20,000kN. A major drawback of shredding light scrap metal, for example from car bodies, with guillotine shears is the low volumetric mass obtained for the shredded material (800–900kg/m3). This is primarily due to the initial volumetric mass of the collected material (400–600kg/m3) and the large cutting width. Modern guillotine shears have the possibility of additional pre-compression of the material before cutting, reducing the cutting width by up to half and thus obtaining a material with an increased volumetric mass (1,000–1,300kg/m3).

Baling of light ferrous waste is done with hydraulic presses, with pressing forces between 1,000 and 16,000kN, with intermediate stages of 2,500, 4,000 and 10,000kN. In general, hydraulic presses are equipped with feeding vats. With the help of pistons driven by hydraulic pumps, the light material is introduced into the vat and compressed successively in the three directions to the finished dimensions of the bale. These presses can also process long turnings, up to 15-18% of the mass of the prepared material. In this case, compact packages can be ensured that do not open during handling. Baling can be done cold or hot. In the case of hot baling, the waste is heated to 700–8500C, temperatures at which the elimination of unwanted components such as water, oils, etc. also takes place.

The preparation of turnings with very low density, especially long ones in the leaf state (200–300kg/m3), begins with sorting into short (under 50mm) and long chips (this can be done simply with an inclined rotating drum equipped with holes). They are prepared by shredding (crushing) and

briquetting. For shredding, hammer mills with productivity from 1t/h to over 20t/h are used, and for briquetting, presses with productivity of 1.5–10t/h are used. Briquettes with a mass ranging from 3 to 20kg/piece (and a volumetric mass greater than 4,000kg/m3) can enter the electric furnace charge.

The iron shavings used in the charge of electric induction furnaces must also be processed to reduce the degree of oxidation. Rust, Fe(OH)3, is transformed in air into Fe2O3 and this, when heated, decomposes into Fe3O4 and O2. The Fe3O4 oxide easily detaches from the metal part, so it can be removed with the help of an air jet. After these operations, the oxide content in the dry shavings decreases to 0.1…1.5%. Fig. 4 shows the scheme of the iron shavings processing plant and its loading into the furnace.

The preparation of old cast iron (parts from scrapped machinery with frames, flywheels, casings, ingot molds, casting bridges, household items) consists of mechanical or pyrotechnic breaking to the dimensions and unit mass corresponding to the technological requirements for further use. For mechanical breaking, ball mills of 1-2t and a fall height of 5-8m and ball crushers of 10-20t and a fall height of 15-25m are used

For thick pieces, pyrotechnic breaking is used in open areas (between hills) or in armored blast pits. Since this method produces noise, tremors, and throwing pieces over long distances, it is used less and less, and in order to mitigate these effects, the pyrotechnic breaking method in a liquid medium is used (especially applicable to the dismantling of large ingot molds).

If more advanced shredding is required, it is supplemented with high-power guillotine shear shredding or cryogenic shredding is used.

Cryogenic shredding is a modern method with high separation efficiency, which can be combined with the mechanical shredding method on a shredder. It is based on cooling the waste to temperatures below –1200C, when steel, unlike non-ferrous metals, becomes brittle. Liquid nitrogen is used as a coolant. The shredding continues in a shredder mill and the separation is carried out with a magnetic separator.

Before low temperature crushing. After low temperature crushing (copper wire separated from ferrous component); crushing temperature -1050C

Chapter 7. WASTE MANAGEMENT CHALLENGES AND STRATEGIES

7.1. Air quality challenges in the Republic of Moldova

The Republic of Moldova has made less progress in terms of transparency of environmental, climate and resource efficiency assessments in recent decades. However, the most important factor causing climate change and damaging the environment is inextricably linked to economic activities and lifestyles, especially societal systems that provide people with basic necessities such as food, energy and mobility. Therefore, society's resource use and pollution are complexly linked to jobs and earnings along the value chain, to major investments in infrastructure, equipment, skills and knowledge, to people's behaviours and lifestyles, as well as to public policies and institutions.

The most important measures to mitigate climate change are reflected in strategic documents at national and international levels. According to the 2015 Paris Agreement, ratified by the Republic of Moldova by Law no. 78/201757, an action plan was established to limit global warming to below 2°C. In order to achieve the objective of the 2015 Paris Agreement, all signatory Parties to it are to communicate to the UNFCCC, through Nationally Determined Contributions (NDCs), the efforts undertaken at national level to reduce GHG emissions. The Republic of Moldova submitted its first NDC to the UNFCCC on 25 September 2015 (PNUD, 2017).

According to the 2030 Agenda for Sustainable Development, it establishes sustainable development goals and target indicators to be achieved. Thus, targets related to air quality are found in Goal 3 "Health and Well-being", which aims to minimize the mortality rate determined by ambient air quality, and Goal 11 "Sustainable Cities and Communities", which establishes the minimization of harmful substances emitted into the air by road transport.

At the same time, the provisions of the Association Agreement between the Republic of Moldova and the European Union, in Chapter 16 "Environment", provide in Art. 89 letter (b) that cooperation between the Parties also includes the development of a sectoral strategy on air quality - its draft is in the process of being promoted for approval. Similarly, Annex XI to the RM-EU Association Agreement establishes the European directives in the field of air protection and the deadline within which they must be transposed into national legislation. These are:

- Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air,

- Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe,
- Council Directive 1999/32/EC of 26 April 1999 relating to a reduction in the sulphury content of certain liquid fuels,
- Directive 94/63/EC of 20 December 1994 on the control of emissions of volatile organic compounds (VOCs) resulting from the storage of fuels and their distribution from terminals to service stations,
- Directive 2004/42/EC of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products,
- Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants.

Therefore, following the above, the Republic of Moldova has committed to achieving more ambitious GHG emission reduction targets by 2030. Thus, the unconditional target is to increase from 64-67% to 70% compared to the level recorded in the reference year (1990), and the conditional target will advance accordingly from 78% to about 88% compared to the level recorded in 1990. The new GHG emission reduction targets will be introduced in the Low Emission Development Program of the Republic of Moldova until 2030 and the Action Plan for its implementation.

Table 9. Sectoral GHG emission reduction targets,%

	Until the year 2025		**Until the year 2030**	
Sectors:	unconditional	conditional	unconditional	conditional
Energy	83	87	81	87
Transport	56	58	52	55
Buildings	76	78	74	77
Industry	34	37	27	31
Agriculture	48	50	44	47

Source: National Inventory Report 1990-2020, Chisinau June 30, 2022, www.clima.md

However, the country's most important strategic planning document is the National Development Strategy "Moldova 2030", which includes among its priorities the development of a sustainable and environmentally friendly economy, as well as adaptation to climate change in all economic sectors.

The vision outlined in Moldova 2030 is anchored in two strategic international commitments. The first is the Association Agreement with the

European Union, signed in 2014, and the second major international commitment is outlined in the 2030 Agenda for Sustainable Development. Namely, Sustainable Development Goal (SDG) 8.4, localized by the Government of the Republic of Moldova in 2017, specifies that the authorities commit to progressively improving, by 2030, resource efficiency in consumption and production processes in order to decouple economic growth from environmental degradation. In addition, SDG 12 is dedicated to responsible consumption and production. Thus, according to the commitments, Moldova will fully incorporate the principles of sustainable development and efficient management of national resources in the development of national policies and regulations. In the meantime, it will encourage industries and enterprises to adopt resource-efficient production and share responsibility for the disposal of toxic waste and pollutants.

Following the above, we will define the notion of air, according to law no. 1422 of 17-12-1997 on the protection of atmospheric air, thus air represents a unique mixture of gases (nitrogen and oxygen, small amounts of argon, neon, helium, krypton, xenon, radon, carbon dioxide, hydrogen, water vapor and various particles) of major vital importance, in which living organisms can live, the most mobile component of the environment, not defined by borders and which, as a result of the movement of its masses, spreads the consequences of anthropogenic influence to unpredictable distances. And, pollutant represents any substance in solid, liquid, gaseous (vapor) state or energy (radiant, electromagnetic, ionizing, thermal, sound or vibrating), present in the air, which may have a negative effect on human health and/or the environment. The main pollutants taken into account are: Solid substances and Liquid and gaseous substances (carbon monoxide, sulfur dioxide, nitrogen oxide, hydrocarbons, volatile organic compounds, etc.). The main specific substances are: Polycyclic aromatic hydrocarbons, Metals and their compounds, Persistent organic pollutants, Sulfuric acid, etc.

Therefore, the quality of atmospheric air in the Republic of Moldova is influenced by emissions from three types of polluting sources (Environmental Agency, 2021):

- Fixed stationary sources, which include electrothermal power plants (CEPs) and boiler houses, industrial enterprises in operation;
- Mobile sources, which include road, rail, air, river transport and agricultural machinery;
- Cross-border transfer of pollutants.

The most important pollutants resulting from these processes are: carbon, sulfur, nitrogen oxides, suspended particles, formaldehyde, benzo(a)pyrene, etc. Air pollution from fixed and mobile sources is not uniform. The degree of pollution of urban air space is higher than that of rural

air space due to the existence of major industrial enterprises, thermal and thermal facilities and heavy traffic in cities.

In the Republic of Moldova, a higher concentration of pollutants is observed only in the Chisinau municipality and near large power plants. However, the general air pollution situation in Moldova has proven to be favorable, especially in comparison with other European countries, including Ukraine, Romania and others. The national air monitoring system is updated daily, using information from only 17 monitoring stations, not being fully covered. Thus, the municipalities of Chisinau, Balti, Bender, Tiraspol and Ribnita are covered by the respective monitoring system, and 2 other automatic monitoring stations are located in Rezina and Leova.

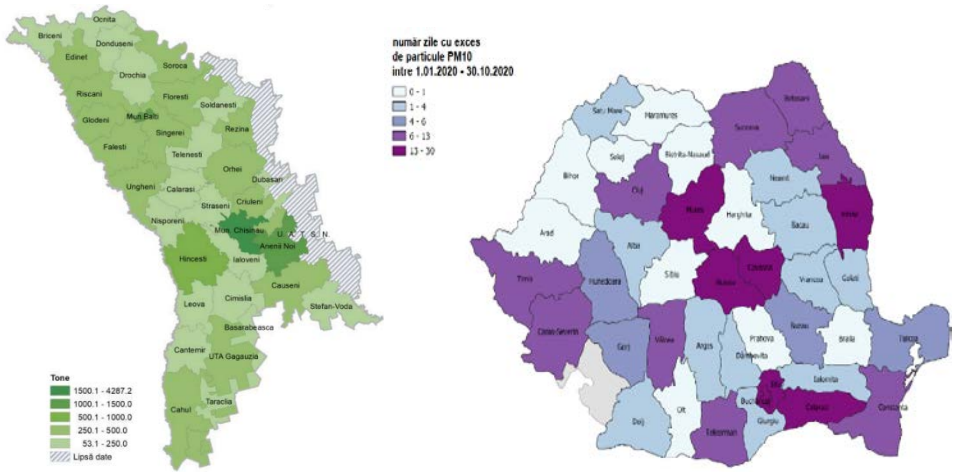

Figure 46. Emission of pollutants into the atmospheric air from stationary sources of economic entities in the Republic of Moldova and Romania, during 2020
Source: developed by the authors based on data provided by (NBS, 2021

The most important greenhouse gas in the atmosphere is water vapor (H2O), responsible for approximately 2/3 of the total greenhouse effect. The water content in the atmosphere is not directly influenced by anthropogenic activities, being determined rather by the natural water cycle, expressed more simply as a difference between evaporation and precipitation. Carbon dioxide (CO2) is responsible for the greenhouse effect in a proportion of 30%, and methane (CH4), nitrous oxide (N2O) and ozone (O3), all three in a proportion of 3%. In the Republic of Moldova, from 1750 to the end of 2021, the CO2 concentration increased by about 148.4%, the CH4 concentration – by 264.2%, and the N2O concentration by about 123.9%, (Tab.2). These trends can be largely attributed to human activities, especially the burning of fossil fuels and the continued deforestation of forested areas.

Table 10. Tropospheric concentration (in the Northern Hemisphere), rate of change in concentration and tropospheric lifetime of direct greenhouse gases

Greenhouse gases	Pre-industrial Tropospheric Concentration (1850-1900)	Tropospheric Concentration at the end of 2021 Global Warming	Potential for a 100-year horizon (IPCC, 2014) Tropospheric	Lifetime (years)
Carbon dioxide (CO2)	280 ppm	415,7ppb	1	50-200
Methane (CH4)	722ppb	1907,2ppb	28	12,4
Nitrous oxide (N2O)	270ppb	334,6ppb	265	121

Notes: ppm - concentration in parts per million volume; ppb - concentration in parts per billion volume

Source: (National Inventory Report, 2022)

Therefore, the air in the Republic of Moldova is polluted above the permissible standards due to emissions from the transport sector. On average, the transport sector accounts for 95% of the total volume of harmful substances emitted into the air.

