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ECO-TRANSFORMATION OF HIGHER EDUCATION INSTITUTIONS AS A PREREQUISITE FOR SUSTAINABLE RECOVERY OF UKRAINIAN REGIONS

ЕКОТРАНСФОРМАЦІЯ ЗАКЛАДІВ ВИЩОЇ ОСВІТИ ЯК ПЕРЕДУМОВА ЗАБЕЗПЕЧЕННЯ СТАЛОГО ВІДНОВЛЕННЯ РЕГІОНІВ УКРАЇНИ

Summary. The directions of eco-transformation of higher education institutions as an important factor in ensuring the sustainable recovery of the regions of Ukraine are examined in the article. The research is devoted to determining the essence and key aspects of eco-transformation in the university environment, taking into account the importance of its influence on the economic, social, and ecological development of regions. A review of foreign experience and modern practices implemented in green universities, including their positions in global sustainability rankings, implemented technological innovations and educational programs, is carried out. Special attention is paid to the role of ecologically oriented universities in the sustainable recovery of the regions of Ukraine and the strategic directions of ecological transformation of higher education institutions. The role of distance learning and digital innovations in the processes of eco-modernization is defined. Modern challenges and prospects of eco-transformation within the national educational system are highlighted. Conclusions about the importance and necessity of eco-transformation of higher education institutions of Ukraine for the sustainable recovery and development of regions are formed.

Key words: green university, sustainable recovery, sustainable development, ecologically sustainable recovery, eco-transformation, ecological transformation, green initiatives, innovations, startups.

Анотація. У статті розглянуто напрями екотрансформації закладів вищої освіти як важливого чинника забезпечення сталого відновлення регіонів України. Дослідження присвячене визначенню сутності та ключових аспектів екотрансформації в університетському середовищі, враховуючи вплив цих процесів на економічний, соціальний та екологічний розвиток регіонів. Мета статті полягає у дослідженні особливостей функціонування зелених університетів на глобальному рівні, огляді сучасних підходів до організації їх екологічно орієнтованої діяльності та визначенні напрямів екологічної модернізації закладів вищої освіти України. Здійснено огляд зарубіжного досвіду екотрансформації та передових практик, впроваджених у зелених університетах, досліджено їх позиції у глобальних рейтингах сталості, впроваджені технологічні інновації та розроблені освітні програми. Особлива увага приділена висвітленню ролі екологічно орієнтованих університетів у процесах сталого відновлення та розвитку, а також виокремленню стратегічних напрямів екологічної трансформації закладів вищої освіти. Визначено роль дистанційного навчання та цифрових інновацій у процесах екомодернізації. Окреслено пріоритетні завдання для закладів вищої освіти України в контексті їх екотрансформації, серед яких: впровадження екологічно чистих технологій, підвищення ефек-

тивності використання ресурсів, розробка відповідних освітніх програм та курсів з основ сталого розвитку, активізація стартап-руху, розвиток екологічної свідомості учасників освітнього процесу тощо. Акцентовано увагу на важливості співпраці закладів вищої освіти з громадськими організаціями та бізнес-сектором задля реалізації спільних екологічних проєктів. Висвітлено сучасні виклики та перспективи екотрансформації в межах вітчизняної освітньої системи. Обґрунтовано важливість та визначено напрями і ключові заходи для екотрансформації закладів вищої освіти України задля сталого відновлення регіонів. Зроблено висновки про те, що реалізація екотрансформаційних ініціатив сприятиме формуванню екологічно свідомого суспільства, підвищенню конкурентоспроможності університетів на міжнародній арені, забезпеченню сталого відновлення та розвитку України.

Ключові слова: зелений університет, стале відновлення, сталий розвиток, екологічно стійке відновлення, екотрансформація, екологічна трансформація, зелені ініціативи, інновації, стартапи.

