INTERNATIONAL AND MULTIDISCIPLINARY PERSPECTIVES ON QUALITY OF LIFE

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GALATI UNIVERSITY PRESS

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Intro

The quality of life has always been a central topic in discussions about social development and well-being, being seen as a complex and multidimensional concept. In recent decades, this aspect has become increasingly important as a measure of societal development. Although difficult to fully quantify, this concept refers to an individual's perception of their own existence, within the context of cultural values, personal needs and aspirations.

The World Health Organization defines quality of life as the perception of individuals on their position in life, within the context of the values and cultural goals in which they live, and in relation to their expectations, standards and concerns.

Quality of life is not limited to material aspects only, but includes a wide range of social, cultural, and educational factors, including freedom of choice, economic security, job satisfaction, living conditions, social well-being, physical and mental health, and level of education .

It is absolutely obvious that many factors, both individual (such as age, sex, health, personality, level of education or income) and social(including culture, political systems, social relations between the masses, access to public services, and even the environment in all its aspects), can influence our perception of the quality of life.

It is very clear that improving the quality of life can bring a multitude of benefits, both at the individual and social level.A healthy and educated population is not only more productive, but alsomore interested in the economic development of society, while the costs associated with social assistance and health insurance/care may decrease. Moreover, it is also well known that a lower quality of life in a society is linked to social instability or increased crime.

It is very difficult to quantify in absolute terms all the factors involved in determining the quality of life of individuals. Nevertheless, the members of the Applied Sciences department of the Crossborder Faculty of the "Lower Danube" University of Galati have made their contributions, each offering insights in the chapters offered for publication in this volume. Just as the factors influencing quality of life are diverse , the fields of expertise of the members of the department mentioned above are equally varied. As a result/ Consequently, in the following chapters of this volume, we will find valuable information from the fields of economics, environmental science and ecology,

automation, material science, biology or even sociology. The cross-border specificity of the faculty in which it operates also enables comparative analyzes between the levels of quality of life between Romania and the Republic of Moldova, both countries striving to improve this key aspect of their societies.

The comparative analysis of the quality of life in Romania and the Republic of Moldova emphasizes the importance of multidisciplinary approaches. Economic, social, cultural and environmental factors interact and influence the well-being of citizens. While Romania has a significant advantage in many fields, Republic of Moldova presents opportunities for development through cultural revitalization and improvement of social infrastructure. Collaboration and exchanges between the two countries can contribute to enhancing the quality of life in both contexts, promoting sustainable development and social cohesion.

We hope that the information presented in this volume, published as part of the "International and multidisciplinary perspectives on the quality of life" project, funded by contract RF2491/31.05.2024, will be of real value in improving the quality of life by showcasing the scientific results of the department's collective efforts.

Research on competition on the digital market of the Republic of Moldova

Mogîldea LUDMILA, Zugravu CONSTANȚA LAURA, Mușat ANGELICA*, Zugravu GHEORGHE ADRIAN

We live in a digital age, and competition these days has a different shape and consistency. We see more competition for new sectors than within a specific domain. Participants in economic activity no longer compete in a market where there are many participants; instead, they create new markets where they can impose monopolistic conditions.

These new markets and goods often/usally form and develop so quickly that antitrust authorities around the world fail to assess and regulate them thoroughly in order to timely react in a given situation. Society can develop very rapidly and obtain major benefits as a result of digitization, but the consumer must bear a disproportionately high price for these advances.

Nowadays, the needs of the consumer are so well digitized that the big companies that have vast information on consumer data can already forecast the demand that will be in the market. The consumer is already trapped in a "digital box" from which it is very difficult to escape [1]–[3].

Nellie Bowles - journalist from the New York Times, published an article in 2019 titled "Human socialization has become a luxury", in which she said that when we discuss a digital economy, we mean an economy for the poor. She writes: "If a doctor consults you online, then you're poor because you can't afford to go to a physical consultation, if you shop online, you're also poor and you can't afford to go to a nice mall downtown. Poor children cannot afford to go to physical lessons and do the school online. If you find out about your death from the computer, it means that you died a pauper in a digital economy [6]–[8].

With the digitization of the economy, we thought that our legislation and legal practices were ready to react adequately to all modern challenges, but today we are talking about the fact that the changes are needed not only in antitrust regulations but also in our ccollective onsciousness.

The world has already changed, and the digital economy is a reality. Stephen Hawking - English physicist said: "If machines will produce everything that humanity needs, then people's standard of living will depend

only on how these goods will be distributed. We will all live well and lack nothing, even if all the wealth produced by machines is shared.

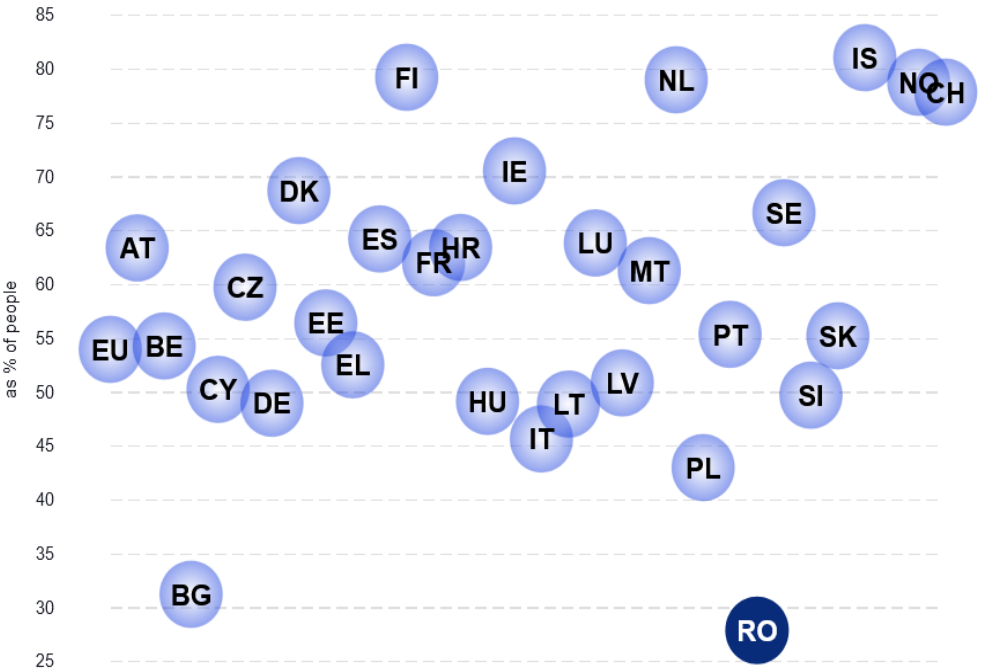


Figure 1: People with basic or above basic digital skills, 2021, %
Source: Eurostat [4], [5].

The world has already changed, and the digital economy is a reality. Stephen Hawking - English physicist said: "If machines will produce everything that humanity needs, then people's standard of living will depend only on how these goods will be distributed. We will all live well and lack nothing, even if all the wealth produced by machines is shared.

Otherwise, a large majority of people will be poor and will not have access to many goods if the owners of the industrial machines succeed in blocking the distribution of these goods. For now, things are going the second way and technologies are bringing us to a growing deadlock between the rich and the poor."

On the other hand, if we were to analyze this, , there would not be this tendency for rich people to develop and invest in production if they knew that all production develops uniformly for everyone, anyway. Each person would think that it would be better for others to work and invest, since, in the end, a share of the production would also belong to them.

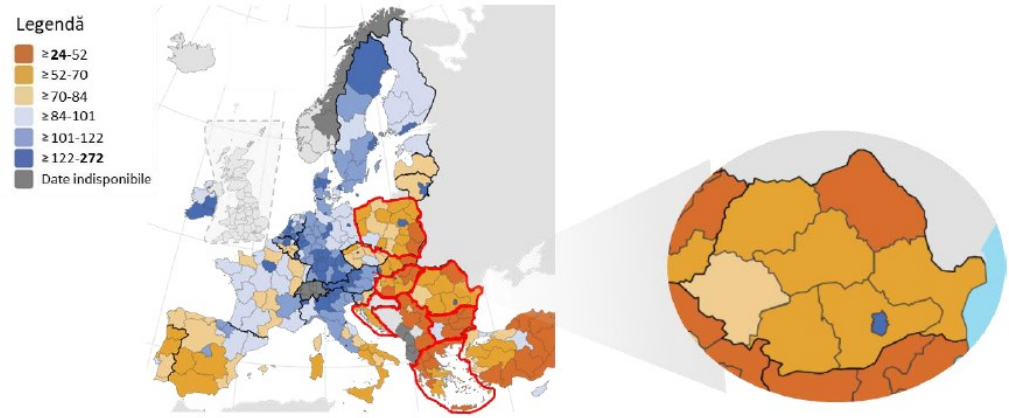


Figure 2: Regional GDP in EU countries and in Romania, measured in purchasing power per capita as %, of the EU27 average in 2020, using NUTS 2 regions
Source: Eurostat [4], [5].

This was the model of life during the Soviet era in Moldova. The state made sure that everyone was employed in the labor field, but whether an individual actually worked or produced something, or simply showed up to work and did nothing, was of little consequence, because everyone received their salary regardless. In the end, it all came crashing down [9]. The term "digital economy" refers to a new quality of economic life that is shaped by digitization and production technology.

This stage in the development of mankind has already arrived. We live in a global economy, and those who know how to turn their knowledge into goods will be successful. Innovation, adaptation, and the use of new technologies are factors that drive the national and global economy. Both the digitization of the economy and the technological transformations that have recently taken place (such as industrialization, electrification) bring about a set of changes.

Someone has to gain from all these transformations, and/while someone has to lose. The present stage of the industrial revolution results not in a diminution, but in a considerable increase in inequality. "Digital divide" used to be a term that represented inequality in access to digital technologies, but now this process encompasses a wider range of factors. Namely, inequality in access to information and technologies determines the increase in digital inequality.

By connecting to global networks, the gap between those who have access to technology and information and those who do not is widening considerably. We could say that it is better not to be connected to the Internet than to be connected without the skills and resources necessary for effective participation in the modern world wide web [10]–[12].

Why is this digital divide widening? According to several experts, the main factor is the rise of digital monopolies and the decline in incomes of small and medium enterprises and consumers alike. Monopoly and the massive concentration of capital are the current state of the digital economy. The purpose of antitrust legislation, since the first days when it appeared, during the industrial revolution in the USA at the end of the century XIX, has been to balance the capitalist system and reduce the pressures in the social and economic life of rapid transformations [13], [14].

The first antitrust law is named after its author, Senator John Sherman, a legendary figure in the US politics, Secretary of State, who put the paper dollar into circulation and laid the foundations for US foreign policy for the next 100 years. Sherman drafted the antitrust law late in his career. This law has been very qualitative and long-lasting, both in the US economy and in the world economy. In the speech he gave to the US Congress, he said things that are more relevant now than 30 years ago: "At the moment, the US, but also other countries, feel enormous pressure from the monopolists and ask the authorities for a solution in the fight against evil, which has grown considerably lately. There have been monopolists before, but such big giants as now, history has not known. You must listen to the demands of the people or be prepared that socialists and communists will come in your place."

Today, the economy and society are going through a transformation analogous to the one 100 years ago, when everything was moved by steam, metal, electricity, railways. These transformations are followed by a visible sharpening of inequality. All these problems in the development of antimonopoly legislation were reflected by Joseph Stiglitz.

For more than 100 years, competition policy has been the central element of market economy legislation [15], [16]. But over the past 30 years, the effectiveness and coverage of competition policy has declined drastically, under the pressure of certain ideas that explain the logic of how the market works.

These ideas continue to negatively influence the practice of antitrust regulation. Recent changes in the economy and in our understanding of political-economic processes have made it necessary to use the tools of competition policy more broadly than was assumed by the first ideologues of antimonopoly legislation, and this necessity is felt, especially, in developing economies.

The scope of antitrust responses to the challenges of the digital economy:

Adapting antitrust regulation to the demands of the digital economy is a fundamental issue for the survival of the economy in the current technological

landscape. As some politicians have said/stated: "Information is a new type of oil". While mechanisms to combat/fight oil monopolies are already in place all around the world, for digital monopolies things are just at the beginning.

There is still insufficient experience in the application of antimonopoly legislation. Just as oil leaders once demanded exclusive status for oil trusts, today's leaders in the digital economy are fighting for immunity for digital monopolies. As the Austrian economist Joseph Shumpeter said, "If business is aimed at stopping progress, then it is dangerous and must be limited. But the history of progress shows how one monopoly replaces another."

Monopolies drive progress precisely because of monopoly revenue expectations, which require you to invest in new technologies. Likewise, monopolies can afford to invest in innovations and new technologies, thanks to monopoly revenues, which allow them to plan and invest in long-term innovation projects. Companies locked in fierce competition cannot afford such investments [17], [18].

On the other hand, it is the large companies that have driven progress and rapid evolution, that have been parties to the most high-profile cases in the history of competition law.

Digital platforms

The notion of a digital platform refers to any natural or legal person, who offers at a professional level, including free of charge, various services that are based on:

1. The accumulation and processing of information about content, goods and services, which are offered to third parties by means of certain algorithms;

2. Allows multiple parties to interact, sell, buy, or exchange goods, services, or content, or to share them. As a digital platform, both hardware devices (phone, tablet, etc.) and software (browser, operating system, etc.) can serve.

Assessing the dominance of a digital platform is problematic from the point of view of antitrust law. First, dominating a digital platform, which is a point of interaction between the consumer and the seller, can create a colossal multiplier effect. While a monopolist who controls the market for a specific commodity holds significant power, a monopolist who owns a digital platform controls all areas of the market related to that platform.

Second, digital platforms are multilateral markets where multiple groups of consumers interact. Digital platforms act as intermediaries between groups that need this interaction but cannot do so as effectively without the platform.

The key challenge in analysing multilateral markets is to detect the boundaries of these markets. Some users can benefit from the platform for free.

Third, a critical element in the digital platform business is user information. This is a core tool that gives the digital platform enormous market power. Also, digital platforms can sustain themselves in the market through network effects. The price of the platform for new users increases as the number of users rises. In addition, the increase in the number of users raises the interest in the platform for other new users.

A popular platform can benefit enormously from users' investment in its development, while also limiting their ability to leave the platform. Another important aspect is the fact that platforms attract and maintain a large number of users due to innovations, improved functioning, efficiency, design. At the same time, innovations can be targeted by antimonopoly legislation as a competitive factor in the digital platform market. But in this case, a broader analysis is needed to determine whether dominant participants of the digital platform are creating artificial obstacles to the emergence of other innovations, or limiting the scope and pace of changes in the hope of keeping the market unchanged [19]–[21]

Network effects and their role in the digital economy

Network effects are generated when the price of the product increases with the rise in the number of consumers of the specific product. These effects often occur on digital platforms that are growing in popularity and attracting new users.

The interaction between user and operator takes place in the digital sphere through multiple channels and in different domains. Therefore, the more diversified the platform is, and the more fields of interaction there are between the user and the operator, the more personalized the services provided to this consumer become. For example, the company GOOGLE receives personal data about users not only from the Google search engine, but also from the correspondence of users through GMAIL, analyzing the use of the ANDROID operating system, the history of user activity in Google Chrome, accessing videos through YOUTUBE, etc.

The possession of a large number of users not only brings the company a competitive advantage, but also an incentive to carry out the strategy of creating new products, which are not compatible with competitors' products. If this strategy is successful, then it is logical to assume that the company will tend to attract more and more users. Likewise, companies could lower prices to attract users, only to raise prices later on, when the number of users is large

enough. Many users will be ready to pay a higher price to fit on a bigger and more popular platform. Network monopoly can be convenient for users because it allows maximizing the external network effect, but market monopolization can stop the development of innovations [22]– [24].

The integration of digital and innovative technologies creates new problems in performing the analysis of the market competition situation and establishing the dominant position. Several questions arise:

- How can the boundaries of the market, which are constantly changing under the influence of digital technologies and innovations, be determined?

- How can the volume of the product market and the shares of its participants be calculated?

- How, in the conditions of the digital economy, can the factors that influence competition be examined, including the conditions of access to the product market?

- How to determine if a company has a dominant position in the market, taking into account all aspects of the digital economy?

To conduct a product market competition analysis, one must first identify the product or group of products that are interchangeable. Traditional product market boundary analysis involves a process to determine which products are interchangeable, or which products have no substitutes within the same market.

Then, we define the boundaries of the market where consumers have the possibility to purchase the product and do not have the possibility to purchase it outside these boundaries [25]–[27]. At the same time, the antimonopoly authorities face the problem of assessing all the particularities of the development of new technologies and their impact on the boundaries of the product market.

There is a tendency to expand both product market boundaries and geographic market boundaries [28], [29]. When different technologies serve the same purpose and consumers perceive them as interchangeable, in most cases they are considered part of a single market with competing technologies.

Regarding geographical boundaries, with the risde of digital platforms and online services, it is very complicated to establish certain market boundaries, taking into account the zero or very low cost of transporting digital products. In the European Union, as well as in other countries, antitrust authorities assess the relevant markets as global.

This refers, first of all, to areas where consumers purchase products globally. For example, when the hard disk manufacturer Western Digital acquired the Hitachi business, the European Commission determined this relevant market as global.

Consumers, especially computer manufacturers, buy hard drives from all around the world, so their price is roughly the same on all continents. However, there are also goods and services that are customized in order to meet the individual needs of certain consumers or groups of consumers.

If market boundaries are defined based on the opinion of the consumer, who prefers the customized product, the antimonopoly authorities may come to the conclusion that the boundaries of the product market are very narrow. In this context, in the conditions of the digital transformation of the economy, we can talk about two opposite tendencies of market development: the expansion of boundaries and the narrowing of boundaries.

These trends lead to the problem of not being able to determine product market boundaries. Thus, the European Commission, taking into account the problematic defining of market boundaries in the digital economy, very often sets quite broad product market boundaries [30].

The company AMAZON serves as an example. On this platform, some products, for example books, are sold at wholesale price and then sold at shelf price. For other products, such as household appliances or textiles, AMAZON works as a portal for manufacturers, who display their shelf prices directly on the platform. The existence of different business models makes it more complicated to determine the boundaries of the market. At the same time, the simultaneous existence of different business models on the market supports the existence of competition on the market [31], [32]..

In the context of the digital economy, in addition to all the questions, there is one more - the interchangeability between demand and supply. Interchangeability in demand means that if the price or quality of a product changes, the buyer may switch from one product to another.

Therefore, defining product boundaries in the market, from the point of view of demand, is based on the opinion of buyers about the interchangeability of products in a certain group. So, from the perspective of the European Commission, in order to determine an economically relevant market, interchangeability on demand is the main factor influencing the suppliers of the product, especially in terms of price formation. [33]–[35].

We must, however, also mention the fact that the interchangeability of the offer also has an important role in the analysis of competition on digital markets. Many digital platforms offer a wide spectrum of products from different categories and of different quality. They can change the production to other types of goods, without incurring large expenses or investments, relying on the not too big but permanent price change. The rapid transition to other new types of products and services is possible due to the reduction of

transaction and production holdings related to digitization. Thus, given the conditions of the digital economy, the interchangeability of offers plays an increasingly important role in determining the respective market. To illustrate how complicated the analysis of competition and examination of antitrust cases is, we present the example of the case involving WhatsApp's of abuse of a dominant market position, reviewed by the competition commission of India. WhatsApp was mainly accused of making changes to its privacy policy on August 25, 2016, forcing users to give access to their personal data from FACEBOOK in order to benefit from WhatsApp services. Considering that users in India did not really understand the terms of sharing personal data, their consent was not informed but rather forced. Regarding product market boundaries, the Competition Commission of India has concluded that WhatsApp operates within the messaging market, specifically through its application installed on the smartphone [36], [37].

Smartphone apps and traditional messaging services are independent product markets. Unlike traditional messaging methods, messaging through the app is an Internet service. Moreover, the WhatsApp service can only be used through a smartphone, while the traditional messaging service can be accessed from any mobile phone.

In addition, the text messaging service can be accessed between users of different mobile phone companies, while WhatsApp is only accessible to people using the app. Regarding the geographical boundaries, the WhatsApp market can be considered global, but it has certain peculiarities depending on the region.

Thus, the examining board determined the relevant market to be a market for messaging services used for communication by users of the smartphone application within the territory of India. Among Internet users in India, the most popular installed application is WhatsApp, used by 96% of those with Internet access. Based on this data, the Commission determined that WhatsApp has a dominant position in the given market. Even so, WhatsApp did not abuse this position. This is demonstrated by the following circumstances:

1. Users who were required to accept the new regulations had 30 days to opt out of this service.

2. The information obtained from the Facebook group was used only to improve the infrastructure and fight against SPAM.

3. All messages and information transmitted through WhatsApp were protected by encryption. In the context of the digital economy, the criteria for determining a dominant position to in the market are based on two key factors: quantitative and qualitative, as used by antitrust authorities.

The quantitative criterion assesses the market share of a product, identifying a market participant as dominant, once a specific threshold is reached. The qualitative criterion shows us the consequences that occur in the conditions where the participant obtains the dominant position on the market. If the participant's market share is greater than 50%, then it is determined as dominant, without examining the qualitative criteria. If the share is between 35% and 50%, then the process of determining the dominant position includes the examination of qualitative criteria:

a) The dynamics of the market participant's share must be constant or with small deviations.

b) Analysis of the market share ratio of competitors.

c) Analysis of the possibility of accessing the market of other new competitors.

Table 1: Top 10 global companies

1	Apple	Technology	851
2	Alphabet*	Technology	719
3	Microsoft	Technology	703
4	Amazon.com	Consumer services	701
5	Tencent Holdings	Technology	496
6	Berkshire Hathaway	Financials	492
7	Alibaba	Consumer services	470
8	Facebook	Technology	464
9	JPMorgan Chase	Financials	375
10	Johnson and Johnson	Health care	344

Source: [38]

Peter Thiel – one of the founders of PayPal - said that monopolies drive progress, because the prospect of earning monopoly income for the next years or decades is a huge incentive in the practice of innovations. He explains this by the fact that high-tech companies develop according to a different algorithm.

The first years are unprofitable, it takes time to create something valuable, and the profits come later. In his opinion, the antimonopoly authorities must be very attentive to the decisions related to pricing in digital markets, placing greater focus on the actions of companies, aimed at eliminating competition by

restricting access to the infrastructure of the digital domain or absorbing/acquiring potential competitors.

As long as a monopolist feels/perceives that excessive price increases attract new competitors to the market, it will try to maintain the price at a ceiling level so that it is not too attractive for new competitors to enter the market [39].

The theoretical model of "competitive markets" shows that the existence of a single producer does not always lead to monopolistic abuse, especially when there are no barriers to the entry into this market. That is why modern economic policy focuses not on the fight against the monopoly itself, but on addressing abuses of a monopolist's position.

The Antimonopoly Department of Great Britain characterizes potential competition as follows: Potential competition is the possibility that new companies entering a market can gain market by challenging adominant company, which has set prices above the competitive level. The degree of potential competition depends on the barriers to market entry [40].

The European Commission sees the importance of potential market competition in driving innovative development within the communications sector. In markets that evolve through innovation, the source of competitive restrictions is often "innovative threats" posed by potential competitors who, at the moment, have not yet established their place in the market. Dynamic or long-term competition can occur between companies that, from a of static competition viewpoint, are not necessarily competitors in the current market.

Modern digital companies could not have achieved such large and rapid growth that we see today without the advanced infrastructure of the digital world. Digital platforms can attain dominance when strong network effects combine with high user spending to switch to another platform. However, the dominant position of a platform stimulates other companies to implement innovations in order to destroy the dominant competitor's market. As both dominant companies and their competitors enhance their capabilities through the implementation of new technologies, market boundaries become unstable.

Data in the digital economy is one of the key resources and a major driver of market dominance. The abuse of a dominant position by companies that hold vast amounts of information can be of several forms: the imposing of contractual conditions, which are not favorable to the user or the creation of discriminatory conditions. In European competition law, the essential facilities doctrine applies to massive datasets.

The company that holds a dominant position in the market is obliged to provide competitors with access to massive data as a key source. Namely,

access to such massive data has been the subject of antitrust cases, such as the "European Union v. Microsoft" case. It was established that Microsoft had refused to disclose information necessary for competitors to be able to develop products compatible with Windows versions, and in this way, abused its dominant market position. So far, there is no definitive answer to the question of whether big data can be seen as a critical element, to which dominant firms will be forced to grant access under certain conditions [41], [42].

If we are to proceed to the conclusions, we must mention the common recommendations, which refer to the examination and antimonopoly analysis per general, and the specific recommendations, which focus primarily on defining dominance within the context of the digital economy. We need to focus less on traditional indicators such as market shares.

Antimonopoly authorities must focus more on indicators that reflect the state of competition, such as the presence of barriers to market entry, the presence of alternative ways to access end users (including measures related to the retention of end users), and the degree of innovation used in technologies and services .

Market shares should not be regarded as a primary factor in determining dominance. Markets characterized by pronounced network effects usually show a very high level of concentration.

The influence of network effects is very difficult to quantify. Likewise, it is very difficult to determine the company's share of the digital market. In this context, the large number of users served by a company can serve as a benchmark.

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ACCESS OF THE MOLDOVAN POPULATION TO HOUSING AND COMMUNAL SERVICES: MAIN PROBLEMS AND SOLUTIONS

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Abstract: *The main challenges related to the access of the population to housing and communal services in the Republic of Moldova, including electricity supply, water and sewage systems, heat energy and natural gas. In order to identify these problems, official statistics, data from international organizations, as well as the results of the sociological survey conducted by the authors were analyzed. The study reveales the low accessibility of housing and communal services for the population and highlights the significant lag of the Republic of Moldova compared to European countries. Proposals for improving the population's access to housing and communal services have been developed. The main directions for solving this problem are: development of infrastructure for housing and communal services, reduction of tariffs for their provision, digitalization of the housing and communal sector, and for rural population - planned territorial-administrative reform.*

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Keywords: *access of the population to housing and communal services, electricity supply, water and canalization supply, heat supply, natural gas supply, tariffs for public utilities, rating of countries by economic accessibility of services.*

Introduction

Housing and communal services (HCS) play a key role in ensuring comfortable living conditions for people and, therefore, access to them is an important factor in improving the living standards of the population. According to the socio-economic content, housing and communal services can be classified into 3 types:

- pure public services (landscaping, improvement of yard territories). Provision of these services is financed by state and local budgets;
- mixed services (drinking water supply, wastewater disposal, electricity, heat and gas supply);
- pure private services (services related to the maintenance and repair of housing stock, collection and disposal of household waste).

Developed countries have adopted a market model for housing and communal services, which implies an increase in the segment of pure private services within the sector, through measures such as privatization and lease of state-owned enterprises, unbundling of services, fostering competition, etc. In the Republic of Moldova, there is a trend toward market-based provision of housing and communal services, including transitioning to full reimbursement of the cost of these services by the population.

However, there are a number of factors that hinder the functioning of a fully market-based model for housing and utility services. Firstly, housing and utility services are life support services that ensure fundamental human rights; secondly, the development of housing and utility infrastructure requires substantial capital investment, whith these facilities often characterized by low commercial return; thirdly, with the rise of tariffs for housing and utility services, their consumption is limited to the population's effective demand, which leads to discrimination against low-income groups in accessing these basic needs.

These challenges underscore the necessity of focusing on the development of market mechanisms in the provision of housing and utility services, as well as on preservating segments of public and mixed services and state regulation of housing and utility services, including direct impact methods.

There are 3 types of accessibility of housing and utility services: territorial, tariff and organizational.

- Territorial accessibility of housing and utility services refers to the presence of organizations providing housing and utility services and ensuring adequate quality in the areas where people live. Measures to improve territorial accessibility to housing and utility services may include expanding the network

of housing and utility service providers and maximising their proximity residential areas.

- Tariff affordability of housing and utility services is characterized by the dynamics of tariff changes and the impact of these dynamics on consumers' ability to pay. Tariff affordability can be ensured through indirect regulation related to tax regimes, competition rules and other measures.

- Organizational accessibility of housing and utility services enures that no user is denied access to these services upon receiving the right to access them. Enhancing competition in the provision of housing and utility services can be achieved by involving efficient private operators in the management of municipal and regional utility infrastructure.

The most important types of housing and utility services are: electricity supply; water supply and sewerage; heat supply; and natural gas supply.

Uninterrupted electricity supply is closely linked to the energy security of the Republic of Moldova. In recent years, due to a number of circumstances, threats to the stable provision of electricity to the population have heightened. For example, in November 2022, there was a cessation of electricity imports from Ukraine, along with supplies from the Moldavian TPP, located in the Transnistrian region, which is not controlled by the constitutional authorities of the Republic of Moldova. These disruptions led to significant incidents within the country's energy system. As a result, on November 15 and 23, 2022, many towns and villages were left without power for several hours. Electricity imports from Romania (but at higher prices) helped mitigate the difficult situation.

The construction of the 400 kV high-voltage transmission line "Vulcanesti-Chisinau" would be a strategic objective to enhance the country's energy security. It is part of a general project of interconnection of electric networks of Moldova and Romania and connection of our country to the energy market of the European Union. The capacity of the transmission line 400 will allow the provision of up to 50% of the electricity consumption during peak demands periods.

The total length of the Vulcanesti-Chisinau transmission line will be 158 km, crossing 8 districts in the South and Center of the country. The project costs 61 million euros and is financed by the International Development Association - IDA, a member of the World Bank Group. The contract for the construction of the Vulcanesti-Chisinau-400 transmission line was awarded to the Indian company CES International. Construction started on March 29, 2024 and is scheduled to be completed by 2025. The new transmission line will directly connect Vulcanesti and Chisinau, bypassing the territory of

Transnistria. Until now, the supply of purchased Romanian electricity to Chisinau has been supplied through the Isaccea - Vulcanesti - Moldavskaya (Cuciurgan) thermoelectric station transmission line, and from the Moldavskaya (Cuciurgan) thermoelectric station another transmission line supplied electricity to the right-bank part of the country. This created certain threats to regular imports of electricity from Romania.

Thus, it is assumed that the problem of increasing the stability of the functioning of the electric system of the Republic of Moldova will be solved by interconnecting the electric networks of our country and Romania. This will be facilitated not only by the construction of the 400 kV Vulcanesti-Chisinau transmission line, but also by the construction of the 400 kV Suceava-Belti overhead transmission line, which will be ready in maximum 3 years. Plans also include connecting the 400 kV transmission line between Straseni and the power plant on the territory of Romania, as well as enhancing the existing 110 kV transmission line Hushi-Choara [5].

Methods and techniques applied

The main purpose of this research is to analyze the access of the Moldovan population to housing and communal services such as: *electricity supply, water and canalization system supply, heat energy and natural gas supply,* while revealing at the same time the main problems and proposing the appropriate solutions.

The analysis in this research was based on information from national and international scientific research, data from the National Bureau of Statistics of the Republic of Moldova, National Agency for Energy Regulation and also data from national and international Reports.

The following research methods were used in the presented work: induction and deduction, analysis and synthesis, monographic analysis, systematic approach, comparative and economic analysis of the statistical data, sociological survey, etc.

To assess the quality of housing and communal services, a sociological survey was conducted in March-April 2024. 237 respondents living in urban and rural areas of the country were interviewed.

The following Software applications were used for the practical implementation of the indicated methods:

- MS Word - for text processing,
- MS Excel - for calculating the data and developing diagrams,
- Microsoft Visio, Nebo Viewer – special applications for elaborating the diagrams/graphs/charts/figures, etc.

Obtained results

The results of the sociological survey revealed that both townspeople and villagers are mostly satisfied and rather satisfied with the quality of electricity supply. However, the respondents expressed certain concerns regarding the quality of power supply. 18.4% of urban residents and 11.9% of rural residents were dissatisfied with frequent power supply interruptions, and every sixth urban resident and every fifth rural resident pointed out low voltage in the power grid. However, the respondents were most dissatisfied with the high electricity tariff. 37.5% of city dwellers and 45.5% of rural residents said that it is excessively high. Table 1 presents data on households' assessments of the quality of electricity supply.

Table 1: Households' assessments of the quality of electricity supply (% of respondents)

	Urban	**Rural**
Degree of satisfaction with the quality of electricity supply		
satisfied and more likely satisfied	84.2	85.7
unsatisfied and more rather unsatisfied	7.9	7.2
What are the main complaints about the quality of electricity supply		
frequent electrical interruptions	18.4	11.9
low electricity voltage	15.8	21.4
no complaints	63.2	66.7
How the quality of electricity supply corresponds to the tariff		
correspond to the tariff	29.2	22.7
the tariff is overpriced	37.5	45.5

Source: calculated on the basis of own sociological survey data

It should be noted that, in the Republic of Moldova, electricity distribution is managed by two companies: Premier Energy and FEE Nord. Premier Energy covers 70% of the country's territory, servicing 20 out of 32 districts in the Center and South, as well as the municipality of Chisinau (939 thousand consumers in total). FEE Nord, on the other hand, serves electricity consumers in the northern region of the country, but its customer base is significantly smaller than that of Premier Energy. This circumstance allows Premier Energy to have a lower electricity tariff due to the use of economies of scale.

The most acute problem for electricity, that of overcharging, has an objective reasoning. It is expressed in a sharp increase in the tariff for electricity supply in 2021-2022.

While in 2021 the tariff for electricity supplied by Premier Energy was 151 bani/kWh, in December 2022 it was 591 bani/kWh, i.e. it increased 3.9 times. During 2022, the electricity tariff increased 6 times, and after December 2022 a downward trend in tariffs began. The most recent decrease in tariff occurred on November 14, 2023 (Figure 1).

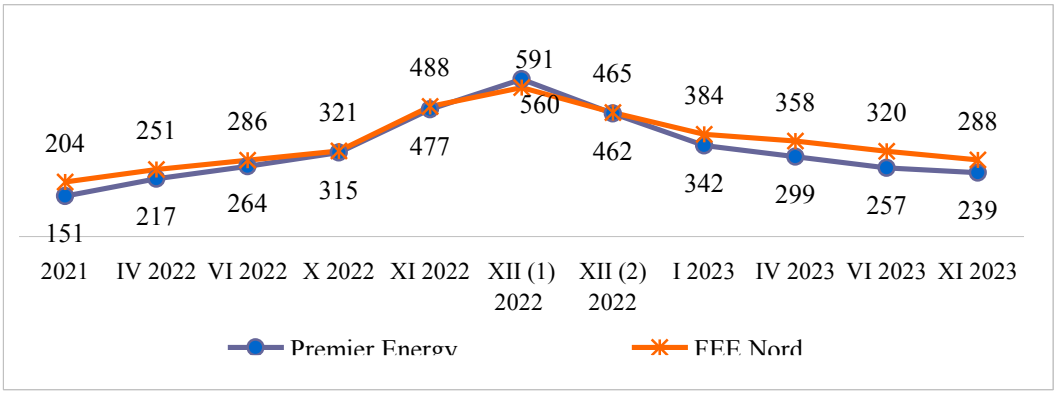


Figure 1: Dynamics of tariffs for electricity supply bani/1kWh
Source: elaborated according to data from [3]

This decrease in the electricity tariff was due to:

- 3-4% decrease in the average purchase price of electricity from the available suppliers: Moldavskaya (Cuciurgan) thermoelectric station, Chisinau cogeneration stations, Balti-Nord cogeneration stations and ORSON Bucharest exchange;

- application of the exchange rate of the national currency against USD in the amount of 18.31 MDL per USD instead of the previously used tariff of 18.99 MDL per 1 USD;

- signing a long-term contract with Moldavskaya (Cuciurgan) thermoelectric station for the wholesale purchase of electricity until the end of 2024, which improved the forecast of electricity supply sustainability in the future.

High electricity tariffs and low wages have led to the Republic of Moldova ranking last among 38 European countries in terms of affordability of electricity (Table 2). While in Iceland it was possible to pay 30.3 thousand kWh of electricity from one average monthly salary, in the Netherlands - 25.6 thousand kWh of electricity, in Liechtenstein - 24.7 thousand kWh, in the Republic of Moldova one could only afford 2.2 thousand kWh (Q4 2022) and 4.3 thousand kWh (Q2 2023). Thus, the affordability of electricity for the population of the Republic of Moldova in the first half of 2023 was lower than in Iceland by 7.0 times, in the Netherlands - by 5.9 times, in Liechtenstein - by

5.7 times. However, a significant reduction in the electricity tariff in 2023 led to a 97.3% increase the purchasing power of wages for electricity consumption.

Water and canalization supply

The volume of water resources available in the country is estimated at approximately 500 m3 per capita per year, which places the Republic of Moldova in the category of water-scarce countries with a heightened risk of negative impacts from climate change. The primary water source in the region is the Dniester River. Groundwater reserves are insignificant, with the largest reserves located in the districts of Anenii Noi, Criuleni, Orhei (central zone), the municipality of Balti (north), and the Stefan Voda area (south). The main source of water supply for settlements is surface water. The water intake is 84% from surface water sources and 16% from groundwater sources. Large settlements (Chisinau and Balti municipalities), as well as Soroca, Rezina and other settlements located on the banks of the river are supplied with water from the Dniester.

Over time, the access of settlements of the Republic of Moldova to the public water supply system has shown a positive trend. However, the situation of water supply to rural residents remains rather acute. The level of access of rural settlements to the public water supply system is only 60.3% (Table 3). At the same time, much better results have been achieved in a number of districts. Thus, the access of villages to the public water supply system in the municipality of Balti is 100%, in the municipality of Chisinau and Stefan-Voda districts - 89-92%, ATU Gagauzia - 83%. In the Rezina and Basarabeasca districts - 2/3 of villages have access to the public water supply system, whereas in Falesti and Soroca districts, only every third village has access to public water supply system. The worst situation is in the districts of Briceni (only 8 out of 37 villages, i.e. 21.6% have a public water supply system) and Ocnita (2 out of 30 villages, or 6.7%).

Table 2. Ranking of European countries by economic availability of electricity (first half of 2023)

	kWh for 1 average monthly salary can be paid for kWh			**kWh for 1 average monthly salary can be paid for kWh**
Iceland	30 314		Italy	5 516
Netherlands	25 652		Greece	5 242
Liechtenstein	24 697		Slovakia	5 206
Luxembourg	19 442		Estonia	5 132
Norway	17 135		Northern Macedonia	5 022
Kazakhstan	16 868		Lithuania	4 459
Russia	13 539		Latvia	3 430
Finland	12 793		Czech Republic	3 371
Austria	12 601		Romania	2 192
France	11 363		**Republic of Moldova*** **Republic of Moldova****	**2 204** **4 348**

* IV quarter 2022.

**II quater 2023.

Source: [6], authors' calculations for the Republic of Moldova

The situation concerning the access of rural population to the public sewerage systems is much worse - only 6.0% of rural settlements are provided with it. The best conditions are found in the villages of the Balti and Chisinau municipalities - half of them have access to the public sewerage system, respectively. Chisinau - half and almost ¾ of rural settlements have access to the public canalization system, respectively. On the other hand, rural settlements in the districts of Briceni, Drochia, Falesti, Glodeni, Ocnița, Sangerei, Soroca, Rezina, Basarabeasca, Cantemir had no access to public canalization systems at all. The problem of inadequate sewerage systems in rural schools remains serious. According to the Ministry of Education, in 175

out of 1208 schools and gymnasiums in Moldova, students still use outdoor toilets, and in 24 schools there is no access to drinking water.

Table 3: Level of access of rural Moldovan settlements to public water and canalization supply, 2022

Municipalities, regions	Number of rural localities	Water supply		Canalization supply	
		Have access	Access level, %	Have access	Access level, %
Total	**1478**	**891**	**60.3**	**89**	**6.0**
Mun. Balti	2	2	100.0	1	50.0
Stefan-Voda	25	23	92.0	2	8.0
Mun. Chisinau	28	25	89.3	20	71.4
UTA Gagauzia	29	24	82.7	4	13.8
Criuleni	42	33	78.6	7	16.7
Rezina	40	27	67.5	-	-
Sangerei	68	43	63.2	-	-
Basarabeasca	9	6	66.7	-	-
Cantemir	50	28	63.2	-	-
Glodeni	34	17	50.0	-	-
Drochia	39	16	41.0	-	-
Falesti	75	29	38.7	-	-
Soroca	67	21	31.3	-	-
Briceni	37	8	21.6		
Ocnita	30	2	6.7	-	-

Source: data from [4]

Unequal access of settlements to public water supply and canalization systems has resulted in disparities in the provision of water and sewerage services in the context of "urban-rural" dwellings. The data from Figure 2 shows a higher level of drinking water supply for urban residents - 96.5% of households have water supply inside their dwellings (66.3% of households in rural areas). Only 2.3% of urban households use water supply outside their dwellings, while in rural areas - 5.2 times more - 12.0% of households.

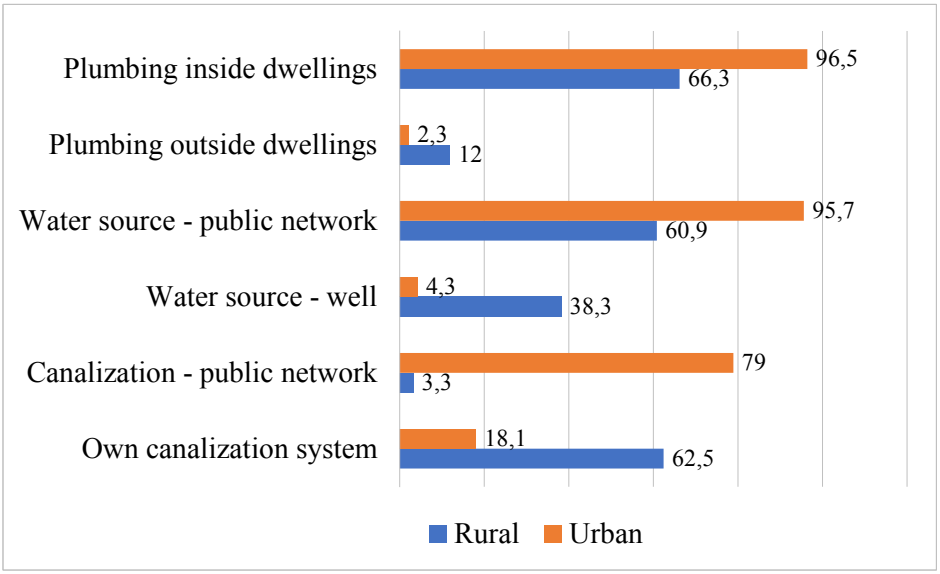


Figure 2: Supply of dwellings with water and canalization in the "urban-rural" context, 2022, %
Source: elaborated according to data from [1]

38.3% of rural households use water from wells, while in the urban area - only 4.3% of households. An important problem is the quality of water. In most wells, water does not meet either chemical or microbiological standards. In many cases, it contains excessive levels of nitrates , which seep into the soil from the improper storage of manure and the use of fertilizers in close proximity to wells. Additionally, in a number of districts of the country (Aneni Noi, Riscani, Glodeni, Causeni, Stefan Voda) the maximum permissible concentration of fluoride in well water is significantly exceeded.

In rural areas, the level of provision of dwellings with public canalization network is extremely low. While, in the city, eight out of ten households use it, in rural areas only every thirty-third household uses it. Rural residents have to provide their dwellings with their own sewerage systems - 62.5% of households (in the city - only 18.1% of households).

A significant number of households (80.0% - in urban areas, and 73.6% - in rural areas) are satisfied or rather satisfied with the quality of centralized cold-water supply (Table 4). Among those dissatisfied with the quality, the biggest complaints are that the water has sediment and is turbid (over 27% - in urban and rural areas).

Rural residents are most unsatisfied with the fact that water has a foreign odor (29.5% of respondents), and, in addition, urban residents have certain complaints about frequent interruptions of the water supply (19.4%).

Respondents believe that the quality of centralized water supply does not justify its high tariff, with56.3% of urban residents and 47.4% of rural residents sharing this view. The high cost of water supply was the main reason why an apartment (house) is not connected to the centralized water supply system. This is the opinion of every fifth urban respondent, while every third rural respondent indicates that the main reason for the non-connection is the lack of centralized water supply system.

Table 4: Households' assessment of the quality of centralized water supply
(% of respondents)

	Urban	**Rural**
Degree of satisfaction with the quality of centralized cold water supply		
satisfied and more likely satisfied	80.0	73.6
unsatisfied and more rather unsatisfied	17.2	15.8
What are the main complaints regarding the quality of water supply		
frequent interruptions in water supply	19.4	6.8
water has a foreign smell	19.4	29.5
water is muddy, with sediment	27.8	27.3
no complaints	33.3	36.4
The quality degree of centralized water supply corresponds to the tariff		
correspond to the tariff	25.0	21.1
the tariff is little overpriced	56.3	47.4
For what reason the apartment (house) is not connected to the centralized water supply system		
no centralized water supply system nearby	14.8	33.3
high tariff for water supply	22.2	14.3
high system connection costs	11.1	4.8

Source: calculated on the basis of own sociological survey data

There is a significant differentiation in the tariffs for drinking water and canalization services across the country. Among the 44 licensed companies operating in this sector, the lowest tariffs have been consistently applied by S.A. "Apa-Canal-Chisinau". As of December 31, 2022, the tariff for water supply for household consumers amounted to 8.65 MDL / m^3, and for sewerage - 2.04 MDL / m^3, which is 3.2 times and 13.6 times less than, for example, in Î.M. "Servicii Comunale Glodeni" (Table 5). In 2023, higher tariffs started to be applied for Chisinau residents, which were due to the following factors:

- 87.9% increase in the electricity tariff (from 1.82 to 3.42 MDL / kWh) and, consequently, an increase in the costs of electricity consumed;

- increase in prices for reagents used for drinking water and wastewater treatment (as compared to 2020, by 4 times);

- increase of the minimum wage from MDL 2,300 to MDL 4,000 per month, which caused an increase in labor costs for employees.

Table 5: Tariffs for public drinking water and canalization, MDL/m^3 (on 31.12.2022)

	Water supply		**Canalization supply**	
	Household consumers	**Non-household consumers**	**Household consumers**	**Non-household consumers**
S.A. „Apa-Canal Chisinau”	8.65*	13.29	2.04*	11.17
Î.M. „Apa-Canal” from Ungheni	13.40	22.15	7.07	16.32
S.A. „Apa-Canal” Cahul	13.98	22.45	8.18	15.30
S.A. „Regia Apa-Canal Soroca”	15.39	35.20	**1.60**	12.33
S.A. „Servicii Comunale Floresti”	23.70	35.09	17.67	37.76
Î.M. „Apa-Canal Ocnita”	25.38	39.95	16.38	36.33
Î.M. „Servicii Comunale Glodeni”	27.68	54.83	27.74	52.99

* As of January 11, 2023, new tariffs for household consumers are in force: drinking water supply - 11.12 MDL/m^3 (by 2.47 MDL more than the existing tariff); canalization and wastewater treatment - 4.18 MDL/m^3 (by 2.14 MDL more than the existing tariff).