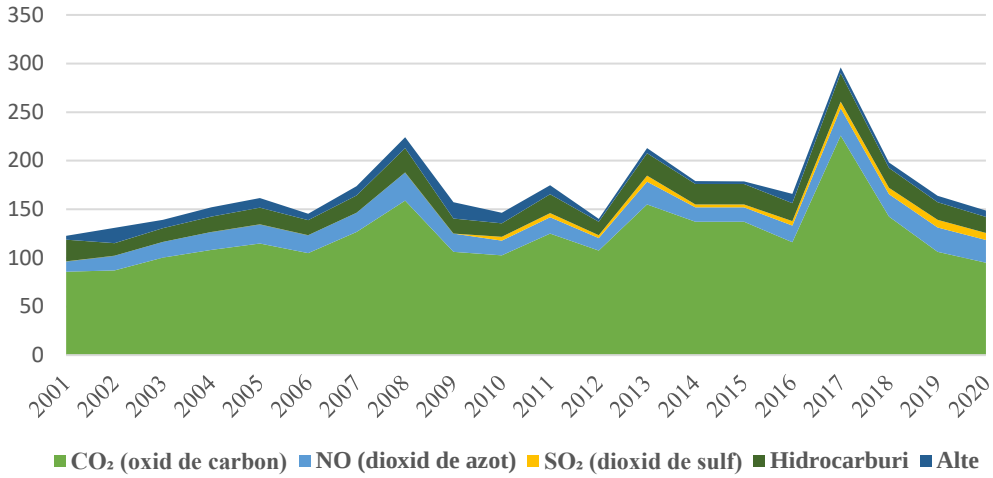

Figure 47. Emissions of pollutants into the atmospheric air from road transport, thousand tons/year

Source: developed by the authors based on data provided by (NBS, 2021)

According to statistical data provided by the National Bureau of Statistics, in 2020, over 95 thousand tons of CO_2 (carbon monoxide) were emitted into the atmospheric air from road transport, or 7.8 thousand tons less than in 2010. Accordingly, hydrocarbons and sulfur dioxide also increased by 1.5 times in 2020 compared to 2010.

In the period 1990-2020, the dynamics of total direct greenhouse gas emissions, expressed in CO2 equivalent, revealed a decreasing trend in the Republic of Moldova, reducing by about 69.8%: from 45,248 Mt CO2 equivalent in 1990 to 13,662 Mt CO2 equivalent in 2020, net direct greenhouse gas emissions decreased in the same period by about 68.7%: from 43,591 Mt CO2 equivalent in 1990 up to 13,658 Mt CO2 equivalent in 2020. Carbon dioxide contributes the most to total direct greenhouse gas emissions in the Republic of Moldova. Figure 3 shows how the share of direct greenhouse gases in the structure of total national GHG emissions varied in the years 1990 and 2020.

The notion of a GHG inventory would represent "*a complex register of anthropogenic sources of emissions by source categories, respectively of sources of sequestration by storage categories, originating from a certain territory in a fixed period*". Thus, a GHG inventory should be developed by using direct measurements of emissions and sequestrations originating from individual categories of sources or sequestration in the country, considering the "bottom-up" methodological approach.

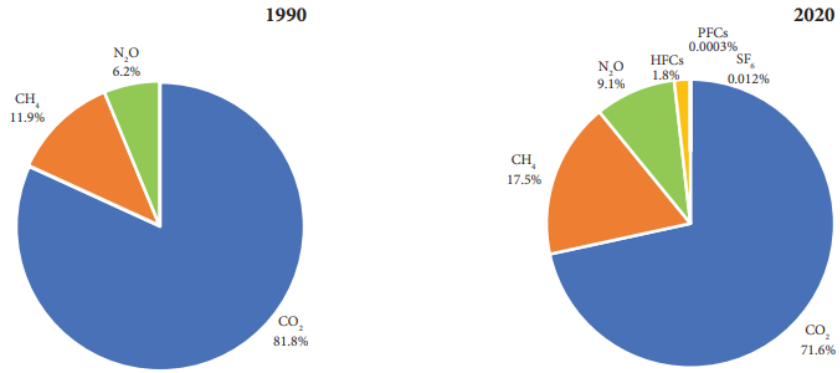

Figure 48. Share of direct greenhouse gases in the structure of total GHG emissions in the Republic of Moldova in 1990 and 2020
Source: (National Inventory Report, 2022)

According to statistical data provided by the National Bureau of Statistics, nitrogen dioxide concentrations in Moldova are generally low. This air pollutant comes mainly from cars and other motor vehicles, as well as oil and metal refining, electricity generation, light and food industry. It affects the respiratory system's resistance to bacterial and viral infections. The highest values were recorded in Chisinau and around the border with Ukraine, especially where the Cuciurgan power plant is located, as well as around the municipalities of Tiraspol and Ribnita. The regions of Chisinau, Bender and Balti have the highest average levels of nitrogen dioxide pollution.

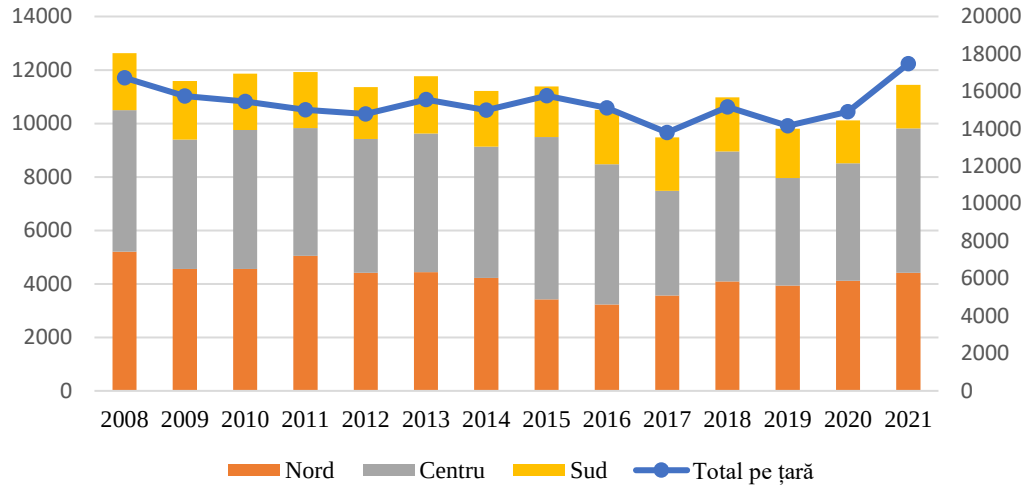

Figure 49. Emissions of pollutants into the atmospheric air from stationary sources of economic agents in territorial profile, thousand tons/year
Source: developed by the authors based on data provided by (NBS, 2021)

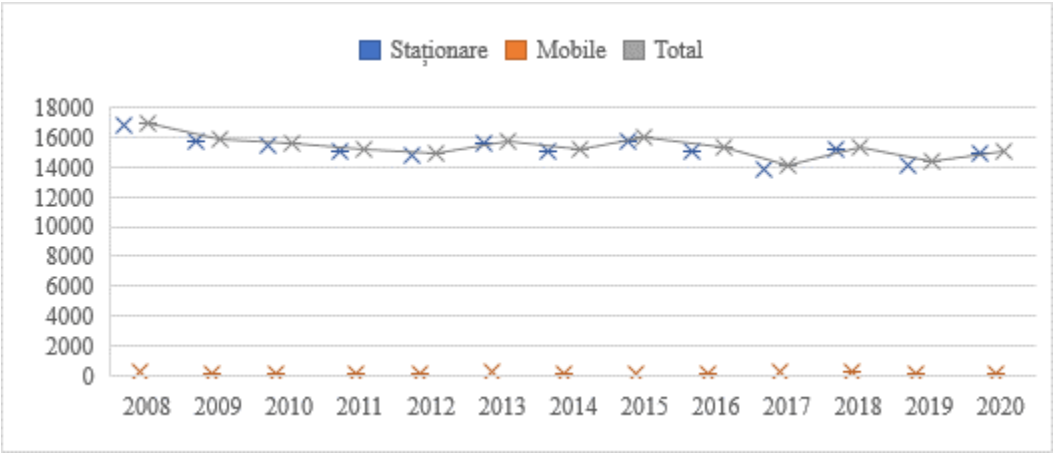

Figure 50. Total emissions of main pollutants from stationary and mobile sources, thousand tons/year, %
Source: developed by the authors based on data provided by (NBS, 2021)

Between 2009 and 2020, the total volume of emissions into the atmosphere was halved: from 15,744 to 15,053 thousand tons annually. However, there are differences between the evolution of emissions from stationary and mobile sources. These sources emit large quantities of hydrocarbons, carbon oxides, nitrogen and sulfur oxides, etc., depending on various factors: the quality of the fuel used, the technical condition of the vehicles, the number of transport units operated, etc.

Emissions from stationary sources increased until 2016, after which they recorded a slight decrease, while emissions from mobile sources reached their maximum value in 2018, after which they recorded decreases to 148.7 thousand tons per year.

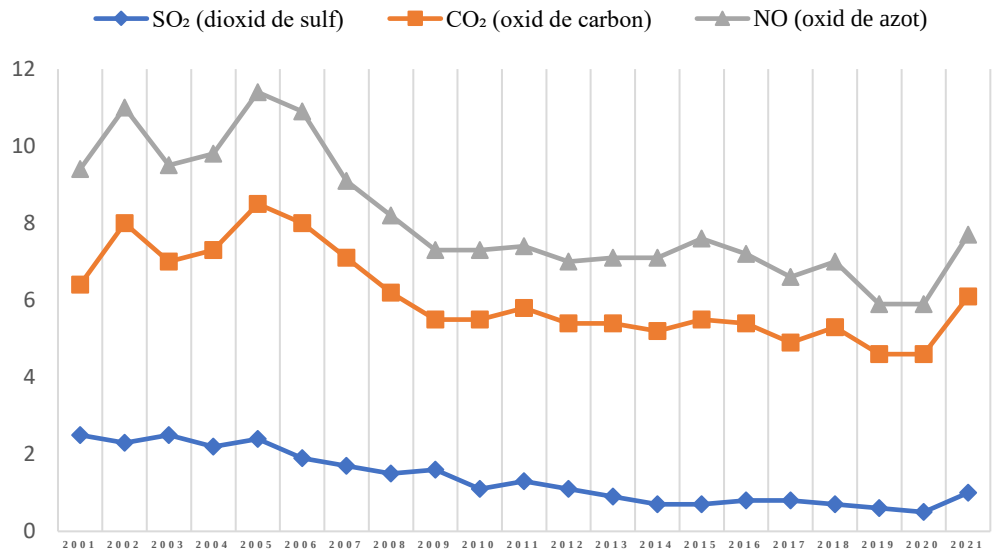

Figure 51. Total emissions of main pollutants from stationary and mobile sources, thousand tons/year

Source: developed by the authors based on data provided by (NBS, 2021)

The greenhouse gas emissions assessment was carried out for five sectors: (1) “Energy”, (2) “Industrial processes and product use”, (3) “Agriculture”, (4) “Land use, land-use change and forestry” (LULUCF) and (5) “Waste”. The interpretation of the results of the GHG emissions inventory within the “LULUCF” sector is somewhat different from the others: positive numbers indicate that the sector is a net source of emissions, and negative numbers establish that the sector is a net source of carbon sequestration.

During the period 1990-2020, total GHG emissions had a decreasing trend, thus, emissions from the "Energy" sector decreased by about 74.2%, those from the "Industrial processes and product use" sector - by about 37.8%, from the "Agriculture" sector - by 69.5%, from the "FTSCFTS" sector - by 99.8%, and those from the "Waste" sector - by 0.4% (Tab. 13).

Table 11. Dynamics of direct greenhouse gas emissions in the Republic of Moldova by sectors, in the period 1990-2020, Mt CO2 equivalent

Sectors:	2015	2016	2017	2018	2019	2020
1. Energy	9.1196	9.2566	8.9249	9.4069	9.4014	9.5499
2. Industrial processes and product use	0.7651	0.7469	0.7797	0.9647	0.9912	0.9988
3. Agriculture	1.7012	1.8267	1.8817	1.8373	1.7987	1.5464
4. FTSCFTS	-1.1819	-0.9375	-0.9933	-0.8411	0.0133	-0.0035
5. Waste	1.4232	1.4499	1.5394	1.5552	1.5605	1.5666

Source: (National Inventory Report, 2022)

The "Energy" sector represents the most important source of total national direct greenhouse gas emissions, its share varying during the period 1990-2020 between 81.8% and 69.9%. Other relevant sources of direct greenhouse gas emissions are represented by the "Agriculture", "Waste" and "Industrial processes and product use" sectors (Fig. 7). Therefore, with the exception of 2019, the "FTSCFTS" sector represented a net source of carbon sequestration. With the decrease in direct greenhouse gas emissions at the national level, the relevance of this sector in the structure of net greenhouse gas emissions at the national level demonstrated a similar trend: in 1990, about 3.7% of total GHG emissions at the national level were sequestered, while in 2020 only 0.03% of total GHG emissions at the national level.