Problem statement. In the conditions of modern global challenges, the need for eco-modernization of higher education institutions to ensure sustainable development and competitiveness is an urgent issue. The relevance of the problem goes beyond the educational system, because the planet is facing an ecological threat, and compliance with the principles of sustainable development is becoming a necessity to preserve the environment. In today's environment, when climate change and the depletion of natural resources threaten ecosystems, it is important to determine the role of higher education institutions in solving these problems. Educational institutions should not only adapt to new challenges, but also become active participants in ecological restoration. Green universities can act as drivers of positive changes aimed at solving environmental, economic and social problems. In the context of modern national realities and the importance of reorienting the activities of universities to the principles of sustainability, it is expedient to transform them into ecologically oriented institutions that will contribute to the generation of green innovations and play a key role in the activities of the city and the region, including in their sustainable restoration. This approach determines the strategic direction for the sustainable recovery of the regions of Ukraine, where green universities can become important agents of change in the ecological dimension. Thus, the problem of eco-modernization of universities becomes relevant not only from the standpoint of the development of the higher education system, but also in the context of solving global environmental problems. Ensuring the sustainable recovery of the regions of Ukraine through the eco-transformation of universities becomes a strategic task, the solution of which is of great practical importance.

Analysis of recent research and publications. The scientific contribution of national and foreign scientists, in particular Vasilyeva T., Antoniuk N., Kyrychenko K., Laznenko D., Marekha I., Kubatova T., Laznenko D., Chygrin O., Makhandi A., Cameron A., Holman N., Kroza D. and other scientists, allows to determine the key specific characteristics of green universities and their role in ensuring the achievement of the goals of sustainable development. Despite the significant scientific output,

the issue of green campuses and eco-transformation of higher education institutions remains insufficiently in the context of Ukrainian realities and in the conditions of wartime challenges. In this regard, it is necessary to determine the role of green universities in recovery processes and to provide proposals for specific strategies and directions of eco-transformation of Ukrainian universities in order to ensure ecologically sustainable recovery of the regions of Ukraine.

The purpose of the article is to define the specifics of the activities of green universities at the global level, review the current practices of their environmentally oriented activities and determine the directions of ecological modernization of higher education institutions as an important factor in the sustainable recovery of the regions of Ukraine.

Summary of the main research material. In the context of modern challenges facing society at the global level, rethinking approaches to sustainable development and environmental sustainability is a critically important task. An important role in achieving the goals of sustainable development at the global level is played by institutions of higher education, which have the potential to become leaders of ecological transformations, initiators of the implementation of a number of green projects and make a significant contribution to ensuring a climate-neutral future.

A green university is an educational institution with a unique approach to existence, which includes various initiatives and actions aimed at implementing the concepts of "sustainable development", which effectively uses natural resources without harming the needs of future generations [1]. To achieve this goal, the following tasks are set and performed: involvement of students in environmental initiatives, efficient use of natural resources, minimization of CO₂ emissions by renewable energy sources and improvement of buildings, zero-waste activities through sorting and efficient recycling and the use of environmentally friendly products, as well as creation of green natural areas on the campus [1].

Ecological transformation of higher education is the process of creating educational institutions that reduce their impact on the environment and increase environmental awareness in higher education communities [2]. Ecological transformation manifests

itself in the reduction of negative environmental impact both inside the institution and outside the institution of higher education, as well as in increasing the environmental awareness of the participants of the educational process. Green universities are considered effective centers for the implementation of environmental initiatives, as they can not only implement the principles of environmental understanding and management, but also convey them to the public. The main difficulty in creating and developing environmentally sustainable universities is related to the lack of clearly defined global standards or directives. The results of the conducted research show that a green university directs its activities to sustainable campus management, sustainable scientific research, cooperation between institutions based on sustainability, the formation of ecologically oriented curricula, the preparation of reports on sustainable development, etc. [2]. The ranking of the world's universities for environmental sustainability and compliance with the principles of sustainable development, known as UI GreenMetric, was launched by the University of Indonesia in 2010. The rating is determined by the commitments and initiatives of universities in the field of environmental protection. The assessment tool demonstrates the use of 39 indicators and 6 criteria, namely: facilities and infrastructure (SI), energy and climate change (EC), waste (WS), water (WR), transport (TR) and education (ED) [3]. In the period from 2021 to 2023, Wageningen University & Research (Netherlands) remained the absolute leader of this rating. Nottingham Trent

University (The UK), Umwelt-campus Birkenfeld (Germany), University of Groningen (Netherlands) also held strong positions. The TOP-10 also includes universities from the USA, Brazil and Ireland (Figure 1).

