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# **ENVIRONMENTAL SUSTAINABILITY**

## CURRENT CHALLENGES OF EUROPEAN SUSTAINABILITY AND COMPETITIVENESS

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For decades, the European Union confidently demonstrated global leadership in the practical implementation of the sustainable development strategy, successfully meeting the challenges related to the main pillars of European sustainability – economic, social, and environmental. In line with this strategy, the EU has been a global leader in climate change mitigation and renewable energy deployment. The European Green Deal and the European Climate Law (EP, 2021), aiming for Europe's climate neutrality by 2050, are bright examples of this policy. The EU also holds a leading position in the sustainable funds market based on the Environmental, Social, and Governance (ESG) principles, accounting for 84% of global assets in this sector (Jovene, 2023).

Nevertheless, the EU is currently facing crucial challenges to its sustainability. The main challenge for the whole of Europe is, of course, the ongoing terrorist war waged by Russia against Ukraine. Unexpectedly for many, this revealed Europe's vulnerability to the brutal violation of international law by the criminal Russian regime, as well as its significant security dependence on the USA and economic dependence, particularly in energy, on Russia itself. This raises the urgent question of transforming the EU into a competitive and self-sufficient community, in partnership with reliable democratic allies. Moreover, undeniable support for Ukraine by the EU is crucial, as by supporting Ukraine, the EU and other European democracies also support the long-term sustainability of Europe. A comprehensive analysis of the weaknesses of European competitiveness and effective ways to overcome them was commissioned by the European Commission and successfully carried out by a team led by Mario Draghi, former President of the European Central Bank. The analysis provides valuable recommendations for the EU, such as profoundly refocusing its collective efforts on closing the innovation gap with the US and China, establishing a joint plan for decarbonization and competitiveness, and increasing security while reducing dependence (Draghi, 2024).

In our report, we provide a detailed analysis of the current challenges to European sustainability and competitiveness and present evidence of both the urgency and the feasibility of joint European efforts to overcome these challenges.

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## SOIL MICROBIAL DIVERSITY UNDER CONTINUOUS CULTIVATION OF INDUSTRIAL HEMP (*CANNABIS SATIVA L.*)

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Monoculture remains a common agricultural practice aimed at maximizing yield and economic efficiency, yet it raises concerns about soil health, biodiversity and sustainability. Soil microbiomes are essential for maintaining plant health, ensuring nutrient availability and supporting overall ecosystem function, especially in agroindustrial environments. This study explores the effects of long-term monoculture on soil microbial communities. Using next-generation sequencing and metataxonomic analysis, we assessed bacterial and fungal diversities in soils where hemp was cultivated for over 90 years, with and without additions of various fertilizers.

Results revealed significant shifts in microbial composition under monoculture conditions. In the unfertilized plots, distinct microbial assemblages emerged, potentially supporting plant resilience under stressful conditions of monoculture. Notably, no substantial increase in pathogenic microflora was observed, suggesting possible stability in soil and plant health despite continuous cropping of the same plant. Fertilized plots showed higher abundance of nutrient-cycling genera, such as *Bradyrhizobium* and *Pseudomonas*, indicating enhanced nitrogen fixation and organic matter decomposition.

These findings highlight the importance of monitoring of soil microbiome in hemp cultivation and support the need for sustainable crop management strategies. Understanding the complex relationships within the microbiomes under stressful conditions can add to the development of sustainable and economically sound agricultural practices. This study was the initial stage of a broader investigation on the impact of agricultural monocultures on the human gut microbiome and human health overall. To the best of our knowledge, this is the first study to characterize soil microbiomes in the unique experiment with the hemp cultivated under monoculture conditions for over 90 years in Sumy region, Ukraine.

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## FOOD POLICIES AND SUSTAINABILITY: EUROPEAN LESSONS FOR TRANSFORMING AUSTRALIA'S FOOD SYSTEMS

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The European Union's "Food 2030" (EC, n.d.) and "Vision for Agriculture and Food" (Politico, 2025) provide invaluable lessons for Australia in transitioning toward sustainable, inclusive and resilient food systems. These initiatives align with the European Green Deal, Farm to Fork Strategy and Bioeconomy Strategy, addressing critical issues such as malnutrition, obesity, alternative proteins, food traceability and sustainability. The Vision outlines an ambitious roadmap for a competitive and future-oriented agricultural sector, focusing on digital-ready farming, generational renewal, climate action and fair living conditions for rural communities. This also helps understand the challenges and find possible solutions for the social determinants of health and health equity.

By contrast, Australia lacks a cohesive national food policy (Ribeiro de Melo et al., 2024). Existing efforts, such as the National Preventive Health Strategy 2021–2030 and the National Obesity Strategy 2022–2032, address health concerns but remain fragmented and lack transformative impact. The 150 current food-related policies of all Federal, State and Territory governments we researched (twenty-four food policies and sixty-two policy actions) identified across Australian Government departments reflect an incremental and uncoordinated approach.

This analysis underscores the importance of developing a unified food policy and a coordinating body for Australia. By adopting strategies inspired by the EU's framework, Australia can advance sustainable food systems, promoting health, environmental preservation and economic resilience. This presentation explores the EU's approach and offers actionable recommendations for Australia to achieve meaningful food system transformation.

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**THE LONG-TERM PATTERN OF ECOLOGICAL DISASTERS RESULTING  
IN CRUCIAL DEPOPULATION OF A ONCE WELL-DEVELOPED AREA  
(CASE OF UKRAINE)**

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War supplies a new perspective for analyzing a range of issues. The geographical characteristics of specific locations affected by the war require careful examination. They are associated with persistent and notable changes in the environment. Environmental disasters demonstrate a sustained and identifiable trend throughout history. Such occurrences may manifest in both peacetime and wartime contexts. The analysis of long-term land development processes reveals specific locations associated with intentional depopulation in those areas. These instances are often associated with a notable reduction in water supply in the affected regions. Human activity has resulted in a notable alteration of the natural hydrological patterns. Examining such phenomena provides important insights within the paradigm of military ecotones. The emphasis is on clarifying the environmental consequences of large-scale destructive actions. The lack of a thorough scientific theory and methodology is evident, as it fails to sufficiently address the long-term trends associated with the deterioration of the environmental conditions in a clearly defined region. The length of a process that spans over a century is marked by fragmentation, frequently assessed only through its individual occurrences. The framework of this transformation in nature, leading to a challenging environmental situation, is often neglected.

## EUROPEAN PRINCIPLES AND OPPORTUNITIES FOR ENSURING ENVIRONMENTAL SUSTAINABILITY IN UKRAINE

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The introduction of green technologies will contribute adaptation to European environmental standards and to economic growth of Ukraine.

Ukraine faces serious environmental challenges that require urgent measures to ensure sustainable development and preserve natural resources for future generations. In accordance with the plan to achieve a shared better future, the UN Resolution «Transforming our world: The 2030 Agenda for Sustainable Development» was adopted, one of the directions is to overcome global climate challenges. European environmental principles are an important guideline for Ukraine, which has the potential for post-war recovery. An important task for the sustainable restoration of the country's economic development is to find ways to develop a green economy, taking into account state business support policies. The assessment of the economic capabilities of an enterprise should take into account the prospect of attracting investments, renew economic resources in the desired directions and levels in order to ensure the innovative development of the enterprise and sustainable development of the country's economy (Gorodianska, 2023). It is important to stimulate local communities and enterprises to implement environmental initiatives, which will make changes more sustainable at the local level. Important is to take into account the Decree of the President of Ukraine «On the Sustainable Development Goals of Ukraine for the period up to 2030», the proposals of domestic scientists (Gorodianska, 2023; Yermakov & Kostetska, 2022; et al.) and focus on several key areas: state support through tax breaks and grants can stimulate enterprises to modernize; participation in international environmental programs will attract additional funding and innovative technologies; the transition to the principles of a closed economy will help reduce the burden on the environment and reuse resources; the formation of an ecological culture through educational programs will help form the environmental awareness of young people; cooperation with international organizations will provide financial support and the latest eco-technologies; the development of electric public transport, the creation of green zones and the construction of energy-efficient buildings will help improve the quality of life in cities.

Thus, Ukraine is worth focusing on key areas implementation the European environmental principles for sustainable economic growth and improving the quality of life of the population.

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## THE PACKAGING WASTE MANAGEMENT IN THE EU IN THE CONTEXT OF CIRCULAR ECONOMY REQUIREMENTS

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The problem of packaging waste accumulation is one of the most acute in the field of environmental protection both worldwide and in the EU countries in particular. On average, an EU resident produces nearly 186,5 kg of packaging waste annually [Eurostat, 2024]. Most of this packaging is disposable, and its short life cycle creates significant environmental burdens. The European Union's response to the need for a systemic transformation of the packaging waste management sector in accordance with the objectives of the European Green Deal and the circular economy was the introduction of the new Packaging and Packaging Waste Regulation (PPWR), which entered into force in 2025 [European Parliament & Council of the European Union, 2024]. The Regulation sets out the main objectives to be achieved in this area. In particular, the reduction of packaging waste generation should reach the following levels: 5% by 2030, 10% by 2035, 15% by 2040 (from the 2018 level). PPWR sets mandatory reuse targets for transport packaging (40%), group packaging (10%) and beverage packaging (10%) by 2030. In the catering sector, the introduction of reusable food and beverage containers is envisaged - at least 10% by 2030. A mandatory level of separate collection of plastic bottles and metal cans has also been established, which should reach 90% by 2029.

Of course, achieving the target indicators specified in PPWR will lead to a reduction in the generation of packaging waste in the near future as well as an increase in the level of packaging waste recycling. However, certain obstacles may hinder the effective implementation of PPWR [Rethink Plastic Alliance, 2025]. For example, insufficient control over the chemical safety of packaging; the need to develop infrastructure for refilling and return and deposit systems, etc.

It should be noted that PPWR implementation requires ambitious cross-sectoral coordination and active participation of all stakeholders - from governments to producers and consumers. At the same time, EU Member States already have examples of successful experience in managing packaging waste, which may be of interest to other countries, in particular, Ukraine as a candidate for EU membership.

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# HARMFUL STEREOTYPES REGARDING THE TREATMENT OF GREEN SPACES IN THE SCOPE OF URBAN DEVELOPMENT

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**Introduction.** The paper considers the 3 most common, in the authors' opinion, stereotypes regarding the treatment of green spaces in the scope of urban development, which influence the practice of carrying out urban greening and harm the environment.

**Materials and methods.** The origin of stereotypes regarding urban greening, the essence of their harmful impact, and options for overcoming them are considered. The material is based on an analysis of scientific sources, the authors' own experience, and the results of surveys of landscaping specialists.

## **Results.**

*Stereotype #1: Grass is a weed, so you should get rid of it as much as possible.*

The stereotype comes from the owners of town cabins, private estates, and farms. The basis of the stereotype is the habit of weeding gardens and mowing grass in backyards. The harmful effects of destroying grass through constant mowing lead to soil degradation and, as a result, the entire ecosystem degradation. Overcoming options: mow grass only where it interferes (paths, passages/driveways), "trim" grass – mow not under the root but leave a few centimeters, remove only harmful plants (poisonous, allergenic and invasive), if possible, leave mulch (cut grass) on the land itself, plant forbs instead of monoculture lawns, use grass in the "rain gardens" systems.

*Stereotype #2: Cutting down large trees is useful, it's called "clearing" the area.*

The stereotype mainly comes from rural residents, from their ancient habit of cutting down trees to reduce shading of vegetable gardens and to obtain firewood. However, the destruction of trees in a settlement significantly harms its ecosystem and local climate. Overcoming options: cut and trim trees only where it really poses a harm or risk (example: branches in power lines), observe the rules for pruning and crowning trees, regularly plant young trees "for the future", in particular, using the technology of transplanting adult trees

*Stereotype #3: Fallen leaves are garbage, they need to be cleaned up and taken away.*

The stereotype comes from the common habit of cleaning (sweeping everything under your feet). From an ecological perspective, life is a cycle of energy and matter. Fallen leaves must remain near the tree to maintain this cycle. Options for overcoming the stereotype: remove leaves only where they are in the way (sidewalks, roads, drains), if possible, leave leaves on the land itself.

**Conclusions.** Stereotypes are formed through repeated repetition and assimilation of certain practices that seem habitual. But when external circumstances change, such stereotypical practices can turn out to be harmful. Overcoming harmful stereotypes about urban greening requires scientific substantiation of such harmfulness. This makes it possible to prove to landscapers with arguments that it is worth abandoning the usual practices. Instead, it is necessary to offer better methods of landscaping to municipal service workers. The use of relevant EU practices is very useful for achieving such goals.

# FROM CORPORATE SOCIAL RESPONSIBILITY (CSR) TO ENVIRONMENTAL, SOCIAL, AND GOVERNANCE (ESG): AN ETHICAL RESPONSE TO ECOLOGICAL CRISIS BY UKRAINIAN KERNEL

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The ecological crisis has highlighted the insufficiency of traditional Corporate Social Responsibility (CSR) approaches, necessitating a broader ethical framework embodied in Environmental, Social, and Governance (ESG) standards. This review article explores the philosophical underpinnings of the transformation from CSR to ESG, using Kernel, a Ukrainian agricultural company operating globally, as a detailed case study.

By critically analyzing key philosophical concepts from environmental ethics, such as Hans Jonas's imperative of responsibility, Klaus Michael Mayer-Abich's notion of ecological co-responsibility, and Deirdre McCloskey's humanomics, this article argues that ESG provides a more integrated, ethically comprehensive response to ecological challenges. The article closely examines Kernel's strategic shift toward ESG principles, emphasizing its proactive environmental initiatives, including sustainable agriculture, biodiversity conservation, and carbon footprint reduction, alongside extensive social commitments and enhanced governance transparency. This shift is contextualized within Ukraine's specific challenges posed by the ongoing war and pressures related to European integration and alignment with EU sustainability policies.

The analysis identifies how Kernel's case exemplifies broader global trends toward sustainability, shaped by ethical imperatives that transcend traditional economic rationales. Ultimately, the study contributes significantly to understanding the philosophical dimensions of ESG transformation and emphasizes the critical necessity of systematically integrating ethical responsibility into corporate practices to ensure effective and lasting ecological sustainability.

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## ECO-FRIENDLY PROCESSING OF ORGANIC WASTE IN UKRAINE: POTENTIAL AND PROSPECTS

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Ukraine is actively implementing modern bioenergy technologies to process agricultural waste, such as straw, corn stalks, sunflower husks, and animal manure. The country possesses significant potential in the field of biomass energy. According to the Bioenergy Association of Ukraine, as of 2018, the biomass energy potential amounted to 23 million toe. The main components of this potential include crop residues (a total of 10 million toe, or 44% of the total biomass potential) and energy crops (a total of 7.5 million toe, or 32% of the total) (UABIO, 2018).

Ukraine is expanding the production of biofuels, including bioethanol, biodiesel, and biogas, utilizing agricultural residues and energy crops. The country has the capacity to produce up to 21.8 billion cubic meters of biogas/biomethane annually, which could significantly contribute to its energy independence. Biomethane production not only serves as a renewable energy source but also generates digestate – an organic fertilizer beneficial to agriculture (SAF, 2024).

The active development of the bioenergy sector will foster Ukraine's energy independence. The biomethane sector alone has the potential to generate export revenues ranging from €0.97 billion to €1.24 billion by 2030 (Low Carbon Ukraine, 2024). Investment in bioenergy can stimulate rural development, create employment opportunities, and strengthen the country's energy security.

An integrated approach to the processing of agricultural waste can reduce environmental impacts and drive economic growth. Ukraine's extensive gas infrastructure facilitates the development of biomethane plants across the country, including in rural areas. The establishment of sustainable bioenergy clusters can replace imported energy sources and contribute to Ukraine's energy sovereignty.

Ukraine has unique opportunities to transform agricultural waste into valuable energy resources. Focusing on biofuel production and the development of sustainable bioenergy clusters will reduce environmental impacts, enhance energy security, and stimulate economic growth. An integrated approach to agricultural waste processing is not only environmentally beneficial but also a powerful driver of Ukraine's economic development.