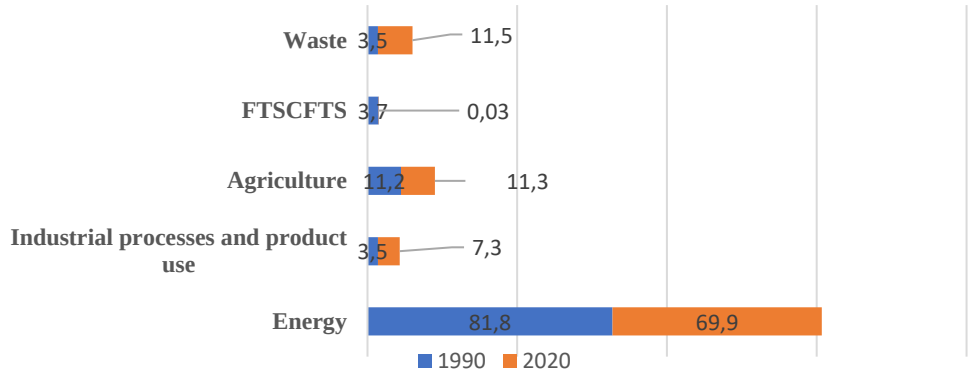

Figure 52. Share of different sectors in the structure of total national GHG emissions in the Republic of Moldova in 1990 and 2020
Source: (National Inventory Report, 2022)

During the period 2001-2021, several specific substances were discharged into the atmospheric air from stationary sources of economic agents. Thus, persistent organic pollutants increased 83 times: from 0.3 thousand tons in 2002 to 25 thousand tons in 2021. Metals and compounds such as lead increased 2.3 times in 2021 compared to 2001. Ammonia also

registered increases of 130% in 2021 from 35.7 thousand tons in 2021 to 82.2 thousand tons in 2021. Substances such as: Xylene, Styrene and Toluene registered decreases in 2021 compared to 2001.

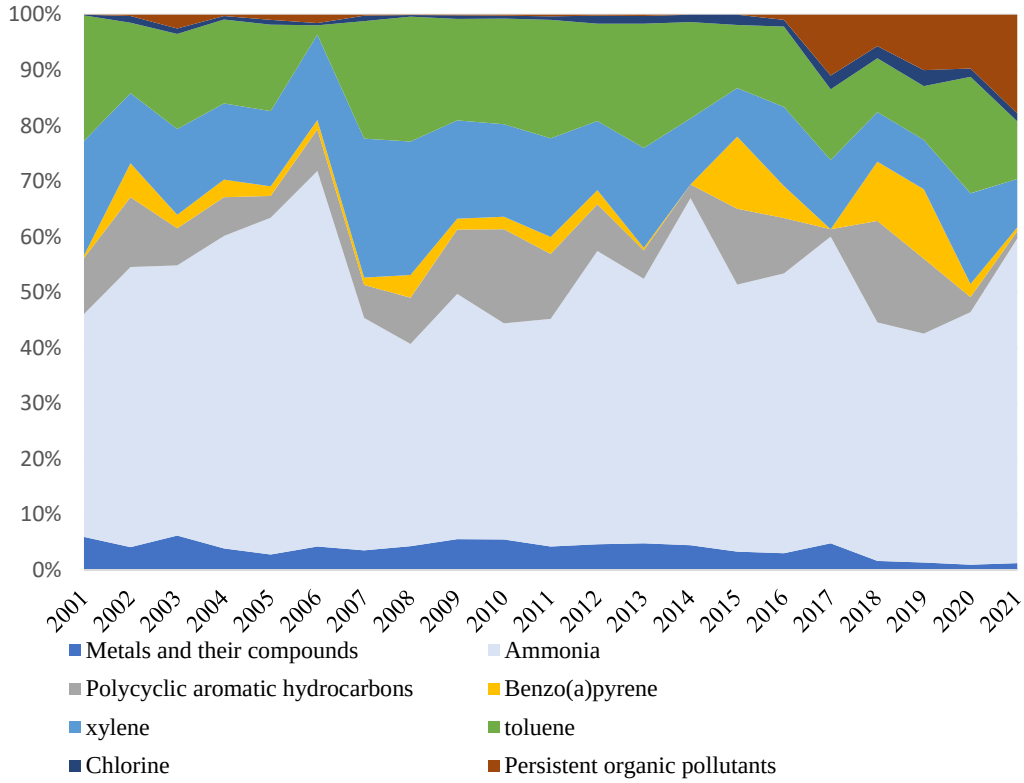

Figure 53. Emissions of specific pollutants into the atmospheric air by stationary sources of economic agents, thousand tons/year

Source: developed by the authors based on data provided by (NBS, 2021)

Photochemically active gases, such as carbon monoxide (CO), nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOCs), are not considered greenhouse gases, but they contribute indirectly to the greenhouse effect in the atmosphere. All these gases are classified as precursors of ozone in the atmosphere, influencing the formation and disintegration of ozone in the atmosphere. They mainly persist in exhaust gases generated by transport units, but also come from the combustion of fossil fuels at stationary sources, from the use of solvents and other household products, etc.

Thus, emissions from the following ozone and aerosol precursor gases: Nox, CO, NMVOCs and SO2 were included in the national greenhouse gas inventory of the Republic of Moldova. During the period 1990-2020, total emissions of nitrogen oxides decreased by about 74.4%: from 95.55 kt in 1990

to 24.47 kt in 2020, total emissions of carbon monoxide decreased by about 49.3%: from 278.79 kt in 1990 to 141.37 kt in 2020, emissions of non-methane volatile organic compounds decreased by about 21.2%: from 141.57 kt in 1990 to 111.56 kt in 2020, and emissions of sulfur dioxide decreased by about 97.1%: from 150.11 kt in 1990 to 4.29 kt in 2020 (Tab. 14).

Table 12. Dynamics of indirect greenhouse gas emissions (NO, CO and NMVOCs) and SO2 in the Republic of Moldova, during 1990-2020, kt

	1990	1995	2000	2005	2010	2015	2020
NO_2	95,5512	30,8466	14,8007	19,9620	21,4697	21,8663	24,4709
CO	278,7930	76,6445	39,9908	54,4534	53,0984	86,7007	141,3672
COVNM	141,5732	46,5154	22,9213	42,1519	40,8386	54,1274	111,5648
SO_2	150,1134	31,9788	4,5137	5,1861	5,3806	4,8979	4,2932

Source: (National Inventory Report, 2022)

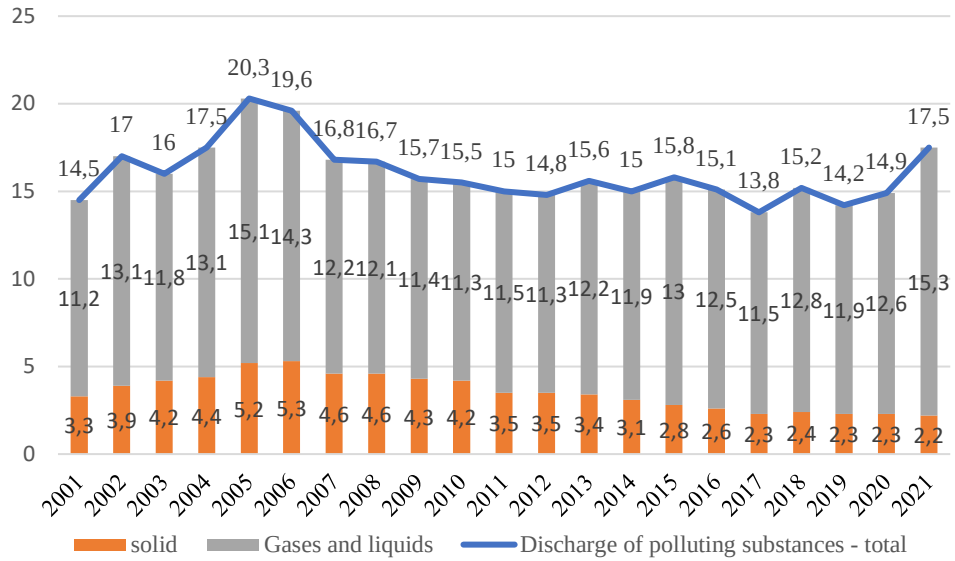

Figure 54. Assessment of pollutants in the atmospheric air from stationary sources of economic agents by ingredients in the Republic of Moldova, thousand tons

Source: developed by the author based on data provided by (NBS, 2021)

According to the assessment of pollutants in the atmospheric air from stationary sources of economic agents, gaseous and liquid substances increased to 15.3 thousand tons in 2021 or by 36.6% compared to 2021. And solid substances decreased by 1.1 times in 2021 compared to 2001. In total, in 2021,

over 17.5 thousand tons of pollutants were discharged, 21% more than in 2001. Respectively, in 2005, the most substances were discharged, around 20.3 thousand tons (Fig. 68). According to the structure of pollutants from liquid and gaseous substances, they are: carbon monoxide, sulfur dioxide, nitrogen oxide, hydrocarbons, volatile organic compounds, etc.

The amount of pollutants captured (neutralized) includes all types of pollutants captured (neutralized) at dust capture (gas purification) facilities from the total volume of pollutants emitted by stationary sources. In 2021, around 96.4 thousand tons of pollutants formed at stationary sources of atmospheric air pollution of economic agents were captured by purification facilities, down by 19.5% compared to 2010. The highest level of pollutants captured was recorded in 2013 – 194.7 thousand tons.

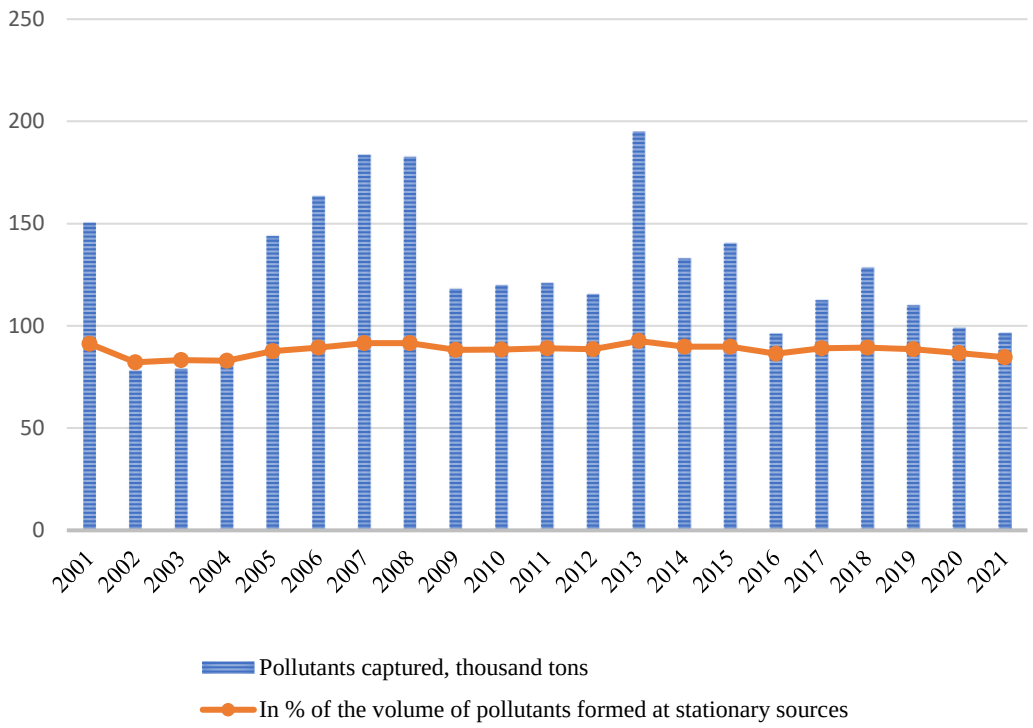

Figure 55. Capture by treatment facilities of pollutants formed at stationary sources of atmospheric air of economic agents, thousand tons/year
Source: developed by the authors based on data provided by (NBS, 2021).

SWOT Analysis

In carrying out the analysis of diagnosing trends and air quality in the field of the environment in the Republic of Moldova, the SWOT analysis is presented in the table below.

Strengths:

- Temperate continental climate with moderate temperatures on average 15-17 degrees C;
- The general situation of air pollution in Moldova is favorable, compared to neighboring countries;
- Assessment of air quality based on the inventory of pollutants emitted into the atmosphere;
- Development of parks and green spaces in the Chisinau municipality;
- Increasing the number of thermally insulated blocks of flats;
- Citizens' interest in reducing energy costs.

Weak points:

- The national air monitoring system is updated daily, using information from only 17 monitoring stations, not being fully covered.
- Degradation of air quality 162lan t anthropogenic activities but also non-compliance with climate and environmental legislation;
- Lack of investment in non-polluting technologies;
- Polluting means of transport and cars;
- Lack of a consistent system of collection and transport separate from the flow of household waste;
- Loss of confidence of the urban population in the separate collection of packaging waste, etc.;
- Burning of vegetation and waste;
- Non-compliance with existing regulations for protected natural areas;
- Reduction of green areas in cities as a result of the construction of apartment blocks;
- Irresponsibility of citizens who do not respect or do not care about the environment.