Wageningen University & Research (Netherlands) has been one of the most sustainable universities in the world for many years. WUR has been able to achieve sustainability on its campuses and already in 2015 announced the achievement of climate neutrality. The WUR Green Office is a unique space that brings together students to exchange ideas and organize joint research to implement sustainable solutions within the university surrounding [5]. The university has a heat and cold storage system in underground sand layers, which is used to cool the campus in the summer and heat it in the winter. In addition, they use clean energy from wind turbines, biogas from dairy farms and plants on a green roof, which also serves to collect water and control the temperature of the building it is located on [6].

Arizona State University's School of Sustainability offers a variety of undergraduate programs, including a program in sustainable development (BSc in Sustainability) and a program in sustainable food systems (BSc in Sustainable Food Systems) [7]. Among the master's educational programs are the master of arts program in sustainable development and the fully distanced master's program in leadership in sustainable development [7]. All courses are aimed at finding real solutions to environmental, economic and social challenges.

Hokkaido University (Japan) has one of the most environmentally sustainable campuses in the

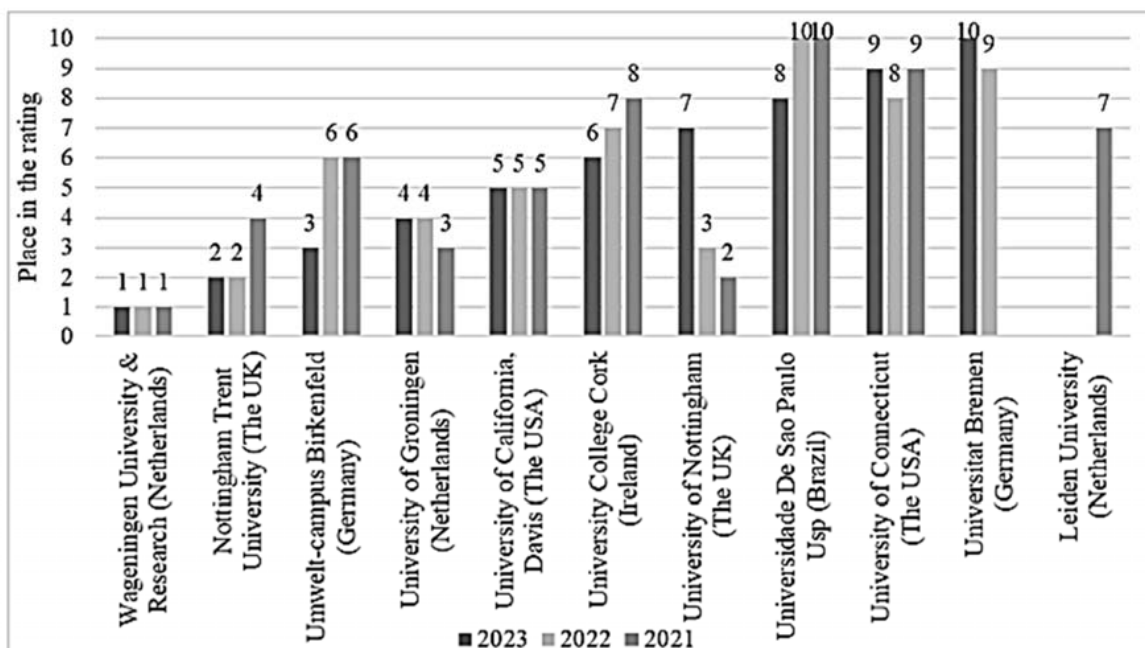


Figure 1 – TOP-10 most sustainable universities in the world in 2021–2023 according to UI GreenMetric World University Rankings

Source: compiled by the authors based on [4]

world. The university provides scholarships to help disadvantaged students purchase modern digital devices. Bicycle sharing programs have also been introduced, which encourage students to use an environmentally friendly mode of transport [7].