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## **EDUCATIONAL COURSE «EUROPEAN GREEN DIMENSIONS» IN PREPARATION OF ECOLOGISTS**

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The course «European Green Dimensions» deepens teaching in European Union studies embodied in an official curriculum of a higher education institution and provides in-depth teaching on European Union environmental security matters for future professionals-ecologists in the green field which is in increasing demand on the labour market. The Jean Monnet Chair has a multidisciplinary character. The one includes knowledge of green initiatives; green roadmap; adaptation to the effects of climate change in the framework of the European green dimension; green economy; biodiversity conservation; energy efficiency, renewable energy; water resources management: water quality and wastewater treatment; protection of atmospheric air; environmental land management; environmental control and monitoring systems; industrial and household waste management and others. The activities equip a wide spectrum of the stakeholders with European experience of this knowledge. Thus, it be introducing the introduction of the European Union practices into environmental policy and practices in the field of environmental security in Ukraine. The course promotes European research and study experience with regard to environmental management, instruments, eco-innovations, implementation of environmentally friendly technologies in the EU. The attractive and close collaboration with European colleagues through mutual participation in research and teaching activities will promote the transfer of first-hand experience and practical knowledge, and prepare local academics and young researchers for the independent management of future European studies. The course has a strong impact on students in Ecology and Environmental Management at the Petro Mohyla Black Sea National University as one of the target groups through getting knowledge about actual green policy in the field of environmental security and best environmental protraction practices. The students and young researchers have a valuable learning experience to compare and evaluate national environmental practices with the EU experience and impacts of individual member states. The realization of the course in the practice of students study promotes future young professionals' understanding of the EU green principles and experience of environmental security and foster transforming the economy of Ukraine into EU and also provides teaching/lectures to students from other departments (e.g. economics, medicine, etc.) to better prepare them for their future professional life, conducts, monitors, and supervises research on EU subjects, also for other educational levels such as bachelors training; activities targeting policymakers at the local, regional and national level as well as civil society. These are the principles: systematic (systemic factors are the goal of natural education in the context of the integrated approach, leading laws and theories, basic categorical concepts, principles of natural science, objects of study); interdisciplinary connections; fundamentalization; professional orientation of the education content; orientation of the content of training to the disclosure of environmental problems, such as climate change, sustainable development etc. A didactic system of an integrated approach has been created, which has shown fairly high efficiency. This system covers the principles of selection of educational content, levels of implementation of the integrated approach. The course is interdisciplinary and connects the greening policy and tools, principally addressing EU and Ukraine practices.

## ENVIRONMENTAL SUSTAINABILITY IS AN INFORMATIVE INDICATOR OF ECOLOGICAL RELIABILITY OF ECOSYSTEMS

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The intensive flow of pollutants into ecosystems leads to their structural and functional changes. In such anthropogenically transformed ecosystems, the mechanisms of balanced functioning are disrupted, which leads to a loss of ecological sustainability. The paper examines the issue of the established response of the biotic component of the ecosystem to the impact of anthropogenic pollutants. It is proved that the biotic component of ecosystems is a reliable indicator of their ecological sustainability (Madzhd S., 2024; Isaenko V., 2019). It is noted that the study of the levels of reactions of living organisms in ecosystems and their thresholds to the harmful effects of anthropogenic pollutants allows developing a system for assessing the level of their environmental sustainability.

The authors have developed a system for assessing the ecological sustainability of ecosystems based on studies of the viability of their biotic component. The need to develop a system for assessing the level of ecological sustainability of ecosystems is due to the need to implement measures aimed at ensuring their reliability in the face of high anthropogenic threats.

The results of the research have shown that the biotic component of ecosystems allows to reliably reflect the level of their ecological sustainability, which is an informative indicator of their ecological reliability. The paper proves that the system for assessing the ecological sustainability of anthropogenically loaded ecosystems developed by the authors is a highly informative indicator of determining the level of their ecological reliability and can be successfully applied in the system of managing the ecological reliability of anthropogenically loaded ecosystems (Madzhd S., 2017).

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## ECOLOGICAL SAFETY OF FOOD PRODUCTS

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Ecological food products do not have a negative impact on the environment and public health, but on the contrary, contribute to it. The quality of a food product is a set of properties that determine its ability to meet the body's needs for nutrients, safety for health, stability of composition and nutritional properties during the shelf life. Therefore, in addition to biological value, a food product must be environmentally safe. To maintain environmental safety, all stages of production must meet the requirements of "green" technologies. The evolution of human-nature interaction has led to the modern structure of the natural environment. This is not only the biosphere and its components, but also the results of scientific and technological progress. The unfavorable modern ecological situation in Ukraine causes pollution of drinking water, air, soil and, as a result, food products. Sources of pollution of the environment, food and food raw materials are emissions from industrial enterprises, transport, municipal waste, means of chemicalization of agriculture, etc.

The general situation requires improvement of technologies for growing agricultural raw materials and their processing in order to produce high-quality and environmentally safe food products. Xenobiotics foreign chemical substances and biological agents that enter the human body with food or other ways, do not perform any of the functions of nutrition and under certain conditions adversely affect health. Xenobiotics include metal pollutants (mercury, lead, cadmium, arsenic, tin, zinc, copper, etc.), radionuclides, pesticides and their metabolites, nitrates, nitrites and nitroso compounds, polycyclic aromatic and chlorinated hydrocarbons, dioxins and dioxin-like substances, metabolites of microorganisms that develop in food. Human exposure to xenobiotics through the alimentary route accounts for 80% of all foreign substances entering the body. Environmentally persistent pesticides enter the human body in 95% of cases with food, 4.7% with water, approximately 0.3% with atmospheric air through the respiratory tract and occasionally through the skin. Radionuclides enter the human body through the chains "soil - plant - human" or "soil - plant - animal - human" in 94% of cases with food, approximately 5% with water and only approximately 1% with inhaled air. An important feature of xenobiotics is that they are able to accumulate (Savchuk E., Malchevska K., Prokina A., 2023)

In modern conditions, the quality (including environmental safety) of products produced by the agricultural sector is becoming one of the main factors of its internal and external competitiveness. The requirements for ecological agriculture include not only the issue of compliance with environme. It ensures a balanced state of the ecosystem, which is the key to sustainable development of the economic and social sphere of the entire society.

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## BACHELORS-ENVIRONMENTALISTS EDUCATIONAL TRAINING ON THE EXAMPLE OF UKRAINE AND SLOVAKIA

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Given that about 8 million Ukrainians left Ukraine due to the Russian-Ukrainian war, Ukraine currently has a population of about 33 million, which with about 200 universities gives approximately 1 university per 165.000 people, while in Slovakia, with a population of about 5.4 million and 20 universities, this figure is approximately 1 university per 270.000 people, which indicates that even taking into account the population outflow, Ukraine currently has fewer universities per capita than Slovakia, although it is important to consider that the number of universities is not the only indicator of the quality of higher education, and factors such as the quality of teaching, scientific research, international relations and graduate employment also matter, as well as the fact that a large number of Ukrainian students study at universities in Slovakia.

In Ukraine, ecologists are trained at many universities, as environmental majors are quite common. In particular, such majors are represented at Taras Shevchenko National University of Kyiv, Ivan Franko National University of Lviv, V. 1 N. Karazin Kharkiv National University, and other large universities throughout the country. In Slovakia, ecologists are also trained at several universities, including Comenius University in Bratislava, Pavol Josef Šafárik University in Košice, and others. However, in general, the number of universities offering environmental majors in Ukraine is greater than in Slovakia, reflecting the larger size of the country and the greater number of higher education institutions.

The Petro Mohyla Black Sea National University (PMBSNU) in Mykolaiv, Ukraine, and the University of Prešov in Prešov, Slovakia, are multidisciplinary higher education institutions, but differ in structure, student numbers, and training concepts; CNU, founded in 1996, is known for its humanities and social sciences, has about 4.000 students, and emphasizes an interdisciplinary approach, while the University of Prešov, with a history dating back to 1665, offers a wide range of programmes, including theology, humanities, natural sciences, and medical sciences, with a student population of about 8.000, and emphasizes regional development and international cooperation, reflecting their different historical contexts and educational priorities.

Both universities offer high-quality professional training for ecologists, but with different emphases. PMBSNU provides a broader theoretical base and emphasizes interdisciplinarity. The University of Prešov has a strong biological, practical orientation and prepares students for specific professional tasks. Both programmes meet modern requirements for environmental education. It is important to note that the choice of university depends on the individual needs and career goals of the student.

# BIOCENOSIS OF AEROBIC ACTIVATED SLUDGE OF THE MAIN STRUCTURE OF THE WASTEWATER TREATMENT PLANT OF A FOOD INDUSTRY ENTERPRISE

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Irrational and short-sighted use of nature in the past has led to a crisis in the relationship between man and nature today. The solution to this problem is possible only if humanity realizes the need for rational use of natural resources and environmental protection, which includes mandatory conditions for the creation and operation of highly efficient ecologically and economically justified treatment facilities at all enterprises of the national economy, including food industry enterprises (Yatsyk et al., 2014). However, the intensity of man-made environmental pollution in Ukraine is outpacing the pace of construction of treatment facilities, which makes sustainable development of the region impossible. The situation requires immediate state regulation. A mandatory condition for developing a project for the construction of a wastewater treatment plant is to take into account the individual characteristics of the enterprise, but in general, the wastewater discharge and treatment scheme should ensure minimal discharge of used water into the reservoir, maximum use of recycled and recycled water supply, as well as complete removal and disposal of valuable impurities (Naydenko, 2019). This can be achieved by using a biotechnological method of wastewater treatment, which is based on a biotechnological cycle of substances, which includes the processes of utilization, transformation and mineralization of organic substances, which depends on a whole complex of biological factors (Petruk et al., 2014). The efficiency of a biological wastewater treatment plant directly depends on the activity of microorganisms that form the activated sludge biocenosis (bacteria, protozoa, algae, which use organic compounds contained in wastewater for their vital activity and development). Since most of the inhabitants of treatment plants can act as indicator organisms of the degree of environmental pollution, as well as testify to the perfection of the selected technological regime, it was decided to conduct an analysis of the qualitative composition of activated sludge organisms. The study was conducted on activated sludge from the water treatment plant of a dairy processing plant, a typical representative of the industry. The most intensive role in the purification process is played by bacteria in the form of flake-like clusters - *Zoogloae*. First of all, they include non-spore-forming gram-negative rods (*Pseudomonas*, *Achromobacter* and *Flarobacterium*). Also, representatives of the *Sarkodina* class were found in the activated sludge, in particular various species of *Amoeba*, the *Ciliata* class – *Opercularia coartata*, as well as *Opercularia microdiscum*, the *Rotatoria* class - *Rotatoria rotaria* and some other organisms in small quantities.

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# PRODIGIOSIN: AN INNOVATIVE BACTERIAL PIGMENT WITH UV-PROTECTIVE FUNCTION FOR THE SUSTAINABLE DEVELOPMENT OF COSMETIC TECHNOLOGIES

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Prodigiosin is an innovative natural alternative to synthetic dyes, distinguished by its high biodegradability and lack of ecotoxic effects compared to complex chemical colorants. The biotechnological synthesis of this bacterial pigment provides an environmentally friendly manufacturing process, aligning with the principles of sustainable development (Venil et al., 2020).

Conventional methods for the production of UV filters are based on multi-step organic synthesis and the precipitation of inorganic particles, processes that involve substantial energy consumption, complex separation of intermediate products, and the generation of toxic waste. In contrast, a biotechnological process using *Serratia marcescens* FZSF02 enables the selective intracellular synthesis of prodigiosin—a natural photoprotective pigment with high molecular specificity—that requires no additional extraction reagents and minimizes harmful emissions (Suryawanshi et al., 2014).

The biotechnologically synthesized prodigiosin from *Serratia marcescens* FZSF02 cultured on a medium enriched with glucose, peanut powder and beef extract, achieves a productivity of 15.4 g/L after 72 h at 26 °C and 180 rpm, with an 86 % recovery following multi-step purification. Incorporation of 4 wt.% prodigiosin into an emulsion matrix increases the SPF of the sunscreen formulation by 20–65 % and preserves approximately 30 % of the antioxidant activity relative to an ascorbic acid standard, confirming its strong photoprotective and radical-scavenging properties (Lin et al., 2019).

Thus, biotechnologically produced prodigiosin demonstrates significant potential as a natural UV filter and antioxidant, combining effective photoprotection with environmental safety. However, its commercial implementation requires detailed investigation of dermatological safety, toxicokinetics, photostability, and ecotoxicological profile to ensure its reliable and sustainable application in cosmetic technologies.

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# SMART AUTOMATION FOR LEAN FOOD MANUFACTURING: REDUCING WASTE AND PROMOTING SUSTAINABILITY

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Lean manufacturing in Europe's food sector is evolving into Lean 4.0, where classical lean tools are reinforced by Industry 4.0 automation. This convergence supports the EU Green Deal and «Farm-to-Fork» Strategy, which demand low-emission, zero-waste food production (European Commission, 2023).

Lean principles – codified by Womack & Jones (2003) deliver far greater impact when paired with smart-factory technologies such as PLC networks, industrial IoT sensors and robotic process automation. A Thai noodle-plant study that embedded IoT data capture in a Lean-Kaizen programme achieved a 7.8 % rise in productivity, 12 % shorter cycle time and 9 % lower operating cost (Pitjarnit et al., 2024).

Across 156 European food manufacturers, firms that combine lean practices with Industry 4.0 enablers report 18 % better on-time delivery, 21 % fewer defects and 11 % lower specific energy use compared with conventional lean adopters (Psomas & Deliou, 2024). Reviews of “Food Processing 4.0” further show that AI-driven predictive maintenance typically cuts unplanned downtime by one-third while smart vision systems intercept defects in milliseconds, preventing full-batch re-work and resource loss (Hassoun et al., 2023).

By overlaying live dashboards of energy, water, material yields and defect rates onto value-stream maps, manufacturers can expose hidden wastes—waiting, re-processing, overproduction and excess utilities and intervene immediately. Integrating lean with advanced automation boosts productivity, safeguards quality and slashes resource intensity. In an era of strict climate targets and volatile input costs, the food sector cannot afford to underestimate or delay adoption of Lean 4.0; implementation has become essential for competitive, climate-responsible manufacturing in Europe.

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## INTEGRATION OF NATURE-BASED SOLUTIONS INTO URBAN ECOSYSTEMS FOR SUPPORTS THEIR ADAPTATION TO NEW CLIMATE REALITIES

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Due to the inevitable processes of urbanisation, urban ecosystems are becoming more vulnerable to environmental problems such as climate change, air pollution and biodiversity degradation. According to preliminary studies, the integration of nature-based solutions into urban landscaping helps to improve the quality of life of residents and create sustainable urban ecosystems (Dudyak et al., 2024; Croce et al., 2021).

Greening of urban roofs and vertical surfaces, green bus stops and green parking help to combat the growth of urban heat islands, settle pollutants, reduce stormwater runoff, and provide energy savings in buildings (Oleshko 2023, Baro et al., 2023).

The creation of natural areas with native plant species (urban meadows) maximises local biodiversity and helps to create habitats for different species of flora and fauna. They also improve the cohesion of green infrastructure by providing ecological corridors for migration and interaction of different species.

Pocket parks, urban gardens, and parklets increase the accessibility of green spaces for urban residents, create opportunities for biophilic design, provide numerous ecosystem services, and contribute to the cultural and social life of different social and age groups.

In many cities, the implementation of nature-based solutions is carried out taking into account environmental, economic and social aspects and involves a wide range of stakeholders. This promotes active community participation in the planning and management of the urban environment, and increases the level of social responsibility for maintaining the ecological balance in cities in the context of climate change adaptation.

Thus, the integration of nature-based solutions into urban ecosystems helps to mitigate environmental impact, increases resilience to climate change, and contributes to social well-being and sustainable economic development.