Source: data from [3]

Higher tariffs for non-domestic consumers are noteworthy. The reason for this phenomenon is the so-called cross-subsidization, where the higher tariffs for non-domestic consumers are used to subsidize and reduce the tariffs for residential consumers.

It should be noted that S.A. "Regia Apa-Canal-Soroca" has the lowest tariff for sewerage services for household consumers - 1.60 MDL / m^3. This is due to the fact that in the municipality of Soroca lacks proper treatment facilities. The only treatment available is a reservoir where large particles settle, and the remaining wastewater goes into the Dniester River, from which water

is supplied to the water supply system of 10 major Moldovan and Ukrainian cities on both banks downstream, including Chisinau and Odessa.

There has never been a wastewater treatment plant of its own in the municipality of Soroca. Until 2001, wastewater was treated in the Ukrainian village of Cekinovka, located on the opposite bank of the Dniester River. After that/However, this station was closed, and since then, 2300 cubic meters of sewage from Soroca have been discharged directly into the Dniester River every day. As a result, an extremely dangerous situation from an epidemiological point of view has persisted for several decades. It is expected that this problem will soon be solved with the help of an 11 million euro loan from the World Bank, intended for the construction of wastewater treatment facilities in the municipality of Soroca.

Heat energy supply

In 2022, 11 licensed enterprises were involved in producing, distributing and delivering heat energy through centralized systems. Of these, only 8 enterprises supplied heat energy to households. Households accounted for 76.7% of the total heat energy consumed,. At the same time, in S.A. "Termoelectrica" Chișinău, this share was 78.1%, while in Î.M. "S.C.L. Orhei" - only 3.7%.

Almost all rural households lack access to public hot water and heating systems. They are forced to rely on their own hot water supply systems - more than half of the rural dwellings are provided with them. At the same time, 19.1% of urban dwellings are provided with hot water through the public network, and 71.5% - through their own system (Figure 3).

Central heating of rural dwellings is common among only 0.4% of them, while one in three urban households benefits from central heating. In rural areas, the primary method of heating is stove heating, with nine out of ten rural households relying on this method (only two out of ten households in urban areas).

Natural gas supply

The access of Moldovan settlements to natural gas networks has increased due to the presence of several large gas trunklines, used for natural gas transmission, that traverse the territory of the Republic of Moldova. The largest of these pipelines were constructed between 1970-1980. These include gas pipelines for natural gas transportation to the Balkans (Ananiev-Tiraspol-Izmail; Shebelinka-Krivoy Rog-Izmail) and for natural gas transmission to the North of Moldova (Ananiev-Chernovcii-Bogorodchany). In 2021, in addition

to the 8 functioning gas trunklines, the Iasi-Ungheni-Chisinau gas pipeline was put into operation. Low-pressure gas distribution networks were constructed, ensuring the supply of natural gas to the country's settlements.

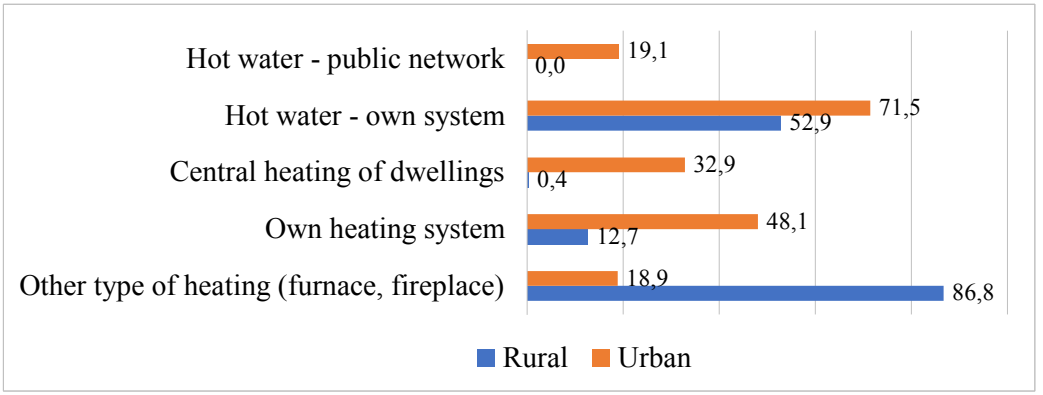


Figure 3: Supply of dwellings with hot water and heating systems in the context of "urban-rural", 2022, %.
Source: based on the data from [1]

Nevertheless, as of January 01, 2002, only 16.2% of settlements had access to natural gas networks . Not a single municipality, nor district, was fully supplied with natural gas. Even in some cities-district centers - Leova, Nisporeni, Ungheni, Hincesti - the population did not have access to natural gas networks (Table 6).

In recent years, there has been a strong tendency to improve the situation. As of 01.01.2023, in the Republic of Moldova, out of 1533 localities, 961, or 62,7%, had access to gas distribution networks. In urban areas, the level of access reached 97,7%, the only city that did not have access to natural gas networks being the town of Cornesti (Ungheni region). Out of the total number of localities and villages (1478 units), 907 units (61.4%) had access to natural gas networks, an increase of 10 localities (in the districts of Soldanesti, Rezina, Ungheni, Leova, Donduseni, Telenesti, Orhei, Cantemir).

The highest level of access to natural gas networks was recorded in the localities of Criuleni, Dubasari, Stefan Voda and Balti municipality - 100%. Access to natural gas networks is also high in UTA Gagauzia and Taraclia district (in each of which only one village did not have access to gas supply), as well as in Straseni district and Chisinau municipality (2 villages each were not connected to the gas supply system). Conversely, the lowest level of access to natural gas networks is in Falesti - 19.7%, Hincesti - 28.6%, and Ungheni - 32.4%.

Table 6: Level of access of Moldovan localities to natural gas networks

Municipalities, regions	on 01.01.2002				on 01.01.2023		
	Number of localities	Have access	Access level, %		Number of localities	Have access	Access level, %
Total	**1528**	**247**	**16.2**		**1533**	**961**	**62.7**
Criuleni	43	22	51.1		43	43	100.0
Dubasari	15	7	46.6		15	15	100.0
Stefan Voda	26	12	46.1		26	26	100.0
Mun. Balti	3	1	33.3		3	3	100.0
UTA Gagauzia	32	27	84.3		32	31	96.8
Taraclia	27	14	51.8		26	25	96.1
Straseni	38	5	13.1		39	37	94.9
Mun. Chisinau	34	13	38.2		35	33	94.2
Mun. Cahul	51	6	11.8		55	50	90.9
Leova	39	-	-		40	28	70.0
Nisporeni	39	-	-		39	23	59.0
Ungheni	74	-	-		74	24	32.4
Hincesti	63	-	-		63	18	28.6
Falesti	75	6	8.0		76	15	19.7

Source: data from [4]

Urban residents have better access to natural gas networks than rural residents. Nine out of ten urban households are supplied with natural gas, while in rural areas - four out of ten households. Consequently, rural residents face more than twice the difficulty in accessing natural gas networks, which negatively affect their living conditions.

One of the problems of limited access to the use of natural gas in households was the inability to connect to the natural gas network. The results of a sociological survey (Table 7) highlighted the reasons for not connecting to the natural gas networks . Both urban and rural respondents pointed out that the territorial and tariff inaccessibility act as barriers to accessing natural gas. However, this problem/issue was significantly more acute for rural residents than for urban residents.

Thus, every fifth rural respondent and only every sixth urban respondent mentioned the unavailability of the natural gas network near their apartments (homes) as a reason for not connecting . More than a half of rural residents were unable to connect to the natural gas network due to the high tariffs for the use of natural gas, compared to only ¼ of urban residents. The tariff inaccessibility of natural gas is underscored by a much higher tariff for its use: dissatisfaction with the cost-to-quality ratio was indicated by more than 2/3 of both urban and rural residents.

Table 7: Households' assessment of the quality of natural gas supply (% of respondents)

	Urban	**Rural**
Degree of satisfaction with the quality of natural gas supply		
satisfied and more likely satisfied	70.9	74.3
unsatisfied and more rather unsatisfied	25.8	14.3
How the quality of natural gas supply corresponds to the tariff		
correspond to the tariff	16.7	6.3
the tariff is little overpriced	66.7	68.8
For what reason the apartment (house) is not connected to the natural gas network		
no natural gas network nearby	15.6	21.7
high tariff for the use of natural gas	25.0	52.5
high costs for connection to the natural gas network	31.3	26.1

Source: calculated on the basis of own sociological survey data

Tariff inaccessibility of natural gas presents a more acute problem for household consumers than territorial inaccessibility. This issue has been conditioned by a sharp increase in natural gas tariffs during 2021-2022. Its dynamics, presented in Figure 4, show that in the time span ranging from 03.11.2020 to 01.10.2022, the tariff changed 4 times and it increased from 4.64 MDL to 29.27 MDL per 1 m^3, i.e. 6.3 times. Especially sharp was the increase of the tariff from 03.11.2020 to 01.11.2021, when it increased 2.4 times in the course of one year. It should be noted that in 2023-2024, a decrease in the tariff for natural gas was recorded, when, on 07.06.2023, it was reduced to 18.07 MDL per 1 m^3 (i.e. by 38.3%), and, on 23.02.2024, to 14.47 MDL (i.e. by 19.9%).

Unprecedentedly high growth rates of tariffs for consumed natural gas have caused a reduction in its economic affordability. The purchasing power of household incomes, including wages, has sharply declined. According to this indicator, the Republic of Moldova ranked last among the 30 countries in the assessment (Table 7). In contrast to this, in Kazakhstan one average monthly

salary could buy 9.9 thousand m^3 of natural gas, in Russia - 7.6 thousand m^3, in Belarus - almost 5 thousand m^3, in the Czech Republic - 656.8 m^3, in Romania - 570.5 m^3, and in the Republic of Moldova - only 421.7 m^3.

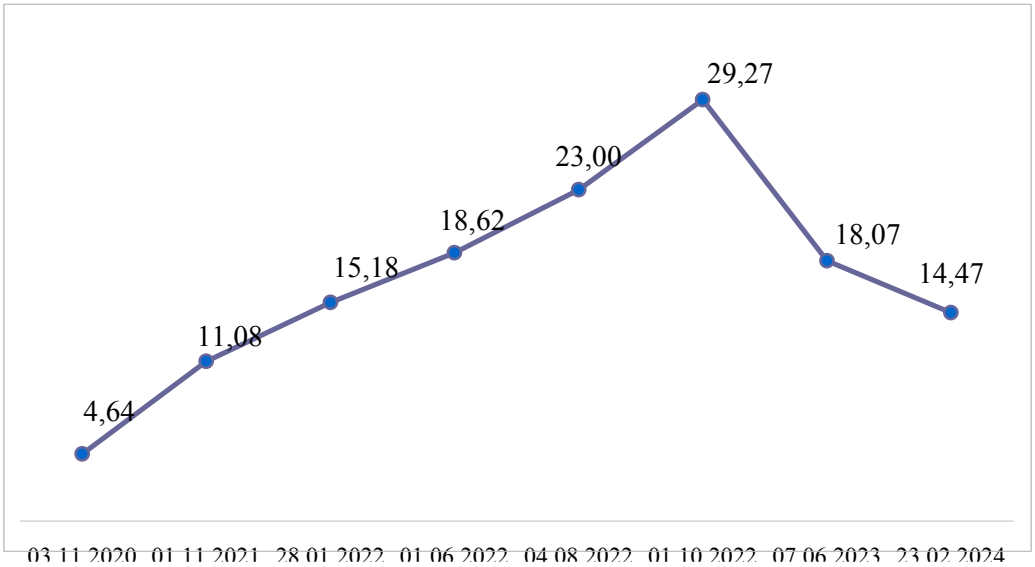


Figure 4: Dynamics of natural gas tariff for household consumers (including 8% VAT), MDL/m^3

Source: elaborated according to data [3]

The challenge of ensuring uninterrupted natural gas supply for the population is expected to be addressed by enhancing gas transportation capacity and expanding the Iasi-Ungheni-Chisinau gas pipeline through the construction of the "Chisinau Belt" gas transportation pipeline (this objective can be achieved by the end of 2031). In addition to this, the development of the natural gas storage system in Romania will be strengthened by increasing the natural gas storage capacity in the Sarmasel field and/or building a new storage facility in Falticeni [5].

Consequently, there are significant problems regarding the population's access to housing and communal services. In many ways, they are similar for both urban and rural populations. However, the peculiarities of settlements and differences in the financial capacities of the urban and rural population predetermined the specificity of ways to solve the problems of their access to housing and communal services. For urban residents, the digitalization of housing and communal services will be important, and for rural residents - the forthcoming territorial and administrative reform.

Table 8: Countries ranked by economic affordability of natural gas for households (first half of 2023)

Ranking number	Country	One average monthly salary can purchase natural gas; m^3		Ranking number	Country	One average monthly salary can purchase natural gas; m^3
1	Kazakhstan	9 899.6		23	Portugal	977.9
2	Russian Federation	7 642.6		24	Latvia	891.8
3	Belarus	4 967.6		25	Bosnia and Herzegovina	839.4
4	Luxembourg	4 300.6		26	Greece	771.4
5	United Kingdom	3 262.9		27	Bulgaria	711.4
6	Germany	2 942.4		28	Czech Republic	656.8
7	France	2 397.4		29	Romania	570.5
8	Hungary	2 381.4		30	**Republic of Moldova**	**421.7**

Source: [6], for the Republic of Moldova - authors' calculations

Digitalization of the housing and communal services sector

The widespread adoption of digital technologies in the housing and communal services sector will significantly enhance the operational efficiency of communal organizations, ensuring a more reliable and secure delivery of services.

The main principles of digitalization of the housing and communal services sector include:

- orientation to the end consumer of public utilities;- reduction of risks of violating legislation due to incomplete information;- reduction of the time required for document processing.

The introduction of modern information technologies in the housing and communal services sector presents a favorable situation for the population. Urban households are in a much better position: among them, eight out of ten households have Internet connection, while among rural residents - only six out of ten households [1].

Digital platforms will make it possible to involve citizens in assessment and management procedures. The digitalization of the housing and communal services sector means, for example, the implementation of the possibility to hold general meetings of homeowners not in person, but through electronic voting. This is provided for by the Law on Condominium in the Republic of

Moldova and, in particular, Article 31 "Use of electronic communication means" [2].

Digitalization will provide residents with full transparency and correctness of charging for the provided housing and utility services. This is evident from the example of "smart" meters, which take readings themselves and automatically transmit them to information systems to generate calculations. Thus, smart meters will give residents:

a) confidence in the correctness of charges for housing and communal services and

b) eliminate the need to submit monthly meter readings.

Territorial-administrative reform

On July 31, 2023, the Parliament adopted the Law on Voluntary Unification of Administrative-Territorial Units in the second reading. The purpose of the Law is to strengthen the administrative capacity of local public administration authorities and to ensure the provision of high-quality and accessible services to the population. The Law envisages voluntary unification of 2 or more administrative-territorial units of the first level (villages/communities and cities/municipalities) based on decisions made by local councils, provided specific conditions are met.

1) The territory to be merged must be continuous, with a combined population of at least 3000 inhabitants.I In the Republic of Moldova, the average number of inhabitants per rural settlement is 1055, while in the districts of Cantemir, Rezina, Soroca, it is slightly more than 700, and in the districts of Leova, Taraclia, Cimislia it is less than 700. At the same time, at the beginning of 2023, the country had large villages in terms of population - Congaz (UTA Gagauzia) - 9463 people, Copceac (UTA Gagauzia) - 7207 people, Costesti (Ialoveni region) - 7484 people, (while some towns had smaller populations - Soldanesti - 4776 people, Cantemir - 2586 people). At the same time, approximately 50 villages in the country had populations ranging from just a few people to a few dozen people.

2) The distance from the administrative center to any part of the settlement shall not exceed 25 km.

The state is expected to provide financial support to localities that choose to unite. This support will include allocations from the state budget for infrastructure development projects, such as water supply and sewerage systems, as well as natural gas networks. Additionally, local budgets will be supplemented for a period of 7 years, along with other financial incentives to encourage unification.

Conclusion

Accessibility of the population of the Republic of Moldova to housing and communal services is influenced by a number of factors. For the uninterrupted supply of electricity to the population, the construction of a high-voltage line of the 400 kV transmission line "Vulcanesti-Chisinau" will be of great importance. This project will facilitate the connection of our country to the European Union's energy market, enhancing the sustainability and reliability of the country's electricity system.

The limited access to public water supply and sewerage systems, especially in rural areas, is expected to be addressed through the construction of new utility networks. This development will be funded both from the national budget and from international financial organizations.

The problem of ensuring uninterrupted natural gas supply is supposed to be solved by increasing the capacity of gas pipelines from Romania and further developing the natural gas storage system on the territory of this country.

A common challenge across all housing and communal services is their low economic accessibility. This problem will be solved through the implementation of policies aimed at increasing the monetary income of the population of the Republic of Moldova.

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Assessing the economic dimension of quality of life. Case of Romania at NUTS II regional level

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Abstract

This article evaluates the quality of life in Romania across NUTS 2 regions by examining the relationship between GDP per capita and several socio-economic factors, including school population, poverty rate, average salary, average income, and life expectancy. These indicators are crucial for assessing economic development trajectories, particularly in developing economies. Utilizing empirical data spanning a decade, the analysis investigates the impact of each factor on economic well-being and human development in the regions studied. The econometric model highlights the interdependence between various socio-economic factors and Romania's quality of life, revealing diverse and sometimes paradoxical results. Achieving equitable and sustainable regional development nationwide necessitates an integrated approach and collaboration among authorities, the private sector, and civil society, with a focus on fostering equal opportunities and reducing socio-economic disparities between regions. Understanding these intricate relationships is essential for crafting effective policies and interventions to promote sustainable and equitable economic and social progress across the country.

Keywords: *quality of life, GDP per capita, NUTS II, development*

Introduction

Quality of life (QoL) has become a significant subject of extensive research, with the economic factor playing an increasingly prominent role in its analysis. This multifaceted concept attracts attention not only from economists but also from specialists in sociology, philosophy, politics, and psychology. As a multidimensional construct, QoL measures the level of social satisfaction derived from individual actions and needs, influenced by one's perception and expectations (Steele, 2013).

The World Health Organization emphasizes the subjective aspect of QoL, highlighting individual perception, cultural context, and value systems. While the economic factor forms the cornerstone of QoL, it is intertwined with other elements such as health status, the quality of healthcare and education systems, and subjective factors.

Analyses of quality of life can take various perspectives, with the economic component being paramount due to its pervasive influence on our surroundings.

According to most social and economic research, the factors that influence the quality of life include economic resources, health status, level of education, financial security, job security, quality of the environment.

In economic literature, these two important concepts are treated separately, with economists recognizing the differences between economic growth and economic development, as well as the misunderstandings that may arise if their true meanings from an economic point of view are ignored (Wijaya et. all. 2021)

Economic development or well-being cannot occur in an economy in the absence of economic growth, but since economic growth can be either sustainable or unsustainable, it may exist without necessarily having positive qualitative effects in terms of quality of life.

We must not forget that the process of economic development is quite complex, driven primarily by economic vectors, and secondly by political, social, geographical, demographic, and other factors. An overview of the world economy reveals varying values across different regions.

The accurate measurement of economic development (human development index - HDI) is based on three key indicators: life expectancy, quality of education, and income per capita. The human development index is calculated as the geometric mean of the normalized indices of the three indicators, the result being a positive and unitary value.

It is true that, from an economic point of view, it is much easier for researchers to make objective measurements when the focus is on economic factors. The challenge arises when research on quality of people's lives goes beyond financial measurements and calculations, which cannot be neglected, to include aspects that are more difficult to quantify, such as emotional well-being, and the type and intensity of lived experiences (stress, joy, affection, sadness, etc.) Other important components of quality of life include health status, the individual's access to the health system and its level of performance.

More and more individuals, when questioned about their quality of life, judge this concept primarily in terms of health status and the accumulation of material goods for both present and future consumption. At first glance, indeed, quality of life does appear to be a subjective measure of happiness, as previously mentioned, yet it is fundamentally influenced byeconomic and financial decisions. Because it is a purely subjective concept, quality of life is perceived differently by each individual, but this subjective quality of life

depends only on the objective situations of individuals. Moreover,the quality of life is also influenced by the level of development of the national economy in which the individual resides.

Regardless of the continent, region, or country in which the individual lives, they have ideals, aspirations, and expectations for themselves and their families. We consider that the quality of life is perceived differently in a developed economy, differently in an emerging economy and differently in a poor economy. In a developed economy the significant elements influencing quality of life differ from those in a developing or underdeveloped economy.

2. Literature review and methodology

While quality of life (QoL) is recognized as a multidimensional concept, its material dimension- encompassing factors such as per capita income, poverty thresholds, and social exclusion- is considered predominant (Cambir & Vasile, 2015).

Additionally, the literature indicates a robust association between QoL, standard of living, and dynamics of real income per capita (Wijaya et al., 2021). Moreover, QoL is subject to cultural, perceptual, and religious variations across different regions of the world（Bowling & Windsor, 2001）.

As individuals are social beings, the QoL they experience is nothing more than a perception of things from their own perspective, strongly influenced by the goals they set and the expectations they hold related to them (Bognar, 2005).

At the macroeconomic level, the degree of an economy's developmentcan be assessed primarily by indicators such as the rate of economic growth, gross domestic product per capita, and average income per capita (Whelan, Fahey & Nolan, 2014). At the microeconomic level, we analyze the individual's level of well-being both according to the economic growth rate and the level of economic development (Achim, Văidean & Safta, 2023).

Most of the time, history has shown many times that an increase in quality of life is not automatically generated by economic growth. (Whelan, Fahey, & Nolan, 2014)

When analyzing the economic dimension of quality of life, a genuine increase in the pace of economic development has been observed, which can only take place when accompanied by a corresponding rise in gross national product. Economic growth that is neither sustainable nor grounded in fundamental economic drivers cannot lead to an improvement in QoL (Samli, 2010).

Within the economic development process, a rather complex one, there are also political, social, demographic factors that influence both the quality of the process and also the quality of life (Ahmed, Zhang & Cary, 2021). An analysis of the global economy reveals different values in terms of per capita income. Some regions, endowed with abundant natural resources, exhibit high per capita income (Layton, 2009). However, there are also regions that, although they lack natural resources, also have a high per capita income. Conversely, some regions and countries, which have ample resources, record low, insignificant per capita income compared to similar countries or regions. What are the explanations for these differences? Is an above-average rate of economic growth sufficient to define economic development?

Many researchers draw attention to the confusion that is often made between the concepts of standard of living and quality of life. The standard of living takes into account the level of wealth, material goods, perceived comfort, as well as belonging to a certain socioeconomic class. Unlike the standard of living, quality of life (although its measurement also involves macroeconomic indicators) encompasses subjective dimensions (Bérenger, & Verdier-Chouchane, 2007).

A holistic analysis of quality of life shows that at the level of this concept a direct link is the one reported to the income per capita, but, at the same time, the effect of changes generated by exogenous factors at the level of this indicator generates surprisingly uneven changes in the quality of life. Research suggests that these variations may be influenced by the long lags and fluctuations that may occur between economic growth and improvements in quality of life, or the possibility that socioeconomic progress may play a more significant rolethan the pace of growth in shaping quality of life indicators. (Easterly , 1999; Haller, 2012).

The pursuit of a good life has accompanied humans since ancient times. Starting in the 20th century, researchers began focusing on the quality of life, striving to define it both qualitatively and quantitatively through the prism of social and economic indicators. (Haller, 2012). These indicators encompass subjective experiences, normative ideals, as well as the ability of goods and services to satisfy human needs. Social indicators are just as important as economic ones because, together, they provide a comprehensivepicture of a society's well-being (Diener & Suh, 1997).

Beyond subjective perceptions, the quality of life is also shaped by concrete circumstances, such as the macroeconomic situation, the education system, the political system, the health system, etc. (Hajduová & Beslerová, 2014). In developed countries, where per capita income is very high, the

quality of life as a concept is perceived differently from a structural point of view, other elements apart from the economic ones being much more significant (Richard, Anghelescu, 2011). On the contrary, in developing countries, the factor that strongly influences and shapes the quality-of-life phenomenon is predominantly the economic one.

Depending on the level of development of a national economy, the quality of life is perceived and approached differently. In developed countries, the factors used to measure quality of life, in addition to those of an economic nature, include efficient health and education systems, political stability, social protection, environmental quality, respect for human rights, gender equality. Once a satisfactory level of per capita income is achieved, individuals tend to shift their focus toward fulfilling higher-order needs (Zuzana et.all. 2013).

The global health crisis triggered by the COVID-19 pandemic has generated a significant decline in quality of life across all world economies. Restrictions on social life, the spread of the disease, the looming threat of an economic crisis, and widespread job losses (as a result of shutdowns of the economy) severely impacted quality of life, both objectively and in people's perceptions (Ferreira, da Fé Brás, & Ilchuk, 2021).

In the present research we have conducted a holistic analysis combining both the specialized literature and qualitative and quantitative comparative studies on the economic dimension of quality of life. In this context, we found it appropriate for this scientific approach to evaluate the quality of life in Romania from a regional perspective, namely at the NUTS 2 level. The quantitative component of the study is based on the collection, processing, and interpretation of statistical data provided by the Romanian National Institute of Statistics and Eurostat. The variables used in the present study include: GDP per capita, average monthly nominal income per capita, average monthly net salary per capita, gross fixed capital formation, poverty rate, life expectancy, and school population by education levels.

Through the analysis of both aggregate indicators and composite indices, we aimed to provide a comprehensive overview of the socio-economic landscape and inequalities across the NUTS 2 regions of Romania, thereby contributing to the body of knowledge on the dynamics of regional development.

Beyond these economic and financial tools of measuring quality of life, we also identify other aspects, such as emotional well-being and the fulfillment of personal ideals. However, these subjective dimensions are closely related to and stem from the economic phenomenon.

By delving into statistical data, the study aims to uncover nuanced insights into the relationship between economic growth, development, and societal well-being in Romania and its regions.

In the next section, we will examine the relationshipbetween GDP per capita, average monthly net nominal salary, total average monthly income per capita, school population by education levels, poverty rate, and life expectancy. We consider the connection between these variables to be extremely important at both the economic and societal levels, as they can significantly influence the quality of life of a population. These indicators are often used to evaluate and monitor progress in terms of the development and well-being of a country or region. For this analysis, GDP per capita will be treated as the dependent variable.

The relationship between GDP per capita and variables such as school_population, poverty_rate, average_net_salary, life_expectancy and total average income per capita can be analyzed within the context of complex economic and social models. The predictors in the present econometric analysis can have significant effects on the dependent variable.

A larger school population may indicate a more skilled and educated future workforce, potentially generating an increase in productivity and income (Powers & Flint, 2016). As for the growing school population, it could contribute to economic growth and an increase in GDP per capita (Ahlgrim, 2010; Efendi, Indartono, & Sukidjo, 2019).

Additionally, a rising poverty rate indicates an unequal distribution of income and limited access to resources and opportunities, which can negatively impact productivity and economic growth (Škare & Drujeta, 2016; Kuznets, 1959).

A suitably qualified workforce at all levels of the economy can be attracted and retained through higher average net wages. A higher net average wage stimulates consumption and saving, with an immediate effect on investment (a component of aggregate demand), generating a sustainable increase in GDP per capita.

A higher life expectancy can be interpreted as a healthier and more active population, contributing to the total labor force and indirectly having positive effects on labor productivity, and implicitly on GDP per capita (Kunze, 2014).

A growing average per capita income serves as the foundationfor improving quality of life; it stimulates consumption, saving, as well as investments. An increase in GDP, viewed from the perspective of aggregate demand, is also associated with a rise in GDP per capita (Precupețu et.all 2018).

To test this hypothesis, we will use econometric analysis on statistical data collected from the INSSE Romania for a period of 10 years (2012-2021)

First, we will analyze the econometric data at the national level of the Romanian economy, and then for each NUTS II region. This approach will allow us to scientifically assess the existing socio-economic gaps between the 8 regions of Romania.

Let's consider a linear regression of the form: y=a(1)x(1)+...+a(n)x(n)+u, where u is the residual variable.

In what follows we will note:

GDP per capita - GDP_capita

School population by education levels - School_population

Poverty rate - Poverty_rate

Average monthly net nominal salary - Average_net_salary

Life expectancy - Life_expectancy

Total average monthly income per capita - Total_average_income_capita

We will look for a linear regression of the form:

$$GDP_capita=a1\cdot School_population+a2\cdot Poverty_rate+a3\cdot Average_net_salary+a4\cdot Life_expectancy+a5\cdot Total_average_income_capita+u,$$

where u is the error term.

To estimate the increase by a number of w units (representing the average growth of the variable over the analyzed period), we will expand the function using Taylor series:

$$GDP_capita=a1\cdot School_population+a2\cdot Poverty_rate+a3\cdot Average_net_salary+a4\cdot Life_expectancy+a5\cdot Total_average_income_capita$$

around points School_population, Poverty_rate, Average_net_salary, Life_expectancy, Total_average_income_capita.

We obtain that:

$$Variation(GDP_capita(School_population+w))=a1\cdot w$$

$$Variation(GDP_capita(Poverty_rate+w))=a2\cdot w$$

$$Variation(GDP_capita(Average_net_salary+w))=a3\cdot w$$

$$Variation(GDP_capita(Life_expectancy+w))=a4\cdot w$$

$$Variation(GDP_capita(Total_average_income_capita+w))=a5\cdot w$$

3. Results and discussion

Table 1 presents a model summary with regression results for different regions in Romania, using GDP per capita as the dependent variable. The predictors include school population, poverty rate, average net salary, life expectancy, and total average income per capita. The table shows the correlation coefficient (R), coefficient of determination (R Square), and adjusted R Square values for each region. These values indicate strong correlations between the predictors and GDP per capita in most regions, with

the North East and West regions showing particularly high explanatory power. In contrast, the South East region seems to have a weaker correlation, as indicated by its lower R Square and adjusted R Square values.

Table 1 Model Summary (b)

Country/Region	R (a)	R Square	Adjusted R Square
ROMANIA	0.997	0.994	0.986
NORTH WEST Region	0.998	0.996	0.991
CENTER Region	0.998	0.997	0.993
NORTH EAST Region	1.000	0.999	0.998
SOUTH EAST Region	0.987	0.974	0.942
BUCURESTI - ILFOV Region	0.999	0.997	0.993
SOUTH-MUNTENIA Region	0.991	0.983	0.962
SOUTH Region	0.995	0.989	0.975
WEST Region	1.000	0.998	0.996

(a) Predictors: (Constant), School_population, Poverty_rate, Average_net_salary, Life_expectancy, Total_average_income_capita

(b) Dependent Variable: GDP_capita

Source: Authors' computation

Table 2 presents a summary of the correlations between the key variables analyzed, including average monthly net nominal salary, total average monthly income per capita, school population by education levels, poverty rate, and life expectancy. This table enables us to identify the relationships and interdependencies between these variables, helping to better understand the relational structure of the data.

From the data in the table above, we observe that the low values of the F-test and their associated p-values indicate that the regression model is statistically significant for all regions included in the analysis. This suggests that at least one independent variable has a significant influence on the dependent variable (although it is not specified in the table). In other words, the results are considered statistically robust, indicating a significant relationship between the tested variables.

Table 2 Statistical Significance of Multi-Region Regression: Effects of Predictors[a] on the Dependent Variable[b]

Country/Region	**Std. Error of the Estimate**	**R Square Change**	**F Change**	**Sum of Squares (Regression)**	**Sig. (b)**
ROMANIA	191.052	0.993	492.128	35926202.872	$30 \cdot 10^{-7}$
NORTH WEST Region	263.909	0.993	534.211	74413536.133	$22 \cdot 10^{-7}$
CENTER Region	355.663	0.992	450.551	113985790.267	$40 \cdot 10^{-7}$
NORTH EAST Region	407.775	0.987	266.601	88660849.214	$25 \cdot 10^{-6}$

SOUTH EAST Region	672.727	0.987	273.973	247979683.530	$23 \cdot 10^{-6}$
BUCURESTI - ILFOV Region	162.352	0.990	352.099	18561294.932	$95 \cdot 10^{-7}$
SOUTH-MUNTENIA Region	282.879	0.983	205.304	32856993.587	$61 \cdot 10^{-6}$
SOUTH OLTENIA Region	803.836	0.942	57.340	74101061.526	$46 \cdot 10^{-4}$
WEST Region	540.508	0.974	130.947	76511924.140	$28 \cdot 10^{-5}$

[a] (Constant), School_population, Poverty_rate, Average_net_salary, Life_expectancy, Total_average_income_capita

[b] GDP_capita

Source: Authors' computation

Table 3 presents the Pearson correlation coefficients between the variables GDP per capita, salary, school population, poverty rate, average salary, average income and life expectancy for the regions analyzed in Romania.

Tabel 3 Pearson Correlations

		GDP_capita	**School_population**	**Poverty_rate**	**Average_net_salary**	**Life_expectancy**	**Total_average_income_capita**
RO	GDP_capita	1					
	School_population	-0.919**	1				
	Poverty_rate	-0.405**	0.328**	1			
	Average_net_salary	0.996**	-0.933**	-0.380**	1		
	Life_expectancy	0.533**	-0.645**	0.216**	0.573**	1	
	Total_average_income_capita	0.994**	-0.909**	-0.445**	0.994**	0.508**	1
NW Region	GDP_capita	1					
	School_population	-0.665**	1				
	Poverty_rate	-0.740**	0.769**	1			
	Average_net_salary	0.997**	-0.668**	-0.740**	1		
	Life_expectancy	0.727**	-0.527**	-0.316**	0.747**	1	

		GDP_capita	School_population	Poverty_rate	Average_net_salary	Life_expectancy	Total_average_income_capita
	Total_average_income_capita	0.991**	-0.653**	-0.781**	0.991**	0.677**	1
CENTER	GDP_capita	1					
	School_population	-0.817**	1				
	Poverty_rate	0.559**	-0.392**	1			
	Average_net_salary	0.996**	-0.843	0.587**	1		
	Life_expectancy	0.550**	-0.731**	0.525**	0.598**	1	
	Total_average_income_capita	0.988**	-0.812**	0.592**	0.990**	0.537**	1
NE Region	GDP_capita	1					
	School_population	-0.947**	1				
	Poverty_rate	0.456**	-0.481**	1			
	Average_net_salary	0.997**	-0.960**	0.467**	1		
	Life_expectancy	0.615**	-0.757**	0.529**	0.659**	1	
	Total_average_income_capita	0.995**	-0.919**	0.422**	0.987**	0.547**	1
SE Region	GDP_capita	1					
	School_population	-0.950**	1				
	Poverty_rate	-0.447**	0.505**	1			
	Average_net_salary	0.983**	-0.970**	-0.410**	1		
	Life_expectancy	0.524**	-0.699**	-0.206**	0.571**	1	
	Total_average_income_capita	0.986**	-0.960**	-0.414**	0.998**	0.534**	1
RESTI-ILFOV	GDP_capita	1					
	School_population	0.867**	1				

		GDP_capita	School_population	Poverty_rate	Average_net_salary	Life_expectancy	Total_average_income_capita
	Poverty_rate	-0.081**	0.226**	1			
	Average_net_salary	0.993**	0.881**	-0.091**	1		
	Life_expectancy	0.436**	0.619**	0.348**	0.518**	1	
	Total_average_income_capita	0.990**	0.839**	-0.148**	0.992**	0.458*	1
SOUTH-MUNTENIA Region	GDP_capita	1					
	School_population	-0.958**	1				
	Poverty_rate	-0.344**	0.167**	1			
	Average_net_salary	0.990**	-0.969**	-0.352**	1		
	Life_expectancy	0.342**	-0.506**	0.216**	0.337**	1	
	Total_average_income_capita	0.980**	-0.933**	-0.459**	0.990**	0.273**	1
SOUTH OLTENIA Region	GDP_capita	1					
	School_population	-0.930**	1				
	Poverty_rate	0.302**	-0.499**	1			
	Average_net_salary	0.994**	-0.945**	0.303**	1		
	Life_expectancy	0.832**	-0.893**	0.415**	0.858**	1	
	Total_average_income_capita	0.991**	-0.921**	0.239**	0.994**	0.807**	1
WEST Region	GDP_capita	1					
	School_population	-0.923**	1				
	Poverty_rate	-0.423**	-0.595**	1			
	Average_net_salary	0.978**	0.842**	-0.446**	1		
	Life_expectancy	0.653**	-0.996**	0.522**	-0.851**	1	

		GDP_capita	School_population	Poverty_rate	Average_net_salary	Life_expectancy	Total_average_income_capita
	Total_average_income_capita	0.976**	-0.748**	0.447**	-0.981**	0.751**	1

**. Correlation is significant at the 0.01 level (1-tailed).

Based on the data in the table, we can conclude that the econometric model has a good performance in predicting GDP per capita for the regions included in the analyss. The predictors are statistically significant in explaining the variation of the dependent variable.

Next, we will briefly present the results of the regression equations generated by the econometric analysis for Romania and each region separately.

Table 4 The results of the regression equations

COUNTRY/ REGION	THE INDEPENDENT VARIABLE	AVERAGE GROWTH	Effect on GDP per capita (RON)
ROMANIA	School_population (pers)	26772	+ 99.056
	Poverty_rate (%)	0.322	- 9.662
	Average_net_salary (RON)	212.111	+ 3323.993
	Life_expectancy (Years)	0.146	- 174.364
	Total_average_income_capita (RON)	153.587	+ 219.783
NORTH WEST Region	School_population (pers)	2180.222	- 89.389
	Poverty_rate (%)	0.7	+ 174.312
	Average_net_salary (RON)	213.667	+ 3506.056
	Life_expectancy (Years)	0.17	- 248.389
	Total_average_income_capita (RON)	170.718	+ 108.577
CENTER Region	School_population (pers)	2164.667	+ 229.455
	Poverty_rate (%)	0.511	- 123.519
	Average_net_salary (RON)	202.556	+ 3914.994
	Life_expectancy (Years)	0.144	- 180.265
	Total_average_income_capita (RON)	157.891	- 393.307
NORTH EST Region	School_population (pers)	8517	- 51.954
	Poverty_rate (%)	1.044	- 32.543
	Average_net_salary (RON)	198.333	+1312.372
	Life_expectancy (years)	0.130	- 36.633
	Total_average_income_capita (RON)	113.811	+ 898.197
SOUTH EAST Region	School_population (pers)	5901.333	- 17.704
	Poverty_rate (%)	0.489	- 141.781
	Average_net_salary (RON)	175.111	- 553.701
	Life_expectancy (Years)	0.108	+ 22.535
	Total_average_income_capita (RON)	131.679	+ 2752.352

COUNTRY/ REGION	THE INDEPENDENT VARIABLE	AVERAGE GROWTH	Effect on GDP per capita (RON)
BUCUREST I -ILFOV Region	School_population (pers)	9585.222	- 277.971
	Poverty_rate (%)	0.944	+ 750.450
	Average_net_salary (RON)	181.111	+ 8116.676
	Life_expectancy (Years)	0.128	- 1198.750
	Total_average_income_capita (RON)	250.103	+ 252.854
SOUTH-MUNTENIA Region	School_population (pers)	7859.889	+ 1116.104
	Poverty_rate (%)	0.867	+ 211.640
	Average_net_salary (RON)	265.444	+ 3323.099
	Life_expectancy (Years)	0.132	+ 193.627
	Total_average_income_capita (RON)	134.684	+ 133.472
SOUTH OLTENIA Region	School_population (pers)	6825.889	+ 300.339
	Poverty_rate (%)	0.678	+ 109.695
	Average_net_salary (RON)	175.222	+ 2931.993
	Life_expectancy (Years)	0.217	- 199.716
	Total_average_income_capita (RON)	139.392	+ 129.914
WEST Region	School_population (pers)	3497.556	+ 329.707
	Poverty_rate (%)	1.422	- 0.0018
	Average_net_salary (RON)	210.778	- 2458.934
	Life_expectancy (Years)	0.158	+ 0.131
	Total_average_income_capita (RON)	133.022	- 16001.110

The results reveal paradoxical effects for some regions: a negative relationship between school population and GDP per capita (in the NW, NE, SE, and Bucharest-Ilfov regions); a positive relationship between the poverty rate and GDP per capita (in the Center, NE, SE, and W regions); a negative relationship between average net salary and GDP per capita (in the SE and W regions); a negative relationship between life expectancy and GDP per capita (in RO, NE, Center,Bucharest-Ilfov, and South Oltenia regions); and a negative relationship between average income per capita and GDP per capita (Center, W).

The school population can have significant effects on economic growth through various channels, including contributing to human capital development, stimulating investment in education, increasing consumption and demand, promoting innovation and research, and enhancing labor mobility. However, in the case of some regions, a negative relationship between the school population and GDP per capita may be observed. If the education system is under-resourced orinefficient, the growth of an inadequately qualified school population can lead to a low-skilled workforce, thereby negatively impacting economic growth and, implicitly, GDP per capita.

The effects of the poverty rate on economic growth can be complex and influenced by many factors. In general, poverty can negatively affect economic growth. A high poverty rate can limit access to education and healthcare, which can hinder the development of human capital and reduce the quality of the workforce in a society. A low-skilled labor force adversely affects an economy's capacity for innovation, technological advancement, and production, ultimately reducing its long-term economic growth potential. Paradoxically, we observe from the analysis data that there are regions where a slightincrease in the poverty rate (below 1%) leads to an increase in GDP per capita. In certain contexts, an increase in poverty can be associated with an increase in economic inequality, and a highly polarized society. This concentration of wealth in such cases may lead to an increase in average GDP per capita, as the reported income and wealth are higher. However, this increase is not reflected in a genuine improvement in the well-being of the majority, particularly that of the poor.

The relationship between net average salary and GDP per capita is complex and can vary depending on several factors. There is generally a positive correlation between wage levels and GDP per capita, indicating that countries or regions with increasing average wages tend to experience a corresponding positive impact on GDP per capita. However, a negative relationship between average wages and GDP per capita indicates a pronounced discrepancy in the distribution of incomes at the population level, which can negatively affect aggregate economic indicators, such as GDP per capita. Additionally, structural imbalances at the macroeconomic level can negatively influence wage levels and, consequently, GDP per capita.

Life expectancy and GDP per capita are closely linked and can positively influence economic growth. Promoting equitable and sustainable economic development can contribute to improving the health of the population and increasing life expectancy across society. However, the results of the statistical analysis reveal (for some regions) the existence of a negative relationship between life expectancy and GDP per capita. This phenomenon can be attributed to population aging, a challenge faced not only by Romania, but also by other countries, and to socio-economic factors such as the migration of the active population.

A positive relationship between average income per inhabitant and GDP per capita reflects a fair income distribution within the population and also a sustainable economic growth. Conversely, a negative relationship between these two variables can be influenced by many other economic factors such as: demographic shifts, an economic environment with inflationary pressures, or

transitional economic policies. The existence of these imbalances, even if the average income per capita increases, can lead to a decline in GDP per capita.

4. Conclusions

In this paper we tried to explore the economic dimension of quality of life through the lens of GDP per capita and the factors that we believed influencethis aspect. The analysis focuses onRomania, a developing country that, after a period in which it was a component part of the former Soviet bloc, since 2007, has been a member of the EU. The process of transition to democracy and a free market economy was arduous and uneven. That's why we chose to deepen the analysis at the level of the 8 NUTS 2 regions to highlight regional discrepancies and disparities in terms of both economic growth and quality of life. The economic, social and demographic differences are significant, being visible at the level of infrastructure, natural resources, industrialization, and access to the foreign market, among other factors.

The poorest NUTS II regions experience the highest migration rates. According to the Global Migration Report, approximately 4 million Romanians live abroad, Romania ranking 17th worldwide in terms ofpopulation migration. In 2020, the value of remittances sent back to the country amounted to over 7 billion dollars, according to the same report. A problem that requires the attention of the authorities is the huge regional discrepancies that exist within the country.

According to INSSE Romania, at the regional level, the most developed region is the Bucharest-Ilfov one, with a GDP per capita of 144589.7 RON in 2021. This is followed by the West and North-West regions, with a GDP per capita slightly over 62000 RON. At the opposite pole is the North-East region, with a GDP per capita of 39275, followed by the South Muntenia and South Oltenia regions, with a GDP per capita of approximately 47000 RON. We notice that the effects of globalization and European integration have not been fairly distributed across the country. At the level of regional policies, local and central authorities must focus on the development of the private sector, the stimulation of investments, and the attraction of FDI, the transfer of technology, the development of the I.M.M. sector, the improvement of infrastructure, the quality of the environment, rural development, health, education, and so on.

The fact that the Bucharest-Ilfov region has the highest GDP per capita, while the North-East region is at the opposite pole, underscores the urgent need to address regional inequalities and promote a more equitable distribution of the benefits of globalization and European integration.

Additionally, major cities (Bucharest, Cluj, Timişoara, Oradea, etc.) have recorded the highest GDP per capita growth rates, primarily due to the attraction of foreign direct investments. This highlights the importance of creating an enabling environment for investment and economic development in less developed regions.

The results of the econometric demonstrate the robustness of the model, and explains the links between the variables for most regions, with high values of correlation and determination coefficients. This suggests that the socio-economic factors analyzed in the model significantly contribute to variations in GDP per capita across regions and in Romania as a whole.

Analyzing the relationship between GDP per capita and socio-economic factors can serve as a tool for monitoring economic progress and evaluating the effectiveness of government policies. By comparing the results between regions, trends and disparities in socio-economic development can be identified, as well as areas that require more in-depth and complex interventions. Understanding the factors that influence the standard of living and well-being of the population can contribute to creating favorable conditions for human development and improving the quality of life. By taking into account the complex interactions between different socio-economic factors, more effective strategies can be implemented to reduce poverty, improve access to essential services and promote social inclusion.

As mentioned, the performed analysis confirmed the robustness of the regression model, using additional validation tests, autocorrelation examination, coefficient analysis, comparison with other models, evaluation of residuals, etc. This strengthens confidence in the results obtained and in their interpretation within the framework of socio-economic research.