The University of Lausanne (Switzerland) implements a project to recycle food waste by sending it to a nearby farm. The waste is used to produce organic fertilizers and the production of biogas, which provides heat and electricity for both the farm and the local community [8]. At the University of Peru (Peru), paper waste is sold to recycling companies, and the proceeds go to scholarships for low-income students [8].

The University of Canterbury (New Zealand) has on-site community gardens where students can grow their own organic produce. The University of Texas (USA) has received numerous accolades for its student service building, which was designed with taking into account natural light, significantly reducing energy costs for air conditioning and lighting. And some university campuses are equipped with "hydration points" that make it easier to fill and reuse water bottles. The main idea is to reduce waste from the use of non-environmental packaging. In some cases, it is even forbidden to sell bottled water on the university premises [8].

Green universities differ from others in implemented practices that promote sustainability, in particular: they actively use green technologies and improved construction standards, sparingly consume resources to reduce the negative impact on the environment, develop educational programs in the field of sustainable development, spread environmental values, form environmental and social responsibility policies, report on the results of achieving specific sustainable development goals, ensure the implementation of energy-efficient systems, the use of renewable energy sources, contribute to the reduction of emissions and waste processing. In addition, green universities play an important role in the formation of environmental awareness of all participants in the educational process and the involvement of students in issues of ecologically oriented development. Educational programs aimed at the formation and development of environmental competences are offered, as well as informal initiatives in the field of environmental education and measures aimed at solving environmental problems are implemented. Green universities emphasize the integration of the principles of sustainable development into all aspects of the educational process, contributing to the formation of higher education students' system of knowledge and skills for the formation of an environmentally responsible society.

One of the ways of eco-modernization of higher education institutions is to give preference to the distance learning format as an environmentally

friendly option for organizing the educational process. It has been confirmed that distance education is a more sustainable and ecological option than traditional. Robin Roy, in his study of distance education in the UK, found that distance-taught courses used 87% less energy and emitted 85% less CO₂ than courses taught offline [9]. Online education provides universities with the opportunity to strengthen their financial sustainability, creating social benefits for higher education learners and teachers, as well as having a positive impact on the environment. Distance education and the use of digital technologies in the educational process make it possible to reduce the environmental footprint of the higher education sector. The introduction of digital innovations contributes to the creation of sustainable educational environments that include electronic resources and means of communication, which plays an important role in the eco-modernization of higher education institutions and the formation of environmentally responsible practices among participants in the educational process.

Startup-activity as the part of universities' initiatives plays a crucial role for achieving the SDG-goals. Startups focused on green technologies and the development of a sustainable educational environment can provide innovative products that help implement progressive approaches to energy conservation, rational use of resources, development of environmental education, etc.

In the context of the eco-transformation of higher education institutions and activities of green universities in Ukraine, Chernihiv Polytechnic National University (CPNU) implements sustainable practices, contributing to the achievement of sustainable development goals. Lecturers and students are actively involved in projects aimed at using green technologies and reducing the ecological footprint. The university implements projects such as the creation of information and measurement systems powered by solar panels, the installation of charging stations for electric vehicles on the university territory. In addition, the university has experience in developing its own electric vehicles and installing a parking station for portable electric vehicles on campus. The institution of higher education implements ecologically oriented educational and professional programs ("Ecology", "Economics of the environment and natural resources", etc.), promoting the formation of environmentally conscious specialists who will have the skills required in the process of green post-war reconstruction of Ukraine. Participants of educational process take part in a number of environmental events and projects. The university actively supports student initiatives and startups in the field of sustainable development, which is an important aspect of eco-modernization. The Center of startups formation and development

is functioning as the structural department of CPNU. It provides consulting and informational support to teams who are working under startups, and it promotes the principles of sustainable development during the startup- and project-activity.

By implementing sustainable approaches to the management and environmentally oriented practices, green institutions of higher education play an important role in ensuring sustainable development. In wartime conditions, the development of Ukrainian universities should take place based on sustainability, which is important for the green recovery of cities and regions of the country.