Threats:

- The CO2 concentration increased by about 148.4%, the CH4 concentration – by 264.2%, and the N2O concentration by about 123.9%, from 1750 to the end of 2021, these trends can be attributed, in particular, to the burning of fossil fuels and the continuous deforestation of forested areas;
- the air is polluted above the permissible norms determined by emissions from the transport sector, on average the transport sector accounts for 95% of the total volume of harmful substances emitted into the air;
- the highest average levels of nitrogen dioxide pollution – Chisinau and around the border with Ukraine, especially where the Cuciurgan power 162lan tis located, as well as around the municipalities of Tiraspol and Ribnita, Bender and Balti regions;
- Related legislation not correlated with environmental legislation;
- Extreme phenomena generated by climate change that cause material damage;

- Irrational use of water resources and pollution of surface and groundwater sources;
- Increase in the area of degraded land resulting from anthropogenic activities, including deforestation;
- Increase in the level of urban pollution;
- The emergence of excessive construction or excessive urbanization without respecting the required area of green space per capita;
- Non-selective waste collection;
- Minimal information on the importance of quality;
- the environment among citizens
- Changing the mentality of public opinion;
- Insufficient funds;
- Increase in the level of atmospheric pollutants originating from the road transport sector;
- Insufficient use of renewable energy resources.

Opportunities:

- Harmonization of environmental legislation with EU legislation;
- Emissions from stationary and mobile sources have decreased by up to 148.7 thousand tons per year;
- Existence of industrial parks or the possibility of creating new industrial zones that can attract investments in green technologies;
- Involvement of local authorities, institutions and NGOs in achieving environmental protection;
- Continuous promotion of the need for selective waste collection among citizens;
- Allocation of EU funds for environmental protection;
- Reduction of carbon emissions by improving the energy efficiency of buildings, transport systems and production processes;
- Conservation of biodiversity in protected natural areas through appropriate and efficient management;
- Promotion of the use of energy from renewable sources;
- Increasing the level of information, awareness and education of the population in order to involve them in the rational management of environmental problems.

The realization of the potential for GHG mitigation in the Republic of Moldova depends largely on how the barriers to the implementation of carbon reduction and sequestration actions can be overcome. The financial, technical and capacity constraints specific to each sector are described in the Environmental Strategy for 2014-2023, the Low Emission Development Program (PDER – 2030) and the Action Plan for its implementation.

Therefore, the current state of air quality, sectoral problems and the need for air protection require the development of measures to reduce pollutant

emissions at source, as well as directions of action to avoid, prevent or reduce the impact of air pollution on environmental components, ecosystems and human health, including in the context of fulfilling the commitments of the Republic of Moldova regarding the ratification of international treaties.

- ✔ Creating an integrated air quality management system:
- ✔ Delimitation of the territory of the Republic of Moldova into zones or agglomerations reflecting their level of pollution;
- ✔ Stationary sources, installations or activities that generate emissions of pollutants into the atmosphere will be inventoried and classified into three categories depending on the level of pollutant emissions: large, medium and small;
- ✔ Temporary tolerance margins will be added for zones and agglomerations where the concentration of pollutants in ambient air exceeds target values or air quality limits;
- ✔ If necessary, air quality plans will be developed, following the plans and programs for the rehabilitation of environmental quality. These plans will be provided at the stage of issuing environmental permits;
- ✔ Harmonization of national legislation on air quality with EU legislation and standards.

The rules on emission limits for air pollutants are outdated and do not meet EU standards. Permissible limit values for air emissions of major pollutants should be introduced gradually, starting with large thermal and power plants and progressively extended to other pollution sources and pollutants. In addition, pollution charges have no deterrent effect on pollutants and are applied to too many substances. For these reasons, the system needs to be revised. The amount of payments for emissions of major pollutants should also be increased.

- ✔ Air quality management problems:
- ✔ The existing legislative framework in the field of atmospheric air does not correspond to the provisions of European Union legislation and international treaties in the field (outdated, obsolete);
- ✔ Lack of a sectoral policy document in the field of air quality assessment and management;
- ✔ Lack of a National Integrated Air Quality Assessment and Management System;
- ✔ Lack of a system for estimating and forecasting emissions, as well as for assessing the quality of estimates;
- ✔ The emission inventory system is not well designed/organized, including the system for Quality Control (QC) and Quality Assurance (QA) of data is not developed;

- ✔ Absence of national emission ceilings;
- ✔ Excessive air pollution from mobile sources;
- ✔ Industrial enterprises use outdated installations and equipment;
- ✔ Use of low-quality fuels;
- ✔ Air quality approaches and standards are outdated and have not yet been brought into line with those of the EU.

Following the above, the authorities of the Republic of Moldova are tasked with implementing the following lines of action:
- improving the system of integrated monitoring, assessment and management of air quality;
- improving the air quality forecasting system, which will provide data on a possible deterioration in its quality (affected area, frequency, degree of impact on population health);
- developing and/or updating air quality management plans and/or programs;
- promoting the best available techniques (BAT);
- controlling pollutant emissions and pollution levels by applying techniques and technologies for pollutant retention and/or by introducing less polluting technologies;
- measuring (monitoring), as appropriate, pollutant emissions;
- developing and implementing measures to temporarily reduce pollutant emissions at some major sources;
- permanent identification of new sources generating atmospheric pollutants, assessing their contribution to the existing level of air pollution and ensuring compliance with air quality objectives for new activities/installations;
- introduction/use of fuels and motor fuels that generate reduced pollutant emissions;
- limitation/exclusion of the use of equipment and products containing substances that destroy the ozone layer;
- development of measures aimed at reducing greenhouse gas emissions, including by valorizing energy from non-traditional sources;
- reduction of the amount of biodegradable waste deposited;
- development and implementation of medium and long-term plans, at national, regional and local levels, for the continuous reduction of pollutant emissions into the atmosphere in all areas of activity;
- reduction of pollutant emissions generated by road traffic by improving the technical condition of vehicles in circulation and adopting fiscal measures that would favor the replacement of old vehicles in circulation, with high pollutant emissions, with new vehicles with low levels of pollutant emissions.

The implementation of strategic objectives in the field of atmosphere protection, included in European legislation, transposed into national legislation, as well as the obligations arising from international conventions

and treaties to which the Republic of Moldova is a party, involves institutional and financial efforts.

Following the above, the capitalization of the potential for mitigating GHG emissions in the Republic of Moldova depends largely on how the barriers that stand in the way of implementing actions to reduce and sequester carbon emissions could be overcome. The financial, technical and capacity constraints specific to each sector are described in the Environmental Strategy for 2014-2023, the Low Emission Development Program (LEDP – 2030) and the Action Plan for its implementation. As a result of the above, we note that important steps are being taken in the Republic of Moldova towards the transition to a circular economy and international practices have begun to be successfully implemented in our country (Popa V., 2023).

Waste digitization – a cleaner future for the Republic of Moldova

Digitalization is a useful and current process in all EU countries. This intelligent system allows both citizens and local public administrations to have concrete, measurable data on the volume of waste and the degree of selective collection. By placing large-volume containers, correctly sized for the number of inhabitants, allowing access only to residents. Thanks to these platforms located in special areas, the blocks of flats will be much tidier and cleaner. With this solution, each town hall in the locality will be able to monitor the total volume of waste and the degree of selective collection for each family, thus being able to calculate the sanitation fee on the quantities actually stored.

For more efficient waste management, in 2018 the Government of the Republic of Moldova approved the Concept of the Automated Information System „Waste Management". The document provides for the accumulation of information about waste in an electronic register, which ensures the record of the waste circuit produced and collected, including data on the export, import, reuse and disposal of waste. The information for completing the register is provided by authorized economic agents in the field of waste management. The digitalization of information aims to improve the activity of operators in the sector. The database on waste management can be accessed by public authorities, entrepreneurs and individuals. This system facilitates the exchange of information between relevant public authorities, as well as with the European Environment Agency. The creation of the information resource facilitates the implementation of the European Classification on the List of Waste, including hazardous waste, which allows the collection and processing of data on waste records according to codes established in the EU.

For any locality, waste management is an important part of building the city of the future, but it is very often neglected in digitalization projects. Existing "simple" solutions are already outdated – cities are growing rapidly and generating more and more waste, and the built infrastructure does not

allow for the integration of smart solutions into processes. Many localities are experiencing difficulties with timely garbage disposal, while others need solutions to improve service productivity. Some waste containers fill up faster than others, some areas are more difficult to access for garbage trucks, and some companies need specific collection and transportation services. There are good examples of solving these problems and implementing them in various localities (IORDACHI, V., POPA, V., POPA, N., 2022).

Figure 56. Digitalization of waste through IoT (Internet of Things) smart sensors
Source: developed by the author

One example is smart IoT (Internet of Things) sensors, which allow city administrations to optimize container distribution. Monitoring the filling level and type of waste is an easy task with the help of smart sensors. They can be installed in any type of garbage container and are resistant to daily use. Smart sensors provide real-time container monitoring and are an important step in eliminating the problems related to overflowing containers.

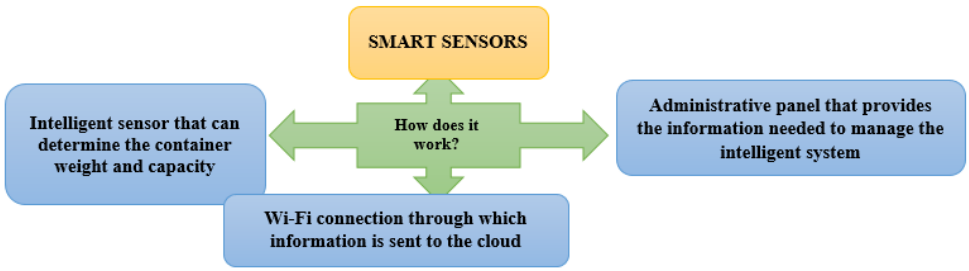

Figure 57. Functionality of smart waste sensors
Source: developed by the author.

Real-time information collection allows for the creation of detailed reports. Reliable and up-to-date statistics are available at any time and the city administration can use them to make informed decisions on how to optimize the system: areas that need more containers or more frequent collection,

optimization of the collection schedule, redistribution of available resources and more. Each garbage truck, container and landfill is an important part of the waste management ecosystem. Therefore, their optimal use is very essential for the productivity of the entire process. Cloud technologies, IoT sensors and an intuitive management platform help create the optimal route for each truck on a daily basis, directing it exactly where and when it is needed, based on the optimal route between the containers and the landfill. This creates the prerequisites for reducing the price and improving the efficiency of the system. Modern cloud technologies and real-time data work together, which allows for remote waste management. This would be a good example to implement for localities in the Republic of Moldova.

7.2. The impact of waste on the environment

The challenge of sustainable development is to identify the optimal interaction between the economic, human, environmental and technological systems in a dynamic and flexible process of functioning. Sustainability must be applied to all subsystems that make up the dimensions of sustainable development, i.e. starting from energy, agriculture, industry and up to investments, human settlements and biodiversity. The concept of sustainable development requires that environmental protection be harmonized with economic and social development. In these conditions, the connection between the need for economic, social development and environmental protection is essential.

According to EU legislation, the rational use of natural resources was one of the first environmental concerns underlying the first European treaties. The Roadmap to a Resource Efficient Europe (COM (2011)0571) is one of the key initiatives of the 7th Environment Action Programme (EAP). One of the main objectives is to unlock the EU's economic potential for better productivity with fewer resources, towards a circular economy. In addition, the recent Circular Economy Package includes measures that will help boost the EU's transition to a circular economy by increasing recycling and reuse, while also boosting global competitiveness, promoting sustainable economic growth and creating new jobs.

Specific policies address the different elements of the circular economy paradigm. In the case of resource efficiency, these include the Roadmap to a Resource Efficient Europe and the Roadmap for moving to a low-carbon economy (EU Strategy, 2050).

In this context, the European Union, through the Resource Efficiency Roadmap, takes into account the progress made under the 2005 Thematic Strategy on the Sustainable Use of Natural Resources (COM(2005)0670) and the EU Sustainable Development Strategy and sets a framework for planning

and implementing further actions. It also defines the structural and technological changes needed by 2050, including intermediate targets to be achieved by 2020. It proposes ways to increase resource productivity and decouple economic growth from resource use and its environmental impact. (EU, 2020)

By 2050, ambitious polices for resource efficiency could reduce global resource requirements by about a quarter and deliver global economic growth of 3 to 5 per cent above the existing trend. This would also have considerable co-benefits for climate mitigation efforts. (UNEP, 2017)

Resource efficiency policies and initiatives could:

- reduce natural resource use globally by 26 percent by 2050, in combination with ambitious global action on climate change, as well as stabilizing per capita resource use at current levels in high-income countries;
- reduce greenhouse gas emissions by an additional 15 to 20 per cent by 2050 (for a given set of greenhouse policies), with global emissions in 2050 falling to 63 per cent below 2010 levels, and emissions in high-income countries in 2050 falling to 74 per cent below 2010 levels;
- more than offset the economic costs of ambitious climate action, so that income is higher and economic growth is stronger than in the 'existing trends' scenario;
- deliver annual economic benefits of USD $2 trillion globally by 2050 relative to existing trends, including benefits of USD $520 billion in high-income nations, while also helping put the world on track to limit climate change to 2°C or lower. (EU, 2020).

According to the report The European Environment - state and outlook 2020 (EEA, 2020), produced by the European Environment Agency, the EU environmental and climate policy landscape aims to address the short-, medium- and long-term time horizons through a range of policies, strategies and instruments that increasingly connect the environmental, social and economic dimensions of sustainability (Figure 71). However, the ambition of the 7th EAP vision and frameworks such as the low-carbon economy, the circular economy and the bioeconomy is such that it implies fundamental societal transitions to transform key production-consumption systems. While political interventions can trigger the change needed, such ambition will inevitably question our collective ways of living and thinking. One positive sign is the increasing awareness and concern around environmental and climate challenges across society.