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Adaptive Solutions for Sustainable Futures: Managing Sustainability in the Context of Risk and Uncertainty

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Abstract

In the face of current challenges, several risks and uncertainties must be addressed to ensure sustainable and adaptable management. Climate change and environmental degradation pose significant threats to global sustainability, severely impacting the environment and disrupting economic and social activities. Effectively identifying and managing these risks is crucial to protecting the environment and mitigating negative impacts on communities and economies. Economic fluctuations and financial crises can also destabilize organizations and strain financial resources allocated to sustainability initiatives. Developing financial resilience strategies is essential to handling these risks and ensuring the continuity of sustainability efforts. The ongoing war in Ukraine introduces additional risks and uncertainties, directly affecting Moldova and neighboring countries. The conflict disrupts supply chains, drives up energy and food prices, increases refugee flows, and heightens regional tensions. Economic agents in these countries face significant challenges, including market instability and long-term planning difficulties. In this context, implementing sustainability strategies is essential for achieving long-term stability and resilience.

This research aims to analyze and propose adaptable solutions for a sustainable future, particularly in the context of risk and uncertainty, including the impact of the war in Ukraine on Moldova. The proposed solutions will focus on sustainability adaptation and crisis management, emphasizing practices rooted in the circular economy, sustainability, and the green economy.

Keywords: *sustainability management, climate change adaptation, economic resilience, social inclusion, circular economy.*

1. Introduction

In a world characterized by rapid and complex changes, sustainability management is becoming increasingly critical (Bansal, P., & DesJardine, M. R., 2014). Climate, economic, and social risks, along with their inherent uncertainties, require organizations and societies to adopt flexible and adaptable solutions (Rhodes, J., et al., 2022). Climate change, marked by increasingly frequent extreme weather events, poses significant threats to the ecological and economic stability of many regions. At the same time, rising social inequalities place greater pressure on vulnerable communities. Global economic fluctuations, exacerbated by unforeseen events such as pandemics, financial crises, and armed conflicts, further complicate this already challenging landscape.

The COVID-19 pandemic has been catastrophic, causing disastrous human and economic losses, exposing the global economy to a variety of risks. As policymakers grapple with the challenges posed by this public health crisis, they must simultaneously focus on recovery efforts aimed at rejuvenating their economy. Thus, authorities in many countries have recognized the necessity and opportunity for a sustainable recovery, adopting concepts such as green recovery. The current crisis requires rethinking the economic theories that guide policymaking, but also the collective planning of actions in order to achieve social well-being. In this context, the push for a more resilient, circular and low-carbon business model has become more relevant than ever (Kirchherr, J., Yang, N., et al., 2023).

In the context of current challenges, there are several risks and uncertainties that need to be addressed to ensure sustainable and adaptive management:

- Climate change and environmental degradation pose a major threat to global sustainability. Extreme events such as floods, droughts, wildfires, and storms can severely affect the environment and disrupt economic and social activities. It is crucial to identify and manage these risks to safeguard the environment and mitigate the negative impacts on communities and the economy.
- Economic fluctuations and financial crises can undermine the stability of organizations and put pressure on the financial resources allocated to sustainability initiatives. It is important to develop financial resilience strategies and mechanisms to deal with these risks and ensure the continuity of sustainability efforts.
- Social inequalities increase tensions in society and can undermine social cohesion and stability. It is essential to address these disparities and

promote social inclusion and equal opportunities within sustainability initiatives.

In addition, it is important to pay attention to the social impact of climate change adaptation measures and related crisis management efforts. At the same time, it is crucial to monitor technological developments and anticipate legislative changes in order to effectively adapt and foster innovation and progress in the field of sustainability.

An additional source of risk and uncertainty is the war in Ukraine, which directly impacts the Republic of Moldova and neighboring countries. The impact of this conflict is felt both economically, by disrupting supply chains, increasing energy and food prices, and socially, by increasing the flow of refugees and intensifying regional tensions. Economic agents in these countries face major challenges, including market instability and difficulties in long-term planning.

In this context, the adoption of sustainability strategies becomes essential to ensure long-term stability and resilience. These risks and uncertainties must be considered in the process of developing sustainability management strategies and policies to ensure they are robust, adaptable and effective in addressing both current and future challenges.

The purpose of this research is to analyze and propose adaptable solutions for a sustainable future through sustainability management, taking into account the context of risk and uncertainty, including the impact of the war in Ukraine on the Republic of Moldova. Specifically, solutions will be proposed in the context of adaptation to sustainability and the management of the crisis generated by the conflict, with an emphasis on the circular economy, sustainability and green economy. Thus, this will study will explore how practices and policies such as recycling, waste reduction, renewable energy promotion and green infrastructure development can contribute to building a resilient and sustainable framework in response tocurrent challenges.

Research Objectives:

- Identifying the main risks and uncertainties affecting sustainability globally, including the effects of the war in Ukraine. Analysis of how the circular economy can be integrated into sustainability strategies to reduce waste and conserve resources.
- Proposing recommendations for companies and governments to enhance resilience and sustainability in regions facing conflict or the threat of war.

2. Methodology

To achieve the aim and objectives of this research, the following methods were used: an analysis of existing literature on climate, economic and social risks, as well as sustainability management strategies, including an examination of the impact of the war in Ukraine on the region; the investigation of relevant case studies to illustrate the successful implementation of sustainability solutions in different geographic and economic contexts; the collection and analysis of statistical data; and the elaboration of recommendations oriented towards public policies and organizational strategies adapted to the current context in the Republic of Moldova.

3. Results and discussion

3.1. The importance of Sustainability in the management of the organization

Business sustainability is about conducting business in a responsible way that takes into account the long-term environmental and societal impacts of the business, to protect the planet and the communities in which the business operates (Rezaee, Z., 2016). Thus, sustainability management involves the integration of ecological, social and economic concerns into long-term strategies to ensure the viability of resources and the well-being of future generations.

Sustainability in business encompasses a range of dimensions, each vital for creating long-term value and ensuring resilience. These dimensions include environmental impact, social impact, and economic impact. Businesses must consider their impact on the environment and take steps to minimize these impacts. These measures may include:

- Reducing greenhouse gas emissions, using renewable energy, reducing waste and promoting sustainable business practices.
- Optimization of the use of natural resources, including water, energy, and raw materials, to reduce their ecological footprint.
- Emissions Reduction by transitioning to renewable energy sources, improving energy efficiency, and adopting carbon offset programs.
- Promotion of effective waste management practices such as reducing, reusing, and recycling materials, which help minimize landfill waste and promote a circular economy.
- Incorporating sustainable practices into daily operations, such as sustainable sourcing, green supply chains, and eco-friendly product designs, can significantly reduce environmental impact.

- Adhering to environmental regulations and transparently reporting environmental performance to stakeholders through sustainability reports and disclosures.

Businesses must consider their impact on society and take steps to contribute to the well-being of the communities in which they operate. These measures may include:

- Promoting a diverse and inclusive workplace that will ensure equal opportunities and foster a culture of respect and collaboration. This can involve policies that address gender equality, racial diversity, and support for marginalized groups.
- Businesses' engagement with the communities where they operate, contributing to local development and addressing community needs through philanthropic efforts and volunteer programs.
- Ensuring the well-being of employees through fair wages, safe working conditions, professional development opportunities, and work-life balance initiatives is essential.
- Upholding high ethical standards in business operations, including fair labor practices, responsible marketing, and transparent governance.

Businesses must be economically sustainable to ensure long-term survival. This may include the following measures:

- Achieving financial health through efficient resource allocation, cost reduction, and revenue generation is essential to ensure the long-term success of a business.
- Investing in research and development to drive innovation, improve products and services, and maintain a competitive edge in the market.
- Streamlining operations to eliminate waste, enhance productivity, and reduce costs, while maintaining or improving product quality and customer satisfaction.
- Identifying and mitigating financial risks, including market volatility, supply chain disruptions, and economic downturns, so as to safeguard business continuity.
- Pursuing growth strategies that align with sustainable development goals, ensuring that business expansion does not come at the expense of environmental degradation or social inequality.

By addressing these aspects, businesses can develop a balanced and comprehensive approach to sustainability that not only supports their long-term viability, but also contributes positively to the environment and society. Thus, the development of a sustainable organizational strategy is a must for all organizations that wish to remain competitive and relevant in today's context.

In order to develop a sustainable organizational strategy, we believe it is essential to integrate the principles of the circular and social economy, aiming to generate long-term value in a responsible and sustainable way. These two concepts can be effectively combined into a strategic and coherent model that enables organizations to operate sustainably and maximize their positive impact on the environment, economy, and society as a whole.

Figure 1 illustrates the interconnectedness of the principles of the circular economy with those of the social economy. Thus, we can identify the pillars on the basis of which sustainable activities can be carried out:

1. The creation of jobs on a voluntary basis or according to the remuneration of work.
2. Ensuring the well-being of the population.
3. Environmental protection.
4. Implementation of the principles of the 3 R - reduce - reuse - recycle in social activities.

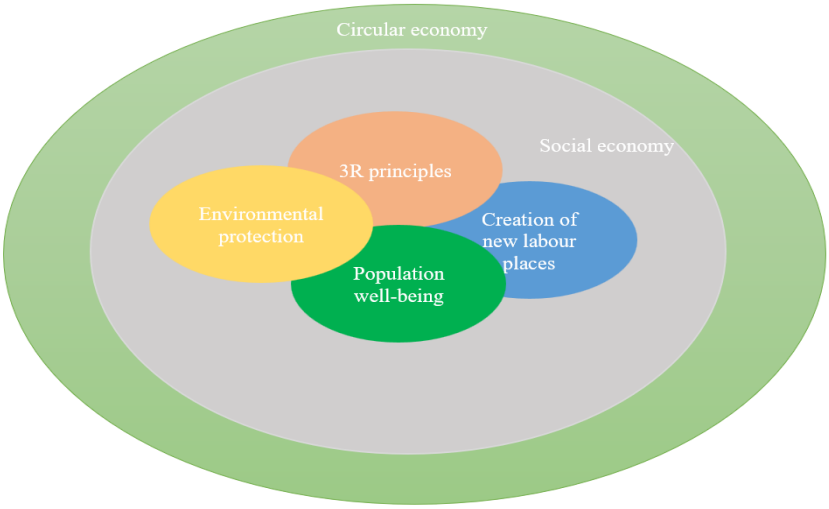


Figure 1. Harmonizing Circular and Social Economies for Sustainable Organizational Strategies (made by the authors)

Shifting the focus from profit maximization to creating social impact can yield significant benefits for societal well-being and environmental protection. Therefore, in the process of redefining business models and strategies, the focus must be shifted towards the principles of the circular economy, which necessitates a change in lifestyle and consumption patterns.

- First, the circular economy entails a decrease in raw material requirements, by altering patterns of goods and services usage and encouraging their remanufacturing.
- Second, the design of the products is done considering for the disassembly, reuse and recycling of biological and technical materials, guaranteeing that the materials are depreciated as little as possible, so that they can be reintroduced into the production process, and therefore anticipating a second life for the product.
- Third, the manufacturing and production of goods and services emphasize best practices and ecological technologies so that the production process does not generate energy loss or waste, being as sustainable as possible.
- Fourth, the marketing of goods and services must reflect the real prices of products, without externalizing social and environmental costs.

The linear model and the circular model represent two different approaches to managing resources and processes within an organization.

Within an organization, the linear model is based on economic growth through the production and sale of new products and services, whereas the circular model focuses on the efficient use of resources and the creation of a renewable, sustainable system (Barros, M., Salvador, R., et al., 2021). Therefore, the circular model encourages organizations to adopt a more sustainable approach, which takes considers environmental and societal impacts while optimizing the use of resources.

Changing current consumption patterns is a necessary condition to address the challenges of the planet generated by the coronavirus pandemic, but also by other social and economic crises. They should shift towards more collective needs-based consumption patterns based on the acquisition of services through borrowing, exchange, barter, exchange, and rental in order to reduce the prevalence of underutilized products.

At the same time, in the circular economy, final waste is meticulously recovered to be either reintegrated into the biosphere through processes like composting or anaerobic digestion or reintroduced into industrial processes as raw materials. This approach ensures that resources are continuously cycled, minimizing the need for virgin materials and reducing environmental impact.

Social enterprises can significantly benefit from adopting the principles of the circular economy. By implementing business models that focus on extracting and creating value from products after their initial use, these organizations can contribute to both economic and environmental sustainability. Such business models not only contribute to waste reduction, but also generate

new economic opportunities and enhance social well-being (Goklas, S., et al., 2023).

Innovation in business models aligned with circular economy principles can be driven by adopting various strategies, including:

- Designing products for durability, repairability, and upgradability to extend their lifespan and reduce the need for frequent replacements.
- Establishing systems for efficient collection, sorting, and processing of used products to recover valuable materials.
- Promoting shared use of products and resources to maximize utilization and reduce overall consumption.
- Transitioning from product ownership to service-based models, where consumers pay for the usage rather than ownership, encouraging manufacturers to design for longevity and recyclability.
- Creating closed-loop supply chains that ensure materials are kept in circulation within the economy for as long as possible.
- Partnering with other businesses, research institutions, and communities to co-develop circular solutions and harness collective expertise.

By implementing these strategies, companies can lead the way in integrating circular economy principles into social activities, fostering sustainable development, and creating a resilient and regenerative economic system.



Figure 2. Strategic Pathways for Implementing Circular Economy Principles in Business Models (made by the authors)

The role of strategic management in this context can ensure a coherent and integrated approach in the development and implementation of organizational strategies that align with the principles of the circular and social economy.

Among the sectors that offer greater opportunities for the implementation of circular economy principles in social activities are waste and water management, power generation, construction and urban development, industry, agriculture and food, mobility and logistics, as well as activities related to environment protection.

It should not be forgotten that social economy enterprises reinvest their profits in social objectives, instead of generating individual enrichment, by:

- creating spaces for participation and exchange of ideas;
- promoting cooperation, awareness and involvement within the community;
- building closer relationships between residents, local communities and society, while fostering collective responsibility;
- the contribution made to the protection of the environment.

Thus, integrating boththe individual and community dimensions of the social economy within a strategic management framework aligns very close with the principles of the circular economy, which, in turn, expresses a deep concern about how the planet's resources are utilized, advocating for an integrated and durable approach. To a large extent, the social economy shares the same concerns and aims to protect the same core values.

3.2. Developing organizational strategies for sustainable organizations amid risk and uncertainty in new realities

The Republic of Moldova, as a developing country, faces unique challenges in fostering sustainable organizations. Risk and uncertainty are integral to the new realities confronting organizations in this region. The war in the neighboring country, economic instability, and fluctuating business conditions create a difficult environment for sustainable organizational development. Consequently, it is crucial to develop organizational strategies that effectively address these risks and uncertainties. These strategies must be flexible, adaptable, and resilient, capable of coping with unexpected changes while capitalizing on emerging opportunities.

The onset of the war between Ukraine and Russia has significantly impacted not only the economy of the Republic of Moldova and its business environment, but also the entire region. The armed conflict has led to the deterioration of trade relations between regional states, severely affecting trade, tourism, and other economic sectors (Orhan, E., 2022). Moreover, the political and military instability in the region has directly affected businesses in the Republic of Moldova with commercial ties to Ukraine.

With the outbreak of conflict in the neighboring country on February 24, trade with Ukraine came to a halt, and many essential and high-demand products from Ukraine were blocked. Consequently, average consumer prices in the Republic of Moldova have started to rise, with certain products facing the risk of shortages. The rush to secure supplies has become a significant concern among the population, dominating public discourse and contributing to the overall sense of uncertainty and instability.

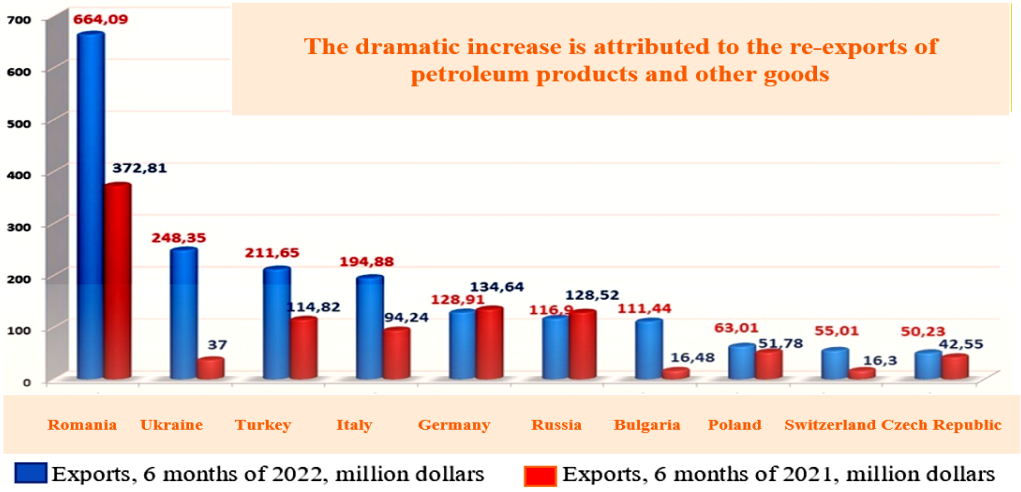


Figure 3. Top 10 Countries by Export Value from the Republic of Moldova, 6 months of 2022 (adapted from the National Bureau of Statistics of Moldova database)

Based on statistical insights (see figure 3), Ukraine has emergedas the second-largest destination for Moldovan exported goods, after Romania, boasting a significant 10.8% share. Notably, this figure has surged to 6.7 times higher than in the first half of 2021, when Ukraine ranked eighth. This remarkable ascent can be attributed not only to the re-export of petroleum products, but also to a diverse range of other commodities.

Given that Romania and Ukraine are two significant trading partners for the Republic of Moldova, the growth in trade presents both opportunities and risks. However, this growth also exposes Moldova to heightened risks due to the geopolitical and economic uncertainties in the region.

The conflict in Ukraine has intensified security and political risks in the region, adversely impacting foreign investments and tourism in Moldova. Economic instability stemming from these issues has eroded trust in Moldova's business environment. During the conflict, the Moldovan-Ukrainian border became more challenging and dangerous to cross, creating difficulties for Moldovan companies reliant on cross-border transportation of goods. Furthermore, the infrastructure linking the two countries has been affected, leading to increased transportation costs and delivery delays.

As Moldova and Ukraine maintain close trade relations, disruptions in supply chains between the two countries have negatively affected Moldovan companies, particularly in sectors reliant on Ukrainian imports, such as food, construction, and textiles. Additionally, during the conflict, Ukraine imposed restrictions on the export of food products, including fruits and vegetables, impacting a significant portion of Moldova's exports.

Also, certain regions of Ukraine have become inaccessible or less safe for freight transportation due to the war, causing problems for Moldovan companies dependent on Ukrainian imports or exports. Transportation costs through Ukraine have significantly increased, and obtaining transport insurance has become more expensive and challenging , affecting the profitability of Moldovan companies engaged in tradewith Ukraine.

Overall, the political and economic uncertainties in the region have had a detrimental impact on Moldovan businesses with ties to Ukraine. The crisis has heightened tensions and security risks throughout the region, forcing Moldovan companies to assess potential risks and adjust their business strategies to address these emerging challenges.

Despite these obstacles, many Moldovan companies have attempted to adapt their businesses and seek new business opportunities to survive during the war. Some businesses have managed to maintain stability or even grow amid the turmoil. For instance, some companies in the food industry have explored alternative export markets and diversified their product offerings. Additionally, efficiency measures and cost-cutting initiatives have been implemented to address transportation costs and energy prices.

The conflict in the neighboring country can significantly impact the strategic decisions of organizations, especially those operating in the region or with economic ties to Ukraine. Firstly, political instability and precarious security can increase business risks and uncertainty, affecting investments and commercial activities. Moreover, supply chains may continue to be disrupted due to border interruptions or government-imposed restrictions.

Secondly, the war can lead to changes in the economic and political landscape of the region, affecting the demand for specific products and services, as well as introducing changes in business rules and regulations. As such, companies must be capable of quickly adapting to these changes and making the appropriate strategic adjustments to remain competitive and cope with the new conditions.

Lastly, companies must also consider the social impact of the war and ensure that their activities do not exacerbate conflicts or contribute to the suffering of the population. In this regard, changes may be necessary in how companies conduct their activities, such as relocating operationsor changing the nature of their products and services.

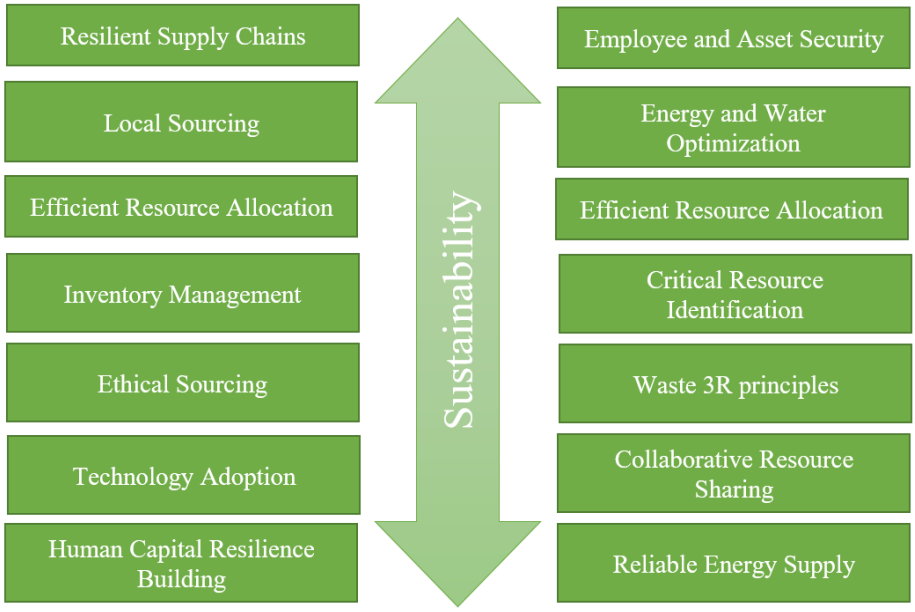


Figure 4. Strategies for sustainable business resilience in conflict zones (made by authors)

In the face of a neighboring conflict or the looming threat of armed confrontation, elaboration of an organizational strategy for sustainable business becomes imperative, considering potential disruptions such as trade blockades, supply chain impacts, and concerns over employee and asset security.

Promoting sustainability amidst such volatile circumstances presents significant challenges, but it remains achievable. As illustrated in figure 4, businesses can adopt a more responsible approach towards resource utilization and waste management, ensuring the efficient allocation of scarce resources during times of conflict.

The responsible management of wartime waste is crucial for maintaining both business sustainability and the well-being of the communities in which they operate (Cooper, T., 2008). In situations of conflict, resources become increasingly scarce, and adopting a responsible approach becomes paramount to maximizing available resources while minimizing environmental harm.

To manage waste responsibly during conflict, businesses must first identify the sources of waste and implement effective management practices to mitigate their environmental impact. This includes initiatives such as waste separation and recycling, implementing waste reduction strategies, and ensuring the proper handling and disposal of hazardous materials like chemicals.

To responsibly manage resources during conflict, businesses should commence by identifying critical resources essential for their operations and

prioritizing their use based on necessity. This requires meticulous inventory and procurement management, optimizing energy and water consumption, and minimizing waste generation.

Additionally, collaborative endeavors with other businesses and organizations can facilitate resource sharing, enhancing efficiency. Establishing resource-sharing frameworks between enterprises operating within the same area can streamline resource utilization and minimize wastage.

Collaborative efforts among businesses and organizations can further enhance waste management practices. Establishing systems for material exchanges between companies operating in the same region can promote resource efficiency and reduce waste generation collectively.

Furthermore, exploring renewable energy sources like solar panels or wind turbines presents an opportunity for businesses to ensure a reliable energy supply amidst potential grid instability or interruptions during conflict scenarios.

Innovative waste management solutions, including modern composting, recycling technologies, or the conversion of waste into energy sources like biofuels, offer promising avenues for reducing environmental impact during conflict.

While challenging, the responsible use of water and renewable energy during wartime is achievable. Natural resources are often adversely affected during armed conflicts, leading to increased water and energy consumption.

Organizations can explore alternative energy sources like solar or wind panels to reduce reliance on traditional power grids that may be vulnerable during war. Implementing energy efficiency measures can further reduce energy consumption and lessen the strain on natural resources.

Similarly, water conservation measures can be adopted, including the reduction of potable water consumption and the utilization of recycled or rainwater for non-potable activities. Effective wastewater management practices can also minimize environmental degradation during such challenging times.

It is crucial to prioritize the responsible use of resources , even during armed conflicts, to safeguard the environment and minimize negative impacts on local communities. By adopting responsible practices, businesses can contribute to environmental conservation and strengthenthe resilience of both their operations and the surrounding ecosystem.

At the same time, amid conflict or the looming threat of armed confrontation, businesses must implement a comprehensive sustainability framework to effectively manage operations and uphold sustainable practices.

This framework includes a set of interconnected strategies and approaches aimed at navigating supply chain disruptions, ensuring continuity of operations, and minimizing risks.

Resilient supply chains are essential components of this framework, designed to withstand disruptions and maintain continuity of operations amidst conflict-related challenges. Local sourcing practices prioritize regional suppliers, reducing dependency on global supply chains and supporting local economies, thereby enhancing resilience and sustainability.

Efficient resource allocation strategies help optimize resource utilization within the organization, minimizing waste, and maximizing efficiency, even in volatile circumstances. Inventory management techniques will ensure the maintenance of adequate stock levels while avoiding excess inventory and reducing carrying costs, contributing to sustainability goals.

Ethical sourcing policies ensure responsible procurement practices, considering factors such as fair labor practices, environmental sustainability, and social impact. Technology adoption integrates innovative solutions to enhance sustainability practices, such as advanced analytics and blockchain, improving supply chain visibility and efficiency.

Human capital resilience-building initiatives focus on workforce development and well-being, empowering employees to adapt to change and fostering a resilient organizational culture. Together, these elements form a comprehensive sustainability framework that guides decision-making and operational activities towards achieving environmental, social, and economic sustainability goals, even in the face of conflict-related challenges.

Investing in workforce development involves providing opportunities for learning, skill-building, and career advancement to empower employees and enhance their capabilities. This may include training programs, workshops, mentoring, and professional development initiatives that are tailored to individual needs and organizational objectives. By continuously investing in the growth and development of employees, organizations can ensure that their workforce remains adaptable, agile, and equipped to effectively navigate changing circumstances.

A resilient workforce is better positioned to adapt to shifting conditions, maintain productivity, and sustain operations during times of uncertainty. Moreover, by prioritizing the well-being and development of employees, organizations demonstrate their commitment to social responsibility and ethical leadership, enhancing their reputation and attractiveness as employers.

4. Conclusions

- Crises have highlighted the interconnectedness of social, economic, and environmental factors. Businesses that adopt a holistic sustainability approach, considering impacts on employees, communities, and ecosystems, cultivate trusting relationships and garner stakeholder support during challenging times.
- Holistic sustainability approaches also enhance resilience during crises. By integrating economic, social, and environmental aspects into their strategies, companies are better prepared to confront challenges and meet evolving market demands. For instance, investments in clean, energy-efficient technologies help mitigate the impacts of energy price fluctuations and regulatory changes.
- A comprehensive sustainability approach not only yields long-term benefits, but also strengthens a company's resilience in the face ofenvironmental crises and shifts. Companies that integrate economic, social, and environmental considerations into their strategies are poised to earn the trust and backing of stakeholders, positioning themselves favorably in an increasingly sustainability- conscious marketplace.
- In regions nearing conflict or facing the threat of war, embracing sustainability principles becomes not just advantageous but imperative for both businesses and countries alike. The uncertainties and vulnerabilities inherent in such environments amplify the significance of sustainable practices, offering a pathway towards resilience and stability amidst turmoil.
- In regions marked by conflict or the looming specter of war, companies face unique challenges that necessitate strategic adaptation and resilience-building measures to ensure continued success and stability. To address these challenges, the following recommendations are proposed:

1. Prioritization of stakeholder engagement and communication to foster trust and build relationships with employees, communities, and other stakeholders. Transparent and proactive communication during crises can help maintain confidence and support.
2. Integration of economic, social, and environmental considerations into business strategies and decision-making processes. By adopting a holistic sustainability approach, companies can enhance resilience and adaptability to changing market conditions and crises.
3. Investing in clean, energy-efficient technologies and sustainable practices to mitigate risks associated with energy price fluctuations and regulatory changes. Embracing renewable energy sources and resource-

efficient technologies can reduce reliance on volatile energy markets and enhance long-term sustainability.

4. Strengthening supply chain resilience by diversifying sourcing strategies, establishing local partnerships, and implementing robust risk management practices. Collaborating with local suppliers and partners can mitigate risks associated with global supply chain disruptions and geopolitical uncertainties.

5. Prioritization of employee well-being and development to build a resilient workforce capable of adapting to change and navigating crises effectively. Invest in training, professional development, and support programs to empower employees and foster a culture of resilience and innovation.

6. Active engagement in community initiatives and support efforts to build resilience and promote sustainable development at the local level. By contributing to community resilience and well-being, companies can enhance their social license to operate and build stronger relationships with local stakeholders.

➢ The policy recommendations outlined above provide a comprehensive framework for governments to foster sustainable practices and build resilience in regions facing conflict or the threat of war. By incentivizing sustainable investments, promoting stakeholder engagement, strengthening regulatory frameworks, investing in infrastructure and technology, promoting education and capacity-building, and enhancing international cooperation, governments can play a crucial role in addressing sustainability challenges and promoting stability and prosperity in these regions.

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Development of the social economy: importance, challenges, impact, prospects

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Abstract

The importance of the social economy and the benefits that organizations in this sector generate for society are recognized by governments at both European and national levels. In many countries, it is possible to address social and economic challenges more efficiently through dedicated strategies and support schemes than by relying solely on the public or private sectors. European studies demonstrate that social enterprises are much more oriented towards society and people than traditional businesses. Social enterprises represent a novel approach to enhancing the welfare mix.

The Republic of Moldova's aspirations for European integration, on the one hand, and the country's level of economic development, the social challenges the country faces, and the opportunities offered by social entrepreneurship (generating both economic and social profit, having a strong inclusive and sustainable character), on the other hand, call for the inclusion of boosting the social economy on the state's priority list to create a favorable development framework. Although several actions (legislative and political) have been undertaken to support the development of social entrepreneurship, it currently faces multiple barriers, and its internal potential and contribution to the socio-economic consolidation and evolution of the Republic of Moldova has not been fully exploited.

This research was conducted to highlight the essence of the social economy, clarify some aspects of its concept; to emphasize European approaches, policies and experiences regarding the evolution and support of this sector; and evaluate the current situation, barriers, and prospects for the development of social entrepreneurship in the Republic of Moldova.

Keywords: *social entrepreneurship, social economy, social inclusion, social innovation, welfare.*

1. Introduction

In recent years, the concept of the social economy has gained recognition and accelerated development in many countries, including European nations. This growth is attributed to the principles and values that underpin activities in this field. Social business models are acknowledged for adding value to local economies and communities by promoting their inclusion, resilience and sustainability. By acting locally, social economy entities aim to serve their communities, keeping population, economic activities and income within the locality. They can substantially contribute to the achievement of the sustainable development goals by promoting responsible consumption and production at the local level, promoting short value chains, which help combat climate change.

However, the concept and benefits of the social economy remain relatively unknown in the business environment, among consumers and young people, and the potential of social entrepreneurship is still undervalued. Additionally, there are deficiencies in the legal regulation of the social economy, public policies, access to markets and financing, visibility, etc. These gaps justify the research carried out in the mentioned field in order to identify innovative solutions that can boost the development of social entrepreneurship.

Although multiple studies on various dimensions and aspects of the social economy have been conducted recently, there is still no unified approach to its theoretical aspects due to its relatively new status as a concept. At the EU level, having recognized the importance of the social economy, several policies and initiatives have been approved to support social entrepreneurship. However, there are differences in terms of recognition, financial support, regulation and implementation practices of the social economy across various European states.

The development of the social economy has also become imperative for the Republic of Moldova, especially considering the country's aspirations to join the EU. In this context, evaluating European experiences and analyzing the state of the social economy sector in the Republic of Moldova – focusing on creating a favorable framework for its development, promoting innovation, inclusion, environmental protection and community development - becomes an important objective. The social economy uniquely leverages such assets as trust and values, based on a new model for the relationship between work and motivations.

2. Methodology

The main purpose of this research is to analyze the social economy at both the EU level and in the Republic of Moldova, based on the study of existing documents and research conducted at European and national levels. This research specifically focuses on analyzing the context and perspectives of the social economy in European countries with advanced experience in this field and comparing them to the current situation in the Republic of Moldova. The aim is to provide suggestions and recommendations that would contribute to the development of an economic system that recognizes, promotes, utilizes, develops, and diversifies the forms and actors of the social economy.

To achieve our objectives, we employed various scientific research methods and tools, adhering to standards of objectivity and precision, validating the obtained results. These methods included documentation and bibliographic analysis, historical and logical approaches, comparative studies, case studies, and others.

3. Results and discussion

3.1. The concept, essence and benefits of the social economy

The social economy, also called the "third sector", emerged from the need to identify innovative solutions to address the social, economic and environmental overlooked of communities and to meet the needs of community members who are often ignored or insufficiently supported by the authorities, and the private sector.

Although the term "social economy" was first used by Charles Dunoyer in his work "Treatise on Social Economy" (1830), the idea of organizing social economic activities appeared and manifested much earlier through the establishment of cooperatives and associations that were based on the principles of cooperation, associative democracy and mutual aid. Thus, the cooperative movement served as the prototype and facilitated the development of the social economy. Over time, driven by societal challenges, this field has developed and expanded both geographically and in terms of the diversity of activities and social services it offered to the population, thanks to the specific nature of these activities.

The major difference between the social economy and the market economy lies in their specific goals and activities. The social economy is primarily focused on improving living conditions and providing new opportunities for disadvantaged people or those belonging to vulnerable groups, while the market economy opts for obtaining and maximizing profit.

Although the concept and understanding of the social economy have penetrated and become common in society, there is still no unified theoretical framework for this concept. This lack of consensus results in different perceptions, attitudes and policies regarding the support for social economic activities among political decision-makers and different economic actors and countries.

Generalizing the multiple definitions of the social *economy,* it can be concluded that it *represents the economic sector that combines economic efficiency with social inclusion and democratic governance systems, collaborating with both public and private sectors to adapt to the needs of the population.*

The essence of the social economy is well expressed in the OECD studies, presented in Figure 1. Organizations in this field implement specific business models, which are characterized, on the one hand, by the fact that they address societal needs, and, on the other hand, they are organized differently from mainstream economic actors. The business models of the social economy are unique in their way, because they prioritize human needs, are anchored in local communities, effectively utilize diverse resources, incorporate inclusive and democratic governance systems, implement sustainable practices and circular models, and opt for the best solutions of social innovation.



Figure 1. The framework of social economy (OSCE, 2020)

Thus, the Social Economy includes various organizational and/or legal ownership forms such as: cooperatives, mutual societies, associations, foundations, etc. However, the primary type of entity within the entire range of social economy organizations are cooperatives, which have a history of about two centuries and have established themselves as an important sector of the world economy with a strong impact on socio-economic development. They initiate actions and develop response programs to global challenges, enhancing resilience to global crises.

In the UN Secretary-General's report "Cooperatives in social development" (UN, 2017) it was mentioned that the social economy accounted for around 7% of global GDP and contributed to increased employment in various economies. In times of multiple challenges, social economy organizations have strengthened the resilience of communities and helped them navigate the transitions of these periods. For example, during the financial crisis of 2008, employment in the social economy grew by 12-20%, while the public and private sectors experienced considerable job cuts (World Economic Forum, 2022a).

It should be highlighted that the social economy currently contributes substantially to the advancement of sustainable development objectives by reducing poverty, promoting responsible consumption and production, and supporting the transition to sustainable communities. In the European Commission's reflection paper "For a Sustainable Europe by 2030" (EC, 2019), it is mentioned that the social economy presents both an opportunity and a driver for implementing the 2030 Agenda and its 17 Sustainable Development Goals at both the European and global levels, especially for achieving SDG8 Goal "promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all".

The social economy continuously aligns itself with the challenges of the times and can provide innovative solutions to many of today's global challenges, such as climate change, digitization, social inclusion, because it is anchored in local communities, has a great potential for job creation, and works with and for these communities.

However, the social economy field faces several challenges and barriers that hinder its development and expansion in different countries. These include the lack or imperfection of the regulatory framework, as well as the absence of policies to support social economy actors; inadequate allocation of financial resources and the lack of financial support mechanisms; limited access to markets and public procurement; limited visibility etc.

Overcoming these barriers and fully harnessing the potential of the social economy can provide new generations with an inclusive and sustainable future. For these reasons, international organizations recommend that governments support the social economy in its multiple forms by creating the appropriate regulatory framework, through the implementation of public policies, provision of financial support, and ensuring fair market access conditions.

Thus, in the Insight Report titled *Unlocking the Social Economy: Towards an Inclusive and Resilient Society* (May 2022) by the World Economic Forum, two key shifts are identified to mainstream the social

economy. The first shift involves five policy areas that governments could develop for building a more inclusive, sustainable and resilient society: recognizing the social economy and building supportive regulatory frameworks; offering incentives for funding, taxation and investment, expanding education and research to make public and private procurement channels more inclusive; and collecting, measuring and visualizing social impact data. For the second shift, it is crucial to promote public policies that enhance accountability and adopt taxonomy; as well as support innovation and participatory business models (Figure 2).

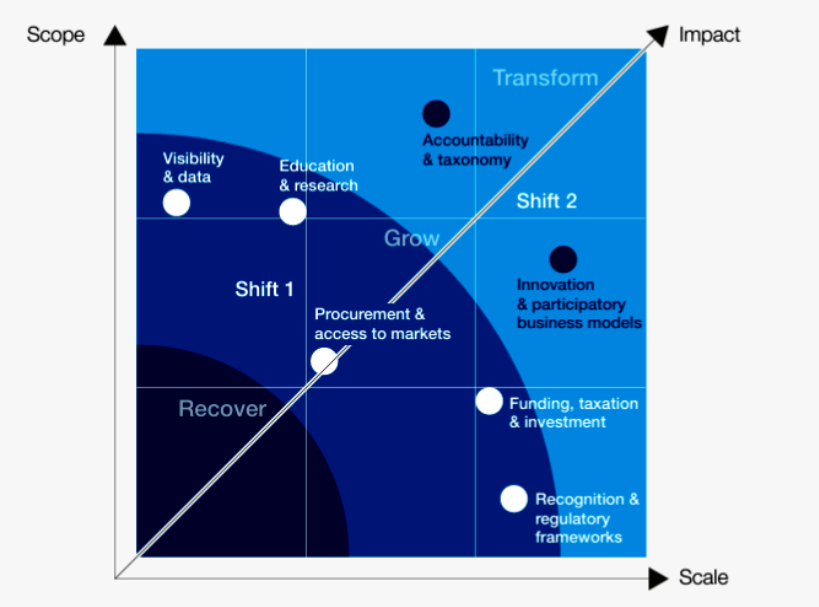


Figure 2. Policy priorities enabling the two shifts to mainstream the social economy (World Economic Forum, 2022b).

The synergistic actions of all key players (governments, businesses, social investors, multilateral organizations, social economy entities, research and academia, civil society organizations) on all these dimensions can maximize the impact of the social economy on economic development and society as a whole.

3.2. The social economy: European approach and context

The social economy is considered to be that part of the European Union (EU) economy that encompasses a specific range of businesses, organizations and legal entities that focus on *social objectives.* According to the European view, the term "social economy" refers to four main types of entities that provide goods and services to their members or society at large: cooperatives,

mutual aid societies, associations (including charities), and foundations. These entities operate independently of public authorities and have specific legal forms. Additionally, social enterprises are also considered part of the social economy, engaging in entrepreneurial and often innovative activities while pursuing social goals.

According to a study carried out by the European Economic and Social Committee on the recent development of the social economy in the European Union, in the European Community there are 2.8 million social economy enterprises and organizations, providing jobs for 13.6 million people (equivalent to approximately 6.3% of the active population), paid jobs ranging between 0.6% and 9.9 % across different states; more than 232 million members belong to cooperatives, mutual societies and other similar entities (EU, 2017). These businesses contribute 8% to EU's GDP (Social Economy Europe, 2024). In countries where the social economy is particularly developed, such as France, this contribution is even higher, reaching 10%.

Recognized for diversifying business models in Europe, the social economy offers consumers a wider range of choices and enhances product and service quality. Consequently, the social economy was considered the core of the "Proximity and Social Economy" ecosystem, one of the 14 industrial ecosystems identified in the updated EU Industrial Strategy (EC, 2021).

However, the level of awareness about the importance and benefits offered by the social economy, as well as that of training in social entrepreneurship, varies significantly from one country to another. While employment in the social economy represents between 9% and 10% of the active population in countries such as Belgium, Italy, Luxembourg, France and the Netherlands, in new EU member states such as Slovenia, Romania, Malta, Lithuania, Croatia, Cyprus and Slovakia, the social economy remains a small, emerging sector, employing less than 2% of the working population (EU, 2017). Accordingly, actions are needed to raise the awareness of society regarding the opportunities and values of the social economy, the forms of achievement, impact on employment and development of communities, etc.

The social economy can contribute to the implementation of the principles of *the European Pillar of Social Rights*, to the diversification of forms of enterprises in Europe, to the achievement of the EU's main objectives for 2030, including increasing employment rates and reducing the number of people at risk of poverty and social exclusion.

In order to facilitate the development of the social economy, the European Commission has launched and facilitated the implementation of a series of initiatives and actions to support this sector. Thus, starting in 2011, it

introduced the "Social Business Initiative - Creating a favourable climate for social enterprises, key stakeholders in the social economy and innovation" (EC, 2011). This initiative outlined 11 key actions, divided into 3 focus areas: facilitating access to financing for social enterprises; improving the visibility of social entrepreneurship; and enhancing the legal framework for social enterprises. A subsequent initiative on start-ups and their expansion was implemented (2016) (EC, 2016), oriented towards social transformation.

To increase private investor interest in social enterprises, the Regulation (EU) on European social entrepreneurship funds (EuSEF) was approved (2013). Additionally, numerous initiatives have been launched to support the social economy, including the Employment and Social Innovation Programme (EaSI), SheSI Guarantee Instrument, the Social Impact Accelerator, EaSI Capacity Building Investments Window etc. However, according to experts, a special European budget policy specifically targeting the social economy has not been developed yet.

Recognizing the importance of the social economy, to help this important sector to exploit its full potential, the European Commission adopted in 2021 an Action Plan *"Building an economy that works for people: an action plan for the social economy"* (EC, 2021*)*. This Action Plan proposes a series of activities for the period 2021-2030, focusing on three dimensions: creating favorable conditions for the social economy to thrive; opening opportunities for the establishment and growth of social economy entities; and enhancing recognition of the social economy and its transformative potential. The action plan aims to bolster social innovation, support the development of the social economy, and harness its capacity for social and economic transformation. To the same purpose, the Commission also launched a "transition pathway" to facilitate the green and digital transitions of the social economy, collaborating with public authorities and other stakeholders for this purpose.

In order to support social entrepreneurship, many European countries have enacted specific laws regarding the social economy (such as in Spain, Greece, Portugal, France, Romania, Belgium, etc.), as well as national plans and institutional initiatives. Reforms have also been implemented to diversify the types of enterprises and social activities within this sector.

However, the concept of the social economy and its regulation differs from country to country. There are also differences in attitudes towards this important economic segment. Thus, in terms of recognition of the concept of social economy, EU countries can be divided into 3 categories: *countries where the concept of social economy is widely recognized* (Spain, France, Portugal, Belgium and Luxembourg); *countries where the social economy concept*

enjoys a moderate level of recognition (Italy, Cyprus, Denmark, Finland, Sweden, Latvia, Malta, Poland, the United Kingdom, Bulgaria, Greece, Hungary, Ireland, Romania and Slovenia); *countries where the social economy concept is poorly recognized or not recognized at all* (Austria, the Czech Republic, Estonia, Germany, Latvia, Lithuania, Malta, the Netherlands, Slovakia and Croatia) (EU, 2017). The potential of the social economy is still insufficiently explored. Greater efforts and national recognition are needed for the concept of the social economy to expand in most EU countries.

The implementation of European policies to support the social economy, as well as the reconsideration of this field in countries where social entrepreneurship is underestimated and underdeveloped, the involvement of state institutions in supporting social economy through appropriate financial mechanisms and stimulating actions will facilitate the development of social economy, the increase of social inclusion and the well-being of the population. To accomplish these goals, tailored policies and actions are necessary in each country. These measures should be grounded in the realities, conditions, and socio-economic perspectives unique to each state.

3.3. The social economy in the Republic of Moldova: current situation, challenges, perspectives

In terms of the Republic of Moldova's aspirations to integrate into the EU, having obtained candidate country status (2022) and with accession negotiations opening by the Council of Europe (2023) — the implementation of European economic and social policies has gained prominence. This strategic orientation prioritizes the well-being of the population and fosters inclusive growth, including adherence to social economy principles.

Although conceptually, social economy and social entrepreneurship have seen significant development internationally and in several European Union states, Moldova has not fully capitalized on them for several reasons. These include legal and normative deficiencies, lack of understanding or non-acceptance of the concept of social economy by public authorities and regulatory bodies, weak relations with local public authorities, reduced motivation for engaging in social activities, and limitations in the necessary competencies for social entrepreneurship, etc.

In many countries of the European community, as mentioned above, a specific regulatory framework for the social economy has been adopted and implemented. In Romania, the neighboring country, for example, social economy activities are governed by the Social Economy Law (2015). In the Republic of Moldova this field has been regulated much more narrowly.

Certain general provisions in support of the social economy are stipulated in art. 126 of the Constitution of the Republic of Moldova (art. 126), which outlines that the *country's economy is a market economy, socially oriented, based on private and public property, and engaged in free competition*. Although this article outlines the foundational premises for the development of the "third sector" of the economy, the current state of the social economy in the Republic of Moldova remains at an underdeveloped level and confirms the need to adopt and implement a specific regulatory framework for the social economy as an environment of this activity.

In the Republic of Moldova there is no special law on the social economy (as in many European countries, including Romania). Instead, the activity of different entities of the social economy is regulated by various legislative acts, such as the Civil Code (which regulates the establishment and functioning of cooperatives, associations, foundations), the Law on production cooperatives, the Law on consumer cooperatives, the Law on entrepreneurial cooperatives. But none of the above-mentioned normative acts contain express references/provisions regarding their attribution to the social economy or social entrepreneurship, although, according to the mission and nature of their activity, they pursue goals and carry out social activities. Consequently, cooperatives cannot benefit from the facilities and support granted to social enterprises.