Therefore, the role of higher education institutions in sustainable recovery is quite significant, due to a number of factors. For the first, increasing the environmental awareness of participants in the educational process becomes the basis for the formation of an ecological environment in future. Students of higher education, studying in conditions where green initiatives and a sustainable lifestyle are

an integral part of the educational process, become drivers of positive changes in society. Secondly, the formation of ecologically oriented leaders becomes the key to the effective implementation of innovative and technological solutions for sustainable development. Students, who received education in an ecologically adapted environment, can use their knowledge and skills to create innovative projects that contribute to increasing the economic, social and environmental sustainability of regions. Thirdly, technological innovations developed based on institutions of higher education can be implemented and used in various sectors of the economy. The university as a center of scientific research and startup-activity ensures the integration of ecologically effective solutions in various fields, which contributes to the greening of the activities of economic entities and the improvement of the ecological situation in the regions. By encouraging sustainable values, responsible consumption and an innovative approach to decision-making, green universities can become the centers for developing

Table 1 – Directions and key measures for ecological transformation of higher education institutions of Ukraine

Directions	Activities and initiatives
Energy efficiency and renewable energy	<ul style="list-style-type: none"> • Implementation of energy-efficient technologies and systems in university buildings. • Use of renewable energy sources such as solar panels, wind generators and others.
Waste management systems	<ul style="list-style-type: none"> • Development and implementation of a waste sorting and recycling program. • Involving participants in the educational process to participate in initiatives related to separate waste collection.
Green construction and infrastructure	<ul style="list-style-type: none"> • Implementation of green building standards in the construction of new buildings and reconstruction of damaged buildings. • Optimization of thermal insulation and use of natural light.
Implementation of digital technologies in the educational process	<ul style="list-style-type: none"> • Expanding the use of electronic textbooks and e-resources to reduce the use of paper. • Use of remote and hybrid learning formats.
Ecological consumption	<ul style="list-style-type: none"> • Implementation of the "green" nutrition program. • Increasing the volume of local and ecologically clean products in food rations.
Scientific research in the field of sustainable development	<ul style="list-style-type: none"> • Promotion of scientific research and projects aimed at solving environmental problems.
Startups-activity	<ul style="list-style-type: none"> • Formation and activation of the startup movement, support for the development of startups aimed at achieving various goals of sustainable development; • Implementation of innovative solutions in the field of sustainable development.
Social responsibility and environmental education	<ul style="list-style-type: none"> • Launch of educational programs on sustainable development; • Formation of social and environmental responsibility policies; • Involvement of higher education students in the implementation of social and environmental initiatives.
Green transport	<ul style="list-style-type: none"> • Encouraging the use of ecological modes of transport (electric cars, bicycles). • Route optimization and introduction of joint transport systems.
Ecological sports events	<ul style="list-style-type: none"> • Organization of environmental sports events and tournaments. • Support for initiatives to study and protect nature.
Partnership and cooperation with local communities and business	<ul style="list-style-type: none"> • Organization of environmental sports events and tournaments. • Support for initiatives to study and protect nature. • Cooperation with local communities to implement eco-transformation projects. • Development of partnerships with sustainable companies and organizations.

Source: it is formed by the authors

strategies and identifying tools for the sustainable recovery of Ukraine's regions in the post-war period.

Table 1 shows recommendations on directions of ecological transformation for national institutions of higher education in order to ensure the sustainable recovery of the regions of Ukraine. The implementation of the proposed initiatives will allow universities to take an active role in the formation of an environmentally responsible approach to conducting activities and contribute to the sustainable recovery of Ukraine in the post-war period.

The defined directions of ecological transformation for higher education institutions of Ukraine are the key elements of the strategy of their sustainable development and becoming the green institutions with a responsible ecological position. The implementation of energy-efficient technologies, green construction, environmental initiatives, as well as social responsibility forms not only an environmentally conscious university community, but also contributes to its involvement into the processes of sustainable recovery of the regions of Ukraine. These directions create a foundation for the formation of a comprehensive strategy for the eco-transformation of the higher education sector, aimed at achieving environmental sustainability and a positive impact on the environment.