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# **ECONOMIC GROWTH FOR SUSTAINABLE DEVELOPMENT**

## LEVERAGING INTELLECTUAL PROPERTY FOR SUSTAINABILITY: CHALLENGES AND RATIONALE FOR INTEGRATION

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Intellectual Property (IP) serves as a fundamental driver of innovation and creativity, which are indispensable for the effective realization of the United Nations Sustainable Development Goals (SDGs) (WIPO, n.d.). The intersection of patents and the SDGs provides a valuable analytical framework for assessing innovation efforts aligned with global development objectives across diverse technological fields. This relationship offers a quantifiable metric of the intellectual capital directed toward each goal, serving as a tangible indicator of the global innovation system's engagement with and commitment to sustainable development (WIPO, 2024).

Intellectual property rights (IPRs) play a critical role in supporting sustainable development by fostering innovation and protecting the commercialization of environmentally friendly technologies through leveraging patents, copyrights, trademarks, and trade secrets. Patents, for example, provide legal protection for green technologies, thereby encouraging continued investment in environmental innovation by securing returns on research and development (Che, 2025). Trade secrets help companies maintain competitive advantages by protecting proprietary sustainable processes which reduce environmental footprints. Copyright protection ensures the integrity and security of sustainability-related data, including metrics and reporting methods, which are increasingly essential for transparency and accountability in corporate sustainability practices. Trademarks support sustainability by strengthening brand recognition for environmentally responsible products and corporate practices. Eco-labels help consumers identify and choose products that meet recognized environmental standards, thereby encouraging sustainable consumption and responsible production. Licensing mentioned IPRs facilitates the transfer of sustainable technologies across organizations and borders, enabling broader adoption and scalability. Collectively, these IP tools create an ecosystem that incentivizes innovation while reinforcing the infrastructure needed for sustainable transformation. Aligning intellectual property strategies with ESG objectives remains complex, as businesses must balance the high costs of sustainable innovation and regulatory hurdles with the need for accessibility, often navigating tensions between profitability and broader societal impact.

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## STRATEGIC MANAGEMENT OF SUSTAINABLE ENTERPRISE DEVELOPMENT BY SETTING GOALS

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In the conditions of contemporary martial law, the national economy should develop according to the principles of a socially responsible development model based on sustainable development. Businesses must respond quickly to external challenges, and analyzing internal opportunities for sustainable development is essential. The goal-setting process is based on identifying the interests of stakeholders.

Correctly set sustainability goals have a significant impact on the performance of an enterprise. Indeed, the path to sustainable development involves creating environmental, social and economic value in the long term through strategies, business models, investments and performance management tools. Sustainability awareness is crucial in implementing sustainability management tools (Talbot et al., 2020). Addressing the information gap and providing targeted resources and guidance to business owners and senior management is crucial to enable them to navigate the sustainable challenges. By filling this gap, managers can overcome obstacles, embrace sustainability and leverage digital technologies to drive their businesses forward (Martínez-Peláez et al., 2023).

It is advisable to actively adopt digital technologies for business development to reduce the barriers to adopting sustainable development principles. In turn, digital transformation can facilitate and accelerate the development of a data-driven decision-making culture in organizations. Such a culture of data-driven decision-making can profoundly impact the organizational capabilities that underpin innovative products and processes (Chaudhuri et al., 2024). Currently, the volatility of environmental factors requires companies to make detailed forecasts of their strategic and current activities, take into account threats, opportunities for further development, and achieve the goals set out in the Sustainable Development Strategy of Ukraine for the period up to 2030.

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## MANAGING THE IMPLEMENTATION OF THE ESG CONCEPT IN A PHARMACEUTICAL COMPANY

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In today's world, the concept of ESG (Environmental, Social, and Corporate Governance) is gaining in importance. It is becoming not just a trend, but a prerequisite for the sustainable development of companies. Implementation of ESG approaches requires strategic management, clear organisation of processes and a deep understanding of the impact of these factors on the business. Implementation of ESG principles helps to reduce risks, improve access to capital, increase employee productivity and strengthen the Company's reputation.

Farmak JSC actively implements ESG principles in its activities, striving to achieve financial sustainability, environmental responsibility, social partnership and effective corporate governance. The Company is implementing measures to reduce greenhouse gas emissions, reduce energy consumption, minimise waste generation and rationally use water resources. For example, the modernisation of production equipment has reduced electricity consumption by 15% (Farmak JSC, 2023). Farmak JSC provides safe and comfortable working conditions for its employees, supports local communities, and adheres to the principles of gender equality and inclusion. The Company actively supports medical institutions, educational institutions and social initiatives. Transparency, anti-corruption measures, and effective risk management are the key principles of corporate governance at Farmak JSC. The Company regularly publishes non-financial reports, implements an internal control system and conducts anti-corruption trainings for employees (Farmak JSC, 2024).

In 2024, according to the rating of the analytical company Ukrainian Business Award, Farmak JSC was the leader of the pharmaceutical market, followed by Arterium Corporation. According to the financial indicators of these companies, both had an increase in revenues in 2023-2024 (from UAH 9,673,587 thousand to UAH 10,783,728 thousand for Farmak JSC, and from UAH 4,108,052 thousand to UAH 5,235,605 thousand for Arterium Corporation). For comparison, over the same period, the net profit of Farmak JSC demonstrates an upward trend (from UAH 1,556,484 thousand to UAH 1,620,295 thousand), which indicates the financial stability of the company. Net profit of Arterium Corporation decreased from UAH 82,184 thousand to UAH 51,825 thousand.

Integration of ESG principles contributes to sustainable development, competitiveness and financial stability of Farmak JSC. Implementation of the ESG strategy helps to meet modern challenges, minimise risks, improve financial performance and strengthen long-term competitiveness and attractiveness for investors.

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## DEVELOPMENT OF DIGITAL INFRASTRUCTURE AND ITS IMPACT ON ECONOMIC GROWTH

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In the modern world, digital infrastructure plays a key role in ensuring economic development. It encompasses information and communication technologies (ICT), data transmission networks, cloud computing, and other digital solutions that contribute to increased productivity, the creation of new markets, and improved service quality. For Ukraine, the development of digital infrastructure is a crucial factor in integrating into the global economy and enhancing competitiveness.

**Materials and Methods.** This study is based on the analysis of scientific publications, statistical data, and official reports related to the development of digital infrastructure and its impact on economic growth. The research employs comparative analysis, systematization, and generalization methods.

**Results.** Research indicates that digitalization strengthens investment potential and fosters economic growth. Specifically, the implementation of digital technologies creates new markets, optimizes business processes, and reduces administrative barriers, thereby attracting investments. A prime example is the European Union countries, such as Denmark and the Netherlands, where active digitalization has led to increased economic attractiveness and development. Ukraine has demonstrated positive dynamics in the field of digitalization. The establishment of the Ministry of Digital Transformation, the launch of the electronic government services system, and the deployment of 4G networks are crucial steps in this direction. However, challenges remain, including unequal access to digital technologies and the need for government support for digital initiatives.

The analysis of the impact of digital development on Ukraine's economic growth shows that the level of financial activity in the online environment has a significant positive effect. However, certain aspects, such as online shopping, may have negative consequences that require further investigation. Including governmental factors in the models assessing the impact of digitalization is crucial for accurately understanding its effects on the economy.

**Conclusions.** The development of digital infrastructure is a key factor in economic growth, contributing to increased investment attractiveness and business process optimization. Ukraine needs to continue its active digitalization, considering global experience and national characteristics while addressing existing barriers to ensure equal access to digital technologies.

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## GENETICS IN INSURANCE: IMPLICATIONS FOR LIFE INSURANCE UNDERWRITING IN UKRAINE

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The review of previous research reveals that insurance markets in different countries are increasingly characterized by the introduction of specific regulations regarding the features and conditions of using a person's genetic information to assess their insurance risks (Joly et al., 2024). Moreover, insurance companies are interested in having as much genetic information (including the results of genetic research) of the applicant for insurance at their disposal for the purpose of assessing insurance risks (Macdonald, 2024).

Currently, in Ukraine, the regulatory framework for the insurance market does not contain provisions that directly determine the features and conditions for using genetic information to assess insurance risks (Arych & Joly, 2022). The research revealed that life insurance companies in Ukraine collect genetic information about insurance applicants for insurance purposes (in this case, it is about signs of genetic heredity). In addition, life insurance companies want to know the results of genetic test results that were previously performed and about which the insured person is already aware.

It was also found that, life insurance companies in Ukraine in accordance with current legislation before concluding life insurance contracts require policyholders to provide voluntary consent for policyholders to receive data about them from any third parties (for example, doctors, institutions, etc.) regarding circumstances that have or have occurred (for example, diseases, health disorders, results of medical and diagnostic procedures, etc., among which there may potentially be genetic information of policyholders), and which may characterize the likelihood of insured events (Arych & Joly, 2022).

The analysis shows the interest of insurance companies in genetic information about future owners of insurance policies. So, it can be interpreted as the desire of insurers to avoid information asymmetry and to more qualitatively assess the risks that are planned to be insured.

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## INNOVATION AS A PRIORITY AREA OF STRUCTURAL POLICY

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The economic structure inherited by Ukraine as an independent state was extremely deformed, capable of changing only at the initiative of a single center and in the case of using huge resources that were also redistributed through the center. It did not have internal, immanent sources of development and efficiency improvement. The motives for improving the structure through innovations were mostly rejected. The lack of freedom of entrepreneurship and competition made it impossible to produce high-quality goods on a significant scale, reduce costs, increase productivity and quickly respond to changing demand. To produce final products, it was necessary to spend a large amount of primary resources. Hence the hypertrophied development of raw materials industries. The raw materials direction in the structure of the Ukrainian economy had formed even earlier and was inherited from the past. Structural changes that have occurred in the economy over the years of transformational transformations indicate a reduction in the processing industries, an increase in the share in the creation of gross added value of agriculture, mining, as well as information and telecommunications. The structure of the national economy adapted to the requirements of domestic and external demand. In the absence of structural policy, structural changes were carried out spontaneously in favor of industries that satisfied demand in the domestic and external markets. With the transition to market methods of regulation, the real competitiveness of domestic enterprises and industries and the competitive advantages of the national economy were revealed. Due to the real competitiveness of enterprises and industries, the new structure of the economy removed the contradictions of the inherited structure and created the prerequisites for the transition to a cyclical form of the movement of industrial capital in the process of its reproduction.

Structural changes in the national economy affected the structure of enterprises. If they do not constantly seek innovations as a way to increase the efficiency of functioning capital, but compete for preferences from the government, they will not be able to ensure future development. Due to the lack of a structural industrial policy, labor productivity in the national economy lags behind the world growth rates by more than half. Competitiveness in the markets of finished goods should be defined as a goal of modernization, a large-scale national goal of a strategic nature, the achievement of which would allow Ukraine to take a worthy place in the world. The competitiveness of enterprises is characterized by an increase in labor productivity or total factor productivity. These indicators can become indicators of efficiency. Achieving high competitiveness is not possible without an active structural (industrial) policy.

The desired direction of structural policy is innovations associated with the adaptation of the technologies involved to operating enterprises. The world economy has modern methods of structural policy, but their application is accompanied by risks, corruption, rent-seeking behavior caused by state privileges and subsidies, which, naturally, do not increase the efficiency of capital at the expense of innovations. Structural policy is not a set of methods of state intervention, but a means of interaction between business and the state to increase the competitiveness and productivity of production factors. This requires significant institutional transformations that should ensure catch-up development in the post-war period.

# **SOCIAL INCLUSION AND PUBLIC HEALTH**

## INTELLECTUAL PROPERTY AND ACCESS TO MEDICAL INNOVATION – CHALLENGES OF SOCIAL JUSTICE AND SUSTAINABLE DEVELOPMENT

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In today's globalized world, innovation in healthcare is essential for delivering high-quality medical services, with intellectual property (IP) acting as a driver of scientific progress while simultaneously raising concerns about equitable access, as traditional patent systems may restrict availability of innovative treatments for vulnerable groups. The European Union promotes models that balance the protection of developers' rights with sustainable development principles, including open science initiatives, fair licensing practices, and limits on monopolization of publicly funded knowledge. In Ukraine, healthcare digitalization is progressing through the national eHealth system, which integrates electronic medical records, e-prescriptions, referrals, and platforms like Helsi, Medics, and Askep.net, facilitating automation and improving access to healthcare services; notably, over 70% of healthcare institutions use Helsi for managing patient records and scheduling. However, the expansion of digital platforms also underscores the need for robust legal frameworks to ensure the protection of patients' personal data and intellectual property rights over medical software.

The healthcare system and the institutional framework for intellectual property protection in Ukraine are undergoing a process of alignment with international legal standards. While the general implementation of international norms has progressed, certain areas, notably the regulation of generic medicines, remain insufficiently addressed. In response, draft Law No.13087 was introduced in 2025 to incorporate the Bolar provision, aiming to accelerate access to generic pharmaceuticals, thereby reducing the cost of innovative treatments and expanding their availability. Concurrently, the draft legislation is intended to stimulate innovative activities within the pharmaceutical sector, contributing both to industrial development and the establishment of a socially oriented and sustainably developed healthcare system.

Effective use of intellectual property mechanisms in medicine requires cross-sectoral collaboration, transparent legal frameworks, and a strong focus on the public good. Policy development should be based on ethical responsibility, equitable access, and the balanced integration of interests across government, industry, academia, and civil society.

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## THE PROBLEM OF TOBACCO AND NICOTINE USE BY SCHOOLCHILDREN ON THE EXAMPLE OF TEENAGERS IN KYIV

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**Introduction.** The tobacco epidemic continues to pose one of the biggest public health threats the world has faced. Despite a global decrease in the prevalence of tobacco use among all age groups during the last two decades, the rates of tobacco and nicotine use in young people are concerning. Most adult smokers start smoking in adolescence, and prevalence trends in tobacco smoking among 11–15-year-olds show a rapid increase by the age of 15 for both sexes.

The STEPS survey (STEPS: WHO Regional Office for Europe; 2020.) showed a high smoking prevalence among those aged 18–69 (33.9%). It demonstrated a significant gender gap in tobacco smokers, where half of all men (50.3%) and every sixth woman (16.7%). Among these, novel tobacco products (heated and electronic cigarettes) were increasingly used, especially by younger groups (18.7% of the population aged 18–29).

**Methods.** Number of respondents surveyed: 769 students 13-14 years old. Data collection method: self-filling of a formalized questionnaire by students, conducted in an online format, using the RatingBot software (<https://ratingbot.ua>), at the place of study, i.e. offline in the classrooms. A link to the survey was developed for each school and class, which the interviewer provided to the respondents before the survey.

**Results.** Over the past 30 days 13% of respondents have used nicotine and tobacco. From 6% to 7% of students used nicotine and tobacco products daily, which may indicate an already formed nicotine addiction in this group. At the same time, among daily smokers, boys often choose traditional tobacco products (cigarettes), and girls choose e-cigarettes or vapes.

E-cigarettes (9%) are the most popular type of tobacco use among adolescents, due to their availability, variety of flavors and perception as "less harmful". Traditional cigarettes, tobacco products for electric heating and hookah are consumed by 4% of respondents.

**Conclusions.** Half of those who use nicotine and tobacco are already addicted to nicotine. The most common type of tobacco and nicotine use among adolescents aged 13-14 in certain schools in Kyiv is electronic cigarettes. They provoke further use of other types of tobacco and nicotine in adulthood. Other types of tobacco products are also quite popular and encourage continued nicotine use.

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# SOCIAL PREFERENCES AND RESPONSIBLE CONSUMER BEHAVIOUR AS DRIVERS OF SUSTAINABLE CONSUMPTION: A BEHAVIOURAL ECONOMICS PERSPECTIVE

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**Introduction.** This paper explores how social preferences influence responsible consumer behaviour and contribute to sustainable consumption. Behavioural economics and Social Value Orientation (SVO) theory provide tools to understand why individuals make environmentally responsible choices, particularly in collective dilemmas (Murphy & Ackermann, 2014). This study aims to conceptualise and empirically test a behavioural model linking social preferences to sustainable choices through an experimental game simulating real-life consumer trade-offs. This problem directly relates to SDG 12, which ensures sustainable consumption and production patterns. It highlights the importance of behavioural change at the individual level to support global sustainability goals.