In 2017, amendments were made to the Law on Entrepreneurship and Enterprises through the Law on Amending and Completing Certain Legislative Acts. These changes, which came into force on May 24, 2018, introduced a separate chapter titled "Social entrepreneurship and social enterprise". According to this law," social *entrepreneurship is defined as an entrepreneurial activity whose main purpose is to solve some social problems in the interest of the community. The social entrepreneurship activity, carried out by social enterprises and social insertion enterprises, is aimed at improving living conditions and offering opportunities to people from disadvantaged categories of the population by strengthening economic and social cohesion, including at the level of local communities, through employment, by developing social services in the interest of the community, by increasing social inclusion*".

The law establishes (art.2) that non-profit organizations (public associations, foundations, religious cults, and private institutions) can carry out social entrepreneurship activities after obtaining the status of social enterprise (SE) or social insertion enterprise (SIE). However, this list does not include cooperatives, which are considered and appreciated as the backbone of the social economy in international vision and practices. Later (2018), the types of

activities that can constitute social entrepreneurship activities were regulated, as well as the National Commission for Social Entrepreneurship's organization and operation, which is empowered to grant the status of social enterprise or social insertion enterprise (GD, 2018).

To truly support the development of the social economy field, in addition to legislative regulations, coherent public policies are needed, adapted to the context of the realities and long-term development objectives of the Republic of Moldova. The design of such policies must be based on a multilateral and broad analysis of the current situation and challenges regarding the development of social entrepreneurship.

With the assistance of international experts and external technical support, relevant studies were conducted to assess the development stage of social entrepreneurship in Moldova. Their findings are reflected in *the Report of the analysis of the current situation and challenges regarding the development of social entrepreneurship in the Republic of Moldova* (Report, 2019),"*Social Entrepreneurship in the Republic of Moldova: Findings and Recommendations"* (Regulatory Analysis, 2021) which contains an evaluation of the problems and social challenges the country faces, of the existing legislation, of the applied financial mechanisms, access to public and private financial resources, of the perception of the actors involved in social activities, and proposals aimed at creating a favorable framework for boosting the development of this sector.

Their conclusions and recommendations formed the basis for developing the project of the National Program for the enhancement of social entrepreneurship between 2021-2025, intended to ensure the necessary policy framework for the creation of an ecosystem that facilitates the development of social entrepreneurship in the Republic of Moldova. The program encompasses a series of ambitious actions structured around the following general objectives: developing and fostering a culture of social entrepreneurship among population; creating a normative framework favorable for social entrepreneurship and harnessing the potential of this sector; facilitating access to the market and financial instruments specific to the social entrepreneurship sector; improving social entrepreneurship and professional skills in this field. In the document provided for the annual establishment and authorization of at least 20 social enterprises, i.e. 5 years after the implementation of the Program, it was estimated that approximately 100 legal entities will hold the certificate of social enterprise, creating at least 5,000 jobs, with at least 30% reserved for people from vulnerable groups. The estimated cost of implementing the Program for the period of 2021-2025 accounts for 36.2 million lei.

Although it had followed public consultations, this Program was not approved and implemented by the Government. According to experts, the main reason was the change of government. It should be noted that the mentioned Program was specifically tailored to the field of social entrepreneurship.

In another policy document, the National Program for Promoting Entrepreneurship and Increasing Competitiveness in 2023-2027 (GD, 2023), the topic of the social economy is addressed in a more limited scope. It is found in one of the specific objectives - *sustainable economic growth by encouraging the green transition, development of a transparent economy, the social economy in order to ensure a sustainable, socially and ecologically responsible, inclusive and fair economic development*. The program focuses on the development of the capital market and entrepreneurs' access to new forms of financing, the stimulation of new forms of economic activity, such as start-ups and electronic commerce, and the direction of economic development towards green practices and financing, promoting underrepresented groups (women, young people, etc.) in entrepreneurship, as well as strengthening the support infrastructure (consulting and training companies, accelerators, hubs, incubators, specialized parks) and entrepreneurial culture.

Nonetheless these actions do not specify specific mechanisms to support social entrepreneurship, except for the provision for the elaboration of a separate law on social entrepreneurship and the increase in the number of social enterprises from 7 (2022) to 14 in 2025. The total cost for the implementation of the Program in 2023 -2025 is estimated at 828.3 million lei, of which 634.9 million lei come from the state budget.

However, in 2022, 11 enterprises were certified in the Republic of Moldova (7 social enterprises and 4 insertion enterprises) (Ciumac, I. Turcan, A., 2022); in 2023, 15 social enterprises were registered in the country, according to the Catalogue of Social Enterprises from the Republic of Moldova (Catalogue SE, 2023), and presently, 23 social enterprises are listed on the "Initiative for Social Entrepreneurship in Moldova" Platform (Initiative for social entrepreneurship, 2024). However, the expansion rate of social economy entities is very slow, and the potential of this sector is still not fully exploited. The actors in this field highlighted, among other causes for this situation, the difficult process of obtaining the status of a social enterprise, the mandatory fees paid upon registration, the lack of mechanisms for the application and implementation of support measures, and fiscal facilities from public institutions as provided by legislation. Additionally, there is a lack or insufficiency of skills for conducting social businesses and insufficient public

information about the social economy and its contribution to society's development, etc.

It should be noted that, due to the lack of knowledge and limited information about non-profit organizations, or insufficient promotion of the social economy in their area, out of 15 existing social enterprises and social insertion enterprises, none of them has the status of being a cooperative, while their potential is huge for activities with a social character.

The previously mentioned converge towards the conclusion that *the social economy and social entrepreneurship represent and continue to be little-known and exploited concepts in the Republic of Moldova*. Those activities, that have been carried out so far, are largely due to the support provided by foreign donors, with minimal assistance from national authorities. And this is happening under the conditions where the Republic of Moldova, according to the World Bank, has a low-middle-income economy, being classified as the poorest country in Europe, with a poverty rate of 15.0% in 2023 (World Bank).

In light of these challenges, effective actions are required to "take" the field of social economy "out of the shadows", to dynamize its development in the multitude of its forms and to engage a diverse range of stakeholders to enhance the well-being of the population.

First of all, it is fortunate to adopt a *special law* that would regulate the field of social economy, as they do in several other European states, including Romania. A distinct law would emphasize the importance of the social economy, regulate all types of businesses (including cooperatives) and the way of functioning of social economy actors, as well as support actions (financial and non-financial) from public authorities, would make the political factor and public authorities more responsible for supporting the expansion and boosting the development of the social economic sector, etc. At the same time, adjustments are needed to be made in connection to the related legislative framework regarding taxation, public procurement, etc. in order to facilitate the implementation of support mechanisms. Currently, for example, according to art. 365 (1) of the law on entrepreneurship and enterprises "the state grants tax facilities for the development of social entrepreneurship according to the Fiscal Code", but this Code does not contain provisions with reference to such facilities. Moreover, introducing a preferential tax regime for newly established social enterprises would be advantageous to support their initial stages of growth.

Access to the market and public procurement is another problem faced by social economy entities in Moldova. Due to theirb small numbers, they lack visibility and are often overlooked by authorities and other economic actors in

the procurement process. In this context, legislative amendments to the legislation on public procurement are needed, which would regulate/establish the obligation to auction a certain share of the budget for procurement, intended specifically for social entrepreneurship entities (called ”reserved procurement”), and expand the list of services that social enterprises could offer.

According to the “Report of the analysis of the current situation and challenges regarding the development of social entrepreneurship in the Republic of Moldova” (The Report, 2019), our country has a low degree of *understanding of the concept of social entrepreneurship*. This lack of understanding extends not only to the central and local public authorities, but also to the population and consumers. This finding is also confirmed in the Report on the results of the sociological study “Knowledge, skills and behaviours in the field of social entrepreneurship in the Republic of Moldova” (The Report, 2022). This issue requires information, training and promotion of educational programs focused on social entrepreneurship on the entire LLL dimension, on dissemination of experience and good practices in the field of social entrepreneurship, consultancy and advice in the development of social businesses, etc. In this regard, the EU and Sweden supported the creation of the Platform for the Development of Social Entrepreneurship in the Republic of Moldova. It is a very useful tool that provides information on social economy, expresses the voice of civil society and organizations that practice social entrepreneurship. However, this aspect requires an integrative, systemic approach.

Surveys/interviews with social entrepreneurs have outlined the fact that people who want to start a business are very poorly informed about the legislative framework, the social businesses specifics, the management of social enterprises, etc. In this sense, it is opportune to organize guidance and consultancy assistance, as well as training in the domain of the social economy, especially for newly created enterprises.

Although *entrepreneurship education programs* (in general) are implemented at different levels of education (from general to higher), aspects related to the social economy and social entrepreneurship are not found in the curricula in most cases. In such conditions, promoting social entrepreneurship in educational programs is imperative, especially in the context of the social responsibility of enterprises. It includes developing educational contents, integrating the fundamentals of social entrepreneurship into educational programs, training trainers and attracting experienced teachers for teaching.

Although a series of courses for the development of social enterprises have been held in the Republic of Moldova with the support of external donors and European funding, there are no *coaching and mentoring programs specialized in social entrepreneurship* on the market. The main reason for this is the lack of funding to support the social economy. This issue also extends to continuing education programs.

At the same time, it needs to be mentioned that the support structures for social enterprises, created and supported by different donors, have made a substantial contribution to the development of this sector. However, they mainly focus on certain project objectives or specificactivity segments, often without sectoral coordination, and without an integrative vision and a systemic approach to the development of the social economy in Moldova.

Implementing a *system for keeping records of social enterprises*, as well as for monitoring and evaluating their social impact, is another objective for boosting the development of social entrepreneurship in the Republic of Moldova. The information obtained would provide an objective assessment of the impact that social enterprises have on the employment rate, meeting the needs of different categories of people, and community development. This will allow for improving the performance of enterprises, identifying and substantiating the most relevant initiatives and projects aimed at increasing the well-being of the population and accessing financial resources.

Access to financing is a priority for accelerating the expansion of social entrepreneurship. Until now, the main source of funding for the field of social entrepreneurship has been external donors. But in this process, state institutions must also be involved in order to ensure the sector's sustainable development. In this respect, effective tools are needed to support the social economy, including tax or non-tax facilities, non-refundable state-financed projects, the application of subsidy mechanisms, the provision of subsidies and preferential loans, etc.

Although several studies have been carried out on the social economy situation in Moldova and multiple recommendations have been formulated regarding the development of this sector, it is still apparent that state institutions do not prioritize its development. Raising awareness at the political level about social entrepreneurship and the social economy, including the objective of developing the social economy into the list of public authorities' priorities and implementing the actions required to boost its development, will contribute to increasing the number of jobs, enhancing social inclusion, reducing poverty, creating an ecosystem favorable to development, fostering

social innovation, and, finally, improving the standard of living and the well-being of the population.

4. Conclusions

The social economy, a relatively new concept, has seen significant development across many European countries and has emerged as a global trend in sustainable business practices that are people- and environment-friendly internationally. In the Republic of Moldova, social entrepreneurship is still in its early stages of development. However, there are promising conditions for rapid growth and a substantial impact on the country's socio-economic development, on condition that an appropriate culture of social entrepreneurship will be developed; a legislative framework specific to this field will be implemented; efficient financial mechanisms in support of social entrepreneurs will be adopted, including tax and non-tax facilities; access to markets will be ensured; the development of human resources will be promoted (training, guidance and counselling of interested parties in the development of social businesses); the experiences in this domain will be largely disseminated. Achieving these goals necessitates continuous and sustained efforts from all stakeholders involved in social economy development.

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Mindful consumption: Enhancing quality of life through food waste awareness

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Abstract

Mindful consumption is a framework that emphasizes the significance of awareness and deliberate action in resource utilization and consumption, aiming to decrease overconsumption and food waste. Globally, approximately one-third of the food designated for human consumption is wasted. This significant food waste primarily originates from households and public food services. The purpose of this chapter is to introduce the concept of mindful consumption, examine the various factors contributing to food waste in households and restaurants, and present strategies to mitigate this waste through mindful practices.

Keywords: *mindful consumption, minimizing food waste, sustainable practices, households, restaurants.*

1. Introduction

Mindful consumption is a concept that emphasizes awareness and intentionality in the use and consumption of resources, promoting the reduction of the resources overconsumption , minimizing waste as a key component of reducing overall environmental impact and encouraging a healthier lifestyle [Manchanda et al. 2023; Sheth et al. 2011]. Statistics on global/regional FW (food waste) highlight significant waste along the FSC (food supply chain), from agricultural production through farm-level/industrial processing to consumption (households – home eating, private/public food services – dining out) [Osei-Owusu et al. 2023; Stoica et al. 2022b; Stoica et al. 2023]. In higher-income countries (European, Asian, American), the largest FW fraction occurs during consumption. Approximately one-third of the food intended for human consumption is wasted globally, amounting to around 1.3 billion tons annually, being attributable to the households and public food services (the third-largest generator of FW in Europe, right behind households, primary agricultural and

food processing) [FAO, 2011, 2019, 2020; Filimonau et al. 2019, 2020; Jobson et al. 2024; Stoica et al. 2022a,b, 2023]. Households are regarded as the primary source of FW, being influenced by socio-demographic factors (age, gender, education, employment status, income, household size and type) and household food management (meal planning, food shopping routines and food handling) [Stoica et al. 2022a]. In restaurants, the factors that contribute to PFW (plate food waste) can include food quality issues, the use of low-cost ingredients, lack of culinary knowledge (poor food combinations, difficulties in consuming all edible parts of the food, and the use of unsuitable plates), unfamiliarity with certain foods and preparation methods. This variety of causes presents challenges in accurately measuring PFW as each of them significantly influences FW at serving point . However, each cause also represents a potential point for intervention to reduce PFW [Stoica et al. 2022b]. Minimizing FW in households/restaurants is a multifaceted challenge that requires a strategic approach, combining planning, awareness, innovation, and efficient practices. The aim of this chapter is to introduce the concept of mindful consumption, explore various elements associated with FW in households/restaurants, and discuss mindful strategies to reduce it. Mindful consumption has the potential to positively impact future generations by fostering greater awareness of their environmental footprint and encouraging the adoption of more sustainable practices.

2. The concept of mindful consumption

Mindful consumption embodies a blend of a mindful mindset, which encompasses care for oneself, the community and nature, and mindful behavior, which involves moderating the excesses linked to different consumption patterns (acquisitive/repetitive/aspirational) [Sheth et al. 2011; Tan et al. 2022]. Mindful consumption theory, which is unique because it introduces the concept of consumer choice, suggests that decisions about consumption are behavioral in nature, driven by expectations and values, and that the consumer's concern for their own well-being is at the core of these decisions [Lim, 2017; Milne et al. 2020; Siraj et al. 2022; Zahid et al. 2023]. In practice, these decisions are deeply embedded/shaped by the system of production and consumption in which they operate [Zibell et al. 2021]. Mindful consumers adopt a holistic approach to their purchasing decisions, reflecting a deep understanding of how these choices influence both immediate and long-term economic outcomes [Bahl et al. 2016; Peattie and Peattie, 2009; Sheth et al. 2011; Swami et al. 2010]. They have the ability to see the broader economic implications of their choices, not just for themselves but also for the community and global

economy, recognizing that sustainable consumption can lead to a more stable and equitable economic environment (buy in bulk, buy seasonal fruits/vegetables, invest in higher-quality kitchen equipment, choose local products, purchase from local markets, planning shopping, FW translates to money waste) [Bray et al. 2011; Jackson, 2005; Prothero et al. 2011; Seyfang, 2006; Thogersen and Ölander, 2002]. Socially mindful consumption is about understanding the interconnectedness of consumer food choices and their effects on societal structures. It recognizes the fact that each purchasing decision can contribute to a more equitable and just world and to promoting social welfare (purchase locally produced foods, choose products from companies that ensure fair wages, support initiatives that increase food accessibility, opt for foods that are ethically sourced, participate in initiatives that foster a sense of community around food, support traditional/indigenous food practices, support educational efforts that teach children/adults about the social implications of food choices) [Allen and Sachs, 2007; Connolly and Prothero, 2008; Hinrichs, 2000; Johnston et al. 2011; Lockie et al. 2002; Raynolds, 2002; Seyfang, 2006]. Environmentally-friendly mindful consumption emphasizes making food choices that minimize negative effects on the environment, considering how foods are grown, processed, packaged, and transported, and selecting options that promote sustainability and reduce environmental degradation (opt for organic foods, decrease meat intake, plan meals, properly store food, use leftovers creatively, supporting farms that use regenerative practices, choose foods with minimal or recyclable packaging, eat seasonal products). By integrating these environmentally friendly practices, mindful consumers can significantly contribute to a healthier planet, each choice made at the grocery store or during meal preparation becomes an opportunity to positively impact the environment, promoting a sustainable and equitable food system for future generations [Gliessman, 2014; Manchanda et al. 2023; Smith et al. 2007; Vermeir and Verbeke, 2006]. Through mindful, economic, social, and environmentally friendly choices, consumers can significantly reduce unsustainable and overconsumption, as well as promote sustainable consumption practices [Manchanda et al. 2023; Sheth et al. 2011].

3. Understanding the Food Waste

Food waste detrimentally affects environmental, social, and economic dimensions. Within this intricate economic system, both manufacturers and consumers play pivotal roles, with consumer choices significantly impacting manufacturers' behaviors. These choices dictate the types and quantities of foods produced. Resource utilization – including water, cropland, fertilizers,

pesticides, labor, finances, and energy – is influenced by factors such as manufacturing technologies, storage practices, transportation (distribution/redistribution), and marketing strategies. Additionally, the level of consumption escalates with the increase of global population. FW represents a significant challenge for contemporary society, with substantial quantities of food ending up in landfills. Beyond the initial financial outlay for food procurement, FW incurs additional burdens, including resource costs, environmental externalities, and social costs. Considerable financial resources are expended on producing foods that are ultimately not consumed. Moreover, the wasted labor, materials, time, and energy invested in food production should not be overlooked. Evaluating the potential economic benefits that could be attained by reallocating these resources presents a complex challenge. FW poses an economic sustainability challenge, yet by 2030, addressing it through investment in cost-effective interventions – such as consumer education campaigns, standardized date labeling, spoilage prevention packaging, and waste tracking and analytics – could offer substantial economic opportunities. Beyond the depletion of resources aspect, FW also impacts the environment through resource overuse, leading to issues like soil erosion and water scarcity, as well as contributing to pollution. The environmental cost of FW is estimated to be $700 billion annually. This figure is obtained by quantifying the costs associated with carbon emissions, land use, and water consumption, along with potential savings. Additionally, this estimate incorporates the semi-quantifiable cost of lost biodiversity. Consumer surplus loss due to food waste contributes to higher food prices. Such price increases disproportionately affect low-income individuals who are unable to absorb higher food costs, leading to greater risk of nutritional deficiencies among this demographic. These deficiencies can subsequently result in increased healthcare costs and lost productivity due to food insecurity and poor nutrition, with the social cost estimated at approximately $900 billion annually [Stoica and Stoica, 2022]. Consequently, being mindful of FW has profound environmental, economic, social, and ethical consequences, making it an essential component of sustainable living and conscientious consumption.

4. Mindful strategies to minimize FW in households and restaurants

Addressing FW within households entails a combination of planning, awareness, and efficient practices. Some ways to mitigate FW at the level of households are shown in Figure 1.



Figure 1. Mindful ways to minimize FW in households (own creation).

These consist of meal planning (efficient shopping: creating a meal plan can guide shopping lists, ensuring only necessary foods are bought, checking for sell-by/use-by/best-before dates; portions control without leftover excess); proper food storage (storing foods at proper refrigeration/freezing temperatures; using FIFO – First-In First-Out, clear labeling, proper washing and drying storage); focusing on nutrition over perceived imperfection, don't bin the fruits/vegetables with lower aesthetic quality, perceived imperfections don't influence their safety or nutritional value; utilizing leftovers (creative reuse, proper storage); composting (waste diversion); education and awareness (educating family members about the impacts of FW and how to prevent it, community engagement); connecting with local organizations that collect uneaten edible foods from homes to feed needy people [Collin, 2024; dos Santos et al. 2022; Jobson et al. 2024; Pandey et al. 2023; Principato, 2018; Stancu et al. 2016; Stoica et al. 2022c]. Implementing these mindful methods in households contributes to a more sustainable living (environmental sustainability, economic efficiency, social responsibility). Each strategy is interlinked and supports the broader goal of reducing FW globally. Reducing PFW in restaurants is a multifaceted challenge that requires a strategic approach towards combining awareness, innovation, and cooperation. Some

strategies to minimize PFW consist in customizable portion sizes; menu flexibility; staff training and engagement; consumer awareness and involvement; menu design; data-driven menu adjustments; usage of seasonal and local ingredients; regular waste audits to measure and understand the amount and types of waste generated; implementation of digital solutions for FW management (WT – waste tracking, OIDT – optimizing inventory and delivery times, KA – kitchen automation, FD – food redistribution), reuse and recycling (food donation programs; set up composting systems for organic waste; policy and incentives (discounts or other incentives to customers who opt for smaller portions or participate in waste reduction programs; implement clear, easy-to-follow waste reduction policies that all staff members to abide by) [Carletto et al. 2023; Cozzio et al. 2021; Guimarães et al. 2024; Dhir, 2020; Dolnicar, 2020; Dolnicar et al. 2020; Juvan et al. 2021; Stoica et al. 2022b, 2023; Vizzoto et al. 2021, 2021a]. The most representative digital tools for FW management applicable in restaurants are shown in Figure 2.

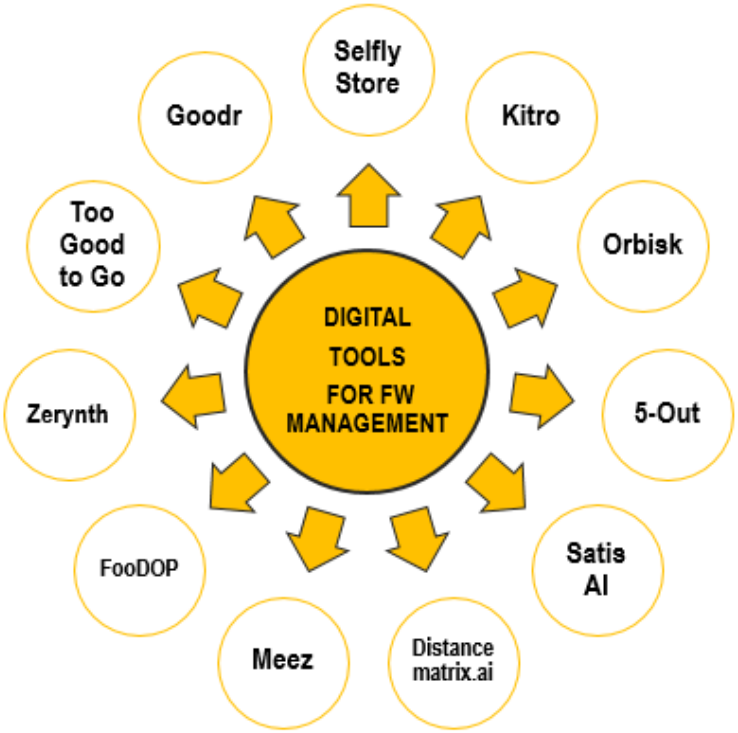


Figure 2. The most representative apps for FW management applicable in restaurants (own creation.

These include: Selfly Store (intelligent storage zones equipped with capabilities for expiration date management – WT), Kitro (classification of FW based on machine learning algorithms – WT), Orbisk (measuring and

automatically categorizing the types of food that are discarded – WT), 5-Out (software developed to enhance purchasing strategies by predicting consumer demand – OIDT), Satis AI (tool for avoiding mixed up orders – OIDT), Distancematrix.ai (tool for time delivery optimization – OIDT), Meez (digital platform for easy recipe organization – KA), FooDOP (IoT-based platform designed for smart menu planning – KA), Zerynth (assisting restaurants in keeping perishable food fresh and safe – KA), Too Good to Go (solutions for saving valuable foods by offering them at reduced prices – FD), Goodr (solutions for donating the surplus food to charity causes – FD). These digital technologies facilitate the transition of foodservice units from conventional record-keeping using paper and pens to digital systems. They enhance the optimization of inventory and delivery processes, automate restaurant kitchens, and provide methods for redistributing food [Stoica et al. 2023]. By integrating strategies to minimize PFW, restaurants can significantly/considerably diminish plate waste, thereby enhancing economic efficiency, promoting environmental sustainability, and upholding social responsibility. These strategies not only directly address the problem of waste, but also promote a culture of sustainability among both the organization and its customers.

5. Conclusions

Mindful consumption is not merely a practice but a lifestyle choice that can significantly enhance one's quality of life. It encourages individuals to think critically about their habits and choices, fostering a deeper connection to their food and its origins, which can lead to greater personal and communal well-being. The chapter outlines mindful strategies for reducing food waste in households (meal planning, efficient shopping, checking for sell-by/use-by/best-before dates, portions control, proper food storage, clear labeling, utilizing leftovers – creative reuse, proper storage, education and awareness) and restaurants (customizable portion sizes, menu flexibility, staff training and engagement, consumer awareness and involvement, menu design, regular waste audits, implementation of digital solutions for food waste management, reuse and recycling, policies and incentives. These strategies not only reduce the environmental impact, but also offer economic and social benefits. This chapter serves as a call to action for individuals, communities, and policymakers to embrace mindful consumption. By doing so, they can contribute to a more sustainable planet and enhance their quality of life through a more thoughtful relationship with food.

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Digital Transformation: a Premise for Enhancing Quality of Life in Europe

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Abstract

This study explores the transformative impact of digitalization on public services, emphasizing its role in enhancing delivery services, efficiency, and public satisfaction. By adopting advanced digital solutions, governments can significantly improve the accessibility and quality of public services, thus meeting the evolving needs of a growing populace. The research investigates the integration of information technology in public administrations and evaluates its correlation with improved quality of life indicators. Through comprehensive analyses, including the Digital Economy and Society Index (DESI), this paper demonstrates how digital competencies among the population and robust IT infrastructure enhance the effectiveness of public services. The findings highlight the critical role of digital literacy and infrastructure in ensuring equitable access to services and underscore the need for sustained investment in digital skills to driver economic growth and improve the quality of life.

Keywords: *digitalization, public services, development, quality of life*

1. Introduction

The digitization of services comes to help governments address the needs of the public and transform the online environment, making it more efficient, resilient and secure. While the commitment is complex, rapid development in developing cities with limited resources requires a proven formula by other cities that have made remarkable progress in a short period of time.

The evolution and progress of governments around the world play an important role in the new concept of digitization. As cities grow, the needs and expectations of consumers become greater, which is why the demand for new advances and updates to the public service system is increasing. The major pressure on institutions that provide public services is increasing, because the population needs accessible, fast, high-quality and transparent services. With all these circumstances considered, digitalization becomes a mandatory tool to quickly and promptly respond to consumer demands, and build more efficient and resilient coordination.

Implementing digital innovations is not just a technological improvement. They represent a significant change at the level of a country, because they

represent the way governments communicate with citizens and coordinate public resources. Public administrations respond to the population quicklier and with a higher level of certainty, reducing the time spent at public stations and moving from one institution to another, optimizing internal processes due to these changes. The digitization of public services will help to reduce bureaucracy, will also eliminate redundancies and, consequently, will provide more efficient services, which helps to increase citizens' well-being and build public confidence in state institutions.

The ability of governments to cope with rapid change, crises and overcome all challenges is another key component of digitalization. Due to the evolution of technology, public administrations are becoming closer to consumers, adapting easily to challenges, because we are part of a world where uncertainty and volatility are increasingly present and unpredictable situations arise that are difficult to manage. Digital technology provides the tools needed to manage situations in real time, to make documented decisions and to identify effective responses at the local and national levels. For this reason, digitization not only facilitates government performance under normal conditions, but also ensures increased capacity for crisis management and mitigation.

After a decade of trial and error, municipal leaders are realizing that smart-city strategies start with people, not technology. “Smartness” is not just about installing digital interfaces in traditional infrastructure or streamlining city operations. It is also about using technology and data purposefully to make better decisions and deliver a better quality of life. Quality of life encompasses many dimensions, from the cleanliness of the air residents breathe to the safety they feel while walking the streets. The latest report from the McKinsey Global Institute (Smart cities: Digital solutions for a more livable future), examines how dozens of digital applications address these kinds of practical, human-centered concerns. It indicates that cities can use smart technologies to improve some key quality-of-life indicators by 10 to 30 percent—numbers that translate into lives saved, fewer crime incidents, shorter commutes, a reduced health burden, and averted carbon emissions.

Successful digitization depends on the ability of governments to implement these solutions to meet the needs and expectations of citizens, thereby strengthening the relationship between government and society. This phenomenon involves not only the adoption of new technologies, but also a profound cultural change within public institutions. The effectiveness of digitization is largely based on the competence of governments to implement solutions in a way that adresses the needs and expectations of citizens, thereby

enhancing the relationship between government and society. Digitalization is not just about technology, it is about developing a more efficient, more transparent, clearer and more documented administration to respond to the challenges of an ever-changing world.

2. Literature review

The introduction of the concept of digitalization in public services represents the way governments interact with citizens. This has completely transformed the image of public administration and the way it impacts the population's quality of life . Janssen et al. (2021) argue that e-governance initiatives are paramount in increasing citizen satisfaction by improving service delivery, implying that digitalization is not just a technological integration, but a reimagining of governance, where easy access to services becomes synonymous with empowering citizens. In this era of digital governance, Misuraca and Viscusi (2020) explore the philosophical foundations of public value. Their examination of the relationship between artificial intelligence and public services presents two contradictory ideas: while AI enables unprecedented efficiency and innovation, it necessitates a reassessment of the social and ethical implications of these technologies. Their work suggests that we should consider not only the real advantages and benefits of digitalization but also its disadvantages and broader questions about how technology contributes to the public good.

Lindgren and van Veenstra (2021) highlight how important and essential the digital transformation of the public sector is for the community. They argue that digital public services will succeed provided that they are well-aligned with the needs and expectations of citizens, noting that technology without human considerations risks alienating the very people it seeks to help and attract. This innovative concept underscores the philosophical component, emphasizing that digital services must reflect collective human values and fundamental societal goals.

A comparative perspective on the digitalization of public services and its impact on the quality of life in different European Union countries is offered by Velicu et al. (2022) in their publications. Their final results indicate a close connection between digitalization and the improvement of quality-of-life indicators. They also highlight disparities between nations, noting that the benefits of digital services are not evenly distributed. This brings to the forefront issues of equality and inclusion in the digital age, forcing policymakers to consider how digitalization can be implemented to reduce disparities rather than deepen them. Meijer (2020) addresses the topic of

digitalization from a governmental perspective, exploring how the digital society reshapes the power relationship between the state and its citizens. His analysis suggests that e-governance is not just a tool for making things better or more efficient, but a transformative force capable of reshaping the social contract. Consequently, the digitalization of public services serves to reimagine democratic engagement and participation, in a context where governance increasingly adapts to the needs of a digitally advanced population. Additionally, Cordella and Bonina (2020) discuss the theoretical aspect of public sector reforms driven by ICT. They suggest that the concept of public value is crucial and essential for new government initiatives. They argue that the success of digital reforms depends not only on the adoption of technology but on its capacity to maximize public good. Their work suggests a deeper analysis of what constitutes value in the public sector, a fact which indicates that true success lies in aligning digital services with societal goals.

Gil-Garcia and Helbig (2021) examine the key elements necessary to highlight the success of e-governance. Following their analysis, the core elements identified are leadership, technological infrastructure, and user engagement. Their work highlights the complexity of digital transformation, where success depends on technological skills and strategic vision. This adds to the complexity of the discussion, suggesting that digitalization is as much about technology as it is about organizational culture and leadership. Finally, Santos and Ribeiro (2022) make a comparison between the practical results obtained from digital governance initiatives at the European level. Their studies and research in this field show that, although digitalization has significantly improved public services, quality of life for citizens varies greatly. This significant difference raises a rhetorical and philosophical question about the nature of progress in the digital age—whether it is universally beneficial or context-dependent.

Following the analysis of the specialized literature, the digital transformation of public services is not just a technological effort; it represents a complex and efficient process for both governments and population.

3. Methodology

The primary tool of analysis is the Digital Economy and Society Index (DESI), which provides a detailed assessment of digital progress across various critical domains such as connectivity, human capital, and digital public services. The study analysed DESI data from European Union member states over a five-year period, from 2017 to 2022, to identify trends and correlations between digitalization levels and public service performance. In addition to

descriptive statistics, the research methodology includes correlational analyses to explore the relationships between digital infrastructure, public service quality, and citizen satisfaction. This approach allows for a nuanced understanding of how digital transformation influences quality of life, providing a solid foundation for recommendations on policy and strategy development for enhancing digital public services.

4. Results and discussion

An essential and vital tool for analyzing the digital progress of European Union member states is the Digital Economy and Society Index (DESI). This index tracks performance across various critical areas, such as connectivity, human capital, internet usage, the integration of digital technology in the private sector, and the effectiveness of digital public services. Given/ Considering the fact that we are part of an era where digitalization is a primary driver of economic growth, it is crucial to monitor economic indicators to modernize the society in which we live.

Digital transformation in each EU member state is monitored by DESI. This provides a comprehensive view of the state of digitalization, identifying both strengths and areas that require improvement. Policymakers, economists, and public administrators use DESI as a tool for analysis, measurement, and guidance. By highlighting progress in the implementation of digital technologies, DESI not only helps identify weaknesses and areas requiring intervention but also proposes solutions and fosters healthy competition among states, motivating them to increase their efforts toward digitalization. Furthermore, DESI provides a solid foundation for shaping public policies, guiding investments in infrastructure, digital education, and public services. This approach effectively addreses the needs of citizens by responding effectively to challenges and promoting the development of a sustainable economy.

The ability of a nation to adopt and integrate digital solutions is becoming essential and is a determining factor for its global competitiveness in an increasingly technology-connected world. Therefore, the application of DESI is necessary not only to measure progress but also to guide the strategic development of national economies, ensuring that no EU member state lags behind in the global shift toward digital prosperity and innovation.

Figure 1 provides a valuable and insightful perspective on the degree of digitalization of economies and societies in various European countries. The DESI index not only presents performance in terms of connectivity and human capital but also highlights the effectiveness of digital public services. Another

positive aspect it offers is the integration of technology into the private sector and the usage of the internet by citizens.

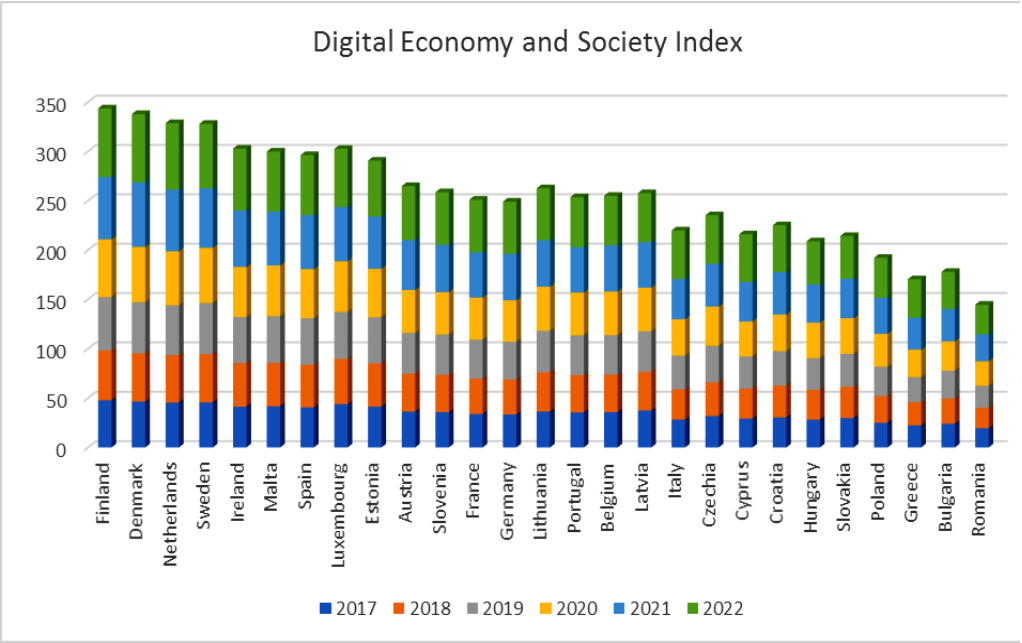


Figure 1. The DESI Index in Europe, 2017-2022 period
Source: Created by the author based on information published by the European Commission on the page: https://www.statista.com/statistics/1372137/eu-digitalization-desi-member-states/

The analysis presented indicates a consistent increase in the DESI index across all examined countries during the 2017-2022 period. This demonstrates that governments are making significant efforts toward digitalizing public services and modernizing them. This growth is not accidental; it is the result of technological progress achieved over a long period. It reflects a fundamental shift in the way public services are conceived and delivered to citizens. The countries with the highest DESI index values are Finland, Denmark, the Netherlands, and Sweden. These nations stand out as digitalization leaders, reaching a score of 69 points in 2022. These states have contributed to economic growth and an improved quality of life for their citizens. They have invested massively in digital infrastructure, promoted digital skills, and developed accessible and efficient public services for all age groups and various needs, easing the workload of those in the public sector. The Nordic countries, Finland and Denmark, have consistently ranked at the top of the digital leaderboard throughout the analyzed period, with an increase of 22 points in 2022 compared to 2017. These results demonstrate that effective

digitalization can strengthen public administrations and transform the relationship between government and citizens.

On the opposite end, Romania faces greater difficulties in adopting and implementing digital solutions. With a DESI index of approximately 30 points in 2022, Romania reflects the challenges of a state that still struggles with major issues in developing digital infrastructure. Additionally, increasing the population's digital skills and optimizing public services through modern technologies are other challenges that the Romanian state faces. This enormous digital gap, with a difference of approximately 40 points between countries, underscores the need for more focused and efficient individual digitalization strategies in developing regions with low performance.

By highlighting strengths and weaknesses, the DESI index has a direct impact on the development of public services. A high DESI value not only indicates a complex digital infrastructure but also a public sector capable of providing lower cost, faster, and more transparent services. This leads to reduced corruption and increased citizen trust in public institutions, as well as reduced bureaucracy and enhanced administrative efficiency. Moreover, a high level of digitalization is associated with better governmental resilience in the face of crises and rapid changes, providing a favorable environment for innovation and economic development. It also tracks a country's digital progress and directly affects its ability to deliver high-quality public services. The DESI index serves as an indispensable measure to understand the impact of technology on contemporary governance and quality of life, emphasizing the importance of continuous, coherent, and well-planned digitalization in ensuring sustainable economic and social development.

Another essential indicator that helps a nation adapt more easily to technology is the level of digital literacy among the population. As reflected in the Digital Economy and Society Index (DESI), the level of literacy plays a crucial role in assessing a country's ability to adapt and advance in a digital economy. Investments in digital education enable a nation to become more capable of utilizing technology, leading to economic growth and improved quality of life for all citizens.

Figure 2 presents the distribution of basic digital skill levels among nations in various European countries for the years 2021 and 2023. Analyzing the presented data provides valuable insights into the diversity of digital capabilities across Europe. This visual representation reveals significant differences between countries, reflecting not only the level of digital preparedness among citizens but also the extent of government commitment to fostering and supporting digital education.

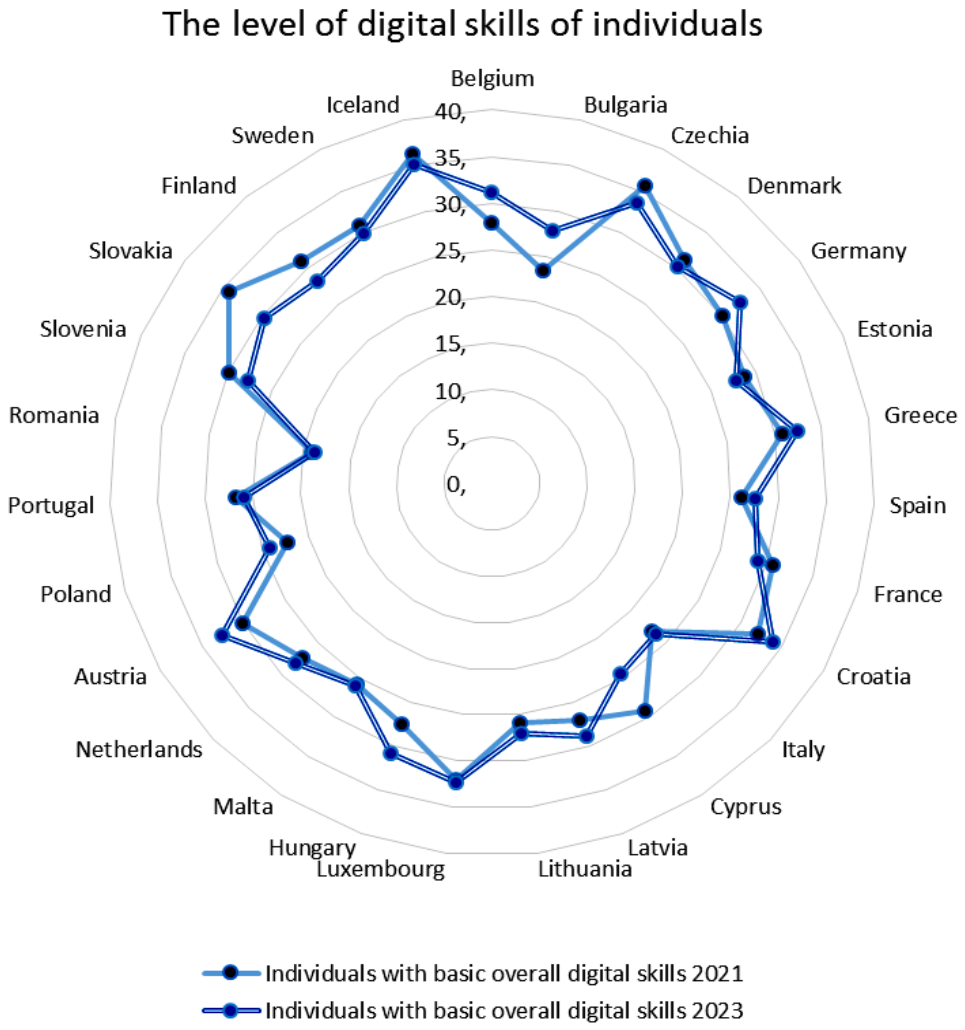


Figure 2. The level of digital skills of individuals in Europe in 2021 and 2023
Source: Created by the author based on information published on the Eurostat website, https://ec.europa.eu/eurostat/databrowser/view/isoc_sk_dskl_i21/default/table?lang=en

Furthermore, it emphasizes the fact that digital skills vary greatly across European countries, which implies that the implementation of IT solutions in public services can be uneven, reflecting disparities in citizens' digital preparedness. Economically developed countries tend to have higher levels of digital skills. For example, Germany, Belgium, and Luxembourg are among the best-equipped countries, fully leveraging the advantages of digitalization in public services. In these countries, significant financial resources have been invested in digital competencies, leading to modest but steady progress between 2021 and 2023. This indicates a level of technological maturity that

allows for the efficient integration of IT solutions, contributing to more transparent governance and easier access to public services.

Conversely, within the European Union, there are countries, such as Romania and Portugal, that have lower levels of digital skills. This is largely due to the lack of funding necessary to acquire IT solutions. As a result, citizens suffer from the absence or complexity of software systems within public services, making them difficult to access. In countries with low or stagnant levels of digital skills, like the afore-mentioned ones, the ability to implement and benefit from IT solutions in public services is significantly limited. The decline in digital skills in Romania, for example, highlights fundamental challenges that could hinder widespread access to digitized public services, potentially exacerbating existing inequalities and limiting the positive impact of digitalization on quality of life. Currently, the lack of digital skills poses a major obstacle to the efficient modernization of public administration.

Analyzing these trends makes it clear that the successful implementation of IT solutions in the public services sector largely depends on the level of digital competencies among the population. In countries where these skills are well developed, digitalization can lead to significant time and resource savings, a reduction in bureaucracy, and increased access to essential services, all of which contribute directly to a better quality of life. In contrast, in countries where digital literacy remains low, the positive effects of digitalization are harder to be achieved, and investments in technology may not reach their full potential unless accompanied by additional efforts in digital education and increasing technology accessibility.

Digital transformation plays a key role in improving quality of life by providing innovative solutions for optimizing and making public services more efficient. Through digitization, administrations can respond faster and more precisely to citizens' needs, reducing waiting times and bureaucratic complexity. For example, the implementation of digital systems in health services allows easy access to medical records and online appointments, increasing the effectiveness of treatments and patient satisfaction. In education, digital platforms facilitate access to diverse and personalized educational resources, supporting lifelong learning and catering to individual needs. In addition, the digitization of municipal services such as tax payments or the management of urban services through smart applications transforms the interaction between citizen and administration, increasing transparency and trust in state institutions. Thus, digital transformation not only simplifies administrative processes, but also significantly contributes to enhancing quality of life, bringing public services closer to the needs and expectations of citizens.

Table no 1 provides an extensive comparative analysis of quality-of-life indices for different countries, covering key aspects such as purchasing power, safety, health, cost of living, property prices, shuttle time, pollution and climate index. It provides a valuable insight into how different nations manage to promote the well-being of their citizens.