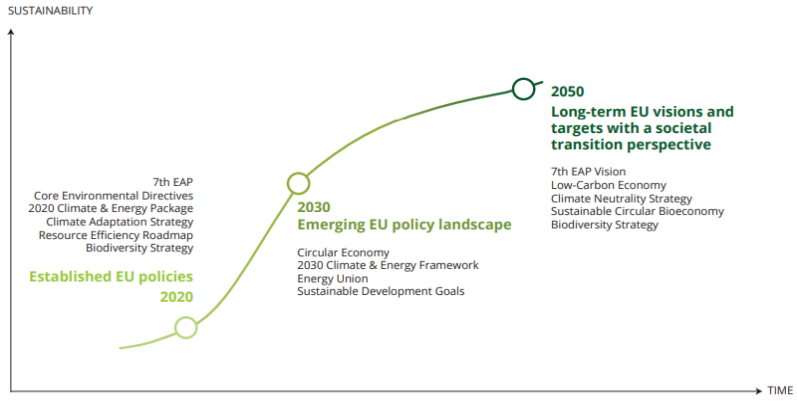

Figure 58. The emerging EU environmental and climate policy landscape
Source: (EEA, 2020)

The Republic of Moldova has made less progress in terms of transparency of environmental, climate assessments and towards efficient resource use in recent decades. However, the most important factor causing climate change and damaging the environment is inextricably linked to economic activities and lifestyles, especially societal systems that provide people with basic necessities such as food, energy and mobility. Therefore, society's use of resources and pollution have complex links with jobs and earnings along the value chain, with major investments in infrastructure, equipment, skills and knowledge, with people's behaviors and lifestyles, as well as with public policies and institutions.

The most important measures to mitigate climate change are reflected in strategic documents at national and international levels. According to the 2015 Paris Agreement, ratified by the Republic of Moldova by Law no. 78/201757, an action plan was established to limit global warming to below 2°C. In order to achieve the objective of the Paris Agreement, 2015, all signatory Parties to it are to communicate to the UNFCCC, through Nationally Determined Contributions (NDCs), about the efforts undertaken at national level to reduce GHG emissions. The Republic of Moldova submitted its first NDC to the UNFCCC on 25 September 2015.

Thus, following the above, the Republic of Moldova has committed to achieving more ambitious GHG emission reduction targets by 2030. Thus, the unconditional target is to increase from 64-67% to 70% compared to the level recorded in the reference year (1990), and the conditional target will advance accordingly from 78% to about 88% compared to the level recorded in 1990. The new GHG emission reduction targets will be introduced in the Low Emission Development Program of the Republic of Moldova until 2030 and the Action Plan for its implementation.

Table 13. Sectoral GHG emission reduction targets,%

	Until the year 2025		Until the year 2030	
Sectors:	unconditional	conditional	unconditional	conditional
Energy	83	87	81	87
Transport	56	58	52	55
Buildings	76	78	74	77
Industry	34	37	27	31
Agriculture	48	50	44	47

Source: (National Inventory Report, 2022)

However, the country's most important strategic planning document is the National Development Strategy "Moldova 2030", which includes among its priorities the development of a sustainable and green economy, as well as adaptation to climate change in all economic sectors.

The vision outlined in Moldova 2030 is anchored in two strategic international commitments. The first is the Association Agreement with the European Union, signed in 2014, and the second major international commitment is outlined in the 2030 Agenda for Sustainable Development. Namely, Sustainable Development Goal (SDG) 8.4, localized by the Government of the Republic of Moldova in 2017, specifies that the authorities commit to progressively improving, by 2030, resource efficiency in consumption and production processes in order to decouple economic growth from environmental degradation. In addition, SDG 12 is dedicated to responsible consumption and production. Thus, in accordance with the commitments, Moldova will fully incorporate the principles of sustainable development and efficient management of national resources in the development of national policies and regulations. Meanwhile, it will encourage industries and enterprises to adopt resource-efficient production and share responsibility for the disposal of toxic waste and pollutants.

Progress on the implementation of the 2030 Agenda was assessed in 2020 in the framework of the first Voluntary National Assessment Report on the Implementation of the 2030 Agenda for Sustainable Development (Government of the Republic of Moldova, 2020). Despite some progress, the review found many shortcomings. In particular, the field of environmental protection faces a lack of institutional capacity and funding from the state budget, as the financial resources available each year for environmental protection are clearly lower than those needed to address the existing challenges; sectoral strategies and programs estimate the cost at hundreds of millions of euros. Therefore, it is quite important to reassess funding in this area and streamline budget allocations so that financial resources are used transparently and in accordance with the priorities set in policy documents for environmental protection and promotion of the green economy.

Thus, the main sectoral policy planning document –the Environmental Strategy for 2014-23 (Government of the Republic of Moldova, 2014) – lists as one of its priorities the integration of the principles of sustainable and ecological economy in all economic sectors. The Ministry of Environment periodically monitors and evaluates this Strategy.

The Republic of Moldova, like many other countries, faces challenges in the field of resource efficiency, having limited natural resources. According to the OCDE indicators on green growth, the most important indicators regarding the natural resource base of the Republic of Moldova are:

Land resources. The Republic of Moldova has a unique land fund, which is distinguished by the predominance of chernozem soils, with high productivity potential, very high degree of valorization (>75%) and rugged terrain: over 80% of agricultural land is located on slopes. According to statistical data provided by the National Statistical Office, as of January 1, 2020, the total land area was 3384.7 thousand ha (NSO, 2021), including 2492.1 thousand ha (73.6%) - agricultural land; of which 1841.9 thousand ha (54.4%) - arable land, 283.5 thousand ha (8.4%) - perennial plantations; 339.9 thousand ha (10.1%) - hayfields and pastures; 26.7 thousand ha (0.7%) - fallow; 467.5 thousand ha (13.8%) – forests and lands with forest vegetation; 96.4 thousand ha (2.9%) – rivers, lakes, basins and ponds and 328.7 thousand ha (9.7%) – other lands. The extremely high degree of land use in agriculture requires rational use, improvement and protection of soils against erosion, landslides and other consequences of reckless human interventions.

Table 14. Distribution of land fund by land categories in the Republic of Moldova during 1992-2020, thousand ha

	2017	2018	2019	2020
Land – total, of which:	3384,6	3384,6	3384,7	3384,7
Agricultural land, of which:	2499,8	2496,4	2496,4	2492,1
Arable land	1827,3	1832,3	1838,5	1841,9
Perennial plantations	288,8	290,1	286,6	283,5
Forests and other land	465,3	466,3	467,2	467,5
Rivers, lakes, ponds and reservoirs	96,1	96,1	96,1	96,4
Other land	323,4	323,4	325,7	328,7

Source: (NBS, 2021)

Water resources. In the Republic of Moldova there are 3621 permanent or temporary rivers, streams and rivulets with a length of over 16 thousand km, 90% of which are less than 10 km long and only 9 exceed 100 km long. Large lakes, including for supplying hydroelectric power plants, were

created on the Prut River in collaboration with Romania – Costești-Stânca (59 km2), on the Dniester River – Dubăsari (67.5 km2), Cuciurgan (27.3 km2) and on the Bâc River – Ghidighici (8.8 km2). Approximately 40% of the rural population is supplied with water from underground layers with hydrostatic pressure, with about 4970 wells being recorded (in 2020, only 2614 wells were exploited, including for drinking water - 1666, for technical purposes - 662, for agricultural purposes - 47, for industrial purposes - 224, for curative purposes - 16), respectively, water supply also takes place from the first aquatic layer (without pressure), from about 178.7 thousand wells, of which 144.9 thousand wells are equipped, and 3,094 thousand springs, of which 2,060 thousand springs are equipped, which ensures about 1.8 million m3/day of confirmed reserves. Of the total amount of groundwater administered on the territory of the country, only 50% can be used for drinking purposes without prior treatment**.**

Forest resources. The country's afforestation rate in 2020 increased from 11.1 to 11.4%, with variations depending on the area: in the North – 7.2%, in the Center – 13.5% and in the South – 6.7%.

Biodiversity. The geographical location, climate and relief have determined the formation of a varied and species-rich vegetation – the flora of the Republic of Moldova currently includes about 5513 plant species: higher – 1989 species and lower – 3524 species. According to the floristic composition, the richest are forest ecosystems (over 850 species), steppe (over 600 species), meadow (about 650 species), petrophyte (about 250 species), aquatic and marsh (about 160 species). There are five scientific reserves in the Republic of Moldova with a total area of 19,497 thousand hectares. Two forest reserves – "Codrii" and "Plaiul Fagului" – are located in the center of Moldova; two others – "Prutul de Jos" and "Pădurea Domnească" – are located in the Prut River valley; the fifth reserve – "Iagorlâc" in Dubăsari district – aims to protect and study the unique aquatic ecosystem of the Dniester River

Organic farming. According to the Atlas of Organic Agriculture, at the end of 2020, 144 organic agricultural producers were active, processing an area of about 29.3 thousand hectares, or 1.4% of the country's agricultural area. However, certain statistical limitations must be taken into account, as official statistics sometimes do not include those producers who apply organic farming practices, but are not certified or are certified by foreign organizations. According to NBS data, the volume of agricultural production in 2020 amounted to about 30,061 billion lei (in current prices). The agricultural production volume index compared to 2019 decreased by 27.2%. The reduction in global agricultural production was determined by the decrease in crop production by 35.9% and livestock production by 3.8% (Șavga, L., Perciun, R., & Popa, V., 2023).

7.3. Green Instrument for Resource Efficiency and Cleaner Production (RECP)

To solve environmental problems in the Republic of Moldova, it is necessary to implement effective tools based on the increased application of environmental pollution prevention strategies to processes, products and services with the aim of increasing efficiency and reducing risks for the human factor and the environment. An effective tool is Resource Efficiency and Cleaner Production (RECP), which refers to the methods and practices of Cleaner Production as tools that generate multiple benefits relevant to solving global environmental problems. The RECP tool approach involves the integration of environmental policies to create appropriate incentives for actors in green enterprises. As part of the research, the author aims to conceptually study the RECP tool for enterprises in the Republic of Moldova, through the prism of existing programs and projects to produce sustainable effects in the future. This study was carried out within the framework of the State Program 20.80009.0807.22 Development of the mechanism for forming a circular economy in the Republic of Moldova.

Therefore, by implementing the RECP tool within enterprises, it is understood, the continuous application of preventive environmental strategies within processes and services to increase the efficiency of their consumption of materials, water and energy, their productivity and, therefore, their competitiveness. The application of RECP leads to a reduction in the volume of pollution and waste generated and reduces the dangers and risks for people and the environment (RECP, 2022).

In 2011, the Republic of Moldova initiated the implementation phase of the National Cleaner Production Program (PNPP), launched in 2012. The Program's goal is to promote and adopt the concept of resource efficiency and cleaner production (RECP). In the following year, 2013, the Republic of Moldova joined the Green Industry Platform. It promotes the creation of new green industries and supports existing industries in improving their contribution to economic development and social and environmental protection. This objective is achieved by providing a framework in which signatory organizations can develop, based on common tools, roadmaps for the integration of green industry policies and practices into organizational strategies and business plans, exchange practices to overcome the current situation and boost development, application and innovation within the Green Industry Initiative (EU4Environment, 2021).

Currently, the EU4Environment programme seeks to identify, train and mentor national experts in the field of RECP methods, applications and specialized topics related to resource efficiency. Thus, this programme seeks to increase the understanding of the practices and benefits of the circular

economy at national and regional level among small and medium-sized enterprises (SMEs), government entities and civil society. Therefore, these practices lead to improved resource productivity and environmental performance by demonstrating how to apply RECP methods in manufacturing industries.

In our view, implementing resource efficiency policies and cleaner production is only possible by adapting modern technologies within green enterprises, which aim to reduce the harmful impact on the environment and the population, and ensure a much higher profitability of companies. Through the new approaches implemented, each company aims to correctly manage waste management, which is the future of our planet. Only through technology will efficient results be achieved, such as saving raw materials and other material and financial resources.

The purpose of the research is to analyze the conceptual approach of the RECP tool - for an efficient and cleaner production of resources that would contribute to the reduction of waste and would contribute to the increase of the productivity of some companies through the process of reuse or recycling, which would have a contribution to the circular economy. By implementing RECP, industries can reduce the intensity of materials, energy and pollution per industrial production unit; thus reducing the overall ecological footprint, while simultaneously improving productivity and competitiveness.

According to the EU4Environment program, the RECP approach aims to facilitate the transition of industry to a circular economy, which promotes the prevention of waste generation as a primary priority and prepares enterprises to reuse or recover residues by reintroducing residues into the value chains of products. According to this objective, industrial waste mapping is applied as a tool that can help maintain the value of resources, preventing their transformation into waste. Industrial waste mapping assesses waste generated by manufacturing companies, assesses relevant waste management services and identifies opportunities to introduce circular economy practices such as prefabrication, recycling, industrial symbiosis and other recovery strategies to close resource loops. As part of this outcome, recommendations are developed and promoted on (EU4Environment, 2023).