**Materials and Methods.** An experimental Green Game was created to simulate consumer decisions involving a trade-off between individual costs and environmental benefits. Participants (N=126) were randomly assigned to different treatment groups: (1) control (no intervention), (2) norm-based information (“Most others chose the green option”), and (3) eco-label conditions. Social preferences were measured using a validated SVO slider measure before the task.

**Results.** Participants with higher prosocial orientation (based on SVO) were significantly more likely to choose sustainable options. Norm-based messaging increased sustainable choices by 22% ( $p < 0.05$ ), particularly among participants with above-median prosocial scores. Eco-labelling also had a positive, though smaller, effect (+11%,  $p < 0.1$ ). Regression analysis confirmed the interaction between social preferences and treatment conditions.

**Conclusions.** The findings support a three-step model: (1) Social Preferences → (2) Responsible Consumer Behaviour → (3) Sustainable Consumption. Policy interventions targeting social norms and transparency can promote sustainability, especially among socially oriented individuals. The Green Game provides a low-cost tool for testing behavioural responses in a policy-relevant context. Future research may apply the model in comparative international settings.

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# HOW A MODERN PUBLIC HEALTH SYSTEM SHOULD WORK TO ACHIEVE THE AMBITIOUS GOALS OF THE AGENDA FOR SUSTAINABLE DEVELOPMENT

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**Introduction.** In the abstract along with our presentation we would like to propose the discussion about the Public health system in general, along with how it should function in our modern time and why, as well as what is missing for that along with what we can improve to eliminate the gap. Such discussion is important nowadays, because the centuries-old history of the Public Health system demonstrates its effectiveness in the protection of human health on the global level (Remington RD, 1988), while healthy people/workers are vital for the sustainable development of any field of economy.

**Method.** Literature search in scientific databases and review of websites of international and Ukrainian institutions involved in the maintaining and improvement of the Public health system.

**Results.** Historically, two factors promote the improvement of Public health system: first, the growth of scientific knowledge about causes as well as prevention and curing of diseases; second, the growth of public acceptance of disease control as both a possibility and a public responsibility (Remington RD, 1988). The second factor largely depends on the institutions that maintain the public health system, their ability to act as a bridge between the scientific and clinical fields, society, and the sectors involved in the physical implementation of scientific and clinical advances in the Public health system, including business. Well-coordinated communication between all participants in the Public health system has always been a weak point; unfortunately, it is still the case today. The scientific field has already identified new therapeutic targets – the primary causes of systemic diseases, often common to all such diseases, such as vascular disorders caused by environmental factors (Munzel T., 2022), iron deposition in human tissues/organs (Ellervik C., 2014), as well as - new approaches and substances for disease prevention, such as the supplementation of various micronutrients (Moritz B., 2020) to enhance the human body's own defense mechanisms, but they have not yet been implemented in the Public health.

**Conclusion.** In order to improve the Public health system, it is currently more beneficial to invest in the implementation of already scientifically known approaches and substances than to research new.

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# FUNCTIONAL FERMENTED BEVERAGES AS A TOOL FOR SOCIAL INCLUSION AND PUBLIC HEALTH

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Since ancient times, fermented beverages have been an integral part of every culture and have played an important role in maintaining health and social integration, combining culture and local traditions, bringing people together through shared food habits. The drinks we are used to, such as cider, kvass or kombucha, actually have a long history. Their recipes were passed down from generation to generation, and traditional consumption during certain events brought people together. For example, the inhabitants of the Caucasus Mountains passed kefir grains to the younger generation as a symbol of the tribe's prosperity. It was only with the development of technology and the spread of kefir across Europe that it became known that this drink existed under different names among many peoples of the world. This allows us to understand what certain cultures have in common. And at the same time, learn something new by sharing cultural traditions of traditional beverages, including unique functional drinks in certain regions (Chong, Lau, Chin, Talib & Basha, 2023).

Functional fermented beverages are a great alternative to alcoholic or carbonated beverages that are commonly consumed in society. They have a probiotic, prebiotic, antioxidant or immunomodulatory effect, which has a positive impact on the gastrointestinal tract and health in general. Promoting these beverages and integrating them into people's daily diets improves their dietary habits and lifestyles. In addition, the production of non-dairy fermented beverages allows us to expand the range of products that can be consumed by people with lactose intolerance or certain diets (Dahiya & Nigam, 2022).

An additional factor that makes the drink more accessible to different segments of the population is the use of local raw materials. For Ukraine, apples are a promising raw material. This reduces production costs, provides jobs for a significant number of workers, and supports local producers and their cooperation between farmers and consumers, which contributes to the creation of relevant communities (Chong et al., 2023; Guiné, Barroca, Coldea, Bartkiene & Anjos, 2021).

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# PUBLIC HEALTH APPROACHES TO THE PREVENTION AND TREATMENT OF SYSTEMIC DISEASES TO ENSURE SUSTAINABLE DEVELOPMENT OF THE GLOBAL ECONOMY

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**Introduction.** The sustainable development of the world economy certainly depends on the quality of human potential - people, how effectively they can work in various sectors of the economy, while this primarily depends on the physical condition of people, on their health. For centuries, since its inception during the Roman Empire, Public health has been a social field that has introduced approaches and measures to support the health of large groups of people, up to the entire world population. Measures such as hand washing, disinfection, including water disinfection, vaccination, the use of antibiotics and effective insecticides, which Public health has been able to implement globally, have allowed infectious diseases to be controlled and life expectancy to increase dramatically. Nowadays people live longer and usually do not die from infectious diseases, however, another challenge has emerged – millions of people develop severe systemic diseases such as cardiovascular or cerebrovascular, chronic respiratory or pulmonary, cancer, diabetes, neurodegenerative, therefore cannot live and work effectively. Therefore, we now need to find approaches and measures to combat systemic diseases that could be applied globally. In our presentation, we will introduce such approaches and measures that have already been proposed and that we found in scientific publications.

**Method.** To find novel data/publications in the field, we searched various scientific databases.

**Results.** We found the information on recently identified causes of various systemic diseases that were not previously considered in their prevention as well as curing, for example - environmental factors acting through stress mechanisms, the accumulation of various metals in the human body, the role of periodontal pathogens, etc. We also found interesting approaches, supposing the involvement of other sectors of economy/business (Park et al., 2022), that Public health might use for the rapid improvement of the situation with systemic diseases; and the food industry might play a key role (Olson et al., 2021).

**Conclusions.** By strengthening the body's own defense mechanisms, including through therapeutic nutrition, it is possible to prevent and cure even most incurable systemic diseases (Mangelsdorf et al., 2017). Scientists have already suggested such mechanisms for various diseases, but these data have not yet been implemented in clinical practice. Public health has already tools to implement.

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## SUSTAINABLE DEVELOPMENT: EDUCATIONAL INNOVATIONS FOR A CHANGING WORLD

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The issue of education for sustainable development is particularly relevant in modern society. Due to innovative approaches in the field of education, there is a gradual transition to sustainable development both through the formal education system and through informal educational practices. An important condition for successful education for sustainable development is well-established interaction between all stakeholders. Educators from different countries actively create and implement innovative educational models, integrating sustainable development competencies into curricula. The implementation of such initiatives takes place at the local level. Advancing education for sustainable development demands deep and systemic change. The research is based on the interviews with the teachers, observational data and an analysis of material provided by the educational institutions. Education is essential for making ready future generations to tackle the complex challenges of sustainable development, including climate change, environmental decline, and social inequality. Setting up a sustainable support system for educational institutions involves the following key components. 1) Goal-oriented exchange between teachers, which contributes to the teacher's professional growth. It provides fresh ideas for teaching and stimulating interdisciplinary interaction. 2) Development of a culture of trust. The trustful environment aggravates teacher's self-esteem, assertiveness, readiness to implement new approaches and risk-taking, which contributes to the upgrading of educational content. 3) Sharing practical experience between educators contributes to improving the quality of teaching, professional development and the implementation of educational innovations. 4) Systematic planning and evaluation help maintain a balance between practical actions and reflection in the educational process (Yetti, 2024; Leal Filho et al., 2024). This research has confirmed that networking partnerships can be established across various geographical regions to exchange effective practices and address local challenges through collaboration. Network of critical friends encourages critical reflection on teaching and learning quality for sustainability, while providing constructive feedback on related initiatives and projects

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## PEDAGOGICAL ASPECT OF A HIGHER EDUCATION SUSTAINABILITY

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Modern universities are being challenged fulfil more and more roles, very seldom supplied with the necessary resources for these roles. Such a tendency makes the academic missions to become quite vague posing a threat to the conventional emphasis on the quality of the academic activity of universities. “The function of universities as institutions devoted essentially to teaching and research may be weakened by the struggle to be entrepreneurial and market relevant” (Altbach, 2007).

Among the *global factors* the following are worth mentioning: 1) the quality of the present-day education is questioned in most cases; 2) higher education establishment graduates do not apply their diplomas into the occupations they were meant to be gained for; 3) universities to be slow at adopting on-going formats of education services provision; 4) global society and mobility opportunities question the traditional format of education provider management patterns; 5) the popularity of mobile learning, that is getting higher and higher, poses a threat to the existence of such an institution as a university.

The *local factors* play their toll on the development of tendencies being adopted by the parties in the education sector. These have been defined as follows: a) university staff often complain about students being passive/ inactive receivers of educational services, thus showing little or no motivation at all in getting the most and the best practices of what the teachers try to equip students with. As a result, the quality of education decreases dramatically; b) at the same time, university students often complain about teachers being outdated with respect to knowledge provided, applying irrelevant educational methods (predominantly teacher-centered) and techniques incapable of supplying students with the necessary knowledge, skills and competencies; c) universities in smaller residential areas lose students who decide to give educational preferences to more experienced and branded educational establishments, often building their trust on the basis of previously earned reputation rather than the criterion of quality in providing educational services. Several concerns arise whether sustainability should relate educational setting. “The things that people do in science and education support economic activity, environmental quality, and governance, while religion and the arts lend meaning and purpose to a community’s way of life. Each of these four areas has some form of enlightenment, edification, or growth in knowledge and awareness as a mission or organizing purpose. As such, it is appropriate to accentuate the ways in which teachers, researchers, spiritual leaders, and artisans help us appreciate the essentials of sustainability” (Thompson & Norris, 2021).

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## **OPERATIONAL CONTROL OF CONSUMER SAFETY THROUGH RAPEX AND RASFF NOTIFICATION SYSTEMS**

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The European Union has a Rapid Alert System for Food and Feed (RASFF) to ensure food safety. Its main purpose is to promptly inform member states about food, feed or food-contact materials that pose a risk to human or animal health.

Through RASFF, reports on food contamination (pesticide residues, heavy metals), microbiological risks (salmonella, listeria), incorrect labeling of food allergens, and product adulteration are transmitted.

Information is shared in real time between member states, the European Commission, the European Food Safety Authority (EFSA) and other agencies. There is also a public part of the system – the Public RASFF portal, where weekly reviews of dangerous products are posted.

Ukraine does not yet have direct access to RASFF. However, within the framework of the Association Agreement with the EU, our state undertook to adapt its procedures to the standards of this system. Currently, a national contact point has already been established in Ukraine (with the State Production and Consumer Service), which analyzes cases of detection of dangerous food products and feed.

For non-food products, the EU operates the RAPEX system (Rapid Alert System for Dangerous Non-Food Products), which was created on the basis of Directive 2001/95/EC on General Product Safety. Its task is to quickly inform EU member states about products that pose a serious threat to consumer health or safety.

RAPEX coordinates the actions of national market surveillance authorities and customs and provides for the rapid exchange of information through the European Commission. The system covers non-food, non-medicinal and non-medical products, including children's products, electrical goods, textiles and vehicles. The data is published through the open online platform Safety Gate.

Ukraine has been implementing an internal alert system since 2015, which should be harmonised with RAPEX requirements in accordance with the Concept for the Development of the Market Surveillance System. The main challenges remain the lack of direct access to RAPEX, insufficient digitalisation of processes, and limited technical and human capacity of supervisory authorities.

A comparative analysis of RAPEX and the Ukrainian system shows significant differences: limited coverage of product groups, lack of automated exchange of risk information, and insufficient public access to up-to-date data. Currently, the exchange of messages in Ukraine is mainly internal and is not updated on a daily basis.

Thus, Ukraine's integration into the European RASFF and RAPEX systems of operational control over the safety of goods is an important condition for increasing the level of consumer protection and fulfilling its obligations under the European integration process.

## USING TECHNOLOGIES IN HIGHER EDUCATION TO DRIVE SUSTAINABLE DEVELOPMENT

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The integration of technology into higher education is becoming increasingly recognized as a catalyst for achieving sustainable development goals. Educational access, equity, and quality can be enhanced with digital platforms, smart learning environments, and data-driven decision-making. These are foundational pillars of sustainable societies (Badshah et al., 2023; Ahmad et al., 2023).

This study employed a mixed-methods approach involving a survey of 50 university educators and case studies from institutions implementing EdTech strategies aligned with the sustainable development goals.

Findings reveal that the use of digital technologies – particularly learning management systems (LMS), virtual reality (VR), and AI-powered tools – has significantly contributed to promoting sustainability in higher education. The study shows an increase in access for marginalized groups as well as improved energy efficiency through online classrooms, and increased awareness of sustainability issues through gamification. Implementing open educational resources enables cost reduction and broader community engagement.

Furthermore, students who used sustainability-focused digital curricula showed an increase in sustainability literacy compared to peers in traditional programs. However, the study identified barriers including insufficient digital infrastructure, limited staff training, and resistance to pedagogical change. Despite the challenges, using technologies in higher education drives sustainable development, and positively influences institutional practices and student engagement.

Technology-supported higher education has great potential for driving sustainable development. Strategic investments in digital infrastructure, inclusive access, and faculty development are essential to maximize its impact and ensure equitable, long-term progress toward the sustainable development goals.

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# AUSTRALIA'S EXPERIENCE IN SHAPING THE QUALITY OF HIGHER EDUCATION FOR THE IMPLEMENTATION OF THE CONCEPT OF SUSTAINABLE DEVELOPMENT IN UKRAINE

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Modern trends in globalization and the integration of higher education require national systems not only to adapt to new conditions but also to ensure high quality aligned with international standards. Australia's higher education system is internationally recognized for its quality, innovation, and focus on interdisciplinarity and global collaboration. Sustainability is embedded in course content and in teaching methods, infrastructure, and institutional strategies. This is achieved through national policies, the autonomy of educational institutions, the involvement of professional communities, and partnerships with industry. Innovative teaching methods – such as project-based learning, case studies, and simulations – are widely used to equip students with the competencies needed to address real-world sustainability issues. For Ukraine, which is currently undergoing comprehensive education reform, the Australian experience is highly relevant. Ukraine faces the need to align its education system with the demands of the labor market, European integration, and sustainable societal development. Australia's experience can serve as a valuable model for updating curricula, teaching strategies, and quality assurance mechanisms in Ukrainian higher education. The Australian system is regulated by national bodies such as the Tertiary Education Quality and Standards Agency (TEQSA, 2023) and the Australian Research Council (ARC). One of the key aspects of Australia's success is the interdisciplinary nature of sustainability education, allowing students to understand the interconnection of global challenges and their professional responsibilities. Teaching methods emphasize practical, problem-solving approaches that simulate real-world conditions and promote teamwork, critical thinking, and systems thinking. Ukraine has considerable potential to adopt these practices, but this requires systemic modernization. One priority is curriculum reform to include sustainability-related courses and modules across disciplines. Ukrainian universities also need to adopt participatory teaching methods – such as project-based learning – which are effective in building practical skills and encouraging active engagement with sustainability issues (Kovalchuk, 2022). Australia's integration of sustainability into education – from national strategy to classroom practice – offers a roadmap for Ukraine. Adopting similar approaches can enhance the relevance and quality of Ukrainian higher education, preparing graduates who are not only professionally competent but also globally responsible.

