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CONSTRUCTING A SUSTAINABLE DEVELOPMENT MODEL FOR UNIVERSITIES: MECHANISMS OF INTEGRATION AND EFFICIENCY

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The object of this study is the processes of ecological transformation of university activities, aimed at integrating the principles of sustainable development into the educational, scientific, and managerial aspects of their functioning.

The task addressed relates to the insufficient integration of the principles of sustainable development into the activities of universities, which limits their competitiveness at the international level and hinders the implementation of environmentally oriented educational and scientific initiatives.

A conceptual model of environmentally oriented transformation (CMEOT) of universities has been devised, which enables the integration of environmental, social, and economic aspects into all levels of the educational process. The proposed mechanisms for adapting European practices allow for effective consideration of national characteristics. The implementation of the model contributes to the growth of environmental awareness of students, improving the quality of education and activating international cooperation.

The results are explained by an interdisciplinary approach to sustainable development, which allows universities to flexibly adapt to global challenges.

The main feature of the proposed model is its universality and the ability to adapt to different types of universities. It includes an algorithm for unifying approaches to ecological transformation, which makes it possible to take into account the specificity of educational institutions.

The model devised could be used at universities of various profiles to improve the level of environmental education, implement sustainable development, and strengthen the international integration of higher education institutions. The conditions for effective implementation are support at the state level, financing of environmental initiatives, and active cooperation between universities and stakeholders

Keywords: ecologically-oriented transformation, sustainable development goals, social integration, university network

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1. Introduction

In the current context of the pursuit of sustainable development, the world is facing a number of challenges related to the search for a sustainable balance between environmental, economic, and social aspects, as well as digital transformation and (geo)political uncertainty. These circumstances require a strategic rethinking of the future under the influence of global changes that encompass society, education, and the world as a whole.

Transformational processes in the field of education have received significant impetus under the influence of the global COVID-19 pandemic, which forced the education system to adapt to new conditions. This experience has become a catalyst for the formation of a new paradigm of educational change aimed at ensuring sustainability and compliance with modern challenges.

In this context, the key vectors of development are rethinking the missions of universities, reforming their values and operating conditions in accordance with the needs of society. It is these circumstances that determined the choice of our research topic and its main direction.

The formation of an environmentally oriented, balanced, and innovative space in the field of higher education is one of the key priorities of the global strategy for sustainable development. Analysis of the international regulatory framework and scientific publications over the last decade has made it possible to reveal the main directions of university transformation in the context of achieving sustainable development goals.

Universities play a key role in the formation of an ecological culture, raising the level of environmental awareness of the population and implementing innovative solutions aimed at preserving the biosphere. In addition to fulfilling their educational and scientific functions, higher education

institutions contribute to informing the public about global environmental challenges, climate change, and possible ways to overcome them.

Therefore, research on devising strategies for the transformation of universities in the context of sustainable development is relevant. It contributes to the creation of an environmentally oriented educational space, the formation of a new culture of responsible attitude to the environment and ensuring an innovative approach to the educational process. Given global challenges and dynamic changes in society, such research is an important step in ensuring the sustainable development of education and society as a whole.

2. Literature review and problem statement

Paper [1] reports the results of research on the integration of sustainable development principles into university strategies. It is shown that the effective implementation of environmentally oriented management is possible under the condition of an interdisciplinary approach that covers environmental, economic, and social aspects of education. However, issues related to the development of a single conceptual model of the transformation of universities towards sustainable development remain unresolved. The likely reason is objective difficulties associated with the variability of national educational systems, as well as with different levels of readiness of universities to implement environmental initiatives. In addition, the financial costs of implementing long-term environmental strategies may complicate their large-scale application. An option for overcoming the difficulties may be the adaptation of international experience to national conditions, which involves the development of universal but flexible approaches to the integration of sustainable development principles into higher education.

This is the approach used in [2] but it does not take into account the specificity of the local educational environment and there are no specific mechanisms for adapting international models to the conditions of individual universities. Study [3] focuses on the regulatory and legal aspects of the ecological transformation of higher education but does not offer effective tools for their practical application.

Paper [4] examines the impact of digital technologies on the sustainable development of universities, shows the positive effects of distance learning and ecological optimization of the educational process. However, the issues of integrating digital and ecological aspects remain insufficiently explored. Study [5] focuses on the importance of international cooperation in the field of environmental education, emphasizing the need to create global educational networks. At the same time, it does not consider the mechanisms for their effective implementation at the level of individual universities.

Work [6] analyzes the role of cognitive modeling in planning the ecological transformation of higher education institutions but does not contain specific practical recommendations for its application. Study [7] emphasizes the need to combine environmental initiatives with the social responsibility of universities but does not propose methods for assessing the effectiveness of such initiatives.

In the context of analysis of modern approaches to the transformation of educational institutions, it is important to consider the study of the mechanisms of innovative activity in higher education institutions. One of such studies is [8], which considers the entrepreneurial innovation system at higher education institutions. The study emphasizes that the effective development of the educational and scientific space requires the integration of the efforts of universities, businesses, and the state. The mechanism of interaction of these three key subjects is considered for the commercialization of scientific developments, stimulation of innovations and creation of conditions for the development of entrepreneurial initiative in the sphere of higher education.

An important aspect of analysis of the modern development of education is the consideration of the impact of crisis conditions on the functioning of higher education institutions. Study [9] considers the challenges and features of the adaptation of the educational process in times of crisis. Particular attention is paid to the need to form sustainable educational models that can ensure the continuity of the educational process, preserve the innovative potential of universities, and promote their transformation in response to modern challenges.

In the process of devising a model of environmentally oriented transformation of universities, it is important to take into account innovations in the educational process and pedagogical technologies, in particular those that arise under the influence of crisis phenomena and global digitalization. Study [10] emphasizes the need to update pedagogical approaches and develop educational clusters as a basis for increasing the effectiveness of learning and integrating educational processes with real production sectors.

Study [11] examined the role of socio-ecological aspects of sustainability. An integrative monitoring framework was proposed. These results are important for creating an environmentally-oriented model of university transformation, as they show the need to develop sustainability indicators and take into account socio-ecological aspects when implementing innovations.

In the context of our study, it is important to take into account the concept of a smart university discussed in [12]. This work focuses on the potential of smart solutions to contribute to the achievement of the Sustainable Development Goals. The researchers analyzed university initiatives that meet all 17 SDGs and identified practical solutions that can be adapted to the educational environment to ensure sustainable development.

Therefore, all this gives grounds to argue that it is advisable to conduct a study aimed at devising a conceptual model of ecologically-oriented transformation of universities (CMEOT). It could provide scientifically sound approaches to integrating sustainable development into the educational process, management decisions, and scientific research at universities.

Our review of the literature revealed that most studies focus on individual aspects of sustainable development of