In this context, according to the Programme on the Promotion of the "Green" Economy in the Republic of Moldova, Specific Objective 2, the United Nations Industrial Development Organization (UNIDO) provides professional and general support to the NPPP of the Republic of Moldova, in particular through the Cleaner and Sustainable Production Centre (EU4Environment, 2021). Currently, NPPP Moldova holds the status of observer member of the global network RECPnet and thus benefits from access to its resources. The Action Plan for the Republic of Moldova on Resource Efficiency and Cleaner Production (approved in 2016) has the following

general objective: enterprises and other economic entities in the Republic of Moldova are informed about RECP methods and practices and are encouraged, supported and rewarded by the Government for adapting and adopting RECP in their activity (RECPnet, 2023).

Thus, the notion of Resource Efficiency and Cleaner Production (RECP) refers to Cleaner Production methods and practices as tools that generate multiple benefits relevant to solving the following acute global problems:

- Migration of greenhouse gas emissions and adaptation to climate change;
- Attitude towards the depletion of water, fuel and other natural resources;
- Ensuring decent jobs;
- Stopping environmental degradation (NCPP, 2017).

Following the above, the RECP concept is based on the increased application of environmental pollution prevention strategies to processes, products and services with the aim of increasing efficiency and reducing risks for the human factor and the environment. RECP addresses three dimensions of sustainability individually and synergistically:

a) enhanced economic performance through the productive use of resources,

b) environmental protection through resource conservation and minimizing industry's impact on the natural environment, and

c) social improvement through the provision of jobs and the protection of well-being (UNIDO, 2023).

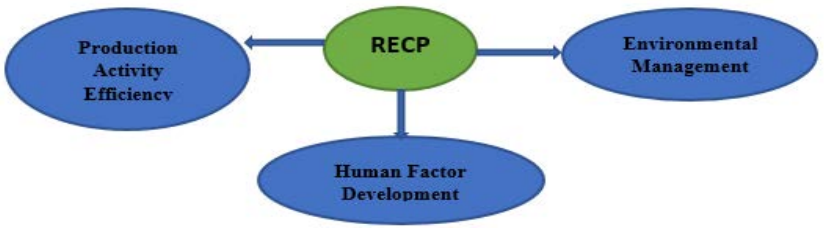

Figure 59. Sustainability dimensions of RECP, (Economy, Environment, Social)
Source: developed by the authors based on data provided by the National Cleaner Production Program of Moldova (NCPP).

The definition of Cleaner Production (CP), formulated by UNEP in 1991, is current and is applied by companies according to the following principles:

- Cleaner Production consists of the continuous application of integrated strategies to prevent environmental pollution to

production processes, products and services in order to increase efficiency, reduce risks to the human factor and the environment;

- Several RECP techniques or practices are possible, as they are complementary and range from low-cost or even no-cost solutions to large investments, advanced technologies, (EU4Environment. ODA., 2023), including

➢ *Good housekeeping principles:* Changes in operational and management procedures to eliminate waste and emissions. Examples are leak prevention, improved training and education of work personnel;

➢ *Change in input material:* use of less polluting raw materials and use of process auxiliaries (such as lubricants and coolants) with long service life;

➢ *Better process control:* modification of operating provisions and maintenance of equipment operating instructions, and maintaining records of processes operating with increased efficiency and processes with low waste and emissions.

➢ *Equipment modification:* modification of production equipment in order to achieve increased process efficiency with reduced waste generation and emissions.

➢ *Technology change:* For example, improving process automation, process optimization, equipment redesign and process replacement;

➢ *Recycling:* the useful application or reuse of waste within the same company where it was generated and its recycling outside the company;

➢ *Production of useful by-products:* the transformation of previously disposed waste into materials that can be reused or recycled by other companies;

➢ *Product modification:* modification of product characteristics, such as material composition and shape. Thus, the life span of the new product could be extended, the product easier to repair, or the manufacturing of the product could become less polluting. Changes in product packaging are generally also considered product modifications (NCPP, 2017).

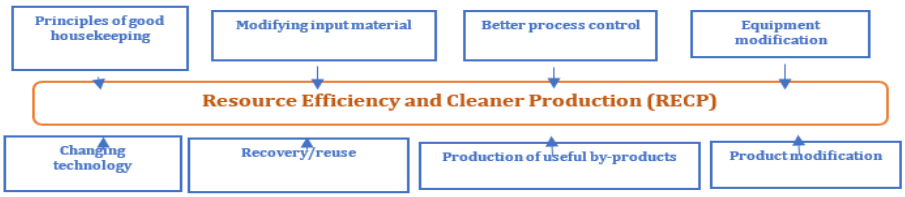

Figure 60. RECP techniques

Source: developed by the authors based on data provided by (EU4Environment. ODA., 2023)

According to the Program on the Promotion of the "Green" Economy in the Republic of Moldova, the promotion of the concept of resource efficiency and cleaner production can be achieved through:

- ✔ implementation of the RECP concept, increasing the efficient use of resources and increasing environmental performance within enterprises and organizations in the Republic of Moldova, contributing to sustainable industrial development and sustainable production and consumption;
- ✔ implementation of the Framework for the next 10 years on programs in the field of sustainable production and consumption.

Businesses and other organizations that adopt RECP increase the efficiency with which they use materials and energy, improving their productivity and competitiveness. At the same time, through greater efficiency, businesses reduce the amount of pollution and waste they generate, thereby reducing their environmental impact, including their carbon footprint. As waste and emissions are reduced, and hazardous substances are eliminated, the risks of industrial operations to workers, communities, and consumers decrease. In short, businesses and other organizations that implement RECP methods, practices, and technologies achieve a triple benefit:

1. Improving the efficient use of natural resources, including water, energy, and materials;
2. Minimizing the impact on the environment and nature by preventing the generation of waste and emissions (including those discharged into water, air, or land);
3. Minimizing risks to people and communities by reducing the use of chemicals and safely disposing of chemicals already used in industry.

Implementation of the green tool - RECP within enterprises. Theoretical analysis of the implementation of RECP within green enterprises involves the application of environmental strategies through processes, products and services to increase efficiency and reduce risks for people and the environment. In the Republic of Moldova, through the EU4Environment action funded by the European Union, it encourages small and medium-sized manufacturing enterprises (SMEs) to become RECP demonstration companies and to participate in the implementation of the RECP methodology in Moldova but also in the formation of RECP clubs.

Therefore, the Resource Efficient and Cleaner Production Network (RECP net) brings together over 70 RECP service providers globally, with the aim of effectively implementing RECP on a large scale in developing and transition countries. The network provides specialized, quality, technical and advisory services, as well as facilitating and synergizing the capacities of its members (RECPnet, 2023).

UNIDO is one of the five partner agencies implementing the EU-funded EU4Environment programme from 2019 to 2023. This regional programme supports 6 Eastern Partnership countries (Armenia, Azerbaijan, Belarus, Georgia, the Republic of Moldova and Ukraine). It makes policy planning and investments greener, stimulates the adoption of innovative products and technologies and raises awareness of the environmental benefits (UNIDO, ODIMM, 2019-2023).

Therefore, RECP Clubs aim to develop and pilot a model of direct support for green businesses, especially small and medium-sized enterprises (SMEs). The model should be replicable, meaning that after the initial efforts in selected municipalities are completed, the model can be made available on an ongoing basis to more regions and eventually to the entire country. The involvement of SMEs in municipal and regional RECP Clubs requires training of SME technical staff on RECP methodology and techniques and helping the Clubs' member companies to develop RECP action plans.

Small and Medium Enterprises (SMEs), participating in the RECP assessment carried out by UNIDO in the Eastern Partner Countries, benefit from tailor-made RECP reports in which concrete implementation steps are provided as action plans. The RECP assessment at enterprises is included by a systematic analysis based on the RECP methodology to optimize the use of resources in the demonstration enterprises.

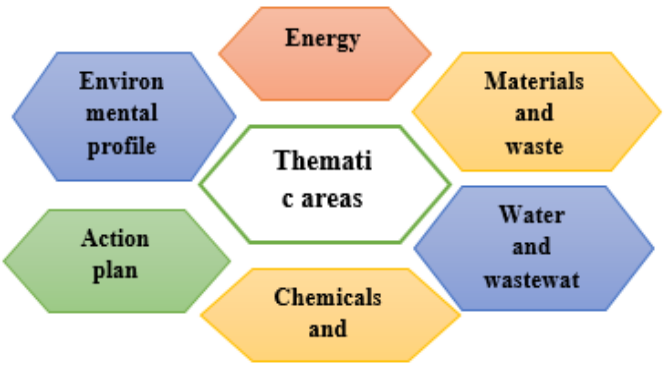

Figure 61. RECP work modules
Source: developed by the author based on data provided by (EU4Environment. ODA., 2023)

This involves data analysis and assessment of inefficiencies, technical, economic and environmental assessment of measures to reduce the negative impact of existing production practices on the environment and supporting the demonstration enterprises to improve their efficiency. Therefore, it also includes training activities for the company staff, provision of a technical report on the assessment findings and the measures identified and monitoring of the measures implemented at the demonstration enterprises.

The clubs provide five work modules based on five thematic areas and a sixth module dedicated to the preparation of the action plan. These are addressed under the coordination of experts in joint workshops, including data collection and analysis activities, training, problem solving, option evaluation and planning of internal improvement actions. The six modules are organized by thematic areas, respecting the following order:

- Company Environmental Profile: Understanding how resources (raw and auxiliary materials, water and energy) are used, as well as the environmental impact resulting from the company's activities, products and services;
- Energy: Understanding energy use and developing energy efficiency options for processes, utility systems and building management;
- Materials and Waste: Understanding the main material flows used in the company and the waste generated and developing options to improve material consumption and reduce waste;
- Water and Wastewater: Understanding the main water flows consumed in the company and the resulting waste water flows and developing options to improve water consumption and reduce effluents;
- Chemicals, Hazardous Waste and Emissions: Understanding the use of chemicals, potential risks, hazardous waste and associated emissions and developing options for responsible use of chemical preparations, reducing hazardous waste and emissions;
- Action plan: unifying the options identified throughout the thematic modules into an integrated approach, with short, medium and long-term objectives and actions for companies.

For each of the 6 work modules, the experts provide Club members with a complete set of working tools, training materials and case studies, which will facilitate the identification and understanding of the causes of inefficiency, the identification of opportunities for improvement and the determination of the most appropriate courses of action for improvement. And for small and medium-sized companies, the RECP program is carried out under the coordination of experts and includes the following stages:

- Initial assessment - Identification and assessment of the company's current situation in terms of energy consumption, materials, chemicals, waste generation and management practices;
- Identification of improvement potential - Determination of improvement potential and determination of action areas. A RECP program approaches the processes / improvement areas step by step, focusing on those aspects with high potential for improvement;

- ❖ Analysis of causes - Using specific methods and working tools, CNPCD experts together with the company team, identify and analyze the causes of inefficiency, determining its root causes;
- ❖ Determination and evaluation of improvement options - In this stage, the work team identifies the various courses of action to eliminate the causes and increase efficiency. Possible improvement options are analyzed using cost-benefit criteria and the options that meet the efficiency and effectiveness criteria are chosen for implementation;
- ❖ Implementation of options - Once selected, the improvement options are transformed into specific measures and actions and the action plan is generated. Implementation can begin and CNPCD experts assist the company in monitoring the implementation of the RECP program (CNPCD, 2023).

According to the Program on the Promotion of the "Green" Economy in the Republic of Moldova, the priorities of the green economy can be integrated into the industrial sector by:

a) promoting the principles of sustainable production and consumption (SCP) in the Republic of Moldova;

b) promoting the principle of extended producer responsibility;

c) wide-scale application of the RECP concept within enterprises and organizations, including through RECP clubs, RECP policy models and greening of economies;

d) promoting innovations in the environmental field that can prevent and reduce adverse environmental effects of products or activities or that can contribute to the creation of new business opportunities;

e) introducing an integrated emission and pollutant control system; introducing a voluntary system of participation in management and auditing for organizations in the field; assessing environmental risks in the process of implementing activities; developing environmental assurance mechanisms for industrial units; etc.;

f) promoting the transition to the best available techniques; investments in modernizing techniques and management for efficient use of natural resources (water, energy, mineral resources) and reduction of polluting emissions; ensuring compliance with these requirements by new installations;

g) improving the quality management system; developing legal mechanisms; implementing and continuously improving the integrated management system in accordance with ISO 9001 and ISO 14000 standards;

h) developing and promoting measures to prevent risks and monitor environmental factors within industrial units; complying with measures to green polluted industrial land;

i) creating mechanisms to stimulate the modernization and renovation of treatment and purification facilities/stations, equipping them with the

necessary equipment to eliminate pollutants from wastewater and reduce emissions into the atmosphere; measures to minimize industrial waste generated for temporary storage (harmless to the environment and human health) in order to eliminate/use completely hazardous waste generated/owned by economic agents (EU4Environment, 2021).