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## IMPLEMENTATION OF NEURODIVERSITY PARADIGM FOR CLASSES WITH INTERNALLY DISPLACED STUDENTS

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The neurodiversity paradigm is attracting widespread interest due to its valuable insights for understanding and supporting internally displaced students (IDSs), particularly in the context of their unique challenges and diverse cognitive profiles. In light of the military situation in Ukraine, there is now considerable concern about the psycho-emotional well-being of internally displaced students. This paper discusses how applying of neurodiversity paradigm to the educational process of internally displaced students fosters inclusion, resilience, and equity in education.

The war in Ukraine has impacted the psycho-emotional well-being of internally displaced students, contributing to a rise in neurodiversity among them. As a result, many internally displaced students may acquire features of neurodivergence in interaction with the surrounding environment, which complicates the learning process. Heightened anxiety, depression, and psychosomatic disorders are altering cognitive functions, leading to variations in perception, problem-solving abilities, and thought processes. These changes affect how internally displaced students analyze, synthesize, and process educational information and influence their responses to different situations within the learning environment.

Observing aspects of the neurodiversity paradigm encourages teachers to use multimodal approaches, such as visual aids, hands-on activities, and technology, to cater to various learning preferences based on internally displaced students' needs (Stefanic, 2024). Also, instead of focusing on deficits, the neurodiversity paradigm can help teachers highlight students' strengths, such as creativity, problem-solving abilities, or unique perspectives. This approach is particularly empowering for internally displaced students while some of them may already feel marginalized.

The implementation of the neurodiversity paradigm in the classroom for internally displaced students can help them to recognize and support neurodiversity in the classroom, identify signs of neurodivergence, and implement effective strategies. Among them can be in-time counseling, therapy, and academic accommodations tailored to individual needs, especially for students with co-occurring challenges related to displacement and neurodivergence.

Thus, integrating the neurodiversity paradigm into educational systems not only benefits internally displaced students but also promotes a culture of inclusivity for all students in the class. It aligns with global goals for equitable education and helps create learning environments where diversity is seen as an asset rather than a challenge. By embracing neurodiversity, teachers can transform the experience of internally displaced students into one of growth and empowerment.

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# **ADVANCED TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT**

## EXPANDING THE ARSENAL OF ANTIMICROBIALS: BACTERICIDAL PROTEINS

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Infectious diseases have been the leading cause of morbidity and mortality throughout most of human history. The introduction of antibiotics into everyday medical practice revolutionized healthcare in the 20th century. These drugs drastically reduced mortality rates from infections that were previously considered fatal. By preventing post-operative infections, antibiotics made surgeries and medical procedures much safer. They have been crucial in controlling infectious diseases that were once widespread, incurable, and deadly. Additionally, antibiotics facilitated the treatment of minor infections and found broad use in veterinary medicine and animal husbandry as growth promoters.

The period between the 1940s and 1960s is known as the "Golden Age of Antibiotics," characterized by the discovery of many new classes of these drugs. However, since the 1970s, the rate of discovery of novel antibiotic classes has dramatically decreased. The last class of clinically used antibiotics, lipopeptides, was discovered in 1987. The overuse and misuse of antibiotics, combined with a lack of new drug development by the pharmaceutical industry, have led to a global rise in antibiotic resistance, often referred to as the antibiotic resistance crisis.

The search for alternative antimicrobials has revitalized research on antimicrobial proteins, such as bacteriocins and bacteriophage endolysins, which have been studied for decades. These proteins are now being explored for their potential to combat resistant bacteria and offer new solutions in antimicrobial therapy.

Nomad Bioscience focuses on developing bacteriocin-based products that target gram-negative bacteria, including colicins for pathogenic *Escherichia coli*, salmocins for *Salmonella*, and klebicins for *Klebsiella*. Additionally, the company works on bacteriophage endolysins to combat gram-positive pathogenic bacteria, such as *Clostridium*.

NOMAD Bioscience has successfully produced recombinant antibacterial proteins using plant-based expression systems. These proteins have demonstrated antimicrobial activity against antibiotic-resistant bacterial strains both in vitro and in vivo, utilizing various animal models. Additionally, the efficient decontamination of diverse food matrices using these antimicrobial proteins has been proven.

Plant-made recombinant colicins (GRN593, GRN676, GRN775), salmocins (GRN824), and *Clostridium* endolysins (GRN802) have been registered in the USA by the FDA/USDA as GRAS (Generally Recognized as Safe) food processing aid products.

## INDUSTRIAL HEMP AS A SOURCE OF NEW NANOMATERIALS

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The most essential natural fiber in textile manufacturing and cellulose chemistry nowadays is cotton. However, due to climatic conditions, many countries have limited or no domestic cotton production, making them heavily reliant on imports. Thus, production of cotton in the EU is only 1% of the world cotton production, while the EU represents 27% of global consumption of cotton. This means that the European countries are heavily dependent on imported cotton and its derivatives. Without any doubts, this dependence is of very strategic importance and requires urgent attention.

Industrial hemp is referred to varieties of *Cannabis sativa* with reduced content of tetrahydrocannabinol (THC), a primary compound responsible for psychotropic effects of cannabis, to values below 0.3%. This low content of THC makes the plant non-usable for drug abusers and therefore could potentially be freely cultivated in open-air plantations for production of fibers, seeds and oil. Industrial hemp offers a variety of advantages across multiple sectors, making it a highly valuable and sustainable crop. It requires significantly less water compared to cotton and can grow in a variety of soil types and climates. Moreover, it improves soil structure and fertility through deep rooting systems, reducing erosion and promoting biodiversity. Hemp actively absorbs CO<sub>2</sub> from the atmosphere, making it an effective tool in carbon sequestration for combating climate change.

Industrial hemp offers unprecedented versatility. Thus, hemp fibers can be used for textiles, paper, building materials (like hempcrete) and biodegradable plastics. Hemp seeds are highly nutritious, rich in protein, omega-3 fatty acids and other essential nutrients, making them a popular ingredient in health foods. Hemp extracts and its components, such as cannabidiol (CBD), are extensively used in wellness products for their potential therapeutic benefits.

Importantly, industrial hemp could be used to obtain cellulose and its derivatives. Cellulose nanomaterials (CNs) possess a unique combination of characteristics that make them valuable in various applications. They include high mechanical strength, reinforcing capabilities, biodegradability, environmental friendliness, self-assembly in water, etc. These properties arise from their shape, size and surface chemistry. As a natural polysaccharide, CNs can act as nanocarriers for removing dyes or delivering drugs. Recent innovations in CNs have led to significant interest in their use as antimicrobial materials and adsorbents for heavy metals and dyes. Intensive research is going on to optimise technologies to grow hemp in various climates and obtain cellulose fibers, cellulose and its derivatives.

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# OPTIMIZED SPECTROPHOTOMETRIC METHOD FOR THE RAPID DETERMINATION OF IRON CONTENT IN YEAST

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**Introduction.** Ensuring the population's access to essential micronutrients, particularly iron, is a key component in achieving the Sustainable Development Goals (SDGs), specifically SDG 2 «Zero Hunger, Achieve Food Security and Improved Nutrition» and SDG 3 «Ensure Healthy Lives and Promote Well-being». Iron-enriched yeasts are gaining increasing attention as functional food ingredients that provide a bioavailable and less toxic form of iron due to its binding with organic matrices. They serve not only as a nutritional source of iron but may also exert prebiotic or probiotic effects, contributing to the maintenance of a healthy gut microbiota. Moreover, yeast biomass can be produced using food waste and secondary raw materials aligning with SDG 12 «Responsible Consumption and Production». In this context, the development of accessible and accurate methods for determining iron content in biomass is critically important for quality control, enrichment efficiency, and the safety of such biotechnological products.

**Materials and Methods.** This study presents a rapid and simple spectrophotometric method for determining iron in yeast. The object of the study was *Saccharomyces cerevisiae* M437 yeast enriched with iron. Iron content was assessed using a spectrophotometric method involving a colorimetric reaction between ferrous iron ( $\text{Fe}^{2+}$ ) and BPS. Ferric iron ( $\text{Fe}^{3+}$ ) was reduced to  $\text{Fe}^{2+}$  using sodium ascorbate.

**Results and Discussion.** To disrupt the yeast cell wall and release iron, solutions of nitric acid with concentrations of 2%, 3%, and 5%, as well as a 2 M hydrochloric acid solution, were tested. The stability of the  $\text{Fe}^{2+}$ -BPS complex was examined at different pH values and time intervals. The optimal sample preparation conditions involved treating yeast biomass with 3%  $\text{HNO}_3$  at 97 °C. The  $\text{Fe}^{2+}$ -BPS complex formed stably at pH 5.3–5.4, within 3 minutes and remained stable for up to 45 minutes in a citrate buffer. The method's reproducibility was assessed using three parallel solutions with iron concentrations ranging from 110 to 360  $\mu\text{M}$ ; the relative standard deviation (RSD) did not exceed 1.4% across the entire range. Linearity was confirmed over the range of 20–950  $\mu\text{M}$  ( $R^2 > 0.99$ ), enabling accurate quantification of both low and high iron concentrations. The iron content in yeast enriched with  $\text{FeSO}_4$  was  $9.7 \pm 0.2$  mg/g, while enrichment with  $\text{FeCl}_3$  resulted in  $5.2 \pm 0.5$  mg/g. These values were in good agreement with those obtained using atomic absorption spectrometry ( $9.3 \pm 0.4$  mg/g and  $5.7 \pm 0.6$  mg/g, respectively). ANOVA analysis confirmed a statistically significant difference in iron content depending on the type of salt used ( $\text{FeSO}_4$  vs.  $\text{FeCl}_3$ ), whereas the difference between measurement methods (spectrophotometry vs. atomic absorption spectrometry) was not significant ( $p = 0.8522$ ), indicating analytical equivalence between the two techniques.

**Conclusion.** The proposed method is suitable for routine control of raw materials and food products, as well as for evaluating iron enrichment in yeast biomass during biotechnological processes for obtaining iron-containing biopreparations. This approach holds promise for developing functional food additives with increased bioavailable iron, potentially addressing dietary iron deficiency.

## PROSPECTS FOR USING MEDICINAL BASIDIOMYCETES IN PREVENTING BACTERIAL INFECTIONS AND PROMOTING SUSTAINABLE AQUACULTURE

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Ensuring the global population's access to high-quality protein-rich food in the context of developing a sustainable agri-food system in the EU is one of the key challenges for today. Fish protein is considered the one among the most balanced sources of protein. However, the aquaculture sector faces a serious problem – a high incidence of diseases among farmed fish (up to 40%), which leads to significant economic losses. Taking into account the increasing resistance of fish bacterial pathogens to conventional antibiotics, there is an urgent need to search for alternative natural bioactive compounds with antimicrobial properties for use in aquaculture. One promising solution involves the use of medicinal basidiomycetes, containing compounds with antimicrobial and antioxidant activities, and capable of accumulating high levels of protein when cultivated on agricultural waste.

The most common bacterial pathogens in aquaculture include representatives of the genera *Aeromonas*, *Edwardsiella*, *Flavobacterium*, *Pseudomonas*, *Streptococcus*, *Vibrio*, *Yersinia*, *Mycobacterium* and others (Miller & Harbottle, 2018). However, the excessive use of antibiotics for the prevention of bacterial infections has led to an increase in antimicrobial resistance, as confirmed by international studies (Abedin et al., 2024). At the same time, Ukrainian researchers have demonstrated the antimicrobial activity of culture filtrates from *Hericium* basidiomycetes against both Gram-positive and Gram-negative bacteria (Lomberg et al., 2023). Turkish scientists have also reported the effectiveness of *Trametes versicolor* extracts against bacterial and fungal pathogenic microorganisms (Özgör et al., 2016). Therefore, considering environmental challenges and the urgent need to reduce antibiotic use in fish farming, medicinal mushrooms represent a promising alternative due to their natural antimicrobial compounds, which can be used to develop environmentally friendly functional feeds and support the sustainable development of the fish industry.

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## INTEGRATION OF ESSENTIAL SUSTAINABLE ELEMENTS INTO UKRAINE'S RECONSTRUCTION EFFORT

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The study by Ruuska and Häkkinen (2015) demonstrated that the carbon footprint associated with energy consumption during the operational phase of an average apartment building is comparable to the combined carbon footprint of construction material manufacturing, the building's construction, repairs throughout its lifecycle, and final demolition. As energy efficiency standards improve in line with directives such as the EU's Energy Performance of Buildings Directive (EPBD) – the share of operational carbon emissions is expected to decrease, making embodied carbon a more critical factor in overall climate impact. To address this shift, Life Cycle Assessment (LCA) according to the EN 15978 standard is a methodology for integrating carbon management.

For new buildings, the greatest impact at the lowest possible cost over the project's lifecycle can be achieved at the design stage. There are several practical approaches that can be implemented immediately during building design to enhance sustainability and carbon performance, including:

- Reduction of embodied carbon through the integration of LCA into the design process.
- Improving energy efficiency, digital twin integration.
- Provision of safe drinking water and strategies for reduced water consumption.
- Indoor air pollutants such as VOCs and formaldehyde control.
- Incorporation of climate change considerations into design decisions.
- Evidence-based performance parameters by voluntary green building certification schemes.

For existing buildings in Ukraine, the development of energy models presents a promising approach to identifying optimal solutions for reducing operational carbon emissions, enhancing energy efficiency, and decreasing reliance on fossil fuels. Energy modeling enables the evaluation of various retrofit strategies and allows for scenario-based analysis of future climate impacts by utilizing modified weather data files that reflect projected climate conditions.

Many of these strategies are embedded within sustainable building certification schemes; however, the concept of sustainability itself is increasingly being challenged and extended by the paradigm of regenerative design. Regenerative approaches - applicable to both new constructions (Reed, 2007) and retrofitting of existing buildings (Craft et al., 2017) – aim not only to minimize harm but to create a net-positive impact on environmental and human health.

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## PROMOTING SUSTAINABLE DEVELOPMENT THROUGH HEALTH-PRESERVING EDUCATIONAL TECHNOLOGIES

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Sustainable development is a fundamental priority for the modern world, aiming to balance economic growth, social well-being, and environmental protection. Education plays a crucial role in achieving the Sustainable Development Goals, particularly Goal 3 – "Good Health and Well-being" and Goal 4 – "Quality Education." Education equips individuals with the knowledge, skills, and values for healthy living and sustainable development, making health-preserving educational technologies vital for well-being, resilience, and lifelong learning.

«... In scientific discourse, human physical and mental health is analyzed as a global phenomenon that constitutes the subject of scholarly investigation. ... Researchers are unanimous in their belief that human health is inextricably linked to lifestyle and its quality» (Plachynda et al., 2024). In this context, a key priority for higher education institutions is the integration of health-preserving educational technologies into the educational process in order to develop conscious, physically and mentally healthy professionals oriented toward driving effective societal change in line with the Global Goals for Sustainable Development.

Health-preserving educational technologies are built upon several key principles that align with the goals of sustainable development. These principles include the prevention of health risks, the promotion of physical activity, the support of psycho-emotional well-being, and the development of digital health literacy. Key types of such technologies include the integration of physical activity into the learning environment, interactive digital resources for cultivating healthy habits, and social-emotional learning programs that strengthen students' emotional resilience and social competencies.

The implementation of these technologies directly supports the achievement of the Sustainable Development Goals, particularly by fostering a sustainable, health-conscious lifestyle among the younger generation. By enhancing quality of life, improving productivity, and strengthening social resilience, health-preserving educational technologies contribute to building sustainable societies (United Nations, 2015; UNESCO, 2023).

Thus, the integration of health-preserving educational technologies is a crucial component of building a sustainable future. By promoting physical activity, supporting mental health, and enhancing digital health literacy, educational institutions contribute significantly to the formation of resilient, socially responsible individuals.

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# INTEGRATING AI IN EDUCATION FOR SUSTAINABLE DEVELOPMENT: INSIGHTS FROM K-12 AND HIGHER EDUCATION

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Sustainable development necessitates innovative educational approaches to equip learners with skills for global challenges. Artificial intelligence (AI), including large language models (LLMs) and computer vision, offers transformative potential to enhance teaching and learning. This abstract explores AI's applications and outcomes in K-12 and higher education, alongside a practical case study.