Table no 1 Quality of life indices in Europe, 2023

Rank	Country	Quality of Life Index	Purchasing Power Index	Safety Index	Health Care Index	Cost of Living Index	Property Price to Income Ratio	Traffic Commute Time Index	Pollution Index	Climate Index
1	Luxembourg	219.3	182.5	65.7	75.3	62.4	8.9	27.2	23.3	82.6
2	Netherlands	207.5	124.9	73.6	79.3	63.1	7.7	23.5	21.4	87.0
3	Denmark	205.6	127.2	73.9	78.5	72.3	6.6	27.8	20.8	83.7
4	Switzerland	204.0	158.7	73.9	71.7	101.1	10.4	32.9	23.3	82.0
5	Finland	199.9	118.0	73.8	77.5	63.2	8.4	25.8	11.9	61.1
6	Iceland	199.7	120.3	74.6	67.7	83.0	6.1	21.3	16.0	68.8
7	Austria	190.8	102.4	70.6	77.2	65.1	11.0	23.9	21.2	81.8
8	Norway	189.0	114.7	67.1	76.0	76.0	7.8	26.4	18.2	60.0
9	Sweden	186.7	122.6	51.7	68.3	59.3	7.7	29.1	17.7	73.6
10	Germany	185.0	120.2	61.0	72.0	62.2	9.4	30.0	28.7	82.0
11	Estonia	183.5	80.4	76.4	75.9	52.0	11.2	21.8	17.0	64.3
12	Spain	180.8	92.1	64.2	77.7	47.3	8.3	26.5	35.4	91.7
13	Slovenia	177.7	80.9	76.4	66.3	49.9	12.5	25.2	22.0	76.1
14	Croatia	172.1	75.0	74.4	65.0	45.5	12.8	25.8	30.8	89.2
15	Czech Republic	171.9	84.0	73.2	75.6	46.6	12.7	29.1	34.9	80.1
16	Lithuania	170.6	75.5	67.5	74.9	47.1	11.9	23.4	26.3	67.8
17	United Kingdom	170.6	115.2	52.2	73.2	62.0	9.1	34.7	40.4	86.0
18	Portugal	167.5	56.9	68.8	72.5	45.1	13.3	28.5	28.7	97.6
19	Belgium	163.5	109.8	50.3	75.6	61.1	7.0	35.3	49.5	83.8
20	Ireland	161.3	101.1	53.2	51.3	64.4	7.2	37.8	34.4	87.8
21	France	159.8	102.4	44.7	77.8	63.7	11.2	34.8	43.7	88.4
22	Latvia	159.4	66.9	62.7	62.4	49.1	9.0	28.9	30.4	74.7
23	Slovakia	154.4	68.3	69.2	58.5	46.7	14.5	27.5	37.4	80.7
24	Poland	149.3	85.8	70.9	57.7	40.8	11.6	31.8	55.6	75.4
25	Italy	145.6	78.3	52.9	65.3	56.2	10.2	32.4	53.8	88.9
26	Hungary	139.7	63.4	66.7	54.0	41.7	13.5	35.8	46.7	78.4
27	Bulgaria	139.6	68.4	63.4	58.0	38.3	9.3	29.1	63.1	81.2
28	Romania	137.4	63.8	67.7	56.4	37.5	10.4	33.3	58.8	76.3
29	Greece	131.5	53.0	53.5	57.6	52.0	13.4	33.9	51.8	91.8
30	Bosnia And Herzegovina	130.4	56.9	58.6	55.6	35.0	13.5	26.3	59.8	78.2
31	Belarus	125.0	51.8	49.4	48.2	26.4	12.8	31.2	45.2	64.4
32	Serbia	120.2	50.2	62.4	52.1	37.7	17.1	30.7	65.2	83.2
33	North Macedonia	115.3	51.0	59.0	55.4	33.0	13.3	25.0	79.6	76.3

Source: https://www.numbeo.com/quality-of-life/rankings_by_country.jsp?title=2023-mid&region=150

At the top of the ranking is Luxembourg, with an impressive quality of life index of 219.3 and a purchasing power index of 182.5, the highest of all the analyzed countries, indicating a superior economic capacity for its citizens to purchase goods and services. Luxembourg also boasts a high level of safety and an excellent healthcare system, as reflected in its high scores on these dimensions. These features are complemented by a relatively moderate cost of living and a low pollution levels, contributing to a high-quality living environment. On the other hand, at the lower end of the ranking are countries

such as Macedonia, Serbia and Belarus, which record significantly lower scores across most categories. For example, Macedonia has a quality-of-life index of just 115.3 and a purchasing power index of 59.0, indicating substantial economic challenges and limited purchasing power among its population. These countries also face higher pollution scores, and higher costs of living compared to the quality of services provided, which can adversely affect citizens' well-being. Comparing the differences between the countries at the top and those at the bottom of the ranking, the impact of economic policy, government efficiency and investment in social infrastructure on the quality of life of citizens becomes evident. Effective policies in healthcare, security and economic management not only improve living standards, but also strengthen the relationship between governments and their citizens, providing a safer and more prosperous environment for all.

A comparative analysis of the quality-of-life indices and the Digital Economy and Society Index (DESI) in various European countries reveals significant correlations between digitalization and quality of living. The data presented in the previous figures indicate that countries with high DESI scores, such as Finland, Denmark and the Netherlands, also demonstrate a high quality of life. These countries are characterized by a strong commitment to implementing digital technology in public services, advanced digital infrastructure, and widespread access to the Internet. These factors significantly contribute to administrative efficiency and to the rapid and transparent access to services for citizens. It stresses that digitization can play a key/pivotal role in improving the various aspects of quality of life, such as health, safety and the efficiency of public services.

On the other hand, countries with lower DESI scores, such as Bulgaria and Romania, also record lower values in terms of the quality-of-life index. This suggests that delays in the adoption of digital solutions and the lack of appropriate technological infrastructure may limit the ability of these states to provide efficient and affordable public services, which is directly reflected in the quality of life of their citizens.

5. Conclusions

The digitalization of public services highlights the essential importance of acquiring up-to-date software within the public administration sector to ensure continuous development. The ongoing development of both governments and the population will positively influence both quality of life and the efficiency of public administrations. The conducted analysis demonstrates a significant interdependency between the level of digitalization,

as measured by the Digital Economy and Society Index (DESI), and the performance of public services in the member states of the European Union.

During the period 2017-2022, the DESI chart revealed a consistent increase in the level of digitalization across most European countries, with Finland, Denmark, the Netherlands, and Sweden occupying the top positions in the ranking, each registering DESI scores of over 65 in 2022. These countries have managed to significantly improve the quality of public services by benefiting from a robust digital infrastructure and a well-qualified workforce in terms of digital skills. Conversely, Romania recorded a DESI score of only 30 in 2022, highlighting significant delays in the adoption of digital solutions and the need for sustained efforts to bridge this gap.

Another crucial aspect highlighted by the analysis of the chart regarding digital competencies in 2021 and 2023 is the significant variation in digital preparedness among populations across different European states. For instance, in 2023, Germany and Luxembourg exhibited high levels of basic digital competencies, enabling them to fully capitalize on the benefits of digitalization. On the other hand, Romania and Portugal showed lower levels of these competencies, which limits their ability to efficiently implement IT solutions in the public sector and ensure widespread access to these services.

These disparities emphasize that the success of public service digitalization depends not only on investments in technology, but also on the ongoing efforts in the education and digital training of citizens. In states where these competencies are well developed, digitalization has led to significant time and resource savings, reduced bureaucracy, and increased accessibility to public services, thereby substantially improving quality of life.

In conclusion, the study underscores the necessity of a strategic and well-planned approach to ensure equitable and efficient digitalization of public services. The DESI index provides a clear picture of digital progress and helps identify areas where additional interventions are required. Governments must continue to invest in the digital competencies of their citizens and develop complex IT infrastructures to ensure that digitalization contributes not only to administrative efficiency but also to a real improvement in quality of life and the reduction of social and economic inequalities. This direction is essential for ensuring sustainable development and maintaining the global competitiveness of national economies in the digital age. Therefore, investments in digitalization can not only improve administrative efficiency, but also have a highly positive impact on the general well-being of the population, highlighting the need for a strategic and well-planned approach to modernizing public services through technology.

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TRENDS AND SIMILARITIES BETWEEN ROMANIA AND THE REPUBLIC OF MOLDOVA REGARDING THE FOREST FUND

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The current state of forest management, aimed at increasing the investment attractiveness of forest resources, intensifying their use, along with the prospects for developing the forestry sector, necessitates a revision of conceptual approaches to public management in the field of forest relations. In this case, the key aspect is defining its content and boundaries of implementation. On these issues, not only is there no consensus within the doctrine of environmental law, and various approaches in forestry legislation can be traced, starting with the terminology used. The terminology is notably diverse, encompassing terms like "state management of forests", "forestry", "forestry complex", "state forest management", etc. This variability does not contribute to a unified understanding of concepts in this field, neither in the doctrinal discussions, nor in legal sources [1].

Management activities cover a complex set of social relations, including not only forestry production, reproduction, conservation and protection of forests, but also the forest complex, which includes forestry and forestry industries for the procurement and processing of wood. As noted in the scientific literature, from the point of view of management, the forest complex is a complex of two interconnected blocks: forest and forestry [3].

State policy in the field of forest relations is shaped by a series of special policies. Among the mechanisms and tasks for implementing state policy in this area are the sustainable use, protection, and regeneration of forests [4]. At the same time, these political, legal and programmatic documents, despite some internal inconsistencies, are nevertheless in close interconnection [2].

This is due to the legal regulation of forest relations and the implementation of state policy, based on the concept of the forest as an ecological system and a natural resource.

On the one hand, state forest policy is an integral part of the policy for the conservation of the biosphere and biodiversity, being regarded as the most important basis for the existence of forests. On the other hand, forest as a

natural resource is involved in the timber industry sectors of the economy, the effective development of which requires ensuring rational forest management, regeneration, and protection of forests. Accordingly, the legislation and the Forestry Code contain such formulations as creating conditions for increasing the efficiency of conservation, protection, reproduction, as well as rational, multi-purpose and sustainable use of forests, while maintaining their ecological functions and biological diversity, improving the efficiency of forest management as the basis for sustainable development of the forest sector economy [10].

In the context of shifts in the general model of environmental management- aimed at not only using, but also restoring forests and other natural resources, preserving and enhancing their resource and ecological potential, and ensuring sustainable environmental management, consistent with economic, environmental, and social sustainability principles- there is a need for a broader understanding of state forest policy. In additionto the use, conservation, protection and regeneration of forests, it is necessary to encompass the development of the forestry sector in the scope of state forest policy [11].

The increasing negative impact of economic activities on the environment requires not only a resource-based, but also an environmentally-oriented approach to the formation of state forest policy. This includes state management in the field of forest communications and the forestry sector, ensuring restoration, afforestation, conservation and forest protection, while taking into account their ecological potential. An important aspect of forest resource protection consists in an understanding of the natural dynamics of forest ecosystems, which are closely linked to the dynamics of species diversity and genetic diversity [12].

The effectiveness of public administration in the field of forest management is determined by the implementation of the following principles that ensure the achievement of the strategic goal of sustainable forest management:

- balancing environmental, economic and social goals;
- ensuring economic responsibility of all stakeholders in forest management, in accordance with the related factors;
- promoting economic incentives for all stakeholders to actively participate in the implementation of sustainable forest management strategies..

It is also necessary to address the challenges associated with implementing public administration functions in the field of forest management. Firstly, to improvement management further, the responsibilities of national

and local bodies should be clearly delineated according to the following principles. At the national level, the following activities are carried out:

- developing policies for the advancement of the forestry sector;
- establishing legal regulations in the forestry sector;
- monitoring and controlling the execution of powers delegated to central authority entities;
- coordinating interregional forest fire protection;
- conducting state forest inventories;
- providing cadastral registration of forest areas;
- monitoring forest management activities, including forest fire, forest pathology, and radiation monitoring;
- organizing forest seed production;
- developing and maintaining a national forest register;
- optimizing forest research and education systems; fulfilling international obligations related to forests;
- organizing interregional cooperation in the event of forest-related emergency situations.

Secondly, within the framework of the state forest policy, it is necessary to implement a comprehensive set of measures to enhance the functional structure of forest management. This should include the establishment of a closed management cycle (comprising analysis, planning, monitoring the implementation of forest plans, and making the necessary adjustments), carried out at various levels of management (national and local). Such measures should ensure the assessment of forest management practices in the constituent entities of Romania and the Republic of Moldova for compliance with internationally recognized principles and criteria. Achieving this goal is only possible with the adoption of appropriate management innovations.

It would also be advisable to revert to the previous system of forest management. The primary object of forest management (including forest taxation and the design of measures for forest conservation, protection and regeneration) should be either a forest district (as a territorial unit for forest management and maintenance of the state forest register) or a forest plot. This approach would ensure that forest management materials are used to obtain accurate and objective assessments of operational reserves of forest stands. These assessments would inform planning for forest resource development, including the implementation of priority investment projects and determining timber allocation on leased forest plots [5].

Outside of forest areas, regions with a high natural fire hazard, unfavorable forest pathological conditions, or intensive silvicultural production

require qualified forest management solutions. These measures should address forest protection, regeneration, and silvicultural maintenance.. Forest management should be carried out exclusivelt by government organizations. In cases where forestry is conducted on privately owned plots, all activities must be strictly supervised to ensure compliance with national standards.

Integrating internationally accepted criteria and indicators into forest planning will provide an opportunity to evaluate forestry activities based on global quality standards. However, challenges remain regarding the compatibility and comparability of data between the national forest register and European standards. Addressing these issues requires improved legislative regulation of forest management, cadastral activities, and the registration of forest areas. The result of such systematic efforts should be the development of regional strategic documents for forest management. These documents should transform existing forest plans into regional strategies for the development of the forestry sector and include quantitative indicators to measure the effectiveness of forestry activities [13].

To ensure sustainable forest management, state policies must clarify forest cutting parameters by taking into account the zoning of territories according to their ecological significance and forest biodiversity. Special attention should be paid to suburban nature conservation and recreational forests. The main objectives of forest management should include the sustainable utilization of all available forest resources while transitioning to planned timber removal practices(calculated cutting area), such as clear and selective felling, combined with robust reforestation efforts. Forest plans for the constituent entities of Romania and the Republic of Moldova should prioritize the optimal use of forest resources within the operating areas of existing processing enterprises. When planning for new processing capacities, the availability of existing forest resources, along with methods for their development and regeneration, must also be taken into account [8].

For effective forest planning and management, it is essential to create a unified information system that combines data from periodic statistical and budget reporting, the state forest register, state forest inventory, forest management activities, forest fire and pathological monitoring, and forest management monitoring [6].

In Romania, such a system already partially exists. The National Institute of Statistics manages a comprehensive database accessible at http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table. This database is regularly updated and provides detailed information on: the forest fund's surface by land categories and forest species, macro-regions,

development regions and counties; land areas where artificial regenerations were carried out, categorized by type of artificial regeneration, macro-regions, development regions and counties; areas within the forest fund subject to felling, by category of felling; the volume of harvested wood by species, macro-regions, development regions and counties; the turnover of forestry units across macro-regions, development regions and counties; the volume of wood exploited by economic operators engaged in forest exploitation, categorized by component elements; the volume of round wood exploited, categorized by varieties and groups of species [7].

At the level of the Republic of Moldova, the National Bureau of Statistics manages and operates the Statistical Data Bank, accessible at https://statbank.statistica.md/PxWeb/pxweb/ro/40%20Statistica%20economica/?rxid=b2ff27d7-0b96-43c9-934b-42e1a2a9a774. This database provides information on: the land and forestry fund, categorized by land type; the main indicators of the forest fund; the performance of forest culture activities by type and year; the performance of forest care activities by type and year; the land fund categorized by its use [8, 9].

1. Analysis of information related to Romania's forest fund

The forest statistical indicators included in forestry statistical research reflect specific characteristics of the Romanian forest resource management system. These indicators are aligned with those in the European Union's statistical system, with the main purpose of achieving sustainable and uniform forest management. This alignment is in accordance with the provisions of forest management and forestry regime regulations, applying to both publicly owned state forest funds and privately owned forests. The overarching objective is to enhance the contribution of forests to improving environmental conditions while ensuring the national economy's needs for timber, other forest products, and specific forestry services are met.

In accordance with the "Methodology for conducting statistical research in forestry", the main objectives of statistical research at the national level are to obtain statistical data on the following:

– the surface and structure of the forest fund and the inventory of the main categories of forest vegetation;

– the quantity and value of specific forestry products sold (wood and non-wood products);

– intermediate consumption and other expenses in the field of forestry;

– the intensity of wood harvesting from forests;

–actions related to the regeneration, including efforts to restore existing forests and initiatives aimed at increasing the area of forests and other lands with forest vegetation.

Figure 1 graphically represents the evolution of the area of the forest fund of Romania, 1990-2023.

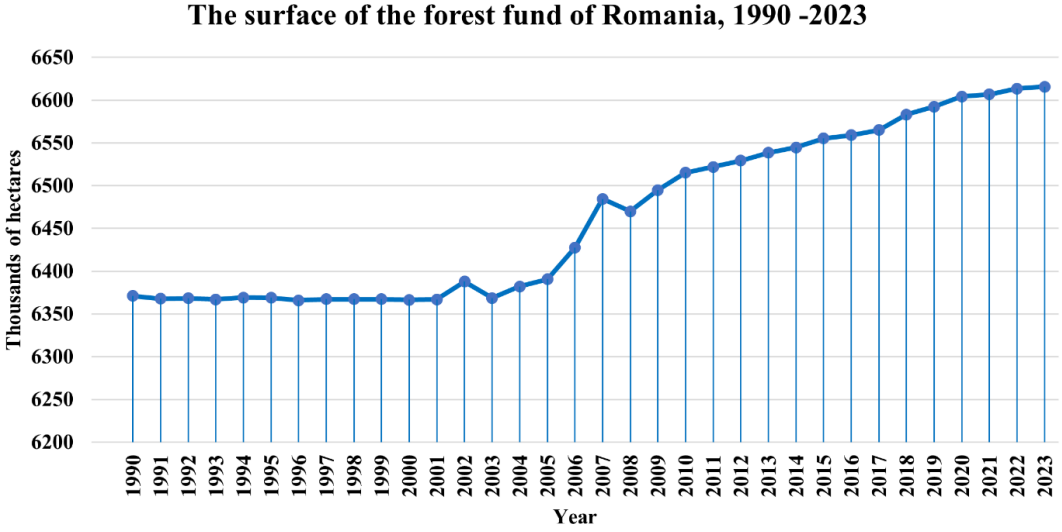


Figure 1. The evolution of the area of the forest fund of Romania, 1990-2023.

From the analysis of the information regarding the area of Romania's forest fund from 1990 to 2023, it is obvious that this area had a significant increase during this period of approximately 245 thousand hectares, which represents a substantial growth. While in the time period 1990-2004, the forest fund area remained relatively constant, starting from 2005, a steady increase can be observed, of approximately 20 thousand hectares per year.

Figure 2 illustrates the land area within the forest fund affected by felling, categorized by the types of felling, for the period 1990-2023 in Romania.

A detailed analysis of the felling categories is of significant importance if we discuss everything that involves forest management practices. In Romania, the main interventions in forest areas are clearly classified, grouped as it follows: regeneration cuttings; replacement cuttings-restoration of poorly productive and degraded stands; conservation cuttings; forest hygiene and cleaning operations;care cuts in young forests; accidental cuttings; cuttings for the transformation of wooded pastures.

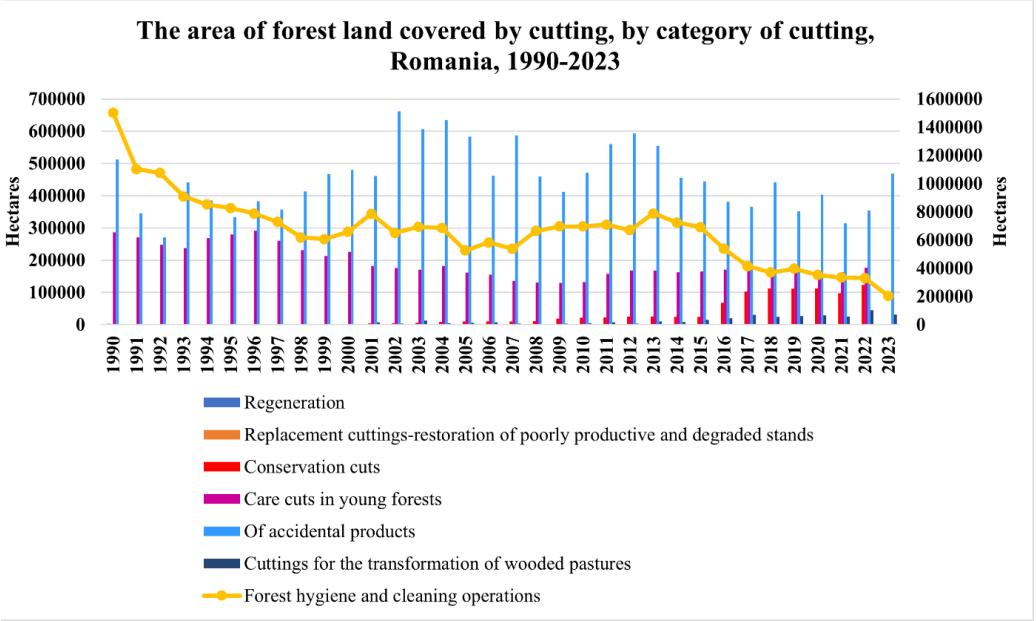


Figure 2. The area of forest land covered by cutting, by category of cutting, Romania, 1990-2023.

For the analyzed period 1990-2023, forest hygiene and cleaning operations represent the most significant type of work, covering 1502188 hectares in 1990 and decreasing to 204 824 hectares in 2023. Although the trend is a decreasing one over the years, it remains an integral part of forest management, with its application tailored to the type and age of the forest.

The cutting of accidental products averages 453 606 hectares per year. These cuttings address damages caused by destabilizing biotic and abiotic factors or result from legally approved deforestation. Another category, care cuts in young forests, averages 193,224 hectares, ranging from 286,902 hectares in 1990 to 168,180 hectares in 2023.

For cuttings aimed at the transformation of wooded pastures for the period 1990-2000 there is no information available. However, in 2001, these works were carried out on7712 hectares, significantly increasing to 31874 hectares by 2023.

Another monitored indicator since 2001 is conservation cuts, with an area of 5,248 hectares in 2001, and 117,035 hectares in 2023- an increase of over 220%.

2. Analysis of information related to Republic of Moldova's forest fund

According to the information taken from the Statistical Data Bank of the National Bureau of Statistics of the Republic of Moldova, the area of land within the forestry fund and designated for environmental protection increased from 354.6 thousand hectares in 2010 to 456.3 thousand hectares in 2024, which represents a growth of 101 thousand hectares over the analyzed period.

Figure 3 illustrates the evolution of the forestry fund and land intended for environmental protection in the Republic of Moldova from 2001 to 2024, measured in thousands of hectares.

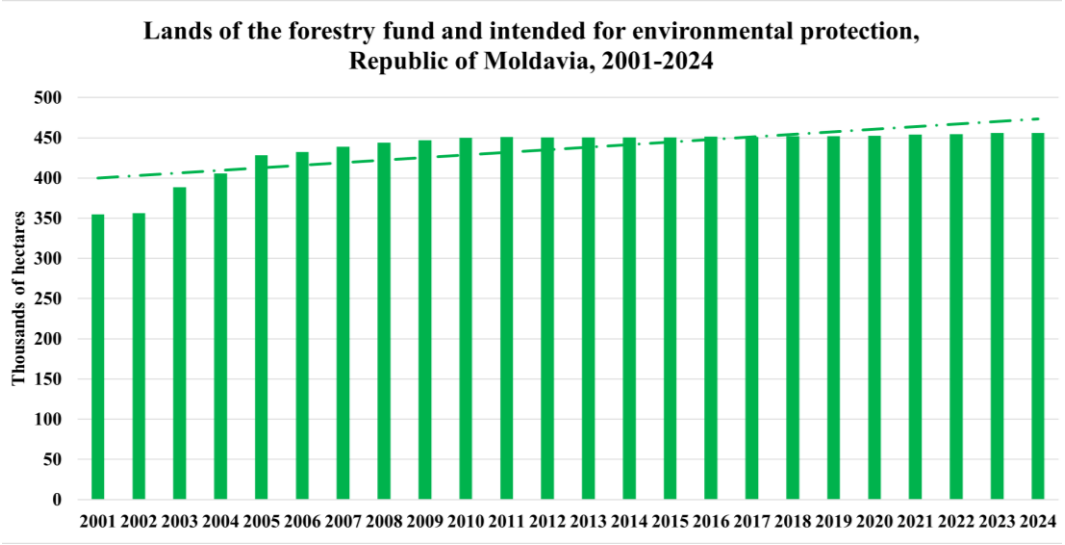


Figure 3. Lands of the forestry fund and intended for environmental protection, Republic of Moldavia, 2001-2024.

The annual average area of lands within the forestry fund and designated for environmental protection in the Republic of Moldova, between 2001-2024, was 436.6 thousand hectares, with a series of insignificant fluctuations. For example, in 2002, the area was 356.2 thousand hectares, and increased up to 428.5 thousand hectares in 2006. In such analyses, the upward trend in forest area expansion is the most significant indicator of the evolution of forest management in a country.

In the period 2010-2022, forest care works in the Republic of Moldova ranged from 18,178 hectares in 2010 to 22,217 hectares in 2022, with an average of 23,587 hectares/year.

The category of forest care works encompasses: cuttings for regeneration and conservation, reconstruction and ecological regeneration, conservation,

caring and management operations, clearances and cleanings, hygiene cuts and various cuts.

Figure 4 illustrates forest care works by type in the Republic of Moldova for the period 2010-2022.

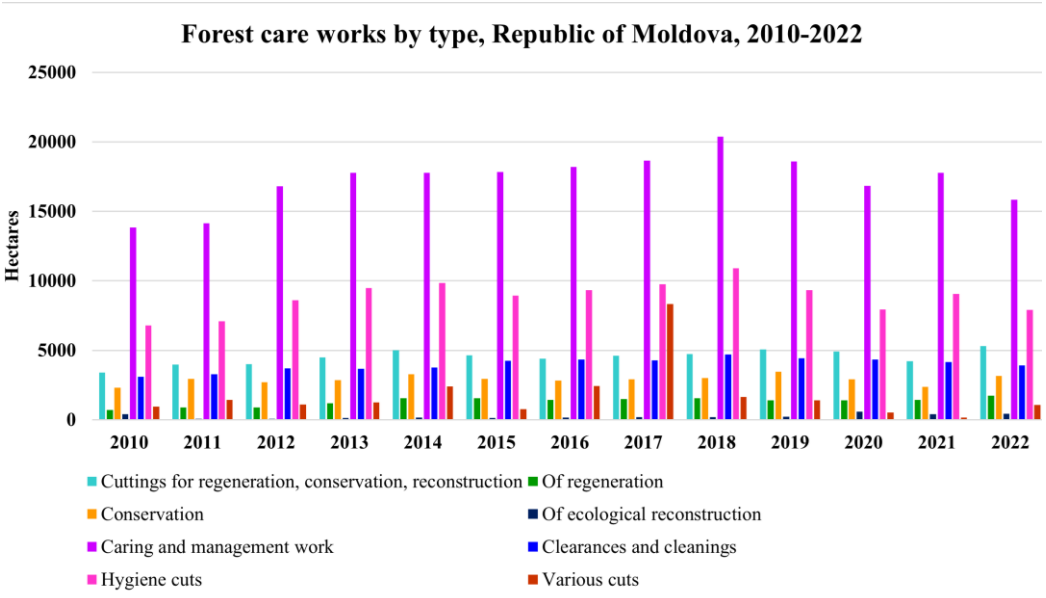


Figure 4. Forest care works by type, Republic of Moldova, 2010-2022

The largest category of care works in the Republic of Moldova during the period 2010-2022, , was caring and management work, ranging from 13825 hectares in 2010 to a peak of 20377 hectares in 2018 and 15844 hectares in 2022.

Hygiene cuts represented the second-largest category of forestry care works, performed in the forestry sector in the Republic of Moldova from 2010 to 2022. In 2010, hygiene cuts were carried out over an area of 6785 hectares increasing to 10915 hectares in 2018 before declining to 7912 hectares in 2022.

Cuttings for regeneration, conservation, and reconstruction were also significant forestry activities during the analyzed period. On average, these works were performed on an area of 4522 hectares annually, ranging from 3405 hectares in 2010 to 5304 hectares in 2022.

Ecological reconstruction works, however, were conducted on the smallest areas, averaging 245 hectares per year. They varied from 390 hectares in 2010 to 81 hectares in 2011, to 600 hectares in 2020 and to only 245 hectares in 2022.

Conclusion

An important aspect of forest management is forest certification. The main objective in this area is the development for a national system for voluntary forest certification, ensuring its harmonization with other systems and securing recognition and accreditation at the international level. It is essential that the “certificate” be universally recognized as a document attesting the origin of wood and wood-based products. This should be applied to all exported wood and products made from it, as well as wood purchased to adequately meet government requirements.

The priority areas for the development of voluntary forest certification should be: certification of sustainable forest management and compliance with the legality of the origin of finished products. These efforts should leverage electronic databases, cartography based on satellite imagery, and monitoring of forest use. Additionally, it is important to focus on training domestic experts and auditors in the field of forest certification, pursuing international certification as part of large-scale investment projects in the field of forest development, and promoting the procurement of certified forest products for both public and private needs.

When implementing forest management, federal executive authorities exercise their powers in the normative legal regulation of forest relations, including the multi-purpose use of forests. This area includes various types of forest activities, such as timber harvesting, the collection of non-timber forest resources, and other forms of forest utilization conducted as part of entrepreneurial activity.

One of the main problems of increasing the investment appeal of forest area utilization is the need for legislative support within the Forest Code and related by-laws to establish the principle of multi-purpose use. Currently, existingforestry legislation does not provide for the possibility of multi-purpose forest management.

Taking into account the above-mentioned facts, there should be introduced a series of amendments that include:

- establishing the possibility of shared use of a single forest plot by multiple forest users. This would include allowing the conclusion of several lease agreements for one forest plot, with the exception of cases where simultaneous multi-purpose forest use is either impractical or infringes upon the rights of other forest users;

- defining a list of prohibited multi-purpose forest uses, specifying the types of forest activities that cannot be carried out simultaneously within one forest area ;

- setting basic requirements for forest users operating simultaneously on a single forest plot. This includes establishing regulations for the registration of rights to forest plots, obtaining permits, and the joint use of forest areas in accordance with the planned types of forest utilization.

These theoretical conclusions and practical proposals aim to improve the efficiency of public administration in the field of forestry development, forest relations, and the rational use, reproduction, conservation and protection of forests. They also seek to enhance the investment attractiveness of forest resources, while preserving their environmental and resource potential.

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Current Approaches in Ex Situ Animal Conservations

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Introduction

Our planet is currently facing an unprecedented biodiversity crisis. The delicate balance of life on Earth is being threatened as countless species teeter on the brink of extinction, their very existence hanging by a thread. Habitat destruction, climate change, poaching, and disease are just a few of the relentless pressures pushing wildlife populations toward a point of no return. In the face of this dire situation, ex situ conservation, the practice of protecting endangered species outside their natural habitats, has emerged as a crucial strategy for safeguarding our planet's irreplaceable biodiversity. Zoos, once viewed primarily as entertainment venues, have undergone a profound transformation, evolving into modern-day arks that play a vital role in this global conservation effort. They now serve as sanctuaries for vulnerable species, centers for scientific research, and platforms for public education and advocacy. This work will delve into the multifaceted ways in which zoos contribute to the preservation of our planet's natural heritage, examining their breeding programs, research initiatives, educational outreach, and the challenges they face in fulfilling their critical mission.

The alarming rate at which species are disappearing from our planet due to a myriad of interconnected factors, such as habitat loss, climate change, and unsustainable human activities, has necessitated a comprehensive approach to conservation efforts (Cowie et al., 2022).

One such approach, known as ex situ conservation, has gained significant traction in recent years as a crucial complement to in situ conservation strategies.

Ex situ conservation, literally meaning "off-site conservation," encompasses a range of strategies aimed at protecting species outside their natural habitats (Ex situ conservation, 2003). This approach becomes especially crucial when threats within a species' natural environment are so severe or widespread that in situ conservation alone is insufficient to ensure their survival. Habitat loss, driven by deforestation, agriculture expansion, and

urbanization, remains the single greatest threat to biodiversity worldwide. As natural habitats shrink and fragment, species lose the resources they need to survive, and their populations become increasingly vulnerable to extinction. Climate change only exacerbates these challenges, altering temperature and rainfall patterns, shifting species distributions, and increasing the frequency and intensity of extreme weather events. Additionally, poaching and illegal wildlife trade further decimate populations, particularly of charismatic megafauna targeted for their valuable body parts or captured for the pet trade.

In the face of these mounting threats, ex situ conservation provides a critical safety net for endangered species. Zoos, aquariums, botanical gardens, and seed banks all play vital roles in this effort, providing safe havens where species can be protected from immediate threats, their populations carefully managed, and their genetic diversity preserved. These institutions serve as essential lifeboats, offering a glimmer of hope for species that might otherwise vanish from the face of the Earth.

Many institutions that are members of the European Association of Zoos and Aquaria (EAZA) are actively engaged in ex situ conservation initiatives, which often integrate with in situ conservation strategies to create a comprehensive approach to species protection (Spiezio et al., 2022).

The European Association of Zoos and Aquaria (EAZA) plays a pivotal role in promoting conservation and education efforts worldwide. Zoos and aquariums have the potential to significantly influence environmental awareness and wildlife protection, with over 700 million people visiting these institutions annually across the globe (Gusset & Dick, 2010). As wild biodiversity continues to decline, zoos are increasingly being called upon to serve as refuges and contribute to ex-situ breeding, animal welfare research, disease monitoring, and population management (Lyles & Wharton, 2013).

In recent years, zoos have embraced their role as leaders in conservation education, recognizing their unique position to engage the public with biodiversity-related issues (Ogden & Heimlich, 2009). Coordinated public engagement initiatives, such as global biodiversity education campaigns, have been shown to amplify the aggregate impact of educational experiences at zoos and aquariums (Moss et al., 2017). The European Association of Zoos and Aquaria plays a crucial role in facilitating these efforts by providing a platform for collaboration, knowledge sharing, and the development of best practices in conservation education.

Historically, zoo and aquarium education has focused primarily on increasing visitors' cognitive knowledge, with less emphasis on changing attitudes and behaviors (Ogden & Heimlich, 2009). However, this trend is

shifting, as institutions recognize the importance of fostering long-term behavioral changes and promoting conservation as a top human priority (Ogden & Heimlich, 2009). The European Association of Zoos and Aquaria is at the forefront of these efforts, working to ensure that zoos and aquariums across Europe leverage their unique position to drive meaningful change in environmental stewardship and wildlife protection.

Ex situ conservation, which involves the management and protection of species outside their natural habitats, has been particularly valuable in safeguarding the genetic diversity and demographic stability of endangered species (Pacheco, 2019).

As wild biodiversity continues to decline, zoos are increasingly called upon to serve as refuges, playing an important role in developing techniques for ex-situ breeding, animal welfare, global wildlife disease monitoring and response, and intensive population management – fields of science that are increasingly important for biodiversity management (Lyles & Wharton, 2013), (Patrick & Tunnicliffe, 2012).

While the conservation work undertaken by zoos may not always involve the preservation of large numbers of mammalian species, the sustainability of smaller, localized populations is crucial for safeguarding these species against extinction and providing the possibility for future reintroduction into the wild (Patrick & Tunnicliffe, 2012).

Through these ex situ conservation initiatives, zoos and other specialized facilities not only contribute to the preservation of endangered species but also serve as valuable platforms for conservation education, research, and advocacy, ultimately working toward the broader goal of biodiversity conservation.

Captive Breeding Programs

Captive breeding programs play a crucial role in ex situ conservation efforts by maintaining genetically diverse populations of threatened species in controlled environments. These programs are essential in safeguarding endangered species from extinction by preserving their genetic diversity and demographic stability, both of which are crucial for their long-term survival and potential reintroduction into the wild.

Successful captive breeding programs require careful consideration of various factors, such as habitat requirements, social structures, and reproductive behaviors of the target species. However, the small population sizes in many captive breeding programs can also present challenges, including inbreeding, loss of genetic diversity, and undesirable adaptation to the captive environment (Ballou, 1997). Addressing these issues through intensive

population management and genetic modeling is essential to ensure the long-term viability of captive populations.

Ex situ conservation efforts, such as captive breeding programs, are most effective when integrated with in situ conservation strategies aimed at protecting and restoring species' natural habitats. Close collaboration between zoos, research institutions, and local communities is essential, as they can work together on a range of initiatives, including habitat restoration, anti-poaching measures, and the carefully planned reintroduction of captive-bred individuals into the wild.

Captive breeding programs are essential for ex situ conservation, as they maintain genetically diverse populations of endangered species in controlled environments. The recovery of the California condor and the increasing wild population of the giant panda are notable success stories, showcasing the transformative power of ex situ conservation when implemented with meticulous planning, scientific expertise, and a strong commitment to preserving biodiversity. However, to ensure the long-term sustainability of these captive breeding programs, it is critical to address the challenges associated with small population sizes, such as the risks of inbreeding and loss of genetic diversity.

Challenges and Ethical Considerations Associated with Captive Breeding

While captive breeding programs have demonstrated their efficacy in conserving endangered species, they also present significant challenges and ethical considerations. Ensuring the genetic diversity and overall health of captive populations is complex, requiring careful management to prevent inbreeding and loss of genetic fitness. Additionally, ensuring the well-being and natural behaviors of captive animals can be particularly challenging, as the controlled environment may not fully replicate their natural habitats and social structures. Additionally, the reintroduction of captive-bred individuals into the wild also poses significant logistical and ecological challenges. Careful planning and management are essential to mitigate the risks of disease transmission, competition with wild populations, and disruption of established ecosystem dynamics. Overcoming these challenges is crucial to ensure the long-term success and sustainability of ex situ conservation efforts.

The Role of Zoos and Aquariums in Ex Situ Conservation

A. Zoos as Conservation Hubs

Zoos and aquariums have become increasingly important hubs for ex situ conservation , serving as sanctuaries for endangered species and centers for research, breeding, and reintroduction programs. These institutions play a crucial role in developing specialized techniques for ex-situ breeding, animal welfare, disease monitoring, and population management, which are essential for effective biodiversity conservation. By leveraging their expertise and resources, zoos and aquariums contribute significantly to the preservation of threatened species and the restoration of their populations in the wild.

Public aquariums have emerged as crucial players in the conservation and rehabilitation of endangered aquatic species amidst the pressing global biodiversity crisis (Shumway, 2001). These institutions have launched a diverse array of initiatives to address the diverse challenges of aquatic conservation, from captive breeding programs to in-situ interventions (Takami, 2019;Silva et al., 2019).

One of the primary roles of aquariums in conservation is their ability to raise public awareness and foster a deeper understanding of aquatic ecosystems and their imperiled inhabitants (Patrick & Tunnicliffe, 2012). Through engaging educational programs and interactive exhibits, aquariums inspire visitors to appreciate the intrinsic value of marine and freshwater life and become active stewards of the natural world.

In addition to public engagement, aquariums also serve as hubs for cutting-edge research and collaborative conservation efforts. Many aquariums have dedicated research facilities and teams of scientists who work to unravel the complexities of aquatic species biology, behavior, and ecology, generating crucial data to inform conservation strategies. These research initiatives often extend beyond the aquarium's walls, with scientists frequently collaborating with field biologists, government agencies, and non-profit organizations to design and implement targeted conservation interventions.

For example, many aquariums around the world host captive breeding programs for endangered species, such as the critically endangered Panamanian golden frog. By establishing self-sustaining populations in controlled environments, aquariums help safeguard against extinction and may eventually reintroduce these species to their native habitats when conditions improve. Additionally, aquariums often provide temporary refuge and rehabilitation for injured or stranded marine animals, such as sea turtles and marine mammals, before eventually releasing them back into the wild.

Aquariums also play a vital role in addressing the complex issue of the marine ornamental fish trade. Recognizing the potential environmental impacts of this industry, many aquariums have spearheaded initiatives to promote sustainable collection and trade practices.

By working closely with local communities, fishermen, and exporters, aquariums help develop best practices, including implementing handling protocols that reduce stress and mortality, and supporting the creation of marine protected areas to prevent overharvesting.

Furthermore, aquariums are at the forefront of developing innovative technologies and techniques to support the conservation of aquatic habitats. For example, the use of environmental DNA (eDNA) allows researchers to monitor elusive species, while underwater cameras and acoustics are deployed to study animal behavior. Aquariums are continually pushing the boundaries of what is possible in the realm of aquatic conservation.(Taylor, 1995)

By fostering scientific advancement through cutting-edge research and innovative technologies, aquariums have expanded our understanding of aquatic species and ecosystems. By nurturing public engagement through immersive educational programs and interactive exhibits, aquariums have inspired millions of visitors to become active stewards of the natural world. Furthermore, by facilitating collaborative conservation efforts with field biologists, government agencies, and non-profit organizations, aquariums have spearheaded targeted interventions that address the pressing challenges facing aquatic ecosystems. In these ways, aquariums have become indispensable partners in the global effort to protect and restore aquatic environments and the myriad species that call them home.

Modern zoos and aquariums have evolved far beyond their historical roots as mere entertainment venues, assuming a significant role in the conservation of endangered species and the protection of natural habitats.(Patrick & Tunnicliffe, 2012) Wildlife conservation research at AZA-accredited public aquariums in North America increasingly focuses on in-situ field studies and collaborative efforts with external partners.(Larson, 2017)

AZA-accredited aquariums are not only conducting important conservation research, but also actively implementing conservation interventions(Ripple et al., 2021). Within the public aquarium community, there is a growing recognition that these institutions must go beyond simply educating the public and take tangible action in safeguarding aquatic ecosystems (Mann-Lang et al., 2020).

Many aquariums are now dedicating significant resources to field-based conservation projects, such as population monitoring, habitat restoration, and

the reintroduction of endangered species. These efforts are further bolstered by aquarium's ability to serve as hubs for information-sharing, data-aggregation, and the coordination of conservation programs across multiple institutions (Hall & Warmolts, 2003).

By leveraging their unique position as public institutions with broad public reach, aquariums are poised to play a pivotal role in inspiring and mobilizing the next generation of environmental stewards. Through immersive educational programs, interactive exhibits, and collaborative partnerships, aquariums empower visitors to become active participants in the conservation of aquatic life and habitats.

Zoos and Conservation Education

Zoos and aquariums also serve as invaluable platforms for conservation education, raising awareness and fostering a deeper understanding of the importance of biodiversity and the threats facing various species. By engaging visitors, especially younger generations, these institutions can inspire and empower individuals to become active participants in conservation efforts.

Collaboration and Partnerships for Holistic Conservation Approaches

Ex situ conservation initiatives led by zoos and aquariums are most effective when integrated with in situ conservation strategies. These institutions often collaborate with research organizations, government agencies, and local communities to develop comprehensive conservation programs that address the multifaceted challenges facing endangered species and their habitats.

Balancing Conservation and Economic Viability

One of the major challenges facing zoos and aquariums is the need to balance their economic viability, while also playing a significant role in biodiversity conservation. This requires sustained public support and collaboration with other conservation organizations, research institutions, and relevant stakeholders (Catibog-Sinha, 2008).

Preserving Genetic Diversity and Restoring Wild Populations

Captive Breeding Programs as a Cornerstone of Ex Situ Conservation

Captive breeding programs are a cornerstone of ex situ conservation efforts, as they (Spiezio et al., 2022) (Lyles & Wharton, 2013), (Catibog-Sinha, 2008) maintain genetically diverse populations of endangered species, while also serving as a potential source for future reintroduction into the wild. These

programs aim to preserve populations of species threatened with extinction, increase or maintain demographically stable numbers of individuals, uphold genetic diversity, and ultimately reintroduce zoo-bred individuals into the wild to either establish new populations or supplement existing ones (Spiezio et al., 2022).

To ensure the long-term viability of captive populations, sophisticated genetic modeling and intensive population management techniques are employed. These strategies help maintain genetic diversity, minimize inbreeding, and prevent the loss of fitness that can occur in small, isolated populations (Lyles & Wharton, 2013).

Collaborative Approaches for Integrated and Holistic Conservation Strategies

Ex situ conservation is most effective when integrated with complementary in situ strategies through collaborative efforts that bring together diverse stakeholders and expertise. By fostering partnerships between zoos, research institutions, government agencies, and local communities, a more holistic and comprehensive conservation framework can be established. This integrated approach enables the coordination of various initiatives such as habitat restoration, anti-poaching measures, education and awareness programs, and the carefully planned reintroduction of captive-bred animals into the wild. By leveraging the strengths and resources of multiple organizations and communities, synergistic conservation outcomes can be achieved, better addressing the complex challenges facing endangered species and their habitats.

Reintroducing captive-bred animals into their natural habitats is a complex and intricate process necessitating meticulous planning and consideration. Successful captive breeding programs demand careful attention to various factors, including the target species' habitat needs, social dynamics, and reproductive behaviors. Additionally, the small population sizes common in such programs can give rise to challenges regarding inbreeding, loss of genetic diversity, and undesirable adaptation to the controlled captive environment.

To address these issues, population viability analyses and comprehensive, economic, cost-benefit evaluations should be conducted to ensure that reintroduction is the most feasible and efficient recovery strategy for the available resources (Rohr et al., 2018). Artificial selection for tolerance to stressors in the target environment may also be beneficial for captive-bred animals before their release (Rohr et al., 2018).

Wildlife Sanctuaries and Rescues

Wildlife sanctuaries and rescues are crucial for safeguarding and conserving animals, particularly those that are endangered, threatened, or have been injured. They provide secure and nurturing environments where animals can live and flourish, shielded from the dangers they would encounter in their natural habitats.

Wildlife sanctuaries serve as safe havens for rescued and rehabilitated animals. **These animals often arrive at sanctuaries with a variety of needs, such as:**

1. **Rehabilitation from injuries:** Animals that have been injured, whether due to human activities like road accidents, or due to natural causes, require specialized care and treatment. Sanctuaries provide veterinary care, medication, and physical therapy to help these animals recover.

2. **Orphaned or abandoned animals:** Young animals that have lost their parents or have been abandoned need a safe place to grow and develop. Sanctuaries provide the necessary care, nutrition, and social interaction for these animals to thrive.

3. **Confiscated animals:** Wildlife trade is a significant threat to many species. Sanctuaries often become homes for animals confiscated from illegal trade, providing them with a permanent and safe haven.

Numerous wildlife sanctuary projects worldwide demonstrate the positive impact these institutions have on animal conservation:

✓ The Wildlife SOS Elephant Conservation and Care Center in India: This sanctuary provides a safe haven for rescued elephants, many of which have suffered abuse and exploitation in captivity. The center focuses on providing veterinary care, a natural environment, and opportunities for socialization.

✓ The Orangutan Rehabilitation Center in Borneo: This sanctuary is dedicated to the rescue, rehabilitation, and release of orphaned and displaced orangutans. The center provides a forest habitat where orangutans can learn essential survival skills before being reintroduced to the wild.

✓ The Cheetah Conservation Fund in Namibia: This organization works to protect cheetahs in the wild and manages a sanctuary for orphaned, injured, and confiscated cheetahs. The sanctuary plays a crucial role in cheetah conservation through breeding programs and reintroduction initiatives.