In the Republic of Moldova, through the National Cleaner Production Programme (NCPP), it contributes to the implementation of the Resource Efficiency and Cleaner Production (RECP) concept through assessments/demonstrations at the level of industrial enterprises, trainings and advice on RECP policies. NCPP is supported by the United Nations Industrial Development Organization (UNIDO) and financed by the Government of Austria. Thus, since 2009, the National Cleaner Production Programme (NCPP) has been providing assistance to enterprises in the agri-food/construction/municipal services sectors, also creating "NO WASTE" CLUBS to train entrepreneurs to reduce their water/energy/material consumption.

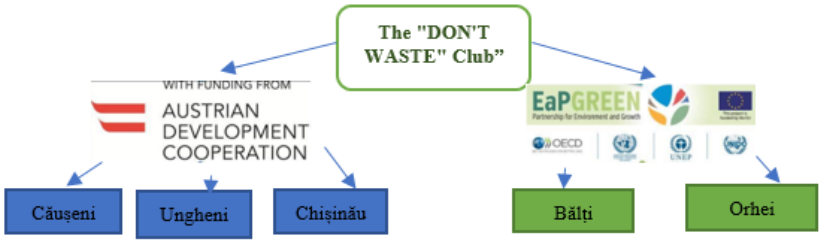

Figure 62. Members of the "NO WASTE" Clubs, RECP
Source: developed by the authors based on data provided by (EU4Environment, 2023)

RECP club members from the Republic of Moldova have achieved successful results following the implementation of the RECP toolkit. Thus, 135 members of the "NO WASTE" Clubs Căușeni, Ungheni and Chișinău with the support of the Austrian Government; Bălți and Orhei with the support of the European Commission in collaboration with local mayors have achieved since the beginning of 2012:

- reduction of energy consumption – 5,972 MWh/year,
- reduction of material consumption – 216 t/year,
- reduction of water consumption – 473,274 m3/year,

The total financial benefit achieved is 453,245 EURO/year. The realization of the identified potential is also stimulated by defining the action plan for each member, calculating performance indicators and developing a success story for the enterprise.

Another success story is the Fruit and Vegetable Factory "Orhei-Vit" SA, the production enterprises in Ungheni, the fruit dryer in Orhei, the alcohol

producer in Balti are just a few of the companies that implemented the EaP GREEN project. Thanks to the implementation of the RECP indicator, the Fruit and Vegetable Factory "Orhei-Vit" SA managed to reduce: natural gas consumption by 56,275 m3 annually; water consumption by 3,300 m3 and respectively the volume of wastewater by 3,300 m3 annually; air emissions by 103.9 tons of CO2; at the same time, about 7 tons of solid waste were recycled, and the volume of auxiliary materials used was also reduced. Following the implementation of the RECP options, the annual savings of the enterprise amount to about 35,150 USD.

The research results present a series of important and general aspects regarding the implementation of the Resource Efficiency and Cleaner Production (RECP) tool within green companies in the Republic of Moldova. Therefore, it is important to mention that Resource Efficiency and Cleaner Production (RECP) is a tool for the continuous application of environmental pollution prevention measures to processes, products and services, thus reducing the consumption of materials/water/energy per unit of finished product. And, the clubs are intended to assist SMEs through thematic training and guiding assessments using personalized technical resources to determine the productivity of water/energy/material resources.

Thus, due to the inertia of the climate system, despite all efforts to reduce greenhouse gas emissions, the global average temperature will continue to increase, generating a negative impact on anthropogenic and natural systems. In order to limit the vulnerability of these systems to the negative effects of climate change, policies and measures are needed to minimize the negative effects and maximize the benefits of the global warming process on different systems. Following the findings of the paper, we come up with the following proposals:

- encouraging the development of projects aimed at ecological houses, smart houses;
- promoting sectoral policies that ensure energy security by increasing the share of renewable energies in final energy consumption, reducing the degree of dependence of the national economy on primary energy imports;
- using environmentally friendly vehicles;
- increasing the surface area of green spaces in urban and peri-urban areas;
- developing research activities in the field of climate change for all sectors of activity;
- applying taxes and other economic instruments that have a significant impact on achieving the objectives of combating climate change.

The recommendations proposed by the author are important for enhancing resource efficiency and cleaner production (RECP) for green

enterprises in the Republic of Moldova. Some of the recommendations are more fundamental and may require substantial changes in the country's governance practices and the way institutions operate. Other measures are more focused and can be implemented with more limited approaches (Popa V., 2023).

Bibliography:

1. Accenture. (2014). *Circular advantage: Innovative business models and technologies to create value in a world without limits to growth*. https://www.accenture.com/t20150523t053139__w__/us-en/_acnmedia/accenture/conversion-assets/dotcom/documents/global/pdf/st
2. AEE. (2021). *Studiu "Evaluarea potențialului implementării proiectelor de energie solar fotovoltaică în IMM conform Clasificatorului Activităților din Economia Moldovei (CAEM), inclusiv în profil sectorial"*. https://aee.gov.md/storage/publicatii/07%20Studiul
3. Alhawari, O., et al. (2021). Insights from circular economy literature: A review of extant definitions and unravelling paths to future research. *Sustainability*, 13, 859.
4. Alivojvodic, V., & Kokalj, F. (2024). Drivers and barriers for the adoption of circular economy principles towards efficient resource utilization. Sustainability, 16, 1317. https://doi.org/10.3390/su16031317
5. Apple. (2030). *A plan as innovative as our products*. https://www.apple.com/environment/
6. Arinze, E. D. (2024). Unravelling exponential growth dynamics: A comprehensive review. https://doi.org/10.59298/iaajsr/2024/113.1926
7. Azwardi, A., Igamo, A. M., & Wijaya, W. A. (2023). The concept of waste management on economic development in the European Union. International Journal of Energy Economics and Policy, 13, 1–6. https://doi.org/10.32479/ijeep.13801
8. Baily, P., & F. D. (2024). *Principiile şi managementul achiziţiilor*. Chişinău: ARC. p. 3.
9. Bakker, C., et al. (2014). Products that last: Product design for circular business models. TU Delft Library: Delft, The Netherlands.
10. Biopartner, G. (2024). *Povestea Genesis Biopartner*. https://genesisbiopartner.ro/
11. Bocken, N. M. P., et al. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, 65, 42-56. https://doi.org/10.1016/j.jclepro.2013.11.039
12. Bocken, N., et al. (2016). Product design and business model strategies for a circular economy. *J. Ind. Prod. Eng.*, 33, 308-320.
13. Busu, M. (2019). Adopting circular economy at the European Union level and its impact on economic growth. *Social Sciences*, *8*(5), 8050159. https://doi.org/10.3390/socsci8050159
14. Candelux. (2023). Candelux. https://candelux.md/en/h
15. Candelux. (2024). https://candelux.md/producere/

16. CE. (2020). *Circular economy*. ISBN 978-92-79-37824-9. http://publications.europa.eu/resource/cellar/c8cfd1ae-6285-40ba-879f-f2e78e4c2b6e.0013.02/DOC_1
17. Chioatto, E., & Sospiro, P. (2023). Transition from waste management to circular economy: The European Union roadmap. Environmental Development and Sustainability, 25, 249–276. https://doi.org/10.1007/s10668-023-01799-0
18. Circular Economy: Definition, principles, benefits, and barriers. (2018). https://youmatter.world/en/definition/definitions-circular-economy-meaning-definition-benefits-barriers/
19. Circulară, D. E. (2022). Hori web. https://hortiweb.ro/economie-circulara
20. CNPCD. (2023). *Centrul Național pentru Producție și Consum Durabile. Cluburi verde*. https://www.cnpcd.ro/arii-tematice
21. COM, E. (2016). *The Code of Good Administrative Behaviour*. https://commission.europa.eu/about/service-standards-and-principles/ethics-and-good-administration/good-administration_en
22. COM/98. (2020). *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A new Circular Economy Action Plan For a cleaner and more competitive Europe*. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN
23. Concurenței, C. (2024, October). *Avantajele competitive ale economiei circulare în sectorul construcțiilor și impactul acestuia în atingerea obiectivelor climatice ale UE*. https://www.consiliulconcurentei.ro/wp-content/uploads/2024/10/studiuEC_site_07oct.pdf
24. Contravention Code RM. (2017). *Contravention Code of the Republic of Moldova No. 218 of 24.10.2008*. Published on 17-03-2017 in the Official Gazette No. 78-84 art. 100. https://www.legis.md/cautare/getResults?doc_id=146727&lang=ro#
25. Decision No 592. (2019). *Government Decision No. 592 of November 27, 2019 on the approval of the Greening Program for Small and Medium-sized Enterprises*. https://www.legis.md/cautare/getResults?doc_id=119235&lang=ro
26. Decision no. 696. (2018). *Approved by Government Decision No. 696 of 11-07-2018*. Published: 10-08-2018 in the Official Gazette No. 295-308 art. 835. https://www.legis.md/cautare/getResults?doc_id=108829&lang=ro
27. Dictionary, F. A. (2024). *Circular economy*. https://dicoagroecologie.fr/en/dictionnaire/circular-economy/

28. Lacatus, E.S. et al. (2019). *Competențe antreprenoriale*. https://www.asistnordvest.ro/wp-content/uploads/2020/08/Suport-de-curs-COMPETENTE-ANTREPRENORIALE.pd
29. EC. (2015, 2020a). *On the implementation of the Circular Economy Action Plan, COM*. European Commission, 2020b, New Circular Economy Action Plan The European Green Deal. European Commission, 2020a, A new Circular Economy Action Plan For a cleaner and more competitive Europe. COM(2020) 98 final. https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en#:~:text=The%20EU's%20new%20circular%20action,cleaner%20and%20more%20competitive%20Europe.&text=It%20targets%20how%20products%20are,for%20as%20long%20as%20possible
30. EEA. (2020). *The European environment — state and outlook 2020*. ISBN: 978-92-9480-090-9. https://www.eea.europa.eu/en/analysis/publications/soer-2020
31. Eestivanapaber (2023). Tartu scrap yard. https://eestivanapaber.ee/en/scrap-yards/tartu/
32. Ellen MacArthur Foundation. (2012). *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition*. Ellen MacArthur Foundation, Cowes, UK. https://ellenmacarthurfoundation.org/towards-a-circular-economy-business-rationale-for-an
33. Environmental Agency. (2021). *Protecția aerului atmosferic*. https://am.gov.md/ro/content/protec%C8%9Bia-aerului-atmosferic
34. EU Strategy. (2050). *Strategia pe termen lung pentru 2050*. https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_ro
35. EU, C. (2015). *Propunere de DIRECTIVĂ A PARLAMENTULUI EUROPEAN ŞI A CONSILIULUI privind anumite aspecte referitoare la contractele de vânzare online și la alte tipuri de contracte de vânzare la distanță de bunuri*. COM/2015/0635 final - 2015/0288 (COD). https://eur-lex.europa.eu/legal-content/RO/TXT/?uri=CELEX:52015PC0635
36. EU, COM. (2017). *Communication on waste-to-energy processes and their role in the circular economy*. Brussels, 26.1.2017, COM(2017)34 final. https://commission.europa.eu/about/service-standards-and-principles/ethics-and-good-administration/good-administration_en
37. EU, COM. (2017). *Communication: Investing in a smart, innovative and sustainable industry. A renewed EU industrial policy strategy*. Brussels, 6.11.2017, COM(2017) 479 final/2.

https://ec.europa.eu/transparency/regdoc/rep/1/2017/RO/COM-2017-479-F2-RO-MAIN-PART-1.PDF

38. EU, COM. (2018). *EU Directive, on port reception facilities for the discharge of waste from ships, repealing Directive 2000/59/EC and amending Directive 2009/16/EC and Directive 2010/2010/65/EU*. https://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf
39. EU. (2000). *Deciziei 94/3/CE*. http://www.anpm.ro/documents/12220/2043942/134482_Decizia+2000_532.pdf/223211f7-284d-4d96-b7f0-0283bcf92528
40. EU. (2018). *Directive 2018/851. REGULAMENTUL (UE) 2018/848 AL PARLAMENTULUI EUROPEAN ȘI AL CONSILIULUI*. https://eur-lex.europa.eu/legal-content/RO/TXT/PDF/?uri=OJ:L:2018:150:FULL&from=EN
41. EU. (2019). *Council of the European Union, on 4 October 2019, adopted several conclusions on the theme: "More circularity - the transition to a sustainable society"*. https://www.consilium.europa.eu/media/40928/st12791-en19.pdf
42. EU. (2019). *Închiderea buclei: Comisia își onorează angajamentele prevăzute în Planul de acțiune pentru economia circulară*. https://ec.europa.eu/commission/presscorner/detail/ro/ip_19_1480
43. EU4Environment ODA. (2023). *Tehnica RECP*. https://odimm.md/ro/despre-recp
44. EU4Environment. (2021). *Programul privind promovarea economiei "verzi" în Republica Moldova*. p.17. https://www.eu4environment.org/app/uploads/2021/09/Programul-pentru-promovarea-economiei-verzi.pdf
45. EU4Environment. (2023). *Eficientizarea resurselor și producere mai pură*. https://www.eu4environment.org/ro/areas-of-work/resource-efficient-and-cleaner-production/
46. EVECO. (2023). EVECO. https://eveco.md
47. Fernandez-Solis, J. L. (2007). *Sustainability as the Force that Tames an Exponentialoid*.
48. Fiscal Code. (1997). *Fiscal Code of the Republic of Moldova No. 1163 of 24.04.1997*. Published in the Official Gazette No. 62 art. 522. https://www.legis.md/cautare/getResults?doc_id=146721&lang=ro#
49. Ford Sustainability. (2020). *Report 2020*. https://media.ford.com/content/dam/fordmedia/North%20America/US/2020/06/24/Ford-Full-2020-Sustainability-Report.pdf
50. Ford, C. (n.d.). *Ford corporate website*. https://corporate.ford.com/