Recent studies identify seven primary AI applications in education: personalized learning, automated assessment, AI-enhanced content delivery, student support, AI literacy education, task automation, and enhanced teacher-student interaction (Yim & Su, 2024; Alotaibi, 2024). In higher education, LLM-driven adaptive systems boost engagement and outcomes (Chaturvedi, 2024). In K-12, machine learning tools like Google Teachable Machine foster computational thinking and AI literacy (Toivonen et al., 2020). Benefits include improved personalization and efficiency, though concerns persist—58% of professors fear evolving roles, and 49% of students worry about independent learning (Zhang et al., 2024). Ethical issues, teacher training, and technological readiness remain challenges.

A case study from a mathematical modeling course on environmental systems demonstrates practical AI integration. Combining traditional tools (e.g., Python, GeoGebra) with LLMs, students enhanced proficiency in modeling and AI-assisted problem-solving, gaining deeper understanding and engagement. AI in education advances sustainable development by improving learning and preparing students for future challenges. Success hinges on addressing ethics, training, and infrastructure needs.

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# POSSIBILITIES OF USING BAKER'S YEAST *SACCHAROMYCES CEREVISIAE* FOR GREEN BIOSYNTHESIS OF METAL NANOPARTICLES: INTEGRATION INTO EUROPEAN PRIORITIES OF SUSTAINABLE DEVELOPMENT AND NANOSAFETY

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In current global environmental challenges the development of sustainable and environmentally friendly technologies is extremely relevant, particularly in the field of nanotechnology. One of the perspective approaches is biosynthesis of metal nanoparticles using microorganisms such as baker's yeast *Saccharomyces cerevisiae*. This approach complies with the principles of “green” chemistry and avoids the use of toxic reagents typically used in traditional chemical synthesis. Currently, the biosynthesis of nanoparticles of various metal groups using yeast of the genus *Saccharomyces* has been investigated. Nanoparticles of noble metals (gold, silver, platinum, palladium), which were synthesized using yeast, have a wide range of biological properties and have prospects for use in the food industry, agriculture, medicine and the energy sector (Koul et al., 2021). The biosynthesis of metal oxide nanoparticles is also being investigated: oxides of silver, zinc, antimony, manganese, iron, selenium, silicon, titanium (Mohamed & Kadium, 2022). Biosynthesis of binary chalcogen nanoparticles (selenium, zinc, cadmium sulfide) using *Saccharomyces cerevisiae* was investigated (Asghari-Paskiabi et al., 2019). There is very little information on the biosynthesis of copper nanoparticles by yeast of the genus *Saccharomyces*. We are conducting research on the use of *Saccharomyces cerevisiae* M437 for the biosynthesis of copper nanoparticles.

Research in this area is closely linked to the priorities of the European Union within the Horizon Europe program. In particular, we are talking about the development of sustainable nanotechnologies, support for the bioeconomy, the implementation of the Safe and Sustainable by Design concept in the field of nanomaterials, as well as the transformation of industry towards environmental safety and a circular economy. Integration of biogenic approaches to nanoparticle synthesis into these research and innovation strategies uncovers new opportunities for the creation of safe, effective, and technologically scalable solutions for industry, medicine, and ecology.

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## TECHNOLOGIES FOR AMARANTH COMPLEX PROCESSING FOR THE PRODUCTION OF HEALTHY FOOD PRODUCTS

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One of the goals of sustainable development is responsible consumption, in particular, the transition to a significant reduction in waste volumes through the use of measures to prevent its formation, its reduction, recycling and reuse (Herrero et al., 2021). Such approaches should be implemented in the processing of plant raw materials in modern food technologies, in particular in the production of food products for health and preventive purposes.

One of the ways to improve the quality of nutrition of modern people is to introduce food additives with high taste and nutritional qualities into the diet, which include processed amaranth seed products. Amaranth (*Amaranthus* L.) is a valuable industrial, fodder, food and medicinal crop. Researchers are actively developing technologies for the complex processing of amaranth seeds to obtain a number of food and medicinal products from them: products of mechanical and thermal processing, amaranth oil, squalene, CO<sub>2</sub>-extracts, protein additives and pectin (Jimoh et al., 2022).

Products of mechanical processing of amaranth seeds, such as whole-grain flour, are obtained by grinding the seeds on roller mills or disintegrators without removing the seed coat. Taking into account the features of the fractional composition of amaranth seed proteins, protein concentrates, isolates, and protein-polysaccharide complexes have been obtained, which have high digestibility, water solubility, and emulsifying capacity. To obtain products from the processing of thermally processed amaranth seeds, it is proposed to extrude or roast them. Extrusion processing helps to reduce the trypsin content and increase the digestibility of the protein, as well as improve the organoleptic properties of the resulting product. Amaranth oil occupies a special place among the products of complex processing of amaranth seeds; its fatty acid composition is close to that of corn and it contains up to 77% unsaturated fatty acids, mainly represented by polyunsaturated acids of the  $\omega$ -3 family.

Vegetable forms of amaranth and its leafy part are considered as a potential source of coloring pigments, protein and vitamins. Amaranth foliage contains a large amount of protein (up to 38.3%), carotenoids, vitamins C, B<sub>1</sub>, B<sub>2</sub>, B<sub>12</sub>, E, flavonoids with P-activity (rutin, quercetin) and pectin, which is not inferior to apple pectin in its complexing ability. Such a valuable biochemical composition of different parts of the plant creates broad prospects for the use of amaranth in modern food technologies.

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# DYNAMICS OF CORN WASTE ENSILING FOR POTENTIAL BIOGAS PRODUCTION: UKRAINIAN AND GLOBAL PRACTICES

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The European Union actively promotes the use of renewable energy sources, as emphasized in Directive (EU) 2018/2001, with biogas production recognized as one of the most promising technologies (European Parliament & Council, 2018). Ensiling lignocellulosic biomass not only extends its shelf life but also enhances biogas production by enriching the substrate with organic acids, thereby improving the efficiency of anaerobic digestion (Sun H. et al., 2021). Lignocellulosic biomass, with a favorable carbon-to-nitrogen ratio (C:N 20–30), represents a cost-effective and sustainable substrate for biogas generation, with the C:N ratio being critical for optimizing anaerobic digestion (Ghaedi M. et al., 2024).

The present study aimed to develop a novel lactic acid bacteria consortium suitable for ensiling corn leaf and to compare its effectiveness with established commercial products and previously published data. Two experimental consortia – “Biogas” (comprising *Lactobacillus buchneri* DSM 107969, *Lactobacillus diolivorans* DSM 14421, and *Lactobacillus rhamnosus*) and “SilakPRO” (comprising *Lactobacillus plantarum*, *Enterococcus faecium*, *Pediococcus pentosaceus*, and *Propionibacterium shermanii*) – were compared with the commercial inoculant “Silasil Energy” (containing *Lactobacillus diolivorans* NCIMB 30141, *Lactobacillus rhamnosus* LAC 1129, and *Lactobacillus buchneri* SBE 10070). The strains used for the development of the “Biogas” consortium were provided by the biotechnology company BTU-CENTER (Ukraine).

Results showed that the “Biogas” consortium achieved a consistently higher acid production rate (20–30 Turner’s units) compared to other formulations (15–25 Turner’s units), maintained a lower pH range (4.2–4.6 vs. 4.5–5.0), and reached a higher viable cell concentration — up to  $4 \times 10^8$  CFU/mL compared to  $1.8 \times 10^8$  CFU/mL in “SilakPRO.” These findings demonstrate the superior adaptability and survival of the “Biogas” consortium under corn leaf ensiling conditions. Future studies should focus on characterizing the specific acids produced and evaluating the effect of the resulting silage on biomethane production efficiency.

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## ANTAGONISTIC ACTIVITY OF ENDOPHYTIC ISOLATE E11 FROM SCOTS PINE SEEDS

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**Introduction.** Endophytic microorganisms establish symbiotic relationships with plants, enhancing their resistance to pathogens and abiotic stresses, making them promising agents for the development of biotechnological preparations (Bolivar-Anillo et al., 2021). This study aimed to determine the taxonomic status of isolate E11, obtained from pre-sterilized Scots pine (*Pinus sylvestris* L.) seeds, and evaluate its antimicrobial potential.

**Materials and Methods.** Isolate E11 was obtained from Scots pine seeds (collected from the Bucha Forestry) after sequential surface sterilization. Identification was performed using MALDI-TOF mass spectrometry and determination of physiological and biochemical characteristics. Antagonistic activity was determined against collection strains of phytopathogenic bacteria (Zabolotny Institute of Microbiology and Virology) in vitro using the radial streak method by measuring the growth inhibition zones of phytopathogens.

**Results.** Isolate E11 consists of Gram-positive rods that form ellipsoidal spores. Using MALDI-TOF mass spectrometry (Tsuchida, Hiroshi, & Tomohiro, 2020), the isolate was identified as *Bacillus pumilus* with 99.9 % reliability. Significant inhibitory activity of the isolate was determined against *Pseudomonas syringae* (inhibition zone – 35 mm), *Xanthomonas campestris* (32 mm), *Clavibacter michiganensis* subsp. *michiganensis* (33 mm), and *Pectobacterium carotovorum* subsp. *carotovorum* (20 mm). Bacteriostatic activity was observed against *Pseudomonas fluorescens*, while no antagonism was detected against *Agrobacterium tumefaciens*.

**Conclusions.** The endophytic isolate E11, identified as *Bacillus pumilus*, exhibits high antimicrobial activity against a wide spectrum of phytopathogenic bacteria. This justifies its potential for the development of biopreparations to plant protection and growth stimulation.

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# COMPARISON OF THE BASIC PRINCIPLES OF THE GREEN AND SUSTAINABLE CHEMISTRY CONCEPTS AND THE PRACTICE OF THEIR APPLICATION

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The growth of global production and use of chemical products increases the risks associated with the adverse effects of hazardous chemicals on human health and the environment. In international practice, there is a shift in emphasis in regulating the circulation of chemical products. The use of administrative methods that require state-level control of the circulation of chemical substances, their mixtures and products derived from them is supplemented by methods to prevent the release of hazardous chemical products onto the market. To this end, preventive measures are being developed that are based on the application of the principles of green and sustainable chemistry, the best available technologies aimed at the sustainable development of industry in the long term.

The scientific direction of "green chemistry" aims to prevent the negative impact of chemicals on the environment and human health at the initial stages of chemical processes by reducing or completely eliminating the use of hazardous chemicals or improving the synthesis processes that produce these chemical substances (Zuin et al., 2021).

"Sustainable chemistry" is a broader concept than "green chemistry" in terms of maintaining a balance between the needs of society in the present and the need to protect the environment in the future. Sustainable chemistry is a scientific concept that aims to increase the efficiency of the use of natural resources to meet human needs for chemical products and services. Sustainable chemistry includes the development, production and use of effective, efficient, more environmentally friendly chemical products and processes. The principles of sustainable chemistry take into account the use of the best available technologies, increasing the life cycle of chemicals used in technological processes, and increasing resource and energy efficiency in order to achieve sustainable development, i.e. a balance between human activity, socio-economic development, as well as natural resources and the ability to restore the natural environment (Blum et al., 2017).

The application of the basic approaches and principles of two concepts – green and sustainable chemistry – in the formation and development of chemistry, chemical technology and other industries is a driver of sustainable industrial development.

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## USE OF NON-TRADITIONAL PLANT-BASED RAW MATERIALS IN THE INNOVATIVE TECHNOLOGY OF HEALTH PATE

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The lack of biologically active substances in the diet, which significantly influence metabolic processes in the human body, requires the search for unconventional raw materials with high biological value, development of new and the improvement of existing technologies production of health foods. At the same time, consumer demand for ready-to-eat products is increasing worldwide. These products include pates, which are very popular among the population due to their versatility, the ability to control their chemical composition and their nutritional value. They can be used in the normal diet, are practical for tourism and are becoming increasingly popular in the catering industry.

The aim of the study is to develop the composition of a meat and vegetable pate for health purposes using germinated lentil and green buckwheat grains and to investigate their quality indicators.

An important factor justifying the choice of non-traditional additives for the production of a new pate in this work was the valuable chemical composition of lentil and buckwheat grains. The sprouting of the selected grains, in turn, was used to increase the nutritional value and bioavailability of the dietary components, reduce antinutritive substances and improve the functional composition of the proteins (Bashta et al, 2019).

The protein and fibre content of germinated grains was determined experimentally, as a high protein content is essential for meat and vegetable pate, and it is advisable to enrich them with natural sorbents. The protein content in the test samples of germinated lentils was 32.2 %, the fibre content 2.9 % and in germinated green buckwheat grains these values were 12.8 % and 9.3 % respectively.

A series of pate recipes were developed containing pork liver, pork, bacon, germinated lentil and buckwheat grains, onions, carrots, salt and spices. The content of germinated lentil and buckwheat grains in the determined optimal ratio (germinated buckwheat grains at 60% and germinated lentil grains at 40%) in the pate recipe varied between 5 and 20%. It was found that the optimum sprouted lentil and buckwheat grain content in the recipe was 15%.

It was found that the meat and vegetable pates with sprouted grains fully meet the set standards in terms of physical and chemical parameters. The developed pate belongs to the category of functional food products. Consuming 100 g per day covers 10 to 50 of the needs of an adult organism for a number of essential nutrients. In particular, the daily macro- and micronutrient requirements of the adult population in the first labor intensity group are met by consuming 100 g of pate as follows in %: proteins – 24.8, carbohydrates – 5.1 (dietary fiber – 5.2), fats – 22.6, vitamins (B<sub>1</sub> – 13.2, B<sub>2</sub> – 13.9, B<sub>6</sub> – 17.5, E – 16.5); minerals (P – 14.9, Fe – 21.8, Cu – 26.7, Zn – 19).

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## CLEANE ENERGY TECHNOLOGIES AND ENERGY EFFICIENCY: THE EU EXPERIENCE AND PROSPECTS FOR UKRAINE

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Energy has entered the lives of each of us and has become an important part of international life. For these reasons, energy policy is of particular interest for research. EU energy policy is a multidimensional phenomenon. It can be presented in different aspects.

Bioenergy can be obtained from various types of biomass raw materials, including agricultural waste and livestock waste; forest plantations; energy crops; organic component of solid waste and other types of organic waste. Through a number of processes, these raw materials can be used directly for the production of electricity or heat or can be used to create gaseous, liquid or solid fuels. The range of bioenergy technologies is wide, and the level of their technical development varies considerably. Bioenergy projects usually depend on the availability of local and regional fuel supplies, but recent developments show that solid biomass and liquid biofuels are increasingly entering international trade.

Among the main mechanisms to stimulate the development of bioenergy in the EU are: market prices and additional taxes on fossil fuels, stimulating "green" tariffs and "green" certificates for electricity from RES, government support, subsidies for equipment and current government policy for RES development.

The leaders in energy use of biomass in Europe are Lithuania (33.6%), Finland (33.5%), Sweden (31.9%), Estonia (26%), Latvia (22.9%). The largest share of biomass in the total contribution of all renewable energy sources occurs in Estonia (93.1%), Latvia (87.6%), Poland (87.3%), Finland (86.3%), Hungary (85.7 %) (Prospects for the development of the biomass market in the EU and Ukraine, 2019). Global energy production by the bioenergy sector in 2050 can be increased almost 35 times from today's level (Geletukha G.G., 2021).

The main types of stimulating the development of bioenergy in the world and in Ukraine are: capital subsidies, grants or discounts, which provide one-time payments to cover interest on capital expenditures on investments; investment or production tax credits; reduction of taxes applied to the purchase (or production) of technologies for the use of renewable energy sources; public investments, loans or grants for infrastructure development and implementation of projects in the field of bioenergy.

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## SUSTAINABLE ENERGY STORAGE THROUGH BIOMASS-DERIVED CARBON: A NEW PARADIGM?