It should also be taken into account that there are threats on the way to transforming universities into green educational institutions, the management of which requires systematic and scientifically based solutions. First, the implementation of green initiatives can be complicated by limited funding and competition for capital investment. Even with the implementation of promising projects, the lack of financial support from investors and the lack of internal resources can inhibit the realization of green initiatives. Without relevant funding, an undesirable solution to problems in favor of environmentally unsustainable alternatives may occur [10]. In addition, involvement of lecturers, scientists and students to participate in green initiatives also appears to be a big challenge, especially considering their excessive workload and time constraints. Educational and scientific staff should play an active role not only in the transfer of knowledge, but also should act as leaders in the field of sustainable development, actively introducing environmental aspects into the educational process and involving students in research and projects aimed at solving environmental problems. An important aspect of the transformation of higher education institutions is the involvement of the university's internal community, the establishment of effective communication and the identification of external stakeholders, which may include high requirements for ethics and social responsibility [10]. Universities should become

responsible and sustainable institutions for which balanced development is a priority.

At the same time, there are many advantages, that green university brings to its members. It allows to gain a deeper understanding of contemporary environmental challenges, which stimulates academic and research interests. On a moral level, members of the university community feel as a part of the global movement to preserve the environment, contributing to a sustainable future [11]. Sustainable development initiatives and environmental management become an important element of their educational and professional experience. Active participation in environmental initiatives enriches the daily life of students and lecturers, making it more dynamic. In addition, the green university develops leadership and organizational skills of participants of the educational process and representatives of the community through participation in environmentally oriented projects and sustainable volunteer initiatives. Belonging to a green university gives them the opportunity to participate in global environmental initiatives, where their knowledge can be applied to solve modern environmental challenges [11]. This approach produces highly qualified, ethical leaders ready for the challenges of today's world and contributes to the creation of a sustainable future through education and practical action. Active participation in the implementation of projects and communication with the university administration expands the role of students of higher education in the formation of strategic decisions, developing their influence and important leadership qualities. This approach encourages the understanding that the opinion of each member of the academic community is essential to achieving the goals of sustainable development.

Conclusions. Eco-transformation of higher education institutions is a strategically important measure on the way to sustainable development, which takes into account the needs of the present and future generations, ensuring harmony with nature and society. The reorientation of Ukrainian universities to the principles of sustainability is a relevant and necessary stage for the comprehensive transformation of the educational sphere, which not only involves internal changes in educational institutions, but also acts as a strategic prerequisite for ensuring the sustainable recovery of the regions of Ukraine in the post-war period. The results of the analysis of the experience of foreign countries show the great potential of eco-transformation for universities as an important tool for solving environmental and social problems of communities. The defined directions for the further development of environmentally oriented universities (in particular, the implementation of energy-efficient technologies, waste management systems, renewable energy technologies, green construction, environmental education, as well as the

development of eco-technologies in the educational process, etc.) are effective tools for creating a sustainable educational environment, that allow to bring positive changes into the higher education sector of Ukraine. The implementation of green measures in institutions of higher education is important both for the academic and for the social environment, as it will contribute not only to the sustainable development of university communities, but also to the formation of a new ecologically conscious generation and the complex of innovative ecological solutions necessary for the country. Green initiatives of universities contribute to the improvement of the well-being of participants in the educational process and form an ecological culture. Eco-transformation of higher education institutions plays an important role in training young professionals for green workplaces and forming a sustainable ecologically oriented society.

Therefore, the eco-transformation of higher education institutions of Ukraine is an important prerequisite for the sustainable recovery of communities, regions, and the country in general. The transition of universities into the principles of sustainability plays a strategically important role in creating green innovations, rebuilding damaged buildings on the principles of sustainability, solving environmental problems, developing the green economy, forming and developing important skills of young specialists for future green job places, that can be created in the post-war period. This process becomes a key step on the way to the formation of a strategy of innovative, ecologically balanced, decarbonized development of the country, ensuring not only the sustainability of educational communities, but also influencing the effective resolution of challenges that will be faced by the country in the process of post-war regional reconstruction.

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