51. Glass. (2023). Glass. https://glass.md/en/home/
52. Huttmanová, E., Chovancová, J., Steiner, M. J. F., Ramharter, P. M., & Kočišičáková, K. (2023). Through circularity towards sustainability: Assessing the progress and challenges of the circular economy in the EU and Slovakia. European Journal of Sustainable Development, 12, 366. https://doi.org/10.14207/ejsd.2023.v12n1p366
53. IORDACHI, V., POPA, V., & POPA, N. (2022). *Economia circulară: Colectarea deșeurilor*. In V. P. IORDACHI (Ed.), *Economia circulară: Colectarea deșeurilor: Ghid informativ* (p. 58). Chisinau: Institutul Național de Cercetări Economice. ISBN 978-9975-3530-3-8. https://doi.org/10.36004/nier.2022.978-9975-3530-3-8
54. JICA, Report. (2019). *Deşeuri Periculoase – Capitolul 1, Volumul 1 Raport Principal: Strategie şi Plan de Acţiune. Studiul privind Planul General pentru Gestiunea Deşeurilor Periculoase în România*. https://openjicareport.jica.go.jp/pdf/11737715_03.pdf
55. Karton. (2023). Karton. https://karton.md/
56. Law no. 209. (2016). *LAW No. 209 of 29-07-2016 on waste*. Published in the Official Gazette No. 459-471 art. 916. https://www.legis.md/cautare/getResults?doc_id=105806&lang=ro
57. Leonhard, G., & A. (2017). *Exponential technology versus linear humanity: Designing a sustainable future* (pp. 77–83). Springer, Cham. https://doi.org/10.1007/978-3-319-54603-2_6
58. Lian, M. (2024). The impact of cleaner energy sources, advanced technology firms, and economic expansion on ecological footprints is critical in sustainable development. *Heliyon*. https://doi.org/10.1016/j.heliyon.2024.e31100
59. Magretta, J. (2002). Why business models matter. *Harvard Business Review*, *80*(5), 86–92.
60. MIRON, V. (2019). *Taxe, amenzi și sancțiuni pentru prevenirea activităților dăunătoare biodiversității: Catalog / Proiect PNUD în Moldova*. Ideea-Com.
61. Moreno, M., et al. (2016). *Conceptual framework for circular design*. *Sustainability*, *8*(937).
62. National Inventory Report. (2022). *National Inventory Report 1990-2020*. Chisinau, June 30. www.clima.md
63. NBS. (2021). *Mediul înconjurator*. https://statbank.statistica.md/pxweb/pxweb/ro/10%20Mediul%20inconjurator/10%20Mediul%20inconjurator__MED030/?rxid=b2ff27d7-0b96-43c9-934b-42e1a2a9a774

64. NBS. (n.d.). *INDICAŢII METODICE*. https://statistica.gov.md/public/files/Formulare_statistice_2010/Mediul_inconjurator/Instructiuni_1_deseuri_toxice.pdf
65. NCPP. (2017). *Programul Naţional de Producere mai Pură din Moldova (NCPP) Conceptul de NCPP*. http://www.ncpp.md/?go=page&p=73
66. Nußholz, J. L. K. (2017). *Circular business models: Defining a concept and framing an emerging research field*. *Sustainability, 9*(10), 1810. https://doi.org/10.3390/su9101810
67. OECD. (2019). *Business models for the circular economy: Opportunities and challenges for policy*. https://www.oecd.org/en/publications/business-models-for-the-circular-economy_g2g9dd62-en.html
68. Orange. (2024). *Aplicăm principiile economiei circulare*. https://www.orange.md/ro/green
69. Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: A handbook for visionaries, game changers, and challengers*. Wiley.
70. Osterwalder, A., et al. (2010). *Business model generation: A handbook for visionaries, game changers, and challengers*. Wiley.
71. Osterwalder, A., Pigneur, Y., & Tucci, C. L. (2005). *Clarifying business models: Origins, present, and future of the concept*. *Communications of the Association for Information Systems, 16*. https://doi.org/10.17705/1CAIS.01601
72. PERCIUN, R., et al. (2022). *Modele de afaceri circulare: Ghid informativ*. In R. T. PERCIUN (Ed.), *Modele de afaceri circulare: Ghid informativ* (p. 96). Chisinau: Institutul Național de Cercetări Economice. Ed. a 2-a. ISBN 978-9975-3579-0-6; ISBN 978-9975-3579-1-3 (PDF). https://doi.org/10.36004/nier.2022.978-9975-3579-1-3
73. PNUD. (2017). *Adaptarea Agendei 2030 de Dezvoltarea Durabilă la contextul Republicii Moldova*. https://www.undp.org/ro/moldova/publications/adaptarea-agendei-2030-de-dezvoltarea-durabila-la-contextul-republicii-moldova
74. Policy. (2019). *Business models for the circular economy: Opportunities and challenges for policy*. https://www.oecd.org/environment/business-models-for-the-circular-economy-g2g9dd62-en.htm
75. Popa, V. (2021). Toxic waste management process in the Republic of Moldova. *Conferința "Dezvoltarea economico-socială durabilă a euroregiunilor şi a zonelor transfrontaliere"*, Iași, Romania, 29 octombrie 2021. https://ibn.idsi.md/vizualizare_articol/144755
76. Popa, V. (2023). Impact and vulnerabilities of climate change in the Republic of Moldova. *Conferința "Creşterea economică în condiţiile globalizării"*,

Ediția 17, Vol. II. Chisinau, Moldova. ISBN (pdf) 978-9975-167-21-5. https://ibn.idsi.md/ro/vizualizare_articol/196739

77. Popa, V. (2023). Implementarea instrumentului de eficientizare a resurselor și producere mai pură pentru întreprinderile verzi din Republica Moldova. *Vector European, Numărul 2 / 2023* / ISSN 2345-1106 / ISSNe 2587-358X. https://ibn.idsi.md/sites/default/files/imag_file/83-90_27.pdf
78. Popa, V., & Popa, N. (2021). Analysis of the European framework on the circular economy. *Journal of Social Sciences, 4*(1), 21-28. ISSN 2587-3490. https://jss.utm.md/wp-content/uploads/sites/21/2021/03/JSS-1-2021_21-28.pdf
79. Popa, V., et al. (2021). *Assessment of the impact of hazardous waste on health and the environment in the Republic of Moldova*. In *Competitiveness and Sustainable Development in the Context of European Integration* (pp. 102–109). https://repository.utm.md/bitstream/handle/5014/18380/Conf-Competitiv-sustain-develop-European-integration-2021-p102-109.pdf?sequence=1&isAllowed=y
80. RECP. (2022). *Resource-efficient and cleaner production*. https://www.eu4environment.org/ro/areas-of-work/resource-efficient-and-cleaner-production/
81. RECPnet. (2023). *The global network for resource-efficient and cleaner production*. https://www.recpnet.org/
82. Reday-Mulvey, S. A. (1977). *The potential for substituting manpower for energy*.
83. Richardson, J. (2008). The business model: An integrative framework for strategy execution. *Strategic Change, 17*(5–6), 133–144. https://doi.org/10.1002/jsc.821
84. Rusu, M. (1989). *Valorization of secondary polymer resources*. Bucharest: Ed. Tehnica.
85. Şavga, L., Perciun, R., & Popa, V. (2023). Air quality – An essential component of quality of life: The case of the Republic of Moldova. In L. P. Şavga (Ed.), *Approaches on the quality of life: Cross-border perspectives* (pp. 397–431). Frankfurt: CEEOLPRESS.
86. SC DIREN EXIM SRL. Colectare Deseuri Hartie Carton Cluj - DIREN EXIM. https://www.colectare-reciclare-deseuri.com/deseuri-carton-hartie/cluj-napoca
87. Sijtsema, S. J., Snoek, H. M., van Haaster-de Winter, M. A., & Dagevos, H. (2020). Let's talk about circular economy: A qualitative exploration of consumer perceptions. *Sustainability (Switzerland), 12*(1), 12010286. https://doi.org/10.3390/su12010286

88. Sulapac. (n.d.). *Eco-supplements packaging*. https://www.sulapac.com/eco-supplements-packaging/
89. TaxNews. (2022). *Economia circulară devine parte din definiția viitorului în business: Conceptul celor 10 R*. https://taxnews.ro/2022/04/20/economia-circulara-devine-parte-din-definitia-viitorului-in-business-conceptul-celor-10-r/
90. Teece, D. J. (2010). Business models, business strategy, and innovation. *Long Range Planning*, *43*(2–3), 172–194. https://doi.org/10.1016/j.lrp.2009.07.003
91. Tîrțiu, V. (2018). *Tranziția către o economie circulară: De la managementul deșeurilor la o economie verde în România*. Institutul European din România.
92. Topliceanu, L., Puiu, P. G., Drob, C., & Topliceanu, V. V. (2023). Analysis regarding the implementation of the circular economy in Romania. *Sustainability*, *15*, 333. https://doi.org/10.3390/su15010333
93. Trica, C. L., Banacu, C. S., & Busu, M. (2019). Environmental factors and sustainability of the circular economy model at the European Union level. *Sustainability (Switzerland)*, *11*(4), h11041114. https://doi.org/10.3390/su11041114
94. UE, C. (2016). *Research and innovation*. https://commission.europa.eu/research-and-innovation_en?pg=home
95. UE. (2000). *Decizia 94/3/CE de stabilire a unei liste de deșeuri*. http://www.anpm.ro/documents/12220/2043942/134482_Decizia+2000_532.pdf/223211f7-284d-4d96-b7f0-0283bcf92528
96. UNEP. (2015). *Studiul de evaluare privind economia verde: Republica Moldova*. ISBN: 978-92-807-3476-8. https://www.oneplanetnetwork.org/sites/default/files/81.pdf
97. Ungur, C. (2021). Soluții financiare de promovare a practicilor verzi în domeniul antreprenorial. In *Culegerea conferinței internaționale științifico-practice "Creșterea Economică în Condițiile Globalizării"*, ediția XV, 2021 (II), 114–122. ISBN 978-9975-3529-6-3.
98. Ungur, C. (2022). Circular business models: Challenges and opportunities. *Proceedings of the International Symposium "Experience. Knowledge. Contemporary Challenges" "Opportunities for changing the Economic-Social Realities of the World"*, May 26th–27th.
99. Ungur, C. (2022). Development of theoretical approaches of circular business models. *The Journal Contemporary Economy*, *7*(2), 55–62. ISSN 2537–4222. ISSN-L 2537–4222. 0.45 c.a. Available at: http://www.revec.ro/article-2022-id-102-vol..7.nr..2-934-dezvoltarea.abordarilor.teoretice.ale.modelelor.de.afaceri.circulare.html
100. Ungur, C. (2022). Posibilități de implementare a practicilor internaționale în dezvoltarea afacerilor circulare din Republica Moldova. In

Culegerea conferinței internaționale științifico-practice "Creșterea Economică în Condițiile Globalizării", ediția XVI, (II), 114–122. ISBN 978-9975-3529-6-3.

101. UNIDO, ODIMM. (2019–2023). *Caiet de sarcini pentru serviciile de Expert RECP, în cadrul proiectului RECP în cadrul întreprinderilor mici și mijlocii din Republica Moldova*. https://storage.mtender.gov.md/get/afc9d777-3bf1-42a9-98dd-8179ce6fc
102. UNIDO. (2023). *National resource efficient cleaner production (RECP)*. https://www.unido.org/our-focus-safeguarding-environment-resource-efficient-and-low-carbon-industrial-production/resource-efficient-and-cleaner-production-recp
103. Uniqa. (2024). *Uniqa*. https://www.uniqa.md/
104. Vtorion. (2022). ГОСТ Р 54564-2022 на лом цветных металлов: обзор документа и как им пользоваться [GOST R 54564-2022 for scrap non-ferrous metals: Document review and how to use it]. https://vtorion.ru/blog/article/gost-r-54564-2022-na-lom-czvetnyh-metallov-obzor-dokumenta-i-kak-im-polzovatsya/#1
105. Walker, S., Coleman, N., Hodgson, P., Collins, N., & Brimacombe, L. (2018). Evaluating the environmental dimension of material efficiency strategies relating to the circular economy. *Sustainability (Switzerland), 10*(3), 10030666. https://doi.org/10.3390/su10030666
106. Wistekmarket. (2022). The pros and cons of a circular economy model. https://www.wisetekmarket.com/blogs/wisetek-market-news/the-pros-and-cons-of-a-circular-economy-model
107. Woodly. (n.d.). *Woodly | A new type of plastic based on wood*. www.woodly.com
108. ГОСТ 10700-97. (2002). Макулатура бумажная и картонная. Технические условия [Paper and cardboard waste. Technical conditions]. ГОСТ 10700-97. https://meganorm.ru/Data2/1/4294816/4294816873.pdf

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ECONOMY