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The urgent demand for clean energy storage aligns with the EU's Green Deal and Net-Zero Industry Act (EC, 2024), driving innovation beyond conventional lithium-ion technologies. Although widely adopted, lithium-ion systems depend on critical minerals, entail complex recycling, and pose fire risks. Emerging carbon-based energy storage cells address these challenges by utilizing agricultural biomass-derived porous carbon, water, and halide salts (Interesting Engineering, 2025).

Operating through ion sorption mechanisms, these cells store charge via physical adsorption into renewable carbon electrodes. Aqueous electrolytes ensure non-flammability and environmental safety. Recent developments have demonstrated cycle lives exceeding 6,000–10,000 cycles and durable system operation over 25 years with energy densities up to 434 Wh/kg reported in metal-free dual-carbon systems (Zishuai Zhang et al. 2022).

Patents and scientific studies confirm that metal-free carbon electrodes combined with saltwater electrolytes enable safe, scalable, and recyclable storage. New designs even eliminate metal current collectors, allowing batteries made entirely from renewable, non-toxic materials (Naresh, R., et al., 2019). This advances the vision of truly circular energy storage, independent from mining constraints and toxic substances.

Aligned with Industry 5.0 principles (EC, 2023), these carbon-based cells represent a critical innovation for resilient, sustainable grids and energy autonomy. This paper discusses their architecture, lifecycle performance, and role in advancing Europe's clean energy goals through fully renewable, low-impact storage technologies.

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## TECHNOLOGICAL INNOVATIONS AS A TOOL FOR MANAGING THE AVIATION INDUSTRY

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The modern aviation market is changing under the influence of rapid technological development, which opens up new opportunities for improving flight efficiency and safety. One of the key areas of innovative projects is the introduction of artificial intelligence and big data analysis to optimize routes, predict maintenance, and improve customer service.

In addition, aviation companies are actively introducing autonomous systems such as unmanned aerial vehicles and automated flight control systems. This helps to improve safety and reduce the risks associated with human error.

Alternative fuel technologies, including biofuels and hydrogen engines, are becoming increasingly important for reducing carbon emissions and achieving environmental sustainability in the aviation industry (Zhyvko et al., 2024).

Another important area is the introduction of digital technologies in the passenger service sector, such as biometric identification, blockchain for baggage management, and mobile applications for travel personalization (Bugayko et al., 2022).

Despite the significant benefits of technological innovations, their implementation is accompanied by a number of challenges, including the high cost of modernization, the need to adapt the regulatory framework, and cybersecurity. At the same time, strategic investments in the latest technologies allow airlines not only to increase their competitiveness, but also to make air travel more environmentally friendly, safe, and affordable.

The rapid development of technology is significantly transforming the aviation market, opening up new opportunities to improve the efficiency, safety and environmental sustainability of air transportation. The introduction of artificial intelligence, autonomous systems, alternative fuels, and digital technologies allows airlines to significantly improve their operational processes, reduce operating costs, and improve the quality of passenger service. However, despite the obvious benefits, the introduction of such innovations is accompanied by significant financial costs and the need to adapt to new regulatory requirements and ensure cybersecurity. Nevertheless, strategic investments in the latest technologies can significantly increase the competitiveness of airlines and make air travel more environmentally friendly, safe and accessible to a wide range of users.

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## ARTIFICIAL INTELLIGENCE IN ENSURING A SUSTAINABLE LABOR MARKET

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Artificial intelligence is one of the key technologies of the Fourth Industrial Revolution, which is fundamentally changing the way we do business, produce and interact with people.

Current trends in technology development cause large-scale changes in the structure of employment. Artificial intelligence is being actively implemented in various fields of activity, changing the requirements for employees' professional skills and facilitating the automation of many business processes. This creates both new opportunities for the labor market and significant challenges for civil society. One of the main aspects of the impact of artificial intelligence on the labor market is the transformation of the requirements for specialist qualifications.

Traditional professions are gradually changing or disappearing, while the demand for data analysts, algorithm developers, and AI ethicists is growing. This requires employees to be flexible and ready for continuous learning, which is becoming an important factor in competitiveness in the labor market. Currently, artificial intelligence is used to automate repetitive and routine tasks such as data entry and processing. Therefore, jobs requiring such skills are likely to be automated in the future.

However, positions that require human skills, such as problem solving, creativity, and empathy, are less likely to be replaced by machines immediately. These qualities are essential for roles that involve complex decision-making and require human intervention. When analyzing the impact of artificial intelligence on the labor market, the following key aspects should be highlighted:

✓ Automation of work processes. Machine learning algorithms and neural networks automate routine tasks in production, service, finance, and logistics. This reduces the need for low-skilled labor, but increases the demand for artificial intelligence specialists.

✓ Emergence of new professions. With the development of artificial intelligence, new professions are emerging, including data engineers, artificial intelligence ethicists, big data analysts, etc. This requires the adaptation of the education system and training programs to changes in the labor market.

✓ Personalization of the workflow and hybrid employment models. Thanks to the use of artificial intelligence, employers can more effectively manage personnel, predict staffing needs, and automate recruitment processes. In addition, hybrid employment models and digital freelancing are becoming popular.

✓ Social and economic challenges. Despite its significant advantages, the introduction of artificial intelligence may increase social inequality, as not all workers are able to adapt quickly to changes. The issue of regulating the impact of artificial intelligence on employment and protection of workers' rights is also important.

Thus, artificial intelligence plays an important role in transforming the labor market by changing the requirements for professional skills and the structure of employment. The introduction of artificial intelligence creates new opportunities for economic development, but also requires the adaptation of the workforce and the introduction of effective social policy mechanisms.

## DIGITALIZATION OF HOTEL SERVICES: THE EUROPEAN EXPERIENCE

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The research on the digitalization of hotel services in the European context has identified key technological trends and analyzed the practical level of digital intensity in hotels. It has been determined that the interplay between the implementation of automation, artificial intelligence, and the Internet enhances the efficiency of service processes, leading to greater guest satisfaction. Digital transformation is a priority for the hotel business in the European Union, as it contributes to increased competitiveness in the industry and opens up new development opportunities. At the same time, within the framework of the EU's Single Digital Market, there is an emphasis on the need to accelerate the implementation of cutting-edge IT solutions in hotels, which will serve as a foundation for improving service quality and attracting new consumer groups.

In 2023, 59% of all enterprises in the EU hotel sector achieved a basic level of digital intensity, with small and medium-sized enterprises (SMEs) at 58% and large enterprises at 91%. An analysis of the level of digitalization in hotel services by country revealed significant disparities in performance indicators. For instance, only 27% of small hotel businesses in Romania operate with a basic level of digital intensity, compared to 86% of hotels in Finland (Peter Lochbihler, 2024; Fahmi Amirulloh Anwar, 2024).

The digitalization of hotel services in Europe contributes to increased operational efficiency, improved guest relations, and revenue growth. Automation, AI, and IoT devices are already demonstrating tangible results among market leaders (Digitalisation in Europe – 2024 edition, 2023). Despite varying rates of implementation across different countries, the overall trend indicates a necessity for strategic investments in digital solutions to ensure competitiveness. Future research should focus on assessing the impact of emerging technologies on the sustainability of hotel operations and the integration of environmental initiatives into digital platforms.

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# GREEN-BY-DESIGN: USING DIGITAL TWINS FOR LIFECYCLE SUSTAINABILITY IN INDUSTRY 5.0

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Digital twins—virtual replicas of physical assets, systems, or processes—are emerging as critical tools for sustainable industrial transformation. Integrating real-time data, simulation, and predictive analytics, they enable optimized resource use, innovative process design, and environmental impact reduction. In alignment with the European Union’s *Industry 5.0* vision, digital twins foster human-centric, resilient, and sustainable production systems (EIT Manufacturing, 2021).

At the design stage, they simulate the environmental footprint of materials and product lifecycles. During operations, they monitor emissions, water usage, and waste generation, enabling real-time interventions to improve sustainability metrics (He & Bai, 2021). This capability is particularly impactful in sectors such as chemicals, food processing, and discrete manufacturing.

European initiatives like DigiTwin4Green and programs by the European Institute of Innovation & Technology (EIT) are funding pilots that integrate sustainability KPIs into digital twin platforms (EIT Manufacturing, 2023, 2024). These systems also advance predictive maintenance, circular economy strategies, and worker well-being, supporting EU climate targets.

Challenges persist in data standardization, cross-platform integration, and the computational cost of high-fidelity models. However, advances in edge computing and cloud-native architectures are making scalable deployments increasingly viable (IBM Research, 2025).

This paper outlines methodologies for implementing digital twins in green manufacturing and argues for their formal inclusion in sustainability reporting, certification, and regulatory frameworks.

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# ULTRASONIC PROCESSING OF FOOD PRODUCTS IN COMPLIANCE WITH THE PRINCIPLES OF LABOR SAFETY AS A DIRECTION OF SUSTAINABLE DEVELOPMENT OF THE FOOD INDUSTRY

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Ultrasonic processing is a promising method for improving the quality of food products due to its ability to improve texture, increase shelf life and intensify mass transfer processes. Ultrasonic vibrations are able to influence the aggregate state of a substance, promote its dispersion, emulsification, and also change the rate of diffusion, crystallization, and dissolution processes. They also activate chemical reactions and increase the efficiency of technological processes (Kryzhak et al., 2022). Sustainable development at a food processing enterprise involves a harmonious combination of economic efficiency, social responsibility and environmental safety. This work studied and summarized the global, domestic, and personal experience of the influence of ultrasound on the physicochemical properties of meat and dairy products, beverages, honey, and dough. In particular, it has been established that ultrasonic treatment of meat improves its tenderness and color, increases its moisture retention capacity, increases the pH level, and also has an antimicrobial effect. Ultrasonic processing of dairy products (milk, yogurt, cheese, mayonnaise) helps to reduce viscosity, which positively affects their organoleptic characteristics. During the ultrasonic treatment of drinks (wine, juices, kvass), a decrease in microbiological contamination is noted, which allows to extend the shelf life of the products. Ultrasonic processing of honey prevents its crystallization, which helps to preserve its fluid consistency for a long time. Ultrasound in dough contributes to the uniform distribution of gas bubbles, which improves its structure and increases the porosity of the final product. In addition, ultrasonic treatment of dough masses activates enzymatic processes, which leads to improvement of their rheological characteristics and increase in the volume of baked goods.

There are more and more devices that emit ultrasounds used for different sanitary procedures, aesthetic treatments and industrial processes, creating more possibilities of ultrasound noise, and therefore an increased risk of occupational hazard and occupational danger (Moyano et al., 2022). The introduction of ultrasonic food processing technologies requires increased requirements for labor protection, as there is a need to train personnel in safe work with high-tech equipment, taking into account protection from ultrasonic waves and control of the acoustic pressure level through the use of modern systems for automatic monitoring of working conditions. Therefore, the combination of ultrasonic processing of food products with compliance with labor safety principles is an important direction of sustainable development of the food industry.

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## USE OF MILLET FLOUR IN THE RESTAURANT BUSINESS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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Efficient use of food resources, particularly the expansion of raw materials with multifunctional purposes, is one of the priority directions in food production. One such raw material is millet, which was declared the plant of the year by the United Nations in 2023 due to its advantages for food security, promotion of healthy nutrition, and environmental sustainability under climate change conditions. Millet has significant nutritional value, particularly a high content of proteins, fiber, iron, magnesium, and phosphorus, as well as a low glycemic index. It is gluten-free, making it an optimal product for expanding the range of gluten-free products and for use in special gluten-free diets (FAO, 2023).

Gluten, a conglomerate of gliadin and glutenin, protein fractions such as secalin, hordein, and their hybrids, is a component of most cereal proteins and thus plays an important role in forming the structural-mechanical and technological properties of products. These components of the protein-proteinase complex of cereals are hazardous for consumers with gastrointestinal diseases, gluten intolerance, celiac disease, or gluten allergies (Khoury et al., 2018).

The issue of expanding the assortment of gluten-free products for craft productions and hotel and restaurant businesses remains insufficiently explored. Therefore, the use of millet and its processed products as alternative cereal raw materials is relevant and promising. The low glycemic index of the studied raw material for bread and bakery products will provide an additional advantage, considering the negative dynamics of diseases related to the endocrine and cardiovascular systems (Capriles et al., 2021).

Different types of millet flour were studied, comparing them with common gluten-free raw materials (rice and oat flour), as well as wheat flour. The main organoleptic, physicochemical indicators, and technological properties of the new raw materials for bread production were determined.

Millet flour has greater water absorption capacity compared analog due to the presence of non-starch polysaccharides. This is an advantage because it allows adjusting the structural and mechanical properties of dough and gluten-free products and reduces the amount of additional structure-forming additives required. The disadvantage is the somewhat high acidity of millet flour and its characteristic tint, which requires additional technological measures to mitigate the impact on the organoleptic quality indicators of bread.

Millet flour is a promising resource-saving raw material with technological and nutritional advantages.

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## THE CIRCULAR BIOECONOMY AND ADVANCED WASTE TREATMENT BIOTECHNOLOGIES IN THE CONTEXT OF UKRAINE'S EU ACCESSION PATH

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The area of environmental and climate protection in Ukraine's negotiations with the EU is a part of the so-called green cluster and, according to the European Commission itself, includes about 200 acquis communautaire on a wide variety of issues. It should be added that Ukraine must comply with Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and waste management, which establishes a legal framework for waste management, defines instruments aimed at protecting the environment and human health by preventing and reducing waste generation, reducing the negative effects of waste generation and waste management, reducing pressure on resources and increasing the efficiency of their use, taking into account the principles of the circular economy (Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and waste management). The EU Soil Strategy 2030 also came into force. Harnessing the benefits of healthy soils for people, food, nature and climate, which defines a framework and specific measures for the protection, restoration and sustainable use of soils in synergy with the objectives of the European Green Deal, which includes the development of a circular (bio)economy, protection of human health and prevention of land degradation (European Commission Working Paper on the EU Soil Strategy 2030). The Ukrainian EM preparation «Baikal-EM» was used for the bioconversion of vegetable waste and expired bread (with signs of mould). The fermentation time of vegetable waste at 30 °C lasted 5-7 days. The destruction factor of organic waste (depending on the amount of added EM preparation) ranged from 78-85%, which indicates the success of the process of biodegradation of organic waste. The amount of biohydrogen yield reached its maximum on the 2-3rd day of fermentation, which indicates the success of this biotechnology for vegetable waste processing.

Given the importance of complying with the above Directive on Ukraine's path to EU accession, we have conducted a study aimed at applying biotechnological approaches to the processing of vegetable waste and expired bread into digestate and biohydrogen, taking into account the principles of the circular economy (this topic is being studied under a grant agreement Waste Management in the Context of Transition to a Circular Economy: the EU Experience (101172378 — CIRCLEMAN — ERASMUS-JMO-2024-HEI-TCH-RSCH)).

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## THE ROLE OF DIGITAL PLATFORMS IN THE DEVELOPMENT OF THE CIRCULAR ECONOMY

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Modern socio-economic development faces critical global challenges, among which climate change, depletion of natural resources, ecosystem degradation, and increasing volumes of waste play a leading role. In this context, the inefficiency of the traditional linear economic model - based on single-use resource consumption and waste accumulation - has become increasingly evident. A response to these challenges is the transition to a circular economy, an innovative model focused on preserving material value and enabling their repeated use within closed-loop systems. This approach minimizes resource loss, reduces environmental pressure, and contributes to the development of more resilient supply chains. In the era of digitalization, digital platforms are beginning to play a pivotal role in implementing circular economy principles. They facilitate the optimization of exchange, repair, reuse, rental, and resale of goods - particularly in resource-intensive sectors such as the textile and electronics industries. Digital tools enhance transparency, enable efficient coordination among market participants, support data integration, and foster the emergence of new consumption models. This article explores the potential of digital platforms as a foundational infrastructure for scaling the circular economy and shaping a sustainable development model on a global scale.