Wildlife sanctuaries play a vital role in educating the public about wildlife conservation:

1. Raising awareness: Sanctuaries provide platforms to educate visitors about the threats facing wildlife, including habitat loss, poaching, and the illegal pet trade.

2. Promoting responsible behavior: By showcasing the importance of conservation, sanctuaries encourage visitors to adopt responsible behaviors, such as reducing their ecological footprint and supporting conservation efforts.

3. Inspiring future generations: Educational programs at sanctuaries can inspire younger generations to become advocates for wildlife conservation and pursue careers in related fields.

By combining animal care, research, education, and advocacy, wildlife sanctuaries and rescues contribute significantly to the preservation of biodiversity and the well-being of animals worldwide.

Collaboration between zoos, research institutions, and conservation organizations is crucial for the success of ex situ animal conservation efforts. Successful conservation partnerships have demonstrated the positive impact of interdisciplinary approaches:

Examples of Successful Conservation Partnerships:

✓ The Frozen Ark Project: A collaboration between zoos, universities, and conservation groups to collect and store genetic material from endangered species, ensuring the preservation of genetic diversity for future reintroduction efforts.

✓ The Sumatran Rhino Sanctuary: A joint initiative between the Indonesian government, international conservation organizations, and research institutions to breed and reintroduce Sumatran rhinos, a critically endangered species, back into the wild.

✓ The Global Tiger Initiative: A worldwide partnership between governments, NGOs, and scientific communities to double the number of wild tigers by 2022 through habitat restoration, anti-poaching efforts, and captive breeding programs.

✓ The impact of global initiatives on ex situ conservation has been substantial. Coordinated efforts by organizations like the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the International Union for Conservation of Nature (IUCN) have played a crucial role in shaping ex situ conservation practices worldwide.

These initiatives have established comprehensive standards, guidelines, and policies that guide the management of captive animal populations. These entail ensuring the responsible implementation of breeding programs and facilitating the successful reintroduction of species into their natural habitats.

By providing a framework for international cooperation and best practices, these global initiatives have significantly enhanced the effectiveness and sustainability of ex situ conservation efforts, ultimately contributing to the preservation of endangered species and the restoration of biodiversity.

The Impact of Global Initiatives on Ex Situ Conservation Efforts

Global initiatives have had a significant impact on ex situ conservation efforts. These international programs and collaborations aim to protect endangered species by maintaining populations in managed settings outside their natural habitats, such as in zoos, aquariums, and botanical gardens. The increased focus on cross-border cooperation and coordination has led to more effective and streamlined conservation initiatives.

Advancements in technology, data sharing, and knowledge exchange have also bolstered the success of ex situ conservation. As a result, many endangered species have been successfully bred and reintroduced into the wild, helping to ensure their long-term survival. For example, the California Condor (*Gymnogyps californianus*) and the Black-footed Ferret (*Mustela nigripes*) have been successfully bred in captivity and reintroduced into the wild, helping to ensure their long-term survival (Grantham et al., 2020; Wisely et al., 2015). Other examples include the red wolf (*Canis rufus*) and the Mexican gray wolf (*Canis lupus baileyi*), which have also been bred in captivity and reintroduced into the wild (Phillips et al., 2003; Fredrickson et al., 2007). Additionally, global initiatives have facilitated the development of techniques for ex situ breeding, animal welfare, and intensive population management, which are crucial for biodiversity conservation (Balmford et al., 1996; Conde et al., 2019). However, challenges remain, as zoos and other ex situ facilities face increasing government regulation, declining financial support, and pressure from animal rights advocates. Nevertheless, as wild biodiversity continues to decline, their role as refuges and contributors to conservation efforts has become increasingly important (Conde et al., 2011; Conde et al., 2013).

Conclusion

Ex situ conservation strategies, particularly those led by zoos and aquariums, play a crucial role in preserving endangered species and restoring their populations in the wild. These institutions act as hubs for research, breeding, and reintroduction programs, while also contributing to conservation education and fostering collaborative partnerships for holistic conservation approaches. However, the path to successful ex situ conservation is not without

its challenges, requiring careful planning, genetic management, and coordination with in situ efforts.

To maintain their position at the forefront of global biodiversity conservation, zoos and aquariums must continue evolving and adapting their practices. Ongoing research, innovative approaches, and a commitment to collaboration are essential for addressing the complex and multifaceted threats facing the world's endangered species.

The role of zoos in the future of conservation is both vital and evolving. By collaborating with in situ conservation efforts, zoos can contribute to a comprehensive approach to protecting biodiversity (Zoological Parks and the Conservation of Biological Diversity: Linking ex situ and in situ Conservation Efforts, n.d). The concept of reintroduction programs, where captive-bred animals are released into their natural habitats, highlights the significant impact zoos can have on the recovery of endangered species. These programs not only help restore wild populations, but also provide valuable insights into the species' biology and behavior, which can inform ongoing conservation strategies. Additionally, zoos serve as important centers for research, education, and public engagement, all of which are crucial for garnering support and resources for broader conservation efforts. As threats to our planet's wildlife, such as habitat destruction, climate change, and poaching, continue to escalate, the contributions of zoos to ex situ conservation will only become more essential in safeguarding the long-term survival of vulnerable species. Zoos play a vital role in preserving genetic diversity, advancing scientific understanding, and inspiring the public to join the fight to protect our planet's irreplaceable biodiversity.

Similarly, wildlife sanctuaries and rescue centers play a critical role in the protection and conservation of animals, especially those that are endangered, threatened, or injured. They provide safe havens where animals can live and thrive, free from the threats they face in the wild.

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The conservation of biodiversity in Europe

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Abstract

Nature is important for our mental and physical well-being, as well as for society's ability to cope with global challenges, health threats and natural disasters (EU 2030 Biodiversity Strategy). Man dominates the natural world irresponsibly, considering nature to be his rightful good, exploiting its resources irrationally, unsustainably, and distributing them unequally without suffering any consequences. But man needs to understand that we depend on nature much more than nature depends on us. Our future fundamentally depends on biodiversity. Our life needs nature. The designation of protected areas is the most important tool for the protection and conservation of biodiversity. Although the continent of Europe occupies only 2% of the Earth's surface, it has established the largest number of protected areas in the world (over 130000 sites), which represents 23% of the terrestrial territory and continental waters. Through this paper, we aim to present the situation of protected areas at the level of Europe, the EU and Romania.

Keywords: *Biodiversity, Protected areas, Europe, UE.*

1. Introduction

From stunning rainforests to the smallest oases and urban gardens, from the blue whale to microscopic fungi, biodiversity exemplifies the remarkable diversity of life forms on Earth. We, as human beings, stand in the midst of this natural order and are deeply interconnected with it: it provides us with the food we eat, purifies the water we drink, and provides us with the vital oxygen we breathe.

Humanity is currently facing two major crises: climate change, which is becoming more and more evident, and the loss of biodiversity. The biodiversity crisis and the climate crisis are intrinsically linked.

What is biodiversity?

The term biodiversity was coined by biologists in the 1980s as shorthand for biological diversity, and usually refers to the variety of life on Earth as a whole.

Biodiversity is a rich concept that admits a wide range of possible definitions. In its broadest sense, it has been defined as the variety of life forms at all levels of organization of an ecosystem, from molecules to individuals to species (DeLong, 1996).

The Convention on Biological Diversity (CBD) defines it as "variation among living organisms from all sources [...] this includes diversity within the same species, between species and ecosystem diversity".

Biological diversity represents the foundation on which human civilization was built, its conservation being an essential condition of sustainable development, which also represents one of the challenges of the modern era.

Why is biodiversity important?

Biodiversity is important because it is a thermometer that measures the health of life on Earth. A richer and more diverse environment is more sustainable, ensuring life and prosperity for those who inhabit it, be they humans, animals or plants. Biodiversity is fundamental to the functioning of ecosystems and the well-being of the entire planet. Each life form has a unique role and contributes to the stability and resilience of ecosystems. Biodiversity supports and sustains life on Earth and underpins the functioning of ecosystems and the diverse benefits that nature provides to people (Kim H., 2024).



Figure 1 The benefits of biodiversity for human society (https://thinklandscape.globallandscapesforum.org/44538/biodiversity)

The negative impact on biodiversity is intensifying as the needs of the growing human population and the ever-increasing consumption of material resources skyrocket.

Since biodiversity represents the fundamental essence of life on Earth, (including all its components that provide essential ecological services and resources indispensable for human existence), its conservation thus becomes an essential condition for the continued maintenance of life on the planet.

Biodiversity conservation is an extraordinary challenge that must be approached through greater understanding of biodiversity itself, through changes in people's behaviors and beliefs, and through various conservation strategies.

2. Methodology

In order to analyze how biodiversity conservation is achieved on the European continent and the EU 27, raw official data registered on the Eurostat statistics website (https://ec.europa.eu/eurostat/data/database) were used, as well as official records from the website of the European Environment Agency (https://www.eea.europa.eu/data-and-maps/dashboards/natura-2000-barometer).

3. Results and discussion

Europe covers about 2% of the Earth's surface (6.8% of the land area). With a population exceeding 700 million people (742 million people in 2020), it is one of the most populated continents on the globe (occupying the third place after Asia and Africa).

Politically, Europe is divided into about fifty sovereign states.

The European Union (EU) is a political and economic union, consisting of 27 member states located mainly in Europe. It covers an area of 4233262 km^2, and has an estimated population of about 447 million.

For over four decades, European states have initiated collaborations to protect biodiversity and preserve their national heritage. The European Union has acknowledged this collaboration by adopting dedicated legislation, such as the Birds and Habitats Directives, to ensure the conservation of European species of birds, animals, plants and habitats, especially those that are threatened or characteristic.

European policy on protected areas

European policy on protected areas is largely the result of initiatives from two main sources: the United Nations Convention on Biological Diversity and the European Union itself. Several instruments have promoted the creation of

protected areas through specific provisions such as the Ramsar Convention, the World Heritage Convention, the UNESCO Man and the Biosphere Programme.

At the pan-European level, the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) has also led to/facilitated the designation of protected areas (Emerald network).

At the EU level, through the Birds and Habitats Directives, the *Natura 2000 Network* was established. Its purpose is primarily to ensure the conservation of the targeted species and habitats of European interest. The Natura 2000 Network is largely complete with respect to the terrestrial environment, but the marine component of the network is still largely incomplete in many countries and mostly includes coastal waters, leaving offshore waters with poor levels of protection.

The Emerald Network was launched by the Council of Europe under the Berne Convention. The Emerald network and Natura 2000 are based on the same principles and are completely compatible with each other, contributing to the development of a coherent approach to the protection of natural habitats and species on the European continent. They constitute the two most important European networks of protected areas and the largest coordinated network of protected areas in the world.

The last century has seen a great increase in both the number of protected areas and the total area that has received protected status.

Protected areas in Europe

Information on protected areas in Europe is structured into two main data sets: one derived from the European perspective, which includes the 38 member states of the European Environment Agency (EEA38), and the other from the European Union (EU) perspective, which includes the 27 member states of the European Union (EU27).

European states offer a rich diversity of terrestrial and marine environments and represent an important center of biodiversity. Starting from the common goal of protecting ecosystems and their varied habitats, the member states of the European Union have made considerable efforts to designate protected areas, including the most extensive network of protected areas in the world, known as Natura 2000. This excludes the UK, which withdrew from the European Union on 31 January 2020.

Although Europe is the penultimate continent in size, it has the largest number of protected areas in the world, with over 130000 sites covering over 1.27 million km², while in the EU27 there are over 118000 protected areas covering 1.06 million km².

The surface covered by protected areas (in percentage) worldwide can be seen in figure 2.

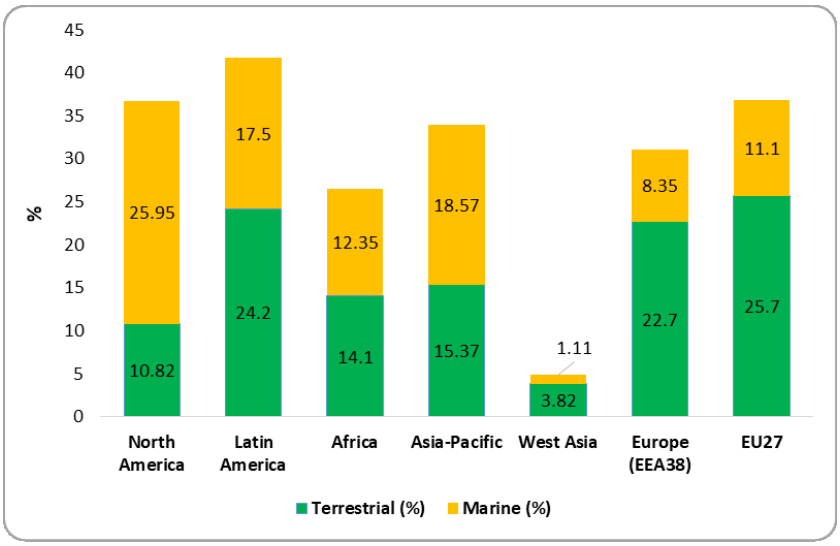


Figure 2 Coverage of protected areas at the continent level

We can say that both in terms of number and surface area, the protected areas of the EU are the dominant ones on the European continent: 90.76% of the total number of protected areas belong to EU member countries, and 83.46% of the surface of protected areas at the European level are found in the EU (figure3).

Also, the system of protected areas in Europe is strongly influenced by the Natura 2000 Network, which can also be seen in figure 3.

Therefore, out of the total 130000 protected areas that exist on the European continent, over 27000 sites are designated as Natura 2000. Of the 1.27 million km² of European land covered by protected areas, over 760,000 km² are part of the Natura 2000 Network.

In terms of number, the national sites are greater than those designated as Natura 2000, but in terms of surface, the Natura 2000 Network comprises of more than 70% of the surface covered by European protected areas.

The average sizes of protected areas in Europe are relatively small compared to other regions of the world. This is due to a combination of factors such as: geographical conditions specific to each country, high fragmentation resulting from agriculture, transport and urbanization. It also reflects the conservation priorities of each country's management approach. More than 86% of protected areas in Europe are smaller than 10 km^2.

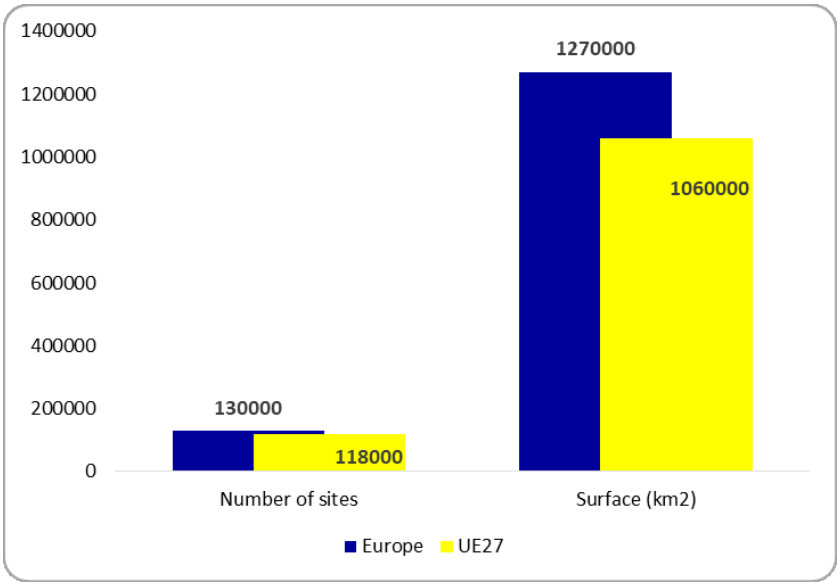


Figure 3 The comparative situation of protected areas at the level of the European continent and at the level of the EU member countries

The situation of terrestrial protected areas at EU 27

At the EU27 level, protected areas cover 25.7% of the terrestrial landscape, and 11.1% of the marine landscape.

According to the Eurostat database, between 2011 and 2021, the percentage of protected area coverage in the EU27 member countries increased by 1.7%.

Terrestrial protected areas at the level of the EU27 member countries, as a percentage of coverage of the country's surface, is what can be seen in figure 4.

Luxembourg is the country with the highest degree of coverage, so that 55.8% of the country's surface is covered by protected terrestrial areas. It is followed by Bulgaria (41%) and Slovenia (40.5%). At the opposite pole is Finland, the coverage percentage of which is only 13.3%.

We can say that at the level of EU27 member countries, the situation regarding the degree of coverage with protected areas is as follows:

- 7 countries have a degree of coverage with protected areas between **10 - 20%** (Finland, Ireland, Belgium, Denmark, Sweden, Lithuania, Latvia);
- 11 countries have a degree of coverage with protected areas between **20 - 30%** (Estonia, Italy, Czechia, Hungary, Portugal, Romania, Netherlands, France, Spain, Malta, Austria);
- 6 countries have a degree of coverage with protected areas between **30 - 40%** (Greece, Germany, Slovakia, Cyprus, Croatia, Poland);

- 2 countries have the degree of coverage with protected areas between **40 - 50%** (Slovenia, Bulgaria);
- 1 country has coverage **>50%** coverage (Luxembourg).

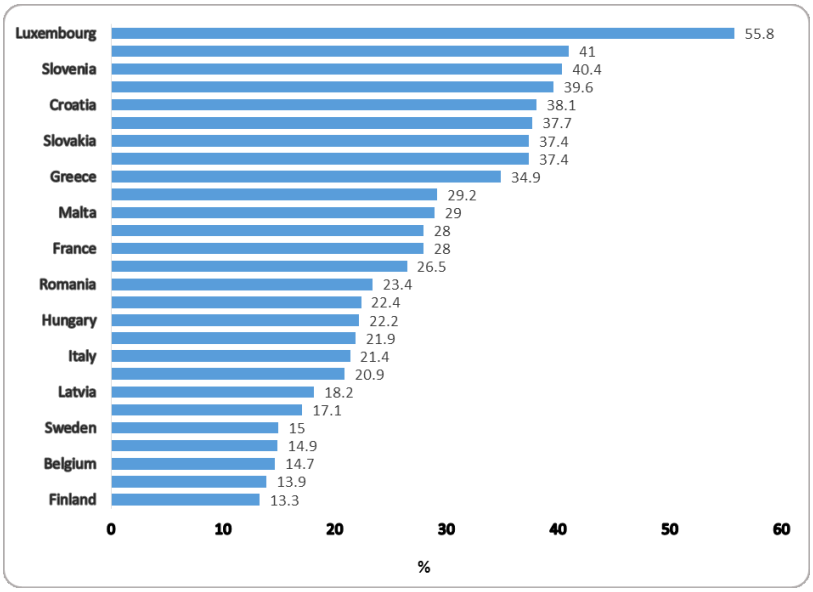


Figure 4. Coverage of terrestrial protected areas in EU27 member states

However, in terms of protected area coverage, France had the largest area among the 27 EU countries in 2021, with approximately 154000 km^2, followed by Spain, Germany and Poland (figure 5).

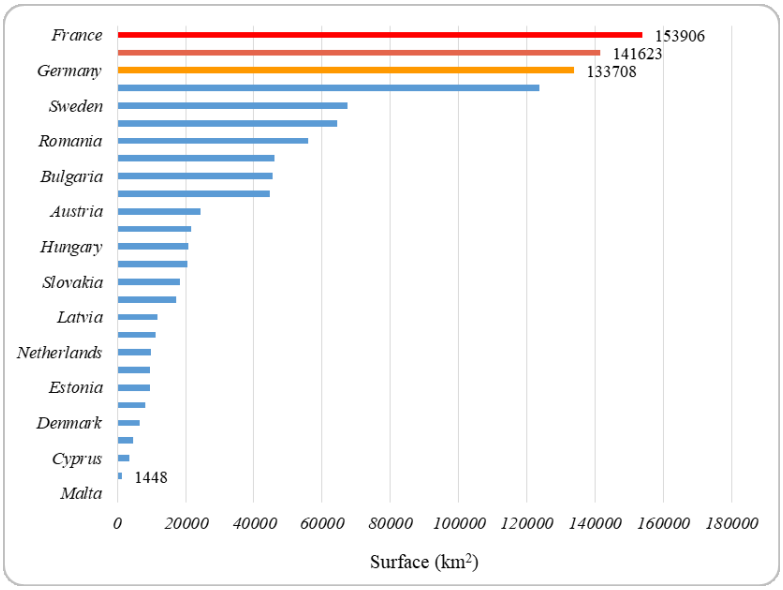


Figure 5 Land surface covered by protected areas at the level of each EU27 member country

Romania has a land surface covered by protected areas of 55890 km^2, which represents 23.4% of the country's surface and 5.17% of the total land surface covered by protected areas at the EU27 level (figure 6).

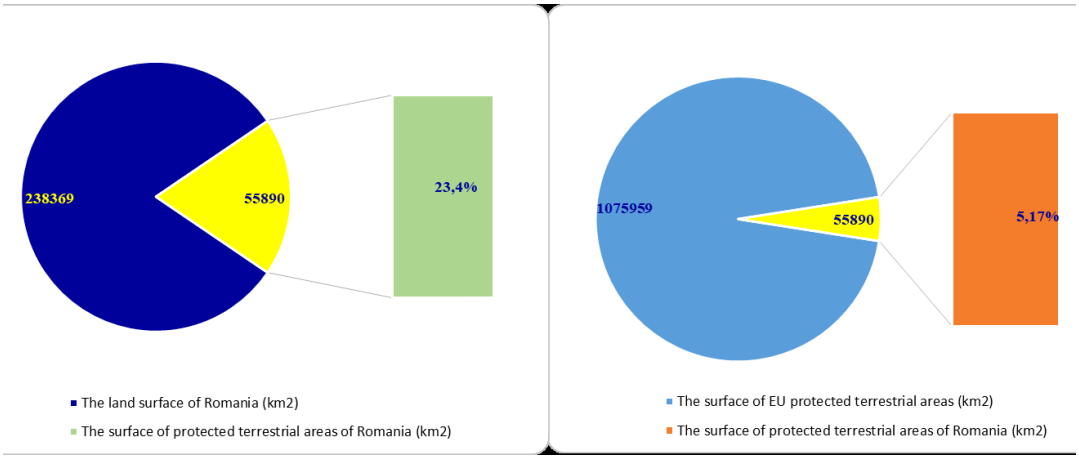


Figure 6 Coverage of protected terrestrial areas at the level of Romania

The situation of marine protected areas at EU 27

More than 65% of Europe is covered by its oceans and seas.

We depend on Europe's seas for transport, energy, food, income, and leisure activities, as well as for often less-recognized life-support functions, such as the oxygen we breathe and climate regulation (EEA, 2019).

Europe's seas contain some of the most diverse ecosystems. These are global biodiversity hotspots. Around 40% of the EU's population lives in coastal areas.

Current pressures and threats (overexploitation, pollution, marine transport, climate change) have significantly deteriorated the state of marine ecosystems.

These pressures are driven by population and economic growth, threatening the flow, quality and quantity of benefits that future generations will derive from Europe's seas.

The EU has established one of the world's most comprehensive policy frameworks with a holistic, ecosystem-based approach to protecting the marine environment: the Marine Strategy Framework Directive (MSFD)

According to www.eea.europa.eu/, the total area covered by Marine Protected Areas in the EU increased from 5.9% (2012) to 12.1% (2021).This was due both to the expansion of the Natura 2000 Network and to the national designation of protected areas.

Within the EU 27, marine areas cover an area of 5609086 km^2.

Marine areas at the level of the 27 EU member countries have surfaces between 214 km^2 (Slovenia) and 1727560 km^2 (Portugal). Czech Republic, Luxembourg, Hungary, Austria, Slovakia landlocked member countries. The situation of marine protected areas at EU27 level is shown in figure 7.

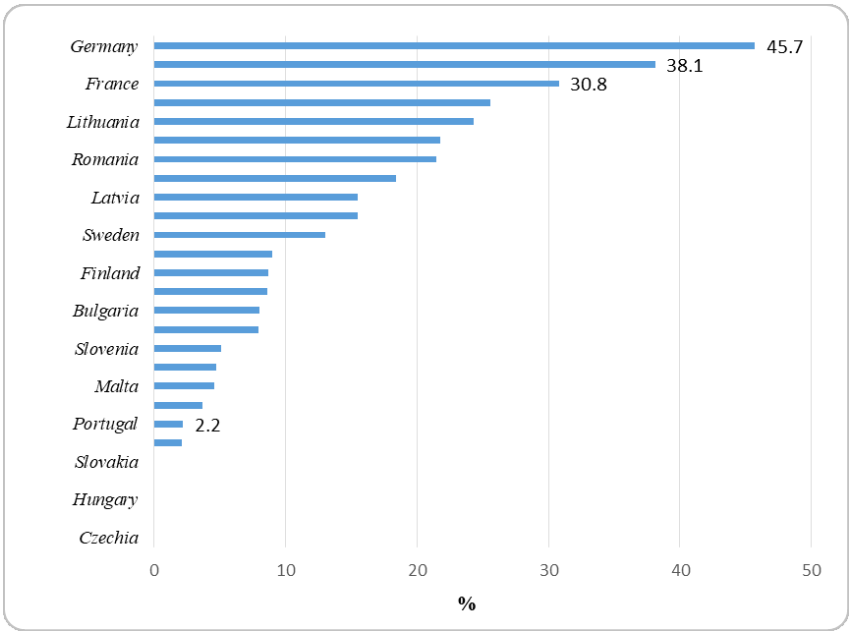


Figure 7 Coverage of marine protected areas in EU27 member states

The country with the largest coverage of marine protected areas is Germany (45.7%), followed by Belgium (38.1%) and France (30.8%), and the lowest percentage of protected areas- Ireland (2.1%) (percentage of total marine areas of each country).

Romania has a total marine area of 29560 km2, which represents 11% of the country's total area (land and sea) and ~0.53% of the EU27's total marine area.

Natura 2000 protected areas

The system of protected areas in Europe is strongly influenced by the Natura 2000 Network, covering almost 767000 km² on land, and approximately 452000 km² at sea. Combined with nationally designated areas, this results in a total protected area coverage of 26.4% on land, and 12.1% at sea in the EU-27.

The degree of overlap between Natura 2000 sites and nationally designated sites varies significantly between different EU member states and outside the EU. It illustrates the different processes that underlie the designation of protected areas.

According to the EU Biodiversity Strategy, EU Member States must step up their conservation efforts by 2030 to reach their target (30% of its land and marine cover to be protected).

The evolution of the coverage with protected surfaces at the EU27 level compared to the 2030 target can be seen in figure 8.

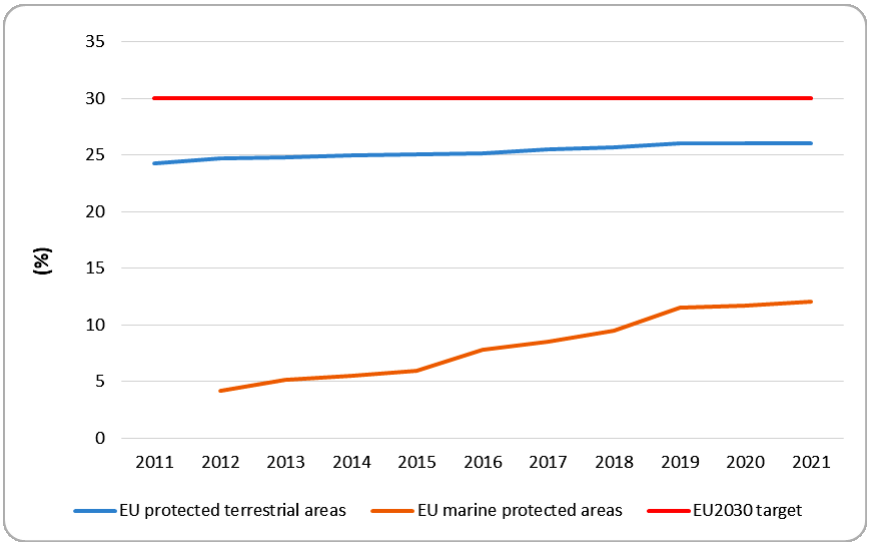


Figure 8 Dynamics of coverage with protected areas (terrestrial and marine) at EU27 in the period 2011 - 2021

Romania has a land area of 238369 km^2 (after EEA) and a total marine area of 29560 km^2. Protected terrestrial areas in our country have a total area of 55890 km^2, 54214 km2 of which are part of the Natura 2000 Network. So, 23.44% of the land territory of the country is covered with protected areas (97% of which are areas that are part of the Natura 2000 network).

The marine area covered by Natura 2000 protected areas represents 21.7% of the country's marine area. The total Natura 2000 protected area in our country is 60577 km^2.

4. Conclusions

In order to meet the needs of a constantly growing population, biodiversity conservation is essential.

Europe is the continent that has the largest number of protected areas in the world (over 130,000 sites), over 31% of its territory being covered by protected areas.

At the level of EU27 member countries, 26.4% of the surface is covered by terrestrial protected areas and 12.1% by marine protected areas.

The EU's system of protected areas is heavily influenced by the Natura 2000 network, with marine protected areas also designated under various regional conventions, such as the Barcelona Convention, the Ospar Convention, the Helsinki Convention, etc.

Over 71% of the protected land area, and over 8% of the protected marine area, at the EU27 level, is covered by the Natura 2000 Network.

The countries with the highest percentage of terrestrial protected area coverage are Luxembourg (55.8%), Bulgaria (41%), Slovenia (40.5%), while Finland and Ireland have the lowest.

The largest areas of terrestrial protected areas are owned by countries such as: France, Spain, Germany.

A site can be part of several protected area categories and networks. Thus, the degree of overlap between Natura 2000 sites and those designated at national levels varies significantly between EU member states.

Additionally, in marine waters, there may also be overlaps with sites designated under one of the regional seas conventions mentioned.

Romania, as a member country of the EU27, has 23.4% of its land surface and 21.5% of its marine surface covered by protected areas, being close to the 30% target set for the year 2030.

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REFLECTIONS ON ENERGY METABOLISM. ITS INFLUENCE ON LIFE AND THE QUALITY OF LIFE

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1. Introduction

Energy plays a role of paramount importance in each aspect of our lives. Not only does it power, but it also regulates our internal biochemical and physiological processes.

The word "energy" originates from the ancient Greek word "energheia", i.e. 'activity', 'work', and broadly expresses the potential of a substance to induce changes in physical and chemical phenomena.

"Energy" is one of the most common and frequently used words for quite the simple reason: everything around us (on a physical, chemical, biological, etc. level) and within us (such as physiology, anatomy, psycho-behavior, etc.) can be traced back to a process of TRANSFORMATION (in structure, time, space, etc.) which is ultimately sustained by ENERGY.

Transformation sustained by energy

Naturally and subconsciously, the word "energy" is used with the unanimously accepted meaning of the capacity to generate a change, any sort of transformation, regarding all phenomena. The word is so commonly used in the forementioned sense that it goes beyond the physical realm, as it is sometimes used in expressions with a more figurative meaning, such as "germinative energy" or "nervous energy".

Thus, behind any potential transformation, a specific energy is required to sustain it. Irrespective of its state, there are manifold forms of energy.

In the sense that it is employed in physics, or more generally in natural sciences, engineering and technology, 'energy' can be described as the 'potential' that causes 'change'. It is a concept utilized to better understand and describe physical and chemical processes.

Therefore, scientists define energy more concretely as the capacity of a physical system to generate mechanical work when it undergoes a transformation from its state to another state chosen as the reference state (Remus Răduleț et al. 1966). Energy is hence a *state function*.

Energy can be converted from one form to another. The food we eat contains chemical energy, and the body stores this energy until it is used as kinetic energy during any sort of activity.

Life, as in a phenomenon, the state of what is alive, is inherently a synthesis of the biological, physical, chemical and mechanical processes that characterize living organisms. It cannot exist without the energy obtained from metabolic processes. Consequently, metabolic energy heavily impacts life and its quality.

2. The energetics of biosystems

In the case of living organisms, thermodynamic equilibrium is equivalent to death. For example, the conversion of proteins to amino acids is an exergonic process and would therefore occur spontaneously in the absence of a continuous supply of energy to the living cell that is owed to basic chemical processes (such as glycolysis). This is what contracts the tendency to reach a thermodynamic equilibrium incompatible with life. Fruton and Simmond (1960, 223-343) regard the organism as a polyphasic system, in which each cell constitutes a polyphasic system, each with its own distinct cytological differentiation (nucleus, cytoplasm, mitochondria, etc.). The considerations of thermodynamics would apply to these polyphasic systems, with the caveat that, in such a system, even when the chemical composition does not change, it cannot be described as a state of thermodynamic equilibrium, but as a "steady state" during which the rate of chemical synthesis and disarticulation is balanced.

It should be noted, however, that the estimation of the free energy exchange in biochemical reactions is still particularly difficult. The free energy values examined in this chapter are the values for reversible chemical reactions in homogeneous systems at a constant temperature and pressure. Their calculation involves both the determination of the equilibrium constant and the determination of ΔH and ΔS from thermal measurements.

Most ΔG^{o} values in the biochemical scholarly literature must thus be considered approximately amenable to correction until new studies provide better accuracy. Fruton and Simmond, (1960, 223-343) consider the accuracy of ΔG^{o} values to be within ±10%.

The following observation is also worthy of mentioning in what concerns the concept of “steady state”: “A steady state is reached in a system, if energy

or substance and energy flow out of the system" (Fruton and Simmond, 1960, 223-343).

Such a system has been combined with an open system, as opposed to the closed system defined for thermodynamic equilibrium, in which there is no outflow of energy or substance. A steady state can be the result of either reversible or irreversible processes, whereas thermodynamic equilibrium could be a certain moment within a more general steady state phenomenon. During a state of thermodynamic equilibrium, a closed system cannot perform mechanical work without an intensive change. However, a stationary system can interact with the environment or the components of the system.

In addition, thermodynamic equilibrium is unstable, in the sense that it changes once a single addition of energy to the system has occurred, while the steady state has a constant (equifinality property). Moreover, the concentrations of reactants in thermodynamic equilibrium are independent of the concentration of substances catalyzing the reaction, while the steady-state concentration of reactants in the steady-state is determined by the concentration of catalysts.

In the biological system referred to as steady state, substance and energy are continuously produced and released, since there is a rate of transformation and translocation of substances and energy within the system. According to Fruton and Simmond (1960, 223-343), these rates are influenced by the enzyme-catalytic concentration, the agents that determine the catalytic activity of the enzyme components, and the variation in irreversible diffusion processes. Within a biological steady-state system, there are certain gradients of substance and energy. The system can work to maintain such gradients. There is a mutually conditioning energy-structure correlation, with energy production being premised on a specific form of organization, from plant plastids and mitochondria to certain mammalian organs that provide control over the burning of food (glands with internal secretion) (Săhleanu, 1965, 34-40). Due to the complexity of the biological system, the application of thermodynamic theories concerning the description of the steady-state system is rather difficult to tackle and therefore, so far it has been undertaken only in a few special cases.

In the case of developing biological systems, there is no increase in entropy, but a decrease. This is due to the fact that the synthesis of macromolecules, along with their growth and differentiation, actually leads to an increase in potential and internal energy, "a path towards increasingly labile states of equilibrium" (Săhleanu, 1965, 34-40). This labile equilibrium conditions the reactivity of the living substance. It is then considered that the emergence of life, and later the biosphere, in fact, signified the emergence of

centers for energy condensation, as well as its retransformation from one form to another, as well as that of a delay in its march towards more and more probable states. By consuming energy from the environment, living organisms build up energy stores in the form of compounds with lower entropy than he raw materials.

As biological organisms have evolved, the expenditure of energy required to maintain them in steady state has also increased, with organisms with higher organization system (homeothermic) requiring greater energy expenditure.

Phenomenologically speaking, a living organism is an open thermodynamic system, which transforms the chemical potential energy of food into the energy of its work products and continuously releases the same amount of energy into the external environment in the form of heat current. Denoting the force of these laboring processes in living systems by means of $\frac{\Delta \overline{A}\ i}{\Delta t}$, the thermodynamic force by *Xi* and the thermodynamic velocity by $\frac{\Delta Xi}{\Delta t}$, he concludes that $\overline{A}\ i$, i.e. the total energy of all the working processes, has the following relation to the thermodynamic force *Xi* and the thermodynamic velocity of the $\frac{\Delta Xi}{\Delta t}$ system:

$$\sum_{i=1}^{n} Xi \frac{\Delta Xi}{\Delta t} = \frac{\Delta \overline{A}\ i}{\Delta t}$$

Which expresses the values of the heat output of the T($\frac{\Delta S}{\Delta t}$) system by the following:

$$T(\frac{\Delta S}{\Delta t}) = \overline{K} F(T' - T)$$

Where:

K represents the average coefficient organism's body heat conductivity

F- separation surface between the organism and the environment

T'- the temperature of the organism

T- the temperature of the environment

He observes that, under stationary conditions of existence, the organism expends a conditional amount of energy of nutrients to ensure all its working

processes; the summation of the forces of these $\frac{\Delta \bar{A}\, i}{\Delta t}$ processes are expressed by the following relation:

$$\frac{\Delta \bar{A}\, i}{\Delta t} = \bar{K}F(T'-T)$$

Under stationary conditions of existence, the body expends a constant amount of energy of nutrients to ensure all its working processes:

$$\frac{\Delta \bar{A}\, i}{\Delta t} = \text{constant}$$

This results in:

$$\frac{\Delta}{\Delta t}\left(\frac{\Delta \bar{A}\, i}{\Delta t}\right) = 0 \text{ and } \frac{\Delta}{\Delta t}(\bar{K}FC\,T'-T) = 0$$

$$\frac{\Delta}{\Delta t}\left(T\frac{\Delta S}{\Delta t}\right) = 0$$

Thus, from a phenomenological point of view, the organism at steady-state equilibrium is an open thermodynamic system. Such a state is considered to exist in adult organisms, which no longer change their body mass and reside in an environment with constant parameters. In the growth phase, however, the situation is different. The growth phase begins at the birth of the differentiated organism and ends upon reaching adulthood. During this time, the organism is constantly increasing its body mass, according to the relationship: m=m(t), where mt is an ascending function of time. Taking into account that the average density of the organism, $\bar{\rho}$, changes little during growth, we have:

$$m(t) = F(t) \cdot a(t) \cdot \bar{\rho}$$

where:

F(t)- the surface of the growing organism

a(t)- a linear random parameter of the growing organism

By replacing the F with F(t) it becomes:

$$\frac{\Delta \bar{A}\, i}{\Delta t} = \frac{\bar{K}\, m(t)}{a(t) \cdot \bar{\rho}}(T'-T)$$

And from here:

$$\frac{\bar{K}(T'-T)}{\bar{\rho}} \cdot \frac{1}{a(t)} = \frac{1}{m(t)} \cdot \frac{\Delta \bar{A}\, i}{\Delta t}$$

Whereas $\frac{\Delta \bar{A}\, i}{\Delta t} = T\frac{\Delta S}{\Delta t}$ we get: $\frac{1}{m(t)} \cdot \frac{\Delta \bar{A}\, i}{\Delta t} = \frac{1}{m(t)} \cdot T\frac{\Delta S}{\Delta t} = T\frac{\Delta S y\delta}{\Delta t}\ \frac{\Delta S y\delta}{\Delta t}$ which is the specific entropy production, that is to say, the change in entropy calculated per unit of body mass of the organism.

$$\frac{\bar{K}(T'-T)}{\bar{\rho}}\ \frac{1}{a(t)} = T\frac{\Delta S y\delta}{\Delta t}$$

$$\frac{\Delta}{\Delta t}\left(\frac{\bar{K}(T'-T)}{\bar{\rho}} \cdot \frac{1}{a(t)}\right) = \frac{\Delta}{\Delta t}\left(T\frac{\Delta S y\delta}{\Delta t}\right) < 0$$

since $\frac{1}{a(t)}$ is a time function.

The expression $\frac{\bar{K}(T\prime-T)}{\bar{\rho}} \cdot \frac{1}{a(t)}$ that represents the flow of heat per unit

measure of the organism decreases as the organism grows.

Indeed, the young homeothermic organism excretes more heat per unit mass than the adult organism, as the young organism has a higher metabolism than the adult. This also occurs in different species that differ in mass. Thus, the smaller the homeothermic organism, the greater the heat production per unit mass according to the relationship:

$$K\frac{1}{a} = T\frac{\Delta Sy\delta}{\Delta t}$$

where:

K= represents an approximately constant magnitude for all homeotherms, and a = some linear parameter characterizing the size of the organism. The larger the organism, the less heat is produced.

$$\bar{K}\,(T'-T) = \frac{1}{F} \cdot T\frac{\Delta S}{\Delta t} = \bar{K}\bar{\rho} \sim \text{constant}$$

This relationship goes to show that the heat production of organisms (calculated per unit area) is an approximately constant quantity in all homeothermic organisms, regardless of their mass. This is what is known as "Rubner's surface law". Recapitulating these data, one can say, in accordance with Prigogin's theorem: *the evolution of the open system approaching the firm steady state is summarized by the fact that the transition of the system to a new steady state is related to a decrease in energy consumption due to a decrease in a parameter of the system.*

Prigogin's theorem is perfectly applicable to energy processes occurring in the organism of homeotherms, which have been in steady state from the adult stage and in growing organisms.

Thus, for the adult organism the following is applicable:

$$\frac{\Delta}{\Delta t}\left[\frac{\bar{K}F\,(T'-T)}{m}\right] = \frac{\Delta}{\Delta t}\left(\frac{\Delta Sy\delta}{\Delta t}\right)$$

And for growing organisms:

1. $$\frac{\Delta}{\Delta t}\left[\frac{\bar{K}\,(T'-T)}{\bar{\rho}} \cdot \frac{1}{a(t)}\right] = \frac{1}{a(t)}\left[T\frac{\Delta Sy\delta}{\Delta t}\right] < 0$$

3. Efficiency of free energy use in the body

The change in the free energy of oxidizing substances in the body (ΔF) can be measured as a change in their heat content (ΔH), which produces changes in entropy (TΔS) during reactions within the system, as shown by the relation:

$$\Delta H = \Delta F + T\Delta S$$

The change in enthalpy, as shown in the previous chapter, can be measured with the aid of the calorimeter bomb, and the change in entropy can be calculated based on the knowledge of the entropy of individual reactants and their resulting products (Armstrong, 1969, 385-414). It is known that the entropy of all substances at absolute 0 temperature (0^ (o) K or - 273 ^ (o) C) is zero, since it is at this temperature that all motions between and within molecules cease. In this case, the entropy can be determined from the heat capacity of substances measured at various temperatures from 310º K (37 º C) to 0) K (Armstrong, 1969, 385-414).

It is not enough, however, to know the amount of free energy involved in certain reactions taking place in the bodies of organisms. In addition, we also need to know how much of this free energy can be captured in macroergic bonds, particularly in the two pyrophosphoric bonds of ATP. This is now known for many catabolic reactions that take place inside the body, as well as for some anabolic (synthetic) ones. It is thus possible to calculate an efficiency of free energy utilization of some biological reactions for a given substance undergoing oxidation in the body, according to the formula below (Armstrong and Blaxter, 1961, 187-197):

$$\text{Efficiency} = \frac{\text{Kcal energy retrieved in the ATP/mol oxidised substance}}{\text{Kcal free eliminated energy/mol oxidised substance}}$$

During the hydrolysis of a pyrophosphoric terminal bond, a free energy of about - 8.4 Kcal is released. Given the physiological conditions existing in the body, the free energy of the hydrolysis of this bond is significantly higher, estimations being placed at 11-12 Kcal. In the following part, the efficiency of these processes will be proven, expressed in the amount of free energy captured in macroergic ATP bonds in relation to the free energy released, based on the data obtained so far on the intermediate metabolism at cellular level of basic nutrients: carbohydrates, lipids and proteins and in accordance with the above relationship.

The theoretical efficiency with which nutrients can be utilized to sustain life in living organisms

Armstrong and Blaxter (1961, 187-197) introduced the idea that in calculating the efficiency of utilization of the free energy of various nutrients metabolized in the tissues, the efficiency with which fat is utilized for the purpose of maintenance of function should be considered. This is based upon the reasonable assumption that the nutrients used by the organism for maintenance replace body fat in direct proportion to the free energy which those nutrients produce in the body when they are dissimilated and therefore using the ratio:

$$\frac{NcCSN - NcCG}{NcCG} \times 100$$

Where each item represents:

-NcCSN - calories required to form 1 mol. ATP from nutrients

-NcCG - required calories for the formation of 1 mol. ATP from fat

The theoretical increase or decrease in heat (ADS) that occurs when the food in question is used in place of fat to provide maintenance energy is possible to be calculated. Since the theoretical heat gain (or loss) is known, we can calculate the energy use efficiency of the substance in question when it is used in place of body fat for maintenance of functions by subtracting its percentage value from 100.

In this way, the lower the energy cost of forming an ATP molecule from ADP, the higher the efficiency of using that substance for maintenance. For example, knowing that the energy expenditure for the formation of one ATP molecule from ADP when oxidizing body fat is 18.1 Kcal and the energy cost for the formation of one ATP molecule from DNA when oxidizing protein is 21.4, it becomes possible to calculate the efficiency of using protein for maintenance as follows:

-Firstly, achieve a calculation of the theoretical heat gain (specific dynamic action, SDA) that occurs when protein is used instead of fat, according to the relationship:

$$\%ADS = \frac{21,4-18,1}{18,1} \times 100 = 18,2\%$$

- Secondly, to calculate the efficiency of using protein for life support, this percentage value is subtracted from 100 to obtain an efficiency of 81.8%. This means that the free energy of casein - when oxidized in the body for life support - is used at only 81.8% of the efficiency of body fat considered to be 100%. Table 3 showcases the theoretical values of ADS and nutrient efficiency when used for maintenance of function instead of body fat.

Table 1. The theoretical caloric gain for nutrients when used in lieu de body fat to provide free energy for maintenance

Nutrient	Caloric requirements /mol. *ATP* (Kcal/mol)	theoretical caloric increase (%)*	Theoretical efficiency of use (%)
Tristearina	18,1	0	100
Glucose	17,7	-2,2	102,2
Casein	21,4	18,2	81,8
Acetic acid	20,9	15,5	84,5
Propionic acid	20,4	12,7	87,3
n. butyric acid	19,4	7,2	92,8

∗ *calculated as follows:*

$$\frac{calories.required./mol\,ATP\,from\,nutriens - calories.solicit./\,mol\,ATP\,from\,lipids}{calories.solicit./\,mol\,ATP\,from\,lipids} \times 100$$

Armstrong and Blaxter (1961, 187-197) reckon that the error involved in the existence of other triglycerides is extremely small, despite triglycerides in the body only naturally consisting of tristearin (especially in monogastric organisms).

Table 1 illustrates that out of all the nutrients absorbed and utilized by the body, it is only glucose that replaces body fat for the scope of the maintenance of bodily functions with greater efficiency than the latter, as other nutrients (amino acids and volatile fatty acids) are being utilized with less efficiency.

4. Energy metabolism, life and the quality of it

Energy metabolism, as mentioned previously in this report, consists of the mechanism by which the energy needed to fuel and regulate internal biochemical and physiological processes is provided and regulated. Consequently, it is correlated with many elements that characterize life and its quality.

Energy metabolism, body size, lifespan and ageing

Longevity and higher energy consumption in large animals is owed to the fact that across species, a gram of tissue consumes on average about the same amount of energy until it perishes, regardless of the organism in which that tissue is found. This has led to the idea that ageing and lifespan are processes regulated by rates of energy metabolism and that increased metabolism could be associated with premature mortality. This is known as the rate of life theory.

Although the underlying processes and mechanisms are complex and not fully understood, it is widely accepted in the academic community that there is a correlation between energy metabolism and ageing/life expectancy, i.e. that restricting energy intake and reducing metabolic rate can slow the rate of ageing and prolong longevity.

The rate of life theory is one of the fundamental dichotomies in biology. On the one hand, living things are bewilderingly diverse - with millions of species that differ enormously in anatomical structure, physiology, ecological interactions and evolutionary histories. On the other hand, the same organisms share common traits that can be quantified by statistical correlations and mathematical equations: aspects such as pondered variation across body size and temperature, compromises in terms of historical evolutionary traits, and patterns of biodiversity across geographical areas, space and evolution time.

Reduced body temperature has been linked to increased longevity in both lab animals and humans.

However, by increasing energy expenditure, for example through sport, one's health condition can be significantly improved, since it has been proven to usually result in a prolonged lifespan.

The correlation between energy metabolism and the quality of life

Quality of life (QoL) is a multidimensional concept that refers to "an individual's perception of their position in life in the context of the culture and value systems in which he or she lives and in relation to his or her goals, expectations and standards" (WHOQOL User Manual). It stands to reason that it is affected by a person's physical health and overall psychological wellbeing. Thus, quality of life can be assessed by factoring in physical health, psychological wellbeing, exposure to social interaction, as well as one's position to key features of the environment.

Globally, the proportion of older people is increasing, while survival rates for chronic non-communicable diseases are also improving. Quality of life (QoL) is directly linked to several non-communicable diseases, out of which the most common are cardiovascular disease, diabetes, hypertension and dyslipidaemia. All these diseases involve complex metabolic processes and, by extension, energy metabolism (both directly and indirectly).

Health conditions associated with uncontrolled positive energy balance, including type 2 diabetes mellitus (T2DM) and chronic hypertension, contribute significantly to the overall prevalence of cardiovascular disease, and therefore represent a major cause of morbidity and mortality. In developing countries, one can simultaneously talk about high incidences of diseases

associated with malnutrition, such as infectious diseases, as well as diseases associated with overnutrition, such as obesity.

The amount of food that people eat, coupled with their nutrition patterns, play crucial roles in the development and health maintenance all throughout an individual's life.

It is important to provide patients suffering from various diseases with a diet in accordance with their specific nutritional needs. 'Food is medicine'-type interventions are increasingly being more studied as a means of preventing and treating multiple underlying diseases and maintaining a high quality of life.

In contrast to medicine, dietary intake comprises a wide variety of ingredients, and each one of their functions are spread across the entire lifespan of an individual, rather than only during a specific moment in time. Providing dietary recommendations to patients, particularly those suffering from chronic illnesses, is thus more complex than most other health recommendations.

Energy metabolism and obesity

Obesity is a consequence of chronic energy imbalance. Accurate and precise measurements of food energy intake and eating behaviours are required to fully understand how energy homeostasis is regulated, as to then develop interventions and evaluate their effectiveness to combat the global obesity epidemic.

Increasing energy expenditure for thermogenesis through exposure to cold or through dietary or pharmacological interventions holds promise for reducing and/or preventing obesity and improving the chances of healthy ageing and longer lifespan.

Restricting caloric intake

Data from epidemiologic, experimental and clinical studies seem to indicate that maintaining a healthy body weight and preventing the accumulation of abdominal fat is essential in preventing the occurrence of multiple chronic diseases and achieving a healthier aging process.

Hundreds of preclinical studies have shown that dietary restriction activates multiple molecular pathways that facilitate orthostasis, genome stability, stress resistance and stem cell function.

Data collected from non-human primates indicate that caloric restriction, in combination with changes in diet quality, significantly decrease the incidence of cardiovascular disease, cancer and diabetes. It attenuates neurodegeneration, sarcopenia and age-related hearing loss.

Energy metabolism and the function of sleep

Sleep is a vital survival strategy for the body. Among the many functions it performs, there is also one related to energy metabolism, i.e. saving energy and replenishing energy stores. The key sleep-inducing molecule appears to be adenosine, which induces sleep on a local level in the forebrain. The continuous activity of sleep-facilitating cells in the forebrain imposes a strain on the mitochondrial energy-producing capacity during periods of wakefulness. When wakefulness is prolonged, these cells begin to suffer from an energy deficit, resulting in increased glycolysis, which in part increases the extracellular concentrations of lactate, pyruvate and adenosine. Bettering the levels of extracellular adenosine contributes to increased sleep propensity and favours the transition from wakefulness to sleep. Increased lactate concentration represents the brain's metabolic response to the sharp increase in energy demand to support increased neuronal activity. As energy resources in the brain become limited during prolonged wakefulness, the demand for energy production in the brain will thus not be met. The immediate effects are that neurons may still function, but more slowly and less efficiently.

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12. *** PROGRAMME ON MENTAL HEALTH, WHOQOL User Manual, DIVISION OF MENTAL HEALTH AND PREVENTION OF SUBSTANCE ABUSE WORLD HEALTH ORGANIZATION

Importance of IoT's in our lives: an overview

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Abstract

The Internet of Things (IoT) is a complex network of interconnected devices that collect and transmit data through the Internet, which itself is a much larger network made up of smaller networks. This emerging technology has led to significant transformations in various fields, including industry, health, transportation and everyday life. By integrating smart technologies into the objects around us, IoT promises not only increased efficiency, but also new possibilities for innovation and improving quality of life.

This chapter aims to be a review on the importance acquired by IoTs in our lives, to increase our/human's quality of life, and, at the same time, tries to compare their involvement in the societies of Romania and the Republic of Moldova.

Keywords: *IoT, Internet, Communications, IT, Technology*

Extenso

The Internet of Things (IoT) is a complex network of interconnected devices that collect and transmit data through the Internet, which itself is a much larger network made up of smaller networks. This emerging technology has led to significant transformations in various fields, including industry, health, transportation and everyday life. By integrating smart technologies into the objects around us, IoT promises not only increased efficiency, but also new possibilities for innovation and improving quality of life.

What exactly are these IoT's? The name "IoT" characterizes a collection of physical devices, vehicles, appliances, sensors and software that are interconnected and can communicate with each other. By their design and definition as computing systems, these devices are capable of gathering data from the environment, analyzing it, and reacting accordingly. For example, a smart thermostat can adjust the temperature of a home by monitoring user behavior and environmental conditions, or an air conditioner can be turned ON or OFF based on the temperature value of a room and/or the presence of people in that room. In practice, IoTs can be regarded as small computing systems, operating according to the same principles, with the exception that they are

reduced in functions, being dedicated to specific activities. They are based, in most cases, on systems with microcontrollers.

The history of the development of IoT's is a fascinating and challenging technological development, full of innovations and fundamental discoveries. The Internet of Things has become a modern technology that has revolutionized the way we interact with the objects around us by communicating between physical devices via the Internet, with applications in various fields from health and transportation to agriculture and the environment

The idea of IoT has its roots in the year 1960, when a few researchers, such as JCR Licklider, began to develop the concept of a global network where users could interact with computers. During the same period, the internal architecture of a computing system developed by von Neumann became the cornerstone of computer system and microprocessor designs. The idea of the World Wide Web could not have materialized without this basic architecture of computing systems, and it contributed enormously to its further expansion,through the subsequent support of Tim Berners-Lee, the later inventor of the World Wide Web, who allowed the exchange of documents and information between computers.

A pivotal moment in the history of IoT occurred in 1999, when Kevin Ashton, a researcher at MIT, first used the term "Internet of Things" to describe a system in which physical objects are connected to the Internet through the sensors. Its idea was to transform raw data into useful information, thus enabling efficient monitoring and management of resources.

A few years later, the first IoT applications started to become operational. For example, in a pilot project at Procter & Gamble, sensors were used to track product inventory. Also during this period, the development of RFIDs (Radio-Frequency Identification) was an important step, allowing the tracking of goods in a more efficient way.

Over the past 15 years, IoT has begun to gain rapid popularity as wireless technologies and broadband internet have expanded. Large companies such as Cisco and IBM, have begun to invest significantly in IoT, developing platforms and infrastructures to facilitate communication between devices. This expansion has led to an increase in the number of devices connected to the Internet, with estimates showing that there were more than 20 billion active IoT devices in 2020. Also, the expansion of 5G technology in the sector of mobile communications has massively led to the expansion of IoT's.

Through their development and spread, IoTs have started to influence many industries, changing the way they do business and increasing the convenience of users. In the healthcare sector, wearable devices have enabled

continuous monitoring of patients. In agriculture, humidity and temperature sensors have helped farmers optimize irrigation. In the field of transportation, IoT has led to the development of autonomous vehicles and intelligent solutions for traffic management.

IoT plays a crucial role in today's industry, where connected sensors monitor and optimize automated manufacturing processes. The use of IoT devices helps increase operational efficiency, reducing costs and minimizing resource wastage, while at the same time reducing worker handling errors.

Another area where the Internet of Things has gained a lot of ground is that of health, being represented by connected medical devices that monitor patients' vital signs and transmit data in real time to doctors. This enables rapid and personalized interventions, thereby improving patient care. With human lives at stake, this once again demonstrates the operational safety and security these devices can provide.

And the area of transport is strongly influenced by the emergence and implementation of these devices, by generating intelligent solutions such as autonomous vehicles and traffic management systems. These technologies not only reduce congestion, but also contribute to increased road safety.

People's daily domestic activity is also greatly assisted by the existence of IoTs. They facilitate the use of smart devices, such as smart refrigerators, washing machines, air conditioners or connected lighting systems, which can be controlled remotely through mobile applications. It brings a degree of comfort and efficiency to modern households.

Thus, the use of the Internet of Things (IoT) has become significant in Romania as well, it has grown exponentially in recent years, reflecting global digitization trends. According to a statistical study from 2022, approximately 25% of companies in Romania have implemented IoT solutions in their activities, and the trend is increasing, as more organizations recognize the benefits of these technologies.

Benefiting from the safety in operation of IoTs, approximately 40% of companies in the energy and utilities sector in Romania use specific technologies for remote monitoring of networks and management of energy consumption, thus contributing to energy efficiency, especially in the area of green energy.

In the field of security, the number of smart surveillance systems that integrate IoT is estimated to have increased by 30% in the last two years compared to the year 2021, indicating a growing concern for security and property protection.

As for agriculture, this sector will adopt the new IoT technologies in approximately 20% of farms in a maximum of two years (2025-2026), due to the advantages in managing resources and increasing productivity.

In total, approximately 4 million IoT devices were connected in Romania in 2022, in a continuous growth trend as consumers become more familiar with smart technologies (e.g. smart appliances and home automation systems). The exponential evolution of IoT implementation in Romania can also be observed from the 15% increase recorded in 2022 compared to the previous year, through the prism of the increased interest from both the public and private sectors.

The increase in the use of IoT both in our country and worldwide, comes with many challenges related to their security and the communications they provide. The majority of companies in Romania mention cyber security issues and the lack of standardization in the field as the main causes of incidents. These aspects, however, underline a positive trend of adoption of IoT technologies in Romania, although it is very important to address security and infrastructure challenges to ensure a sustainable and efficient future of this technology.

Regarding the comparative view between Romania and the Republic of Moldova, in the field of IT, Romania has made considerable progress in the field of information technology, having a better developed digital infrastructure. Investments in telecommunications and bandwidth have enabled the integration of IoTs in various sectors. Smart cities, traffic management systems and energy efficiency solutions are just a few concrete examples of the successful implementation of IoT technologies.

In contrast, at this moment, the Republic of Moldova faces a more limited digital infrastructure, which affects the adoption of the IoT technologies. Although there are promising initiatives, such as digitization projects in agriculture and the development of data management platforms, financial resources and technical expertise are often insufficient. However, the desire to innovate is present, and young entrepreneurs in the technology sector are increasingly active. In agriculture, the application of IoTs represents a major opportunity, given that agriculture is an essential sector for the country's economy. Pilot projects integrating sensors for irrigation or soil monitoring are encouraging, but still in their infancy. Also, smart city initiatives in big cities are being developed, with the aim of improving the urban infrastructure and the quality of life of citizens.

Comparatively, Romania has a significant advantage in the development of IoT's, due to its better developed infrastructure and widespread applicability

in various sectors. The Republic Moldova, although facing challenges, has opportunities to develop innovative solutions, especially in agriculture and smart cities. The collaboration between the two countries and international support can facilitate the integration of IoT's, contributing to the improvement of the quality of life and economic growth.

Even though the benefits of IoT are obvious, the security and privacy challenges are significant. Connecting a wide variety of devices to the Internet creates potential vulnerabilities, and hackers can take advantage of these weaknesses. It is essential that developers implement robust security measures and protect user data.

The Internet of Things is at the heart of today's technological revolution, having a profound impact on how we interact with our environment. Through innovations in various fields, IoT offers promising solutions to contemporary challenges. However, to fully benefit from the opportunities created by the IoT, it is crucial to address the security challenges and implement appropriate data protection policies. Thus, the future of IoT will depend not only on technological development, but also on our ability to responsibly manage these advanced technologies.

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Advanced materials and innovative technologies with implications on the quality of life. A perspective.

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Abstract

These paper wishes to bring in front of the reader a little perpective on how advanced materials and innovative technologies can improve quality of life in many aspects. For this, a holistic appoach is used, which brings to the forefront novelties and details of how materials are used. There are ideas already discussed and broadly applied in fields like: biomaterials, health and safety, sustainability and environmental impact, economic development and affordability, etc. With the use of Ashby diagrams we can receive a more natural perspective on the selection of advanced materials, and thus we can move forward in better understanding the properties of materials, applying this new knoledge in future technologies that can provide us with an improved quality of life.

1. General aspects

The exploration of advanced materials and innovative technologies reveals profound implications for quality of life (QoL) across various domains, including healthcare, social well-being, and psychological health. The World Health Organization (WHO) defines quality of life as the individual's perception of their position in life within the context of their culture and value systems, emphasizing the importance of mental and social well-being alongside physical health (Aydemir & Arli, 2020). This holistic perspective is crucial when considering how advancements in materials and technologies can enhance quality of life, supported by a range of scholarly references..

Advanced materials, as defined by ?, are novel substances that exhibit significantly enhanced performance or unique functionalities compared to traditional materials. This enhancement is achieved through innovative processing techniques that incorporate knowledge from various scientific disciplines, including materials science, engineering, and nanotechnology (Hailing et al., 2016). The advanced materials industry is not only fundamental to national economic growth, but also serves as a cornerstone for advancements in high-technology sectors, thereby influencing the overall quality of life (Hailing et al., 2016).

One of the most promising areas in advanced materials research is the development of functional polymer materials, which have shown potential applications in diverse fields such as energy harvesting, biomedicine, and environmental protection. Emphasis should be focused on the fact that these advanced functional polymers are integral to the evolution of technologies, and can significantly improve energy efficiency and healthcare outcomes (Wang et al., 2020). For instance, in the field of energy storage, advanced polymers can enhance the performance of batteries and supercapacitors, leading to more efficient energy systems that are crucial for sustainable living (Wang et al., 2020).

Moreover, the integration of advanced fiber materials into medical applications has revolutionized regenerative medicine. These materials can be engineered for controlled drug release and tissue repair, showcasing their biocompatibility (Wu et al., 2023). The ability to create fibers that mimic natural tissues opens new ways for treating chronic diseases and injuries, thereby directly improving patient quality of life. This innovation not only enhances medical treatments, but also reduces the burden on healthcare systems by promoting faster recovery and rehabilitation (Wu et al., 2023).

The concept of bioinspired materials, as explored by, further underscores the potential of advanced materials to improve mechanical performance and durability (Cheng et al., 2014). By mimicking the structural properties of natural materials, researchers can develop composites that exhibit superior strength and flexibility. These materials can be applied in various industries, including aerospace and construction, where enhanced material performance translates to safer and more efficient structures, ultimately benefiting society at large (Cheng et al., 2014).

In the field of electronics, the advent of multifunctional nanostructured conductive polymer gels has opened new frontiers in smart technology. These advanced materials have diverse applications, which range from biosensors to energy storage devices (Zhao et al., 2017). The ability to create responsive materials that can adapt to environmental stimuli is crucial for the development of next-generation electronic devices that are more efficient and user-friendly. This innovation not only enhances technological capabilities, but also contributes to a more connected society (Zhao et al., 2017).

The implications of advanced materials extend beyond immediate applications; they also play a critical role in addressing global challenges such as climate change and resource scarcity. For instance, photocatalytic materials are being researched for their potential in solar energy conversion and environmental remediation (Likodimos, 2020). These materials can facilitate

processes such as water purification and air filtration, thereby improving public health and environmental quality. The development of such technologies is essential for creating sustainable living conditions and enhancing the overall quality of life (Likodimos, 2020).

Technological innovations in the field of social security, in particular the aging populations area, have the potential to significantly improve the living conditions of older adults, making social security systems more efficient and responsive to their needs (Zhang, 2024). As the global population ages, the importance of developing materials and technologies that cater to this demographic cannot be overstated, as they directly influence quality of life for millions of people/humans/individuals (Zhang, 2024).

In addition to healthcare and social security, advanced materials are also transforming the construction industry. Significant advancements in cementitious materials have enhanced structural performance and sustainability (Zhang et al., 2017). These innovations enable the construction of buildings that are not only stronger and more durable, but also more environmentally friendly, contributing to a sustainable urban development paradigm. The implications of such advancements are far-reaching, as they promote safer living environments and reduce the ecological footprint of construction activities (Zhang et al., 2017).

In healthcare, the integration of advanced materials, such as biocompatible implants and prosthetics, has significantly improved the quality of life for patients undergoing various treatments. For instance, studies have shown that dental implants, which utilize innovative materials, can lead to substantial improvements in patients' self-esteem and social interactions, thereby enhancing their overall QoL (Sargozaie et al., 2017). The Oral Health Impact Profile (OHIP) is often employed to measure these changes, indicating that patient satisfaction is closely linked to the effectiveness of such dental interventions (Sargozaie et al., 2017). Furthermore, the psychological aspects of dental health, including the embarrassment associated with tooth loss, underscore the critical role of advanced materials in fostering social inclusion and personal confidence (Lixandru & Domnariu, 2021).

Moreover, the impact of chronic health conditions on QoL is a significant concern. For patients with atrial fibrillation (AF), the implementation of advanced monitoring technologies and treatment strategies has been shown to improve QoL metrics significantly. Both rate and rhythm control strategies have demonstrated efficacy in alleviating symptoms and enhancing the overall well-being of these patients (Aliot et al., 2014). The development of specialized QoL assessment tools, such as the Atrial Fibrillation Effect on

Quality of Life (AFEQT) questionnaire, has facilitated a better understanding of how these interventions can be tailored to individual needs, thus improving health outcomes (Chloubová & Bulava, 2020).

The role of advanced materials in energy storage and conversion technologies is another critical area of impact. It emphasizes the importance of developing self-powered cardiac implantable electronic devices, which can significantly improve patient outcomes by eliminating the need for battery replacements (Li & Wang, 2021). This innovation not only enhances the safety and comfort of patients, but also reduces healthcare costs associated with surgical interventions (Li & Wang, 2021). The integration of advanced materials in medical devices exemplifies how technology can directly enhance quality of life.

Moreover, the exploration of triboelectric nanogenerators (TENGs) as highlighted by showcases the potential of advanced materials in energy harvesting (Khandelwal et al., 2021). By utilizing novel materials that extend the capabilities of TENGs, researchers are paving the way for sustainable energy solutions that can power small electronic devices and sensors, thereby reducing reliance on conventional energy sources (Khandelwal et al., 2021). This advancement is crucial for promoting energy independence and sustainability in everyday life.

The correlation between **quality of life** and **materials selection** from Ashby's diagrams can be understood by linking how the properties of materials influence key aspects of human life such as sustainability, safety, health, and economic development. Here's a breakdown of the relationship:

Ashby's materials selection charts are powerful tools used to compare and select materials based on their properties. These charts were developed by Professor Mike Ashby and are widely used in engineering design to find materials that meet specific performance criteria. Ashby's diagrams are widely available in material selection softwares, such as Ansys Granta Edupack formely CES EduPack and demo version, as well as in textbooks like *"Materials Selection in Mechanical Design"* by Michael Ashby.

Methodology

In order to generate Ashby charts, it is better to learn the methodology involved, and below key points are displayed on how to use these diagrams effectively:

a. Understanding the Axes

Ashby diagrams typically plot two material properties against each other, like **density vs. price**.

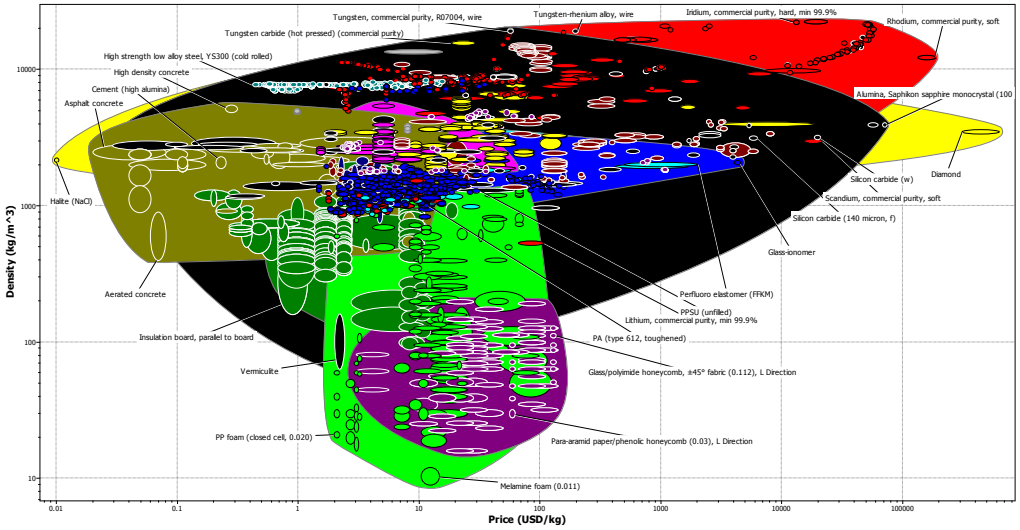


Figure 1. Ashby diagram density(kgm^3) vs price(USD/kg)

This allows you to visualize which materials perform best for a given combination of properties.

For example, a **density vs. Young modulus** chart helps find materials that are both light and stiff, which is essential for applications like aerospace.

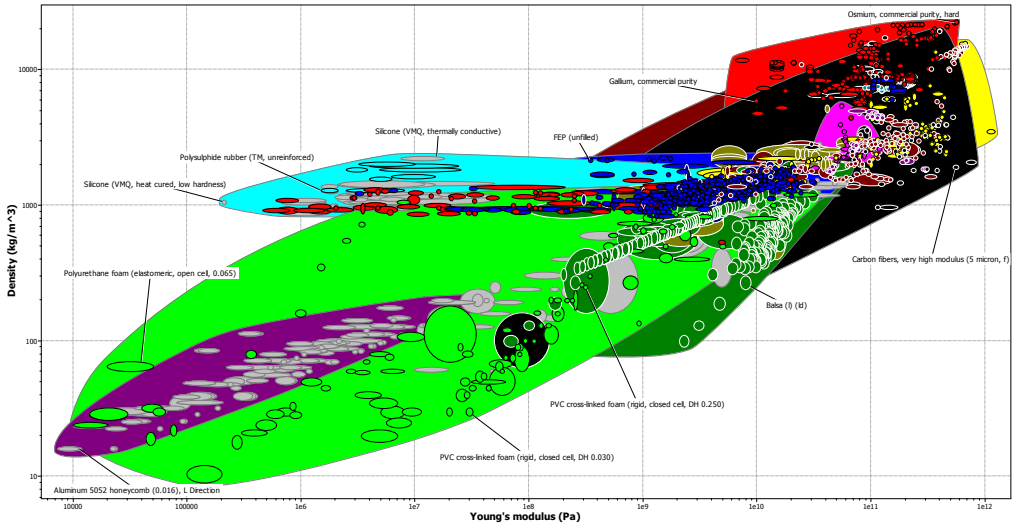


Figure 2. Ashby diagram density(kgm^3) vs Young modulus (Pa)

A **density vs. hardness – Vickers** chart might be used for components that must withstand heavy loads and impacts, like in automotive or construction.

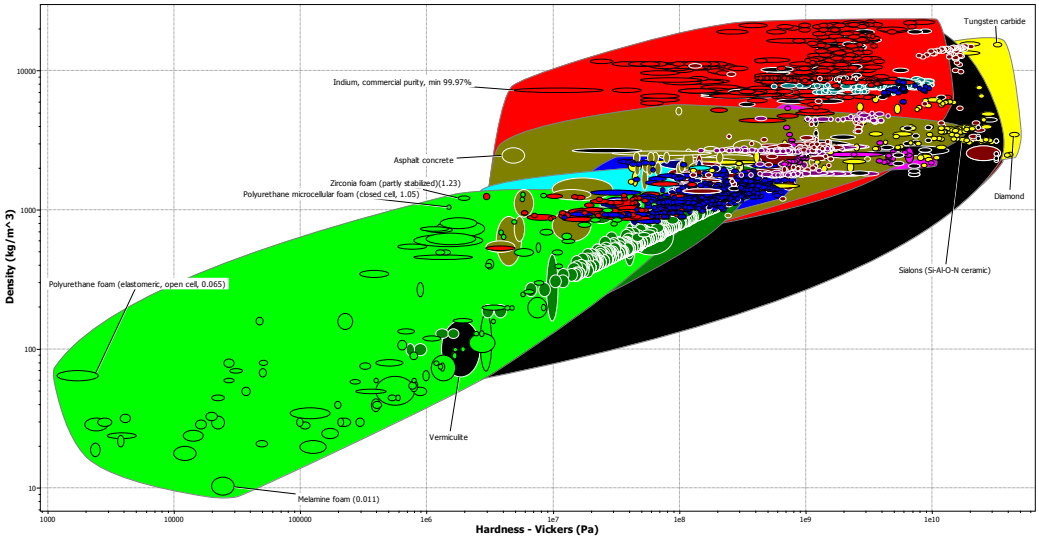


Figure 3. Ashby diagram density(kgm^3) vs Hardness - Vickers (Pa)

b. Material Families

Materials are grouped into families such as **ceramics, metals**, **polymers**, and **composites**. Each family of materials occupies a specific region in the chart based on shared properties. For example, metals tend to be dense, but strong, while polymers are lightweight, but have lower strength.

c. Performance Index

To select the best material for a given application, Ashby's method introduces the concept of a **performance index**. This is a ratio or combination of material properties that reflects the material's performance in a specific application. For example: for a lightweight, stiff structure: E/ρ (Young's modulus over density) is used, and for minimizing the cost: Strength\Cost - Strength might be a relevant index.

Performance indices guide you to find the materials that lie in the upper-right corners of the diagram (higher performance).

d. Material Selection Process

Material selection processes involve using the following steps to visualize the diagram: **step 1**: define the function (e.g., structural, electrical, thermal); s**tep 2**: identify constraints (e.g., weight, strength); s**tep 3**: select a performance index that reflects the searched combination of properties; s**tep 4**: use the Ashby chart to find materials that maximize the performance index.

e. Trade-offs

One of the strength points of Ashby diagrams is that they make it easy to see trade-offs between different properties. For example, if you need a strong but lightweight material, a diagram might show that while metals are strong, composites may offer better weight advantages at a slight sacrifice in strength.
Example: Density vs. Young's Modulus.

We have on **X-axis**: Density (kg/m³) and on **Y-axis**: Young's Modulus (GPa).

Materials like **aluminum** and **titanium** will appear in a region indicating high stiffness for moderate weight, while polymers like **polyethylene** will appear in regions with low density and low stiffness.

f. Customization

Ashby diagrams can also be customized to specific engineering needs. You can overlay contours of constant performance indices or eliminate materials that don't meet environmental, or cost constraints. We can present a series of applications that presented the need to use such diagrams:

- **aerospace**: for the best strength-to-weight ratio.
- **civil engineering**: balance toughness and cost for building structures.
- **automotive**: Balancing weight and durability.

Application 1. Sustainability and Environmental Impact

Material Efficiency*:* Sustainable development focuses on minimizing waste and conserving resources. By choosing materials with the best performance for weight, strength, and durability, engineers can reduce the overall environmental impact of products and infrastructure. This leads to less resource extraction, lower energy consumption, and reduced waste. **Ashby Chart for example - casting energy (J/kg) vs CO2 footprint, recycling (kg/kg)-** figure 4 helps in selecting materials with lower environmental impact on casting parts.

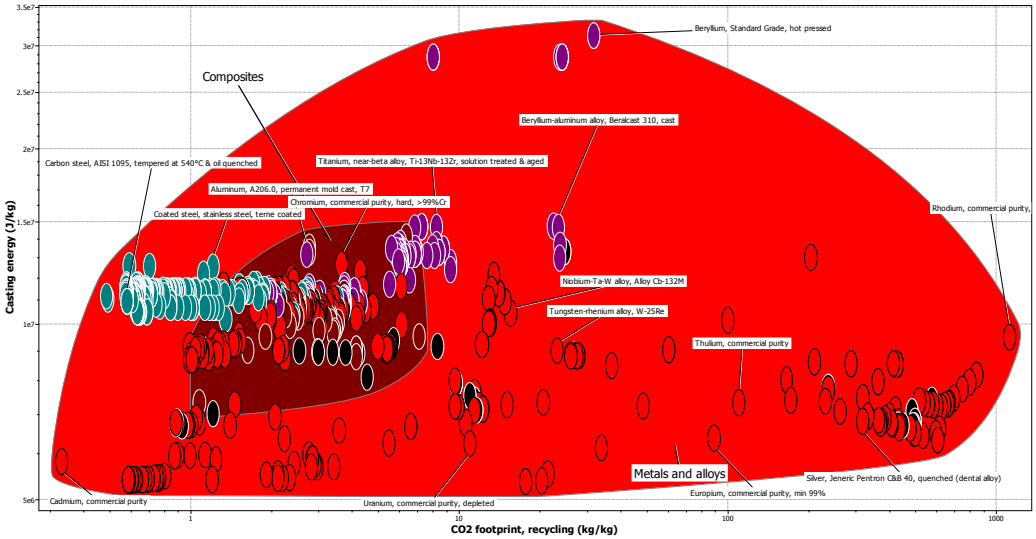


Figure 4. Ashby diagram casting energy (J/kg) vs CO2 footprint, recycling (kg/kg)

***Recyclability**:* Materials that are more easily recycled contribute to a circular economy, reducing waste and preserving the environment for future generations. Materials like **aluminum** and certain **polymers** are excellent candidates for recyclability.

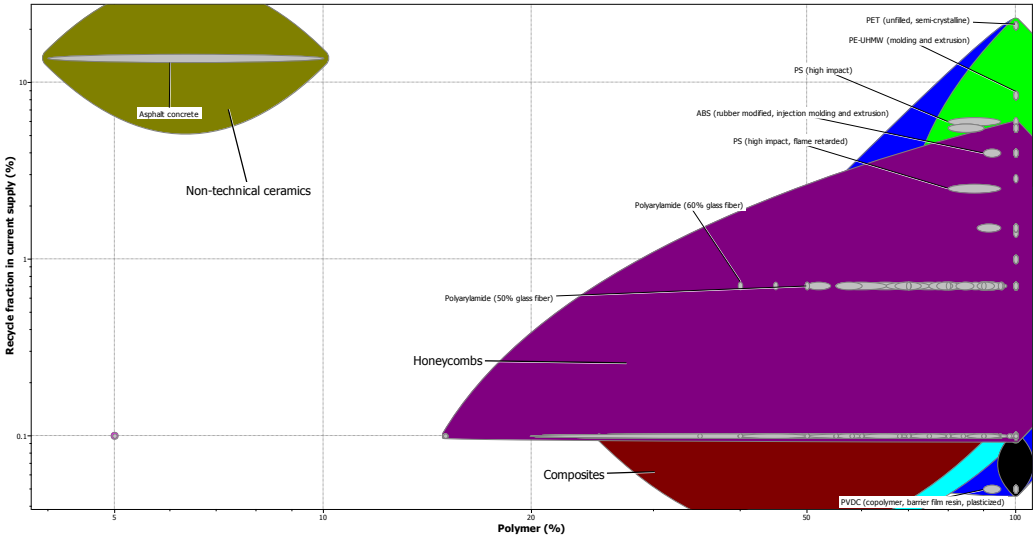


Figure 5. Ashby diagram recycle fraction in current supply (%) vs polymer (%)

Quality of Life Impact: Cleaner production processes (figure 5) and reduced landfill waste directly improve air and water quality, which enhances public health.

Application 2. Health and Safety

Biocompatibility: Materials used in healthcare, such as in medical devices or implants, need to be biocompatible. The selection of **biocompatible materials** (e.g., specific polymers or ceramics) reduces adverse reactions in patients and improves medical outcomes.

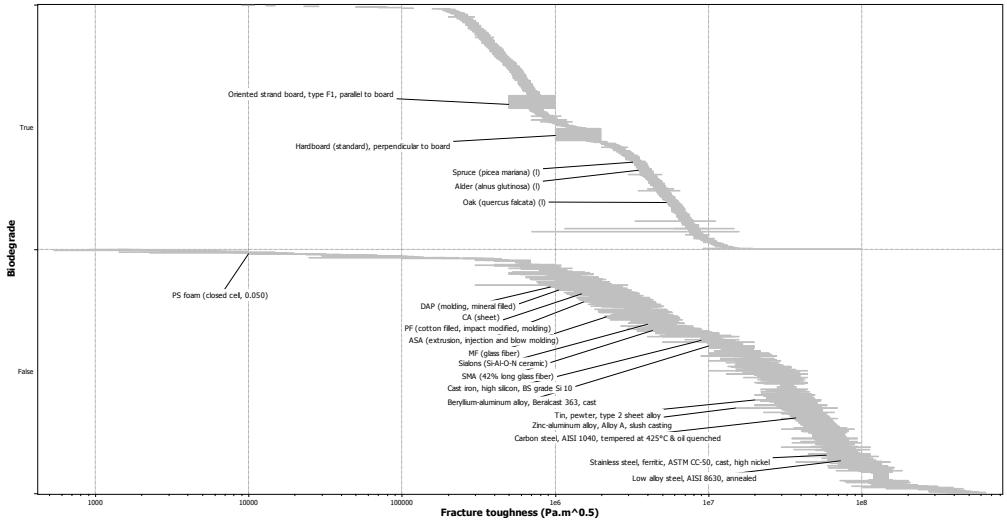


Figure 6. Ashby diagram biodegradability vs fracture toughness (Pa.m^0.5)

Ashby Chart example in figure 6: chart comparing **biodegradability vs fracture toughness** can help in selecting materials for medical devices.

Safe Structures: The materials chosen for infrastructure—bridges, buildings, or transportation systems—affect the overall safety and longevity of these structures. Stronger, more resilient materials reduce the risks of failures and accidents, which directly correlates with better safety and quality of life.

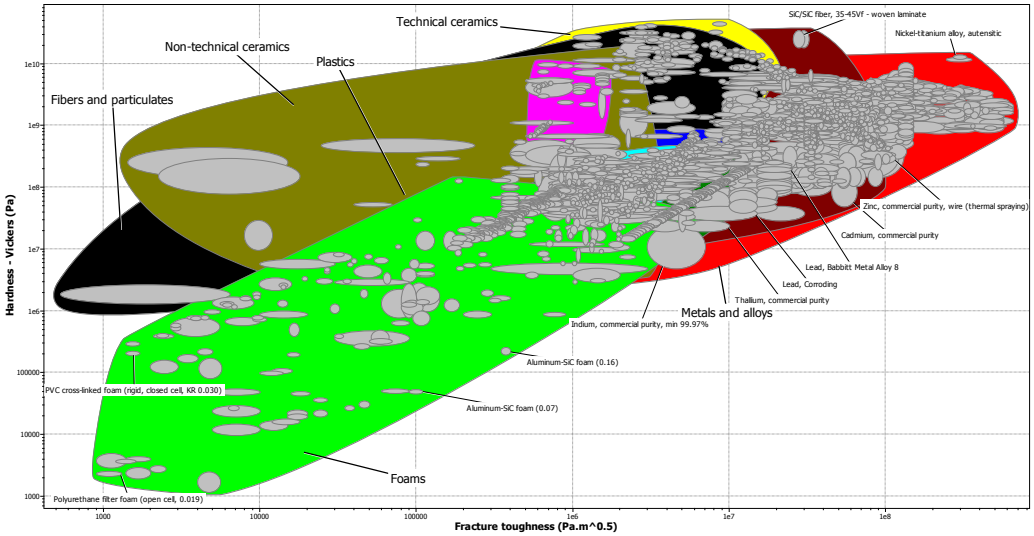


Figure 7. Ashby diagram hardness – Vickers (Pa) vs Fracture toughness (Pa.m^0.5)

Ashby Chart example in figure 7 shows a comparison between **fracture toughness** vs. **density** or **strength** that are critical in selecting materials for construction projects.

Application 3. Economic Development and Affordability

Cost-Effective materials shows that affordability plays a large role in accessing high-quality products and infrastructure, by selecting materials that offer the best equilibrium between **performance** and **cost**. Engineers can design affordable transportation, housing, and consumer goods, making them accessible to a wider population.

Ashby chart example: price vs. compressive strength diagram can guide through decisions that balance cost-effectiveness with performance.

Durability and Lifespan: Materials that are more durable reduce the need for frequent replacements or repairs, leading to long-term savings. These savings can be redirected to other areas of social development, improving the overall quality of life. **Ashby** chart example: wear resistance vs. cost or corrosion resistance charts help in choosing materials that last longer under specific conditions.

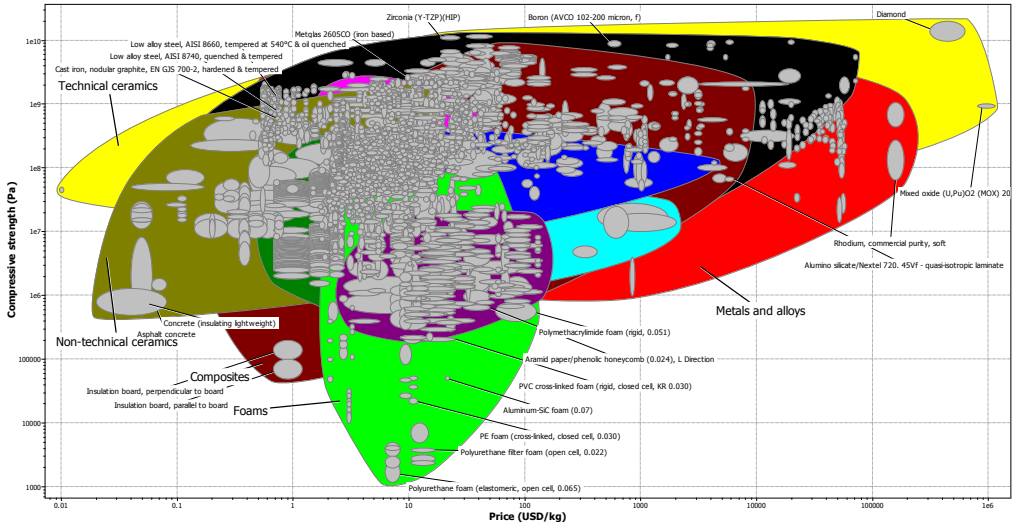


Figure 8. Ashby diagram compressive strength (Pa) vs price (USD/kg).

Application 4. Technological Advancement and Comfort

Advanced materials for better products such as the development of lightweight, high-strength materials like *composites* and *advanced polymers* have led to innovations in transportation, energy, and consumer electronics. These materials improve the energy efficiency of cars, planes, and gadgets, making everyday life more convenient and comfortable. Ashby chart example: stiffness vs. density charts help in identifying materials that improve performance in applications like electric vehicles, smartphones and wearables.

Improved Living Conditions with materials that provide better insulation, noise reduction, and air quality directly improve indoor environments, contributing to health and comfort. Examples include materials used in building insulation (e.g., **polymers**, **foams**), which help reduce energy use while enhancing living comfort. Ashby chart example: thermal conductivity vs. density charts help in selecting materials for thermal insulation in homes and offices.

Application 5. Energy Efficiency and Resource Use

Energy Savings: Choosing materials that improve energy efficiency (such as in construction or transportation) helps reduce the overall energy consumption of a society, which is directly linked to lower utility costs and better environmental outcomes. Lower energy consumption also means fewer fossil fuel emissions, leading to cleaner air and improved public health. Ashby chart example: thermal insulation properties of materials can be evaluated by comparing thermal conductivity vs. cost.

Renewable Energy Infrastructure: Material selection for **wind turbines, solar panels**, and **battery** impacts the efficiency and longevity of renewable energy systems. Better energy generation and storage enhance access to affordable, clean energy, which is vital for raising the standard of living globally. Ashby chart example: stiffness vs. strength charts for turbine blades or energy density for battery materials.

Application 6. Accessibility and Equality

Affordable Products for All: The strategic selection of low-cost, high-performance materials allows for the production of affordable goods, helping bridge the gap between rich and poor communities. Access to affordable, durable materials for housing, transportation, and consumer goods improves the quality of life for marginalized populations. Ashby chart example: Diagram showing cost per unit performance help in balancing performance needs with economic constraints, leading to cost-effective products.

Conclusions

The interplay between advanced materials and innovative technologies is reshaping the landscape of quality of life across multiple dimensions. From healthcare advancements that improve patient outcomes to sustainable materials that address environmental challenges, the contributions of these innovations are extensive and far-reaching.

In essence, materials directly influence the functionality, affordability, and sustainability of the products and infrastructure that shape modern life. Through Ashby's diagrams, we can systematically approach these decisions to balance performance, cost, and environmental impact for a better quality of life.

As research continues to evolve, the potential for advanced materials to further enhance quality of life remains significant, promising a future where technology and materials science work hand in hand to create a better world for all.

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Biopolymers from Industrial Food Wastes: A Review

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Abstract

All food wastes discarded into the environment are biodegradable and compostable, but since they have not found the suitable applications, they accumulate in the environment and have become a serious global issue. At the same time, the alarming global issue regarding plastic wastes remained unsolved. A very good solution to these two major issues is the use of food waste to create biopolymers and their further application in various domains in order to replace conventional petroleum-based polymers. This review explores the potential of utilizing food waste from various sectors of the food industry such as wine industry, vegetable canning industry, the salami and sausage industry, oil industry, beer industry, milk industry and others for biopolymer production. By utilizing food waste from these diverse sectors, it can be created a multitude of biopolymers with various properties. These bio-based alternatives offer a sustainable solution to replace conventional petroleum-based plastics used in packaging, consumer goods, leather substitutes, adhesives and other applications. This approach not only reduces the reliance on fossil fuels, but also addresses the growing problem of food waste management in order to minimize their environmental impact at the end of their lifecycle.

Keywords: *plastic waste, food waste, environmental protection, biopolymers.*

1. Introduction

With the technological development and innovations in the field of plastic materials and their applications on a large scale in all domains, not to mention the packaging industry, respectively the global problem of the plastic waste also occurred. The pollution with plastic materials has become one of the most acute and alarming issues related to the protection of the environment with the very rapid increase in the use of these types of materials. The plastic waste can be found everywhere, on the fields, hills, mountains, forests, rivers, lakes, seas, oceans etc. These types of waste include food packaging, electronics and household appliances, medical equipment, toys, sports equipment, car components, plastic piping, irrigation tubing, clothes hangers and many, many others.

The plastic waste exhibits the plastic synthetic materials made of fossil fuels, which are not biodegradable and compostable and for this reason they

persist for a very long time in the environment being resistant to weather conditions regardless of season and location, but at the same time these wastes accumulate more and more. To fully degradation of these materials, it takes many, even hundreds of years, but in the meantime they break, crumble and they are scattered everywhere, being carried by the wind or the flowing waters of the rivers, even reaching the peaks of the highest mountains or the deepest places of the seas and oceans, affecting the life of the animals, birds, fishes and people.

Also, it must be taken into consideration that in recent years the improvement of the properties of plastic materials has been pursued by adding different types of additives and/or fibers for a certain domain of their applications depending on the operating conditions of the components made of respective material, which also leads to the increase of their resistance in the environmental conditions in which they are discarded. Generally, the wastes made of thermosetting polymers (epoxies, unsaturated polyesters, phenol formaldehydes and polyamides) cannot be routinely recycled and they are difficult to remove, but they can be incinerated to produce electricity and heat, or to be used in road construction, while the thermoplastic polymers (polyethylene, polypropylene, polystyrene, polymethyl methacrylate, polyvinyl chloride, polytetrafluoroethylene, polyethylene terephthalate and polycarbonate) and rubbers (polybutadiene, polychloroprene, styrene-butadiene and silicone rubber) can be collected and recycled. Waste thermoplastic polymers can be recycled into a variety of products, such as plastic containers, tubes, bags and many other types of packaging and consumer goods. They can also be used in the automotive industry for car bodies, seats and other machinery components, in construction to manufacture the roof tiles, wall panels and sewer pipes and they can also be transformed into children's toys and other household items such as clothing and furniture accessories. Rubber wastes can be used to produce heat or electricity by burning, they can also be used to make automotive components such as shock absorbers, tires, gaskets etc., it can be used in art and decoration for sculptures and furniture pieces or they can be turned into rubber granules to produce new products as rubber carpets, playground flooring, surfacing and tiles, street paving etc.

Unfortunately, the process of collecting and recycling of thermoplastics is not profitable and attractive, because it has a higher cost than the production of new ones and, for this reason, a very small percentage of waste is processed compared to the amount of what is produced (Bunea, 2017). The spread of plastic waste is the most visible in underdeveloped countries, whose systems of plastic waste collection and processing are inefficient or inexistent.

Another very important problem related to environmental protection is the food wastes, even if they are biodegradable and compostable, they are very dangerous due to the microbial degradation impact (Gautam et al., 2022). There are many causes that lead to the appearance of food waste: agricultural production, storage, distribution, processing, manufacturing, food services and consumer behavior. The factors that lead to the appearance of food waste in the case of agricultural production are losses due to unfavorable climatic conditions (drought, floods, frost, excessive heat and strong winds/storms), diseases (scabies, diarrhea, mastitis, respiratory diseases, the most serious of which from recent years being swine fever and avian flu etc.), pests (rodents, insects, fungi, bacteria and viruses) and the application of inefficient practices as a result of which the quality of the products does not meet the standards.

Degradation of food products can also occur due to improper storage conditions such as temperature not corresponding to the recommendations that can accelerate the degradation of products or their freezing, humidity that can cause the appearance of mold and fungi or drying and dehydration, excessive light that can lead to the loss of vitamins and other nutrients, the unpleasant smell that can be absorbed by certain products, exceeding the limited storage period that can lead to the loss of nutritional value and inadequate packaging that can allow air and moisture to penetrate. The distribution of the foods also can lead to the waste occurrence due to overstocking, expiration date and damage during transportation. As a result of the processing and manufacturing of food products, large amounts of waste are also generated, such as pomace in the wine industry; fruit and vegetable scraps, vegetable by-products, pulp and seeds in the vegetable canning industry; bones, meat scraps, fats and oils in the meat canning industry and the salami and sausage industry; fish scraps, fats and oils in the fish canning industry; seed cakes, extraction and refining residues and used oils in the oil industry; trub, yeast and residues in the beer industry and many, many others.

Food services (restaurants, cafes, bakeries, catering, canteens of educational institutions, prisons, children's homes, old people's homes and others) and consumer behavior lead to the generation of very large amounts of waste due to overbuying, overproduction, date expiration, improper handling and improper storage.

In order to protect the environment, food wastes can be reduced by using them in the manufacturing of the other products such as natural fertilizers for the soil by composting vegetable wastes, animal feed, biofuels, electricity or thermal energy through combustion and new products as those of bakery, pastry, confectionery, marmalade, jellies, sweets made of pulps and peels of

fruits. So, a very good alternative to reduce the plastic and food wastes is the usage of food waste in the production of biopolymers, which can replace the conventional petroleum-based plastics (Gautam et al., 2022; Ranganathan et al., 2020; Westlake et al., 2023).

2. Biopolymers

The biopolymers are natural polymers obtained from natural sources of vegetables, animals, insect, microbial or other origin. Natural polymers, depending on their ability to be decomposed into biomass by microorganisms in the natural environment (fungi, bacteria, viruses etc.), can be biodegradable and non-biodegradable, because their biodegradability does not depend only on the nature of the origin source, but also on the chemical composition, molecular structure, temperature, humidity, type of microorganisms presented in that environment. Not all biopolymers are biodegradable even if they are made from 100% biodegradable and renewable resources. Generally, the biodegradable biopolymers meet the requirements regarding the environment protection, but they have limited electrical, thermal, chemical and mechanical properties. The use of fillers in their structure improves the targeted properties, but it can be affected their compostability and biodegradability.

A scheme of the biopolymer classification according to their origin and biodegradability is showed in figure 1, where it can be seen that they present three main classes: natural biopolymers, microbial biopolymers and synthetic biopolymers. The natural and microbial ones are biodegradable, while the synthetic ones are non-biodegradable.

The *natural biopolymers* are produced from renewable bio resources partially modified according to the desired properties:

- *plant polysaccharides* as wheat starch (Mohammed et al., 2021), potato starch (Dawam Abdu et al., 2018), rise starch (Laftah & Wan Abdul Rahman, 2021), corn starch (Hazrol et al., 2021) and beans starch (Salmoral et al., 2000); cellulose from wood and straw (Reimer et al., 2021), alginate from brown seaweeds (Abourehab et al., 2022) and carrageenan from red seaweeds (Sudhakar & Bargavi, 2023);
- *animal polysaccharides* as chitin (Liao et al., 2023) and chitosan from exoskeletons of crustaceans and insects (Sady et al., 2021) and hyaluronan from animal and bird tissues (Šedová et al., 2013);
- *plant proteins* as potato (Jung et al., 2023), corn (Tortorella et al., 2021), wheat (Fitriani et al., 2021), soy (Ly et al., 1998) and pea (Hadidi et al., 2022));

- *animal proteins* as leather (Ballús et al., 2022), albumin (Pápay et al., 2021), collagen (Hassabo et al., 2022) and gelatin (Panwar et al., 2022) of the birds and animals; casein (Xu & Gowen, 2019) and whey (Kawecka-Radomska et al., 2015) from dairy products;
- *others* as lignin (Chowdhury et al., 2021), lipid (Yu, 2011) and polylactic acid (PLA) (Swetha et al., 2023).

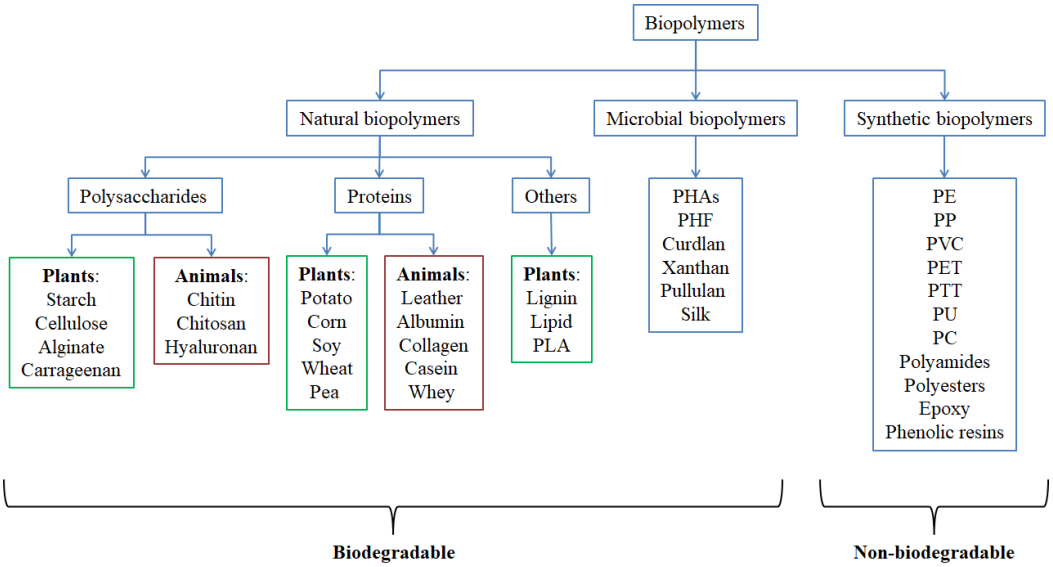


Figure 1. The classification of biopolymers based on their origin.

Herein, the most commonly used natural biopolymers are presented.

Derived from plants, *starch-based polymers* are natural thermoplastic polymers with a semi-crystalline structure. These bioplastics are built from two sugar molecules: amylose and amylopectin, with the proportions varying depending on the plant source. Within the polymer's structure, amylose forms less organized regions, while amylopectin creates the more ordered, crystalline areas. Unlike traditional plastics, starch won't dissolve in water, but it can absorb water to form a thick gel. However, these bioplastics have a downside: they can become more brittle over time due to a natural process called retrogradation. To address this brittleness and enhance their overall performance, manufacturers have developed a two-pronged approach. First, they incorporate special additives called plasticizers, which improve flexibility and counteract the stiffening effect. Second, they might employ chemical treatments to modify the starch structure. These treatments can reduce the material's water sensitivity, preventing it from falling apart when it comes into contact with water. By combining these methods, scientists are creating starch-

based bioplastics that are not only eco-friendly but also more robust and functional for various applications.

The cellulose-based polymers are formed by dissolving a chemically modified cellulose pulp such as cellulose xanthate or cellulose acetate (Bajpai, 2018). Compared to starch-based polymers, these biopolymers exhibit a higher degree of crystallinity and therefore they exhibit higher hardness and tensile strength, but low processability. The cellulose with high purity and strength can be also obtained by using a certain type of bacteria, being able to be used in the production of relatively high strength articles, but its applications are quite limited due to the high price. The applications of bacterial cellulose include packaging, adhesives, paints, acoustic diaphragms, and others (Babu et al., 2013).

The polymers based on chitin and chitosan are the random or block copolymers depending on the distribution of N-acetyl-glucosamine and N-glucosamine monomers joined by a β-(1,4)-glycosidic bond depending on the applied manufacturing method (Min et al., 2015). If the number of N-acetyl-glucosamine units of biopolymer exceeds 50%, it is denoted chitin, otherwise chitosan. The chitosan does not dissolve in water, but it can be dissolved in dilute mineral acids (sulfuric and hydrochloric acids) and in dilute solutions of organic acids (citric, acetic, lactic, formic etc.) (Niaounakis, 2015).

The most commonly used *protein-based polymers* are the ones produced from collagen and gelatin. The collagen is usually obtained from pig or cattle skin, cartilage and bones, and the gelatin is obtained by hydrolysis of collagen (Babu et al., 2013).

The lignin-based polymers are obtained from lignocellulosic biomass through chemical and refining processes, being the second most abundant polymer on Earth after cellulose (Ragauskas et al., 2014). The lignin degrades more slowly than cellulose, starch and proteins (Haider & Guggenberger, 2005).

The polylactic acid (PLA) is obtained by bacterial fermentation of corn, potato or rice starch, sugarcane or other unprocessed renewable sources or waste. It can be obtained various PLAs depending on the degree of crystallinity, from pure amorphous ones to those semicrystalline with a very high degree of crystallinity. This polymer exhibits specific characteristics as glossy appearance, good transparency, tolerance to different processing conditions and high stiffness (Babu et al., 2013). Compared to synthetic polymers as PE, PET, PS, PP and others, the polylactic acid has almost similar mechanical properties and it can replace them in various applications, but it have to take into account that they have poor thermal resistance due to low glass transition (~ 60°C).

The *microbial biopolymers* are produced from renewable and biodegradable resources by various microorganisms and through bacterial fermentation. The most commonly used biopolymers of this group are the *polyhydroxyalkanoates (PHAs)* obtained by bacterial fermentation from various renewable waste raw materials as agricultural waste and vegetable oils. These polymers can be also produced by bacterial fermentation using sugar and lipids. Generally, the PHA films exhibit the good gas barrier properties and UV resistance, but low resistance to acids and bases. Polyhydroxyalkanoates can be both homopolymers and copolymers, of which the simplest homopolymer is polyhydroxybutyrate (PHB), which is rigid and brittle due to its high degree of crystallinity. The first natural polymer produced from the polyhydroxyalkanoate family was poly-3-hydroxybutyrate (P3HB), which exhibits thermal and mechanical properties similar to polypropylene (PP) and polystyrene (PS), but with limited applications due to long process of polymerization, small processing temperature range and creep tendency. The P3HB is a semicrystalline biopolymer with a high degree of crystallinity (~ 80 %), and orthorhombic crystal system (Yokouchi et al., 1973). In order to reduce the degree of crystallinity, it is manufactured the copolymers of PHB with monomers of hydroxyvalerate (HV) or hydroxyhexanoate (HH). These copolymers present greater flexibility and easier processability compared to P3HB, being able to replace synthetic plastics as polypropylene (PP), polyethylene (PE) and polyethylene terephthalate (PET) (Laycock et al., 2013).

The *synthetic biopolymers* includes the natural non-biodegradable thermoplastic polymers PE, PET, PTT, PP, PS etc. with similar structure and chemical, thermal and mechanical properties to conventional petroleum-based thermoplastics of the same name. So, the *bio-polyethylene (bio-PE)* consists of ethylene derived from bioethanol obtained by microbial fermentation of renewable natural sources such as sugarcane, sugar beet, wood, starch and other plant waste (Radovanović, 2023). The *bio-propylene (bio-PP)* is manufactured from sugar cane, vegetable oil and other biomass. The *bio-polyvinyl chloride (bio-PVC)* is made up of 43% ethylene derived from bioethanol and 53% chlorine (Shen et al., 2009). The *bio-polyethylene terephthalate (bio-PET)* is obtained by the polycondensation reaction of monoethylene glycol and dimethyl terephthalate or pure terephthalic acid. The sugar is used to obtain both components, excepting terephthalic acid, which is petroleum based component.

3. Biopolymers from industrial food waste

Depending on the waste generated by each branch of the food industry, it is possible to determine the types of biopolymers that can be obtained. Herein, in figure 2, it is presented schematically the types of biopolymers that can be obtained from food waste for some branches of food industry.

The wastes of *sugar industry* suitable for biopolymer production are bagasse, molasses and filter cake. The bagasse is a residue made of dry pulpy fibrous material resulted after the crushing of sugar beets in order to extract the juice. The filter cake is a solid residue resulted after filtration process during the sugar production. They are rich in cellulose, hemicellulose and contains lignin (Jayasekara et al., 2022), which can be used to produce cellulose, hemicellulose and lignin-based biopolymers. Also, trough fermentation process of sugar obtained by hydrolysis of pretreated bagasse and filter cake, it can be produced polyhydroxyalkanoates (PHAs) and polylactic acid (PLA) as the lactic acid can be produced from sugarcane bagasse in particular (Agrawal & Kumar, 2023). Also, the microbial biopolymers PHAs can be obtained by sugar fermentation of molasses (Kiselev et al., 2022), which is a byproduct of the sugar resulted after refining process. The wastes of beet sugar industry can be used to obtain ethanol. Through a series of transformations, leftover ethanol can be converted into ethylene, a key building block for bio-polyethylene (bio-PE).

The *natural juice industry* and *vegetable canning industry* generate food wastes as leaves, peels, seeds, pulp, fibers, spoiled vegetables and fruits, pomace (mixture of leftover pulp, seeds and peels after the juice extraction) and oils. The biopolymers obtained from wastes of natural juice industry are the pectin, cellulose, hemicellulose, lignin (Okoro et al., 2021) and cutin (Simões et al., 2023) extracted from fruit and vegetable peels and pomace, PHAs derived by microbial fermentation of fruit wastes (H. Liu et al., 2021) and bio-polyethylene produced from ethanol obtained by fermentation of pretreated and hydrolyzed fruit wastes. The same biopolymers can be obtained also from wastes generated by vegetable canning industry. Other biopolymers derived from these food wastes are the starch extracted from potato peel (Y. Liu et al., 2022), residual corn, bean, peas, rise and wheat, and the vegetable proteins extracted from residual vegetable peels, pulp, seeds, cereal grains and legumes. The extracted starch can be converted into PLA by various fermentation techniques and polymerization process.

The grape stalks (Spigno et al., 2008), wine pomace (mixture of leftover grape peels, seeds and stems after winemaking process) and wine lees (sediment of yeast and other particles that settle at the bottom of wine during

fermentation and aging) are the wastes generated by *wine industry*. The grape stalks and wine pomace can be used to obtain the biopolymers, because they contain cellulose (Coelho et al., 2020), hemicellulose, pectin, lignin (Spinei & Oroian, 2021) and tannin. The wine lees resulted from wine production contain yeast biomass, which can be used to produce the biopolymer such as chitin. Further the extracted chitin can be processed to produce chitosan. The wine lees can be a source to obtain PLA by fermentation and the microbial biopolymers PHAs can be obtained from wine pomace (Nanni et al., 2021). Also, it can be obtained the ethanol from wine wastes, which further can be transformed into bio-polyethylene (bio-PE) by polymerization process.

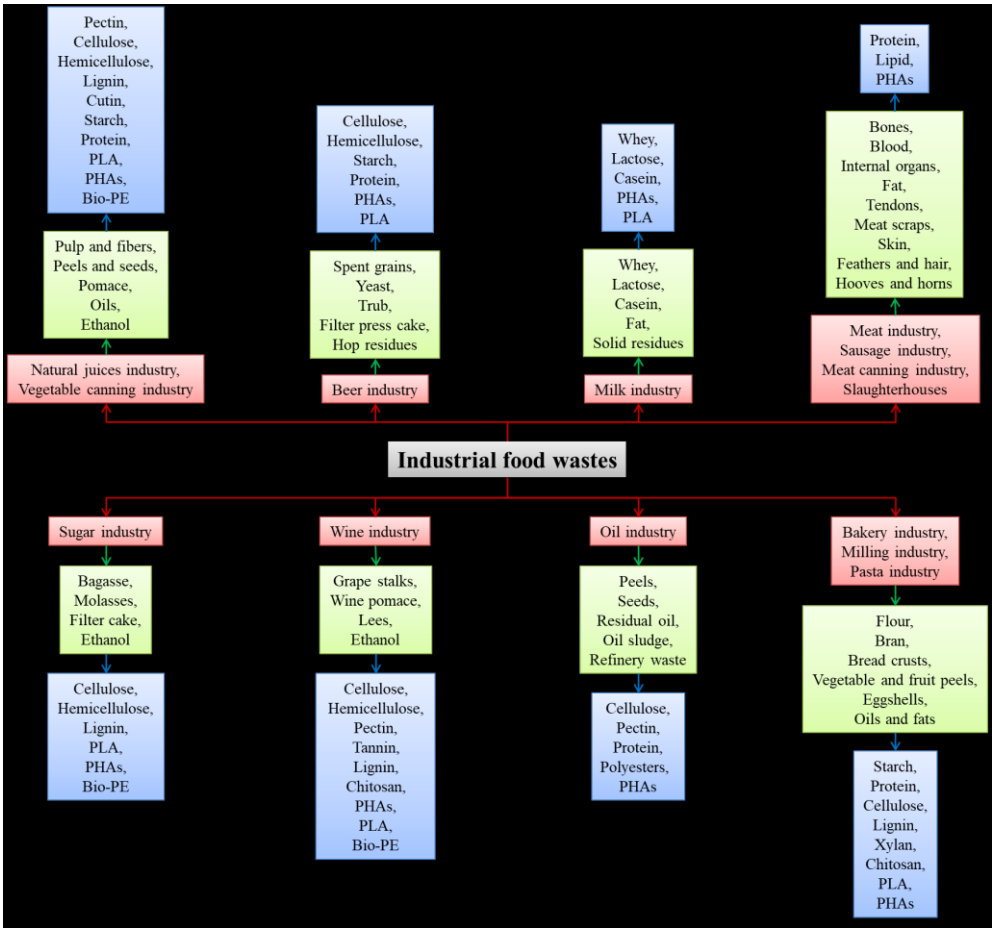


Figure 2. The biopolymers obtained from industrial food waste.

The *beer industry* (Monteiro Claudia C.F. et al., 2021) generate wastes such as spent grains, trub (brewing - sediment that settles at the bottom of fermenting vessels after the beer fermentation), yeast, filter press cake (byproduct of the filtration process containing spent grains, yeast and other

solid particles) and hop residues. So, the biopolymers as cellulose, hemicellulose and protein-based polymer can be obtained from spent grains filter press cake and hop residues. The PHAs can be produced through bacterial fermentation of spent grain (Carvalheira et al., 2022) and PLA can be derived from the spent grain, trub and yeast (Laboratory of Fermentation Technology, Federal Institute of Education, Science and Technology of Rio de Janeiro, Senador Furtado Street, Rio de Janeiro, RJ, Brazi et al., 2017).

The food wastes such as peels, seeds, residual oil, oil sludge and refinery waste are generated by *oil industry*. Peels, seeds and refinery waste can be used to produce cellulose-based polymers, pectin based-polymers, protein-based polymers and bio-based polyesters. The microbial biopolymers as PHAs can be obtained from residual oil and oil sludge (Luka Yelwa Barde & Husseini Adamu, 2021).

The whey, lactose, casein, fat and other solid residues are the food wastes generated by *milk industry*. So, the whey, lactose and casein are used to produce the whey-based polymers (Chalermthai et al., 2019), lactose polyurethanes (Cheng et al., 2022), and respectively casein-based polymer. The fat and other solid residues can be used to obtain milk fat globule membrane (MFGM) (Snow et al., 2010). The whey is used to produce PHAs by microbial fermentation. Also, the whey, lactose and other byproducts which may not meet the quality standards can be used to produce lactic acid through the fermentation, further being converted into PLA.

The food wastes created by *bakery industry, milling industry* and *pasta industry*, which can be used to produce the biopolymers, are the flour that does not meet the quality standards (Esposito Corcione et al., 2020), bran (milling byproduct composed of the outer shell of cereal grains) (Mense et al., 2020), bread crusts, vegetable and fruit peels, eggshells, oils and fats. The flour waste can be used to extract the starch, which further can be processed to produce starch-based biopolymers. The flour residues also contain proteins as gluten that can be extracted and processed to obtain protein-based biopolymers. The bran can be used to produce cellulose-based biopolymers, hemicellulose-based biopolymers (Sutay Kocabaş et al., 2021), lignin-based biopolymers and xylan-based biopolymers. In order to create cellulose-based biopolymers and protein-based biopolymers, it can be used also the bread crusts, which are often removed during food preparation. The eggshells habitually discarded as wastes can be utilized by treating them with acid to obtain the biopolymers such as chitosan. The eggshell membranes contain proteins, which can be extracted and used to produce protein-based biopolymers (Torres et al., 2010). The waste

generated by bakery industry, milling industry and pasta industry can be used also to develop biopolymers by fermentation as PLA and PHAs.

The *meat industry, sausage industry, meat canning industry* and *slaughterhouses* generate the food wastes such as bones, blood, internal organs, fat, tendons, meat scraps, skin, feathers, hair, hooves and horns suitable to produce biopolymers. The bones, internal organs, tendons, meat scraps, skin, connective tissues and hooves contain the main protein collagen that can be used to create collagen-based biopolymers. The blood can be used to develop protein-based biopolymers. The skin, feathers, hair, hooves and horns can be used to produce keratin-based biopolymers (Kumar & Sharma, 2019). The bird and animal fat being an important source of lipids can be used to develop the lipid-based biopolymers and PHAs through microbial fermentation.

4. Conclusions

Very large amounts of waste generated by all branches of the food industry are discarded into the environment and only a very small part of them have found suitable applications such as the production of energy, heat, biofuels, ethanol, by-products for other food products or animal feed. Therefore, the use of industrial food waste to obtain biopolymers is a promising way to reduce both food waste and plastic waste and it offers us the chance to live in a cleaner and healthier environment. Following the study carried out, it can be observed that almost all types of food waste can be transformed into bio-based polymer materials. In reality, natural and microbial biopolymers present inferior properties compared to those of conventional petroleum-based thermoplastic materials, but they can be improved by adding plasticizers, fillers or by applying certain treatments without affecting their compostability and biodegradability.

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Newly Composite Materials for Wastewater Decontamination, as Sustainable Solution for Better Quality of Life: An Overview

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Abstract

In recent years, global population growth and industrialization have led to a rapid improvement in the quality of human life, placing high pressure on water resources. The expansion of economic activities in industrial, medical, and agricultural sectors has resulted in an increasing demand for freshwater. The overall changes in both temperature and weather patterns, coupled with the improper disposal of industrial wastewater, are affecting the quality and quantity of freshwater, a necessary resource for life on Earth. The main sources of wastewater include municipal, agricultural, domestic, and animal waste, as well as contaminants from chemical, pesticides, and oil industries. For example, only 70% of the total freshwater supply is used for agricultural activities. These industrial domains released many contaminants into water sources, such as lakes, rivers, seas and oceans. At the European level, efficient and rigorous legal frameworks have been implemented to reduce water pollution through proper waste management and monitoring procedures. Despite these adopted severe measures, just 40% of European surface water sources currently comply with the ecological strandards. The key-factors for this issue consist in the construction of multiple wastewater treatment plants, the development of effective and low-cost technologies, and the composite materials utilization. The goal of this paper is to explore some ecological, biodegradable and inexpensive solutions for efficiently removing impurities from water and wastewater. Zeolite-based composites have unique properties owing either to the proper materials asociation (named matrix and fillers) or modifications with different functional agents. Zeolite composites modified with graphene, chitosan and cellulose as biosorbents are discussed in this paper in terms of adsorption efficiency.

Keywords: *wastewater treatment, biosorbent, zeolitic composite, adsorption, sustainability.*

1. Introduction

All environmental elements are closely interconnected, making them unavoidably subject to pollution. Life on Earth originated in the hydrosphere, which continues to support vital processes for humans, plants and animals. Water is the only natural irreplaceable component of the biosphere. For daily human consumption, drinking water is necessary to be of high quality to ensure

a good standard of living. Beyond its indispensable role as the universal solving agent, water also serves as a medium for transmitting different infections because of sanitation lakes (it was registered that approximately 80% of diseases stem from poor water quality, according to World Health Organization) [Haseena *et al.*, 2017; Lin *et al.*, 2022].

Over the past few decades, demographic growth (from 5.3 billion in 1990 to 8.1 billion in 2023), along with accelerated industrialization and urbanization, has placed immense pressure on global water resources [Xu *et al.*, 2022]. In these conditions, the benefit of a high degree of quality of life is balanced by several inconveniences, such as intensively domestic and industrial activities, a continuously increasing demand of freshwater amount by 1% every year, beginning with 1980's [UNESCO, 2021], water pollution, and wastewater generation [Ameen *et al*., 2021]; and all of these in detriment of human's health and ecosystems degradation [Ahmed *et al.*, 2022]. Polluted water often contains critical concentrations of contaminants, making it not fit for human consumption and other activities [Kaiser *et al.*, 2013]. Approximately one-third of the world's available freshwater is used by industries. Thus, the main sources of generated pollutants include: industrial landfills, sewage and oil runoff, wastes from stock raising, chemical agents used in agriculture, rock weathering, and naturally decomposable garbage. Therefore, an increasing degree of water polluted with toxic and non-biodegradable effluents, such as heavy metals and organic matter, was observed [Shoumkova, 2011; Chen *et al.*, 2020; Karaman *et al.*, 2022; Obayomi *et al.*, 2023]. To mitigate the impact of water pollutants on ecosystems and conserve the available water resources, researchers have developed and proposed different engineering solutions. Despite the adopted severe regulations, less than 40% of European surface water sources comply with ecological standards, and is loaded with micropollutants from industrial and municipal wastewater, difficult to be decomposed by means of standard technics application [Falås *et al.*, 2016; Lin *et al.*, 2022]. Jabeen *et collab.* reported that 1.1 billion people in Southern Asia consume un-treated drinking water [Jabeen *et al.*, 2015]. Later, World Health Organization (WHO) stated that 2.5 billion people do not have access to sanitized water resources [Dutt *et al.*, 2020].

Recent studies categorize advanced and efficient methods for removing contaminants from industrial wastewater into three classes: a) *physicochemical methods* – these include adsorption [Karimi *et al*., 2022], ion exchange [Ali *et al.*, 2023], membrane filtration [Calabrò *et al.*, 2021], nanofiltration [Hembach *et al.*, 2019], (electro)coagulation [Precious Sibiya *et al.*, 2021; Tahraoui *et al.*,

2024], and desalinisation [Rahighi *et al*., 2022; Günay *et al*., 2022]; b) *chemical methods* – these involve oxidation [Ribeiro *et al.*, 2015; Hübner *et al.*, 2024] and photocatalysis [Ameen *et al*., 2021]; c) *biological methods* – these include aerobic [Cebeci *et al.*, 2016] and anaerobic degradation [Weide *et al.,* 2019].

The global shift in temperature and weather forecast, and uncontrolled depositing of industrial wastewater have affected both the quality and quantity of freshwater [Ahmed *et al.*, 2022]. As result of anthropic activities, over 3 billion ($t \cdot y^{-1}$) of solid wastes are annually released into the atmosphere, water bodies and soil, which is equivalent with 500 km^3 of wastewater capacity. Water pollution results in around 50 million deaths on a yearly basis, especially in African and Asian countries [Praveen *et al.*, 2016], with 75% of China's population still lacking access to safe freshwater [Charles and Pigott, 2002]. Air pollution with fine particulate matter (PM2.5) represents another risk factor which contributes to death and many disabilities, along with the rising and aging population (around 6.7 million of deaths, in 2019) [State of Global Air, 2020].

To limit contaminants from wastewater, some sustainable strategies for production and responsible waste management have been generally proposed: replacing conventional materials with biodegradable alternatives (nanocomposites); implementing ecological and efficient processes; expanding the number of sewage treatment plants; ensuring proper maintenance of equipment; and adopting low-cost techniques for material recycling to conserve natural resources.

In this context, zeolite composites are recommended for their efficiency in adsorption [Mirjavadi *et al.*, 2019], filtration, ion exchange, and photocatalysis, which help reduce toxicity from waters. Zeolites can retain both inorganic and organic compounds due to alumina's crystalline structure and silicate's large surface area, having more industrial applications. Zeolite-based composites have unique properties owing either the proper combination of materials (matrix and fillers) or their modification with different functional agents. Graphenes have been explored as a membrane material for its high mechanical stability during purification and desalinisation processes [Kandjou *et al.*, 2021]. Similarly, another intensely studied bio-agent is chitosan, playing an important role in metal cations adsorption and turbidity processes. A great attention is paid to cellulose-synthetized membranes for their effectiveness in metals and microorganisms separation [Das *et al.,* 2020; Jodeh *et al.*, 2021]. The goal of this paper is to compare three ecological and biodegradable composite materials in terms of impurities removal performance from

wastewater. Zeolite composites modified with graphene, chitosan and cellulose, as biosorbents, are selected and discussed in this work. Alongside other process parameters (temperature, concentration, time, kinetics), the structural configuration and morphology of these materials are very important and could influence their adsorption capacity. Imaging results were obtained by means of scanning electron microscopy (SEM) or transmission electron microscopy (TEM) methods.

2. Methodology

2.1. Materials

Natural *zeolites* are aqueous aluminosilicate minerals with a spatial tetrahedral crystalline nanoporous structure (Figure 1a) and a large active surface area. Their negative charge obtained through the substitution of Si^{4+} by Al^{3+} is balanced by alkali cations (K^+, Na^+, Mg^{2+}, Ca^{2+}), which can be replaced by heavy metal ions (Hg^{2+}, Pb^{2+}, Ni^{2+}, As^{3+}) in contaminated water [Bosso and Enzweiler, 2002]. In this paper, a great attention is focused on natural / artificial zeolite advantages, including their environmentally friendly properties, cost-effectiveness, radioprotective capabilities [Borai *et al.*, 2009], ion-exchange capacity, and adsorption efficiency [Mahmoodi and Saffar-Dastgerdi, 2019]. Unlike natural zeolites, synthetic zeolites possess a microporous and homogeneous structure tailored for industrial applications. These synthetic materials can be produced from clay or agricultural residues [Solihat *et al.*, 2020]. The physicochemical performance of the most important natural zeolites (Table 1) largely depends on their structure and network parameters. For example, mordenite, a zeolite with high Si content, exhibits greater stability at high temperatures, and in acidic mediums. On the other hand, zeolite water adsorption capacity increases with higher Al concentrations, porosity, free pore volume and specific surface area [Wei, *et al.*, 2013].

For this review, three carbon-based agents were selected for their excellent adsorption, selectivity, and extraction capacity, rendering them extremely useful for industrial wastewater treatment. We discussed about graphene and two biopolymers – chitosan and cellulose – used as fillers incorporated into a zeolite matrix. Among all known methodologies for wastewater management, studies showed that adsorption is a widely used method due to its effectiveness in removing both organic and inorganic ions, as well as its low-cost and accessibility [El Mouzdahir *et al.*, 2010; Badawi *et al.*, 2017].

Table 1. Physico-chemical characteristics of different natural zeolites type (Adapted from Likarec, 2003; Nizam et al., 2021).

Nr. Crt.	Zeolite type	Silicon-to-Aluminium ions ratio	Free pore volume [$cm^{-3} \cdot cm^{-3}$]	Pore size [Å]	Exchangeable cations	Cation-exchange capacity [$meq \cdot g^{-1}$]
1	Analcime	1.5÷2.8	0.18	2.60	Na^+	3.6÷5.3
2	Clinoptilolite	4.0÷5.7	0.34	nd*	Na^+, K^+, Ca^{2+}	2.0÷2.6
3	Mordenite	4.0÷5.7	0.28	16÷46	Na^+, K^+, Ca^{2+}	2.0÷2.4
4	Heulandite	4.0÷6.2	0.39	22÷28	Na^+, K^+, Ca^{2+}, Sr^{2+}	2.2÷2.5
5	Natrolite	1.2÷1.7	0.23	10.14	Na^+	2.9÷3.2
6	Erionite	2.6÷3.8	0.35	18.72	Na^+, K^+, Ca^{2+}	2.7÷3.4

*nd – Not determined

Both *graphene* and graphene oxide are carbon nanostructures sheet-like, often used in water disinfection procedures [Bano *et al.*, 2020], owing to their superior mechanical, physical and chemical properties. Despite their many advantages, zeolite-graphene oxide sheet nanostructures are an eco-friendly solution for removing Pb^{2+} and Methylene Blue from water [Farghali *et al.*, 2021]. Therefore, optimum graphene-zeolite association in terms of structure and adsorption performance have been investigated.

Chitosan is a bioactive polymer derived from chitin through a chemical N-deacetylation process carried out in a strongly alkaline solution and elevated temperatures (150°C) [Lizardi-Mendoza *et al.*, 2016]. Thanks to its advantageous properties, such as biocompatibility, bioresorbability, and biodegradability, chitosan becomes more versatile for a variety of industrial applications. Also, its specific structure (the presence of amino and hydroxyl reactive functional groups (Figure 1c)) pointed out its capacity to easily cross-link with polymer macromolecules, including zeolite, and forming new composite materials [Dutt *et al.*, 2020].

Cellulose, a natural biosorbent derived from chitin, is an excellent candidate for heavy metals elimination. Its structure is depicted in Figure 1d. However, due to its poor mechanical properties, a zeolite-cellulose composite membrane is recommended to enhance stability and separation efficiency in aqueous solutions [Rajesha *et al.*, 2017].

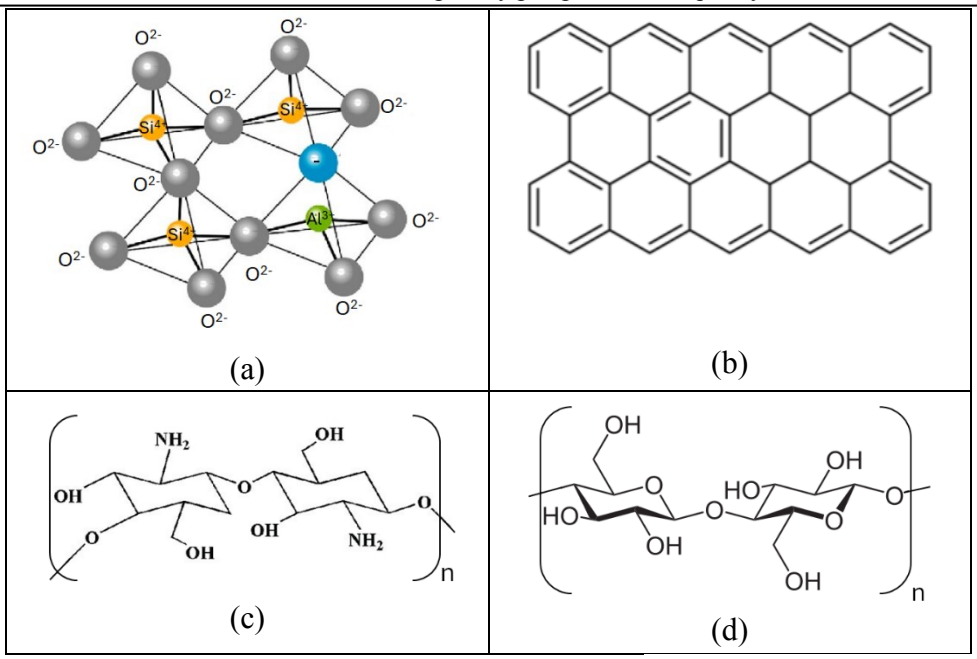


Figure 1. Chemical structure representation of (a) zeolite (Adapted from El Bojaddayni et al., 2023); (b) graphene (Adapted from Dutt et al., 2020); (c) chitosan (Adapted from Jain et al., 2013), and (d) cellulose (Adapted from Dey and Dey, 2021).

2.2. Methods

The first stage of the experimental part consists of the process of composite synthesis, applying the proper method to each studied material. The second stage – the surface morphology and texture analysis of zeolite-biosorbent composites, using SEM technique. Prior to imaging, all samples were coated with a thin metallic layer for resolution improving. Finally, the internal structure of new zeolite-based nanocomposites was evaluated by means of TEM technique.

3. Results and discussion

3.1. Morphological evaluation

To enhance the adsorption capacities of pollutants from industrial wastewater, an emerging technology which incorporates three types of biosorbents into zeolite matrix has been proposed.

Figure 2 shows SEM-TEM results of pure zeolite material, ientified as clinoptilolite (Figure 2a), and natural zeolite-based silver nanocomposites for MB dye in aqueous medium (Figure 2b) [Nizam *et al.*, 2021], which demonstrated its physical adsorptioncapability.

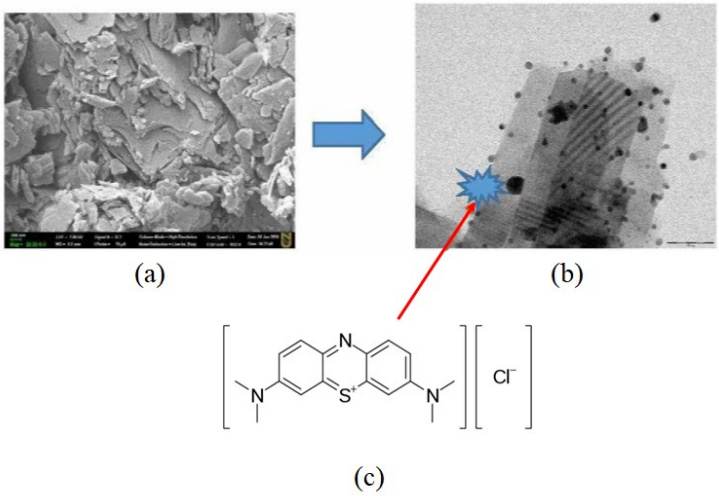


Figure 2. SEM-TEM imaging of zeolite-Ag nanocomposite: (a) natural zeolite; (b) natural zeolite-doped Ag nanoparticles; (c) methylene blue (Adapted from Kuntubek *et al.*, 2020).

The concordance between zeolit and filler materials, in terms of surface adsorption, will be presented in the following images.

Figure 3 illustrated the surface morphology of a graphene doped-artificial zeolite Na-A nanocomposite [Farghali *et al.*, 2021]. The crinkled appearance of graphene oxides is well adhered and uniformly distributed on the surface of the cubic crystals (Figure 3c). A detailed image (upper corner on right side) reveals a porous zeolite surface as a result of the interaction with an functionalization agent.

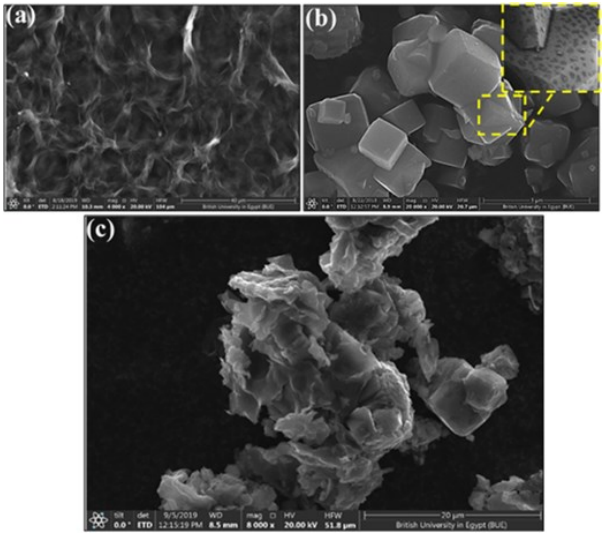


Figure 3. Surface morphology imaging of (a) graphene oxide; (b) artificial zeolite Na-A and (c) artificial zeolite Na-A-graphene nanocomposite (Adapted from Farghali *et al.*, 2021).

The artificial zeolites Na-A obtained from kaolinite exhibited a cubic structure (Figure 4a). The zeolite particles were then completely coated with cellulose fibers, indicating an increase in the active surface area of the newly obtained composite (Figures 4b and c) [Alipour *et al*., 2022].

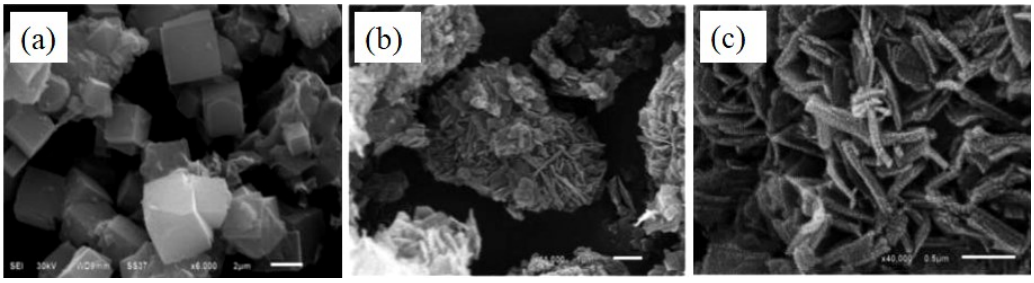


Figure 4. SEM micrographs of (a) artificial zeolite Na-A; (b) and (c) artificial zeolite-nanocellulose composite (Adapted from Alipour *et al.*, 2022).

Lefatle *et colab.* have studied the microstructure of zeolite-chitosan-Fe_3O_4 nanocomposite (Figures 5a–d). The chitosan sample exhibits a crinkled amorphous surface, while the nanocomposite displays granular-shaped aggregates resulting from the crystalline structures of zeolite and Fe_3O_4 [Lefatle, *et al.*, 2023].

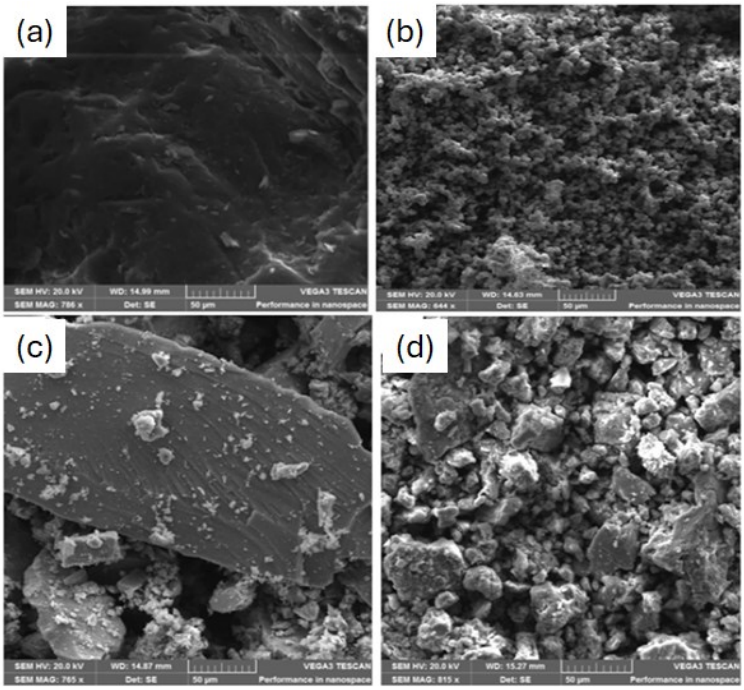


Figure 5. SEM micrographs of (a) chitosan; (b) zeolite; (c) Fe_3O_4 nanoparticles; (d) zeolite-chitosan-Fe_3O_4 nanocomposite (Adapted from Lefatle, *et al.*, 2023).

3.2. Adsorption performance

Table 2 summarizes experimental data regarding the contaminants adsorption capacity for zeolite-based nanocomposite adsorbents, which varies depending on the specific preparation method.

Table 2. Techniques used for functionalization of zeolite-based nanocomposites.

Adsorbent nanomaterial	**Technique**	**Adsorbate**	**Specific surface area [$m^2 \cdot g^{-1}$]**	**Adsorption capacity [$mg \cdot g^{-1}$]**	**References**
Natural zeolite	Natural	MB	403.0	64.80	[Sapawe et al., 2013]
Fe_3O_4-chitosan	Hydrothermal	Cu^{2+}	-	28.0	[Dragan et al, 2010]
		Co^{2+}	-	22.0	[Ngah et al., 2012]
Fe_3O_4-zeolite-chitosan	Sol-gel	Cr^{6+}	-	-	[Gaffer et al., 2017]
Zeolite-cellulose fibers	Mixing and centrifugation	Se^{6+}	456.4	163.0	[Ashraf et al., 2022]
		Se^{4+}		212.4	
		SeMt		109.3	
Zeolite-cerium oxide	Hydrothermal	MB	-	-	[Nyankson et al., 2020]
Zeolite-HDTMA	Co-precipitation	Benzen	-	-	[Bowman et al., 1995]
		Toluene			
		Xylene			
		Cu^{2+}	9.55	2.5	[Zekavat et al., 2020]
		Cr^{6+}		0.78	
		Nitro-phenols	2.53	-	[Guo and Wang, 2016]
Zeolite-graphene oxide	Hydrothermal	MB	-	666.7	[Farghali et al., 2021]
		Pb^{2+}		416.7	
Fe_3O_4-zeolite-multi-walled carbon nanotubes	Solvothermal	Pb^{2+}	286.0	37.8	[Gugushe et al., 2019]
		Tl		45.5	

Note: MB – Methylene blue; SeMt – Selenomethionine; HDTMA – Hexadecyltrimethyl ammonium

4. Conclusions

A state-of-the-art approach to industrial wastewater treatment involves integrating nanomaterials into zeolite matrix to form composites, thereby increasing their adsorption capacity and efficiency. Physico-chemical factors during the zeolitic composite synthesis process, structural parameters, material design, concentration of dopant ions, reaction mechanism modeled through isotherms, and life-cycle analysis, are extremely important to ensure the enhanced stability of these systems. In this context, zeolite-based nanocomposites conjugated with chitosan, cellulose or graphene biosorbents can offer eco-friendly, biodegradable, renewable, antimicrobial, low-cost and sustainable engineered solutions for environmental protection and water conservation.

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