## DIGITAL TRADE AS A CATALYST FOR GREEN ECONOMY TRANSFORMATION

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The transition to a green economy, emphasizing environmental sustainability alongside economic growth, necessitates the exploration of innovative tools and approaches. Digital trade, with its capacity to optimize resource allocation, enhance transparency, and foster new business models, emerges as a significant catalyst in this transformation. This paper examines the multifaceted role of digital trade in promoting green economic development. It analyzes how digital platforms and technologies facilitate more efficient supply chains, reduce waste, and enable the trade of environmentally friendly goods and services. Furthermore, the study explores the potential of digital solutions in enhancing environmental monitoring, promoting sustainable consumption patterns, and supporting the growth of circular economy initiatives. The analysis draws upon recent research and real-world examples to illustrate the tangible impacts of digital trade on ecological sustainability and economic efficiency. Key findings highlight the importance of supportive regulatory frameworks and technological infrastructure in harnessing the full potential of digital trade for greening the economy. The paper concludes by emphasizing the need for further research and policy interventions to maximize the synergistic relationship between digital commerce and environmental stewardship, paving the way for a more sustainable and resilient economic future.

# **EUROPEAN STUDIES FOR SUSTAINABLE DEVELOPMENT**

## EUROPEAN STUDIES ON ACADEMIC PROJECT MANAGEMENT FOR UKRAINIAN PHD STUDENTS

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The European Union provides great opportunities for academic institutions over the world through the world leading academic programmes, such as Erasmus+ and Horizon Europe. These programmes ensure powerful international collaboration with great academic, social and economic outcomes. And studying these programmes policies, terms and conditions gives a perfect understanding of effective European project management approaches. In addition, the European Commission developed PM<sup>2</sup> Methodology for effective management of European Union funded projects (EC, 2021).

The Jean Monnet Module on European academic project management has been implemented in 2022-2025 at the National university of Food Technologies, Kyiv, Ukraine under the support of Erasmus+ programme. The main activity of the Module is a teaching course for PhD students of different specialties at the National University of Food Technologies. The course covers key aspects of effective project management relevant to EU academic programmes. Additional teaching activity of the Module is an annual summer school on EU academic project management for PhD students and young university teachers from other Ukrainian universities, civil society and civil servants. Number of learners directly involved into the Module is about 150 persons annually. Indirect involvement into the Module, e.g. through the website of the project and sharing experience of learners is at least five-seven hundred people per year. The main expected results of the Module are increased awareness on EU effective approaches in academic project management and developing relevant practical skills of learners. The outputs of the Module will include sharing knowledge on world leading EU educational and research programmes, motivation of learners to participate in the EU funded projects, and applying the skills obtained in future academic career.

Currently, the project is at the final stage of implementation, and the project team has highly positive feedback from the participants / learners of the project's activities. The teaching materials and research outcomes of the project will be further used at the educational activities of the project team.

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[EC. \(2021\). PM<sup>2</sup> Project management methodology Guide 3.0.1. / Directorate-General for Digital Services \(European Commission\).](#)

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**EUROPEAN STUDIES ON ENVIRONMENTAL MANAGEMENT  
AND COMMUNICATION FOR BACHELOR STUDENTS  
IN ENVIRONMENTAL SCIENCE AND IN BIOTECHNOLOGY**

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The European Union is a global leader in environmentally friendly strategies, policies and practices, including climate change challenges. Reaching EU ambitious goals toward climate-neutral Europe relies on active involvement of governments, industry and citizens. The EU demonstrates that effective communication between all these parties is crucial for success. The Jean Monnet Chair supported by the Erasmus+ programme to be implemented at the National University of Food Technologies, Kyiv, Ukraine aims to implement European Union studies on environmental management and communication into the curricula of Ukrainian students to increase their awareness in the subject and promote these approaches in Ukrainian society. The main activities of the project imply implementation of three interconnected teaching courses for bachelor's students in environmental science and in biotechnology: 1) European Union environmental policies and legislation; 2) European Union environmental project management; and 3) European Union environmental communication. Additional activities of the project include annual Jean Monnet Summer School for policy makers, civil servants and civil society representatives for broader promotion of European Union values in Ukrainian society. English Speaking Club EcoEurope on effective communication for all interested participants aims to forge environmental communication in English.

The three-year project (2023-2026) will totally cover of 732 academic hours and involve about 540 learners. Indirect involvement through the project's website and sharing experience of learners will be up to one thousand people annually. The main results of the project will be an increased awareness and practical skills of learners on effective environmental management and communication in the EU. The outputs of the project will include three European Union studies / university teaching courses, three manuals for university students, three peer-reviewed research papers, six reports at international conferences, and a website of the project.

The intermediate results of the project demonstrate its relevance to academic and social interests of the participants involved. Positive feedback from the participants of all activities of the project clearly demonstrates its effectiveness.

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## EUROPEAN STUDIES ON THE FORMATION OF CRITICAL THINKING FOR THE SUSTAINABLE DEVELOPMENT OF UKRAINE

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Sustainable development of any country is impossible without quality education. This is confirmed by both the UN Assembly resolution (2015) and the Resolution of the Verkhovna Rada of Ukraine (2019). Quality education is identified as one of 17 Sustainable Development Goals of Ukraine by 2030: “Ensuring inclusive and equitable quality education and promoting lifelong learning opportunities” (About the Sustainable Development, 2019). At the 2020 World Economic Forum in Davos, critical thinking was ranked among the top 10 skills needed for a career in 2025. The formation of critical thinking skills in domestic students of pedagogical specialties should take into account European experience. These skills will help resist manipulation and enable informed decision-making (Baranovska et al., 2020). The imposition of martial law in Ukraine has emphasized the need for teachers who can correct cognitive distortions, analyze information critically, and teach children to think critically. The value of using European studies on the development of critical thinking lies in the fact that modern educators will work with a new generation of students who will live in a united Europe based on its value principles. However, current research shows that only about 35% of Ukrainian schoolchildren and students possess critical thinking skills, which is why the State Standards of Higher Education define critical thinking as a key skill within all competencies. The development of critical thinking in students will contribute to the formation of their civic engagement, and the fight against disinformation and fake news, which create huge obstacles for democratic communities in European countries on their path to civil society development. Extrapolating this experience to Ukraine will facilitate the active participation of student youth in democratic life; the establishment of European citizenship and the fundamental values of the EU: respect for human dignity, human rights, freedom, and equality. An important basis for organizing this activity with students is the participation of higher education institutions in EU projects, in particular Erasmus +. It involves the development of a training course “European Studies in Critical Thinking Development.” Students will have the opportunity to clarify the definition of “critical thinking” and familiarize themselves with key ideas and pedagogical concepts of critical thinking from leading scholars in Austria, Germany, Great Britain, Italy, France, and Switzerland. Students will also be introduced to European practices involving innovative technologies for developing critical thinking and will have the opportunity to identify their advantages over traditional methods.

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# EDUCATIONAL TECHNOLOGIES AND PSYCHOLOGICAL AND PEDAGOGICAL CONDITIONS FOR ENSURING THE QUALITY OF TRAINING OF FUTURE OFFICERS OF THE SECURITY AND DEFENSE SECTOR OF UKRAINE

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High-quality training of officers in Ukraine's security and defense sector is an important criterion for assessing not only the high level of their professional competence, but also the compliance of domestic educational programs with NATO standards.

The relevance of the study is connected with the need to implement international standards of combat officer training in the curricula of domestic military higher education institutions, since the professional and service activities of future officers will be related not only to ensuring the combat capability and defense of Ukraine, but also of the European Union and other countries.

The purpose of the study is to identify the best technologies and pedagogical conditions for ensuring the quality of training of future officers of the security and defense sector of Ukraine.

The results of the study indicate that 1) the educational process should be based on the use of innovative and interactive teaching methods (case study method, case method, situational analysis method, trainings), which in turn are constituent elements of practice-oriented educational technologies; such technologies allow to form both hard and soft professional skills; 2) consideration of mental states and their influence on cadets' adaptation to a new way of life helps to create appropriate pedagogical conditions for the educational process in general, as well as to create the basis for cadets' personal understanding of their own aspirations, goals and achievements in the process of acquiring military education, awareness of the value of the chosen specialty and involvement in the process of self-motivation and improvement of professional military education throughout life.

In order to improve the quality of education and overall professional training of future officers in higher educational institutions, it is proposed to introduce European practices of development of skills of a combat officer, as well as to create a set of psychological and pedagogical conditions, including: psychological support and assistance to each cadet (psychological, pedagogical, including coaching) in determining long-term goals of education, professional development, assessment of the level and quality of professional knowledge and certain competencies, formation of motivation to learn, etc. In order to improve the quality of education and overall professional training of future officers in higher educational institutions, it is proposed to introduce European practices of development of skills of a combat officer, as well as to create a set of psychological and pedagogical conditions.

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# **RUSSIAN INVASION OF UKRAINE AS A THREAT TO EUROPEAN SUSTAINABILITY**

## THE IMPACT OF RUSSIAN AGGRESSION ON THE AIR COMPONENT OF THE ENVIRONMENT

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Russia has been aggressive against Ukraine since the collapse of the Soviet Union. Already in 1993-1994, the Russian Federation made its first unsuccessful attempts to separate Crimea from Ukraine. The war was initiated by Russia in 2014. The Russian army first annexed Crimea, then attacked Donbas. The Ukrainian army stopped the enemy and liberated 2/3 of the occupied Donbas during 2014-2016. But the enemy's insidious shelling continued, killing and wounding thousands of Ukrainian soldiers and civilians. On February 24, 2022, Russia launched a full-scale invasion, and its war crimes expanded throughout our nation.

One of Russia's war crimes is the devastation of ecosystems. 8 379 facts of environmental harm and losses brought on by Russian armed action were recorded during the full-scale aggression (EcoZagroza, 2025). This is 3 635 more crimes than the year before.

Perhaps the greatest damage has been done to the most dynamic component of ecosystems - the air. The destructive impact of Russian aggression on the air is primarily carried out through the following ways that lead to pollution: 1) deliberate destruction of industrial and infrastructure facilities, including hazardous enterprises, chemical warehouses, oil depots; 2) massive use of explosives, rocket fuel, incendiary substances; 3) massive fuel consumption by military equipment and logistics; 4) forest burning, particularly in industrial regions and the Chernobyl zone.

Over 3.1 million tons of oil products were burned in Ukraine due to Russian attacks. This resulted in the release of almost 11 million tons of pollutants into the atmosphere. Additionally, woodland fires caused by Russian invaders discharged more than 62 million tons of pollutants into the atmosphere, as nearly 86 000 hectares of forests burned. Fires caused by Russian attacks destroyed more than 2.5 million  $m^2$  of other objects. Nearly 250,000 tons of pollutants were consequently discharged into the atmosphere. In addition to this, about 181 tons of poisonous substances were released into the air. The entire amount of harm resulting from air pollution topped EUR 16.5 billion (EcoZagroza, 2025).

As a result of the full-scale Russian aggression,  $CO_2$  emissions in Ukraine have increased significantly. And due to the destruction of forests and forest shelterbelts, the number and intensity of negative atmospheric phenomena have increased sharply: storms, dusts, dry winds, etc.

In conclusion, the damage caused to the air in Ukraine as a result of Russian war crimes currently exceeds EUR 16 billion. Air is the most dynamic component of ecosystems. Therefore, damage to it leads to rapid negative consequences for the ecosystem as a whole and for human health. Russia's war crimes continue. They need to be stopped and the damage caused must be fully compensated. For Ukraine to meet both of these goals, international support is essential.

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## CHANGES IN CONSUMER BEHAVIOR OF UKRAINIAN FOOD MARKET BUYERS UNDER THE INFLUENCE OF THE WAR

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Numerous authors from various fields (economists, sociologists, marketers, psychologists, behavioral economists) study the problems of consumer behavior in the consumer market during crises (Grunert et al., 2023). Ensuring economic stability in times of war requires further comprehensive study of consumer behavior and the development of approaches to effective consumer market management.

The purpose of the study was to examine the impact of military events on the consumer behavior of Ukrainian food market consumers and to analyze the factors that change this behavior.

The full-scale war in Ukraine has led to a drop in incomes, inflation, and rising unemployment. All this has had a significant impact on the purchasing power of the population. The security factor has also increased – Ukrainians are changing their habits, avoiding crowds, choosing online shopping more often and focusing on the most necessary products. The deterioration in customer safety has led to a shift in consumer priorities and a redistribution of spending. Established gastronomic practices of Ukrainians have been disrupted, and daily eating patterns and diets have changed (Dyman et al., 2024).

The war has changed the categories of goods that Ukrainians buy most often. Demand has shifted toward staples (eggs, bread, pasta, cereals, dairy products), long-term storage products, and cheaper alternatives. At the same time, consumption of vegetables, fruits, fish, and beverages decreased, in part due to rising prices. The Consumer Price Index for food products increased significantly in 2023–2024, forcing people to reconsider their habits and cut back on spending.

The war has caused severe psychological stress. Eating disorders, panic purchases, and impulsive stockpiling were typical reactions of Ukrainians in the first weeks of the full-scale invasion. Over time, the behavior evolved: there was a tendency to rationalize spending, restore “emotional comfort” through the consumption of favorite foods or brands that inspire trust and are associated with pre-war life.

Ukrainians have become more active in supporting domestic producers. Consumer loyalty to Ukrainian brands, especially those that support the Armed Forces or socially vulnerable groups, has increased significantly. The volume of purchases through online platforms has also increased, particularly among the elderly and internally displaced persons. E-commerce has become not only a means of saving money, but also a safe way to meet basic needs.

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## RUSSIAN AGGRESSION AND WESTERN STRATEGY: THE UKRAINIAN DIMENSION

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Russian aggression against Ukraine has become a critical turning point in the transformation of European political strategy and the global security architecture. The shift toward supporting Ukrainian sovereignty is driven not only by ethical considerations but also by the recognition of Ukraine's strategic importance as a link between the West and the post-Soviet space. The genesis of Western strategy illustrates a transition from episodic indifference to a gradual acknowledgment of Ukraine's civilizational role within the European context. For an extended historical period, Western political thought remained confined within a colonial perception of Ukraine. In the twentieth century, Western powers, particularly the Entente states, largely disregarded the aspirations of the Ukrainian people for self-determination, framing the Ukrainian issue as an internal affair of the Soviet sphere (Minosian et al., 2024). Even after the dissolution of the USSR, a certain hesitancy persisted in granting Ukraine full-fledged subjectivity in the international arena. The Revolution of Dignity and Russia's subsequent aggression in 2014 marked a shift in Western strategic discourse. Ukraine began to be regarded as a stronghold of the democratic world, and its resilience emerged as a critical factor in deterring authoritarian revisionism (Minosian et al., 2023). Nevertheless, underestimation of the Russian threat, the policy of appeasement, and the presence of double standards remained elements of strategic ambiguity. Even amidst the full-scale war launched in 2022, not all Western states demonstrated a unified response. The ongoing war has underscored the urgency of establishing a new geopolitical order (Kissinger, 2024). Drawing on its historical experience of struggle for freedom, Ukraine is gradually integrating into the European security and political sphere. Support from NATO and EU member states is accompanied by the development of new forms of cooperation aimed at strengthening the eastern flank of European defense. At the same time, internal tensions within Western political systems complicate the adoption of long-term decisions. Consequently, a key challenge for Western strategy lies in the articulation of a coherent framework in which Ukraine is treated not as a recipient of assistance but as an equal partner. The gradual transformation of geopolitical consciousness, reinforced through military, political, and economic interaction, is essential to establishing a new balance of power in which national identity and democracy prevail over imperial revanchism.

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**Proceedings of the VII International Conference on European Dimensions of Sustainable Development, May 5 – 7, 2025. – Kyiv: NUFT, 2025. – 83 p.**

Proceedings of the VII International Conference on European Dimensions of Sustainable Development present abstracts of the reports of the Conference held on May 5 – 7, 2025 at the National University of Food Technologies, Kyiv, Ukraine (online) under the support of Erasmus+ projects #101085243-ProEU-ERASMUS-JMO-2022-HEI-TCHRSCH and #101127449-EcoEurope-ERASMUS-JMO-2023-HEI-TCH-RSCH. The proceedings cover economic, environmental and social aspects of sustainable development of European sustainability; advanced technologies for the sustainable development; russian invasion of Ukraine as the threat of European sustainability; as well as European Studies on sustainable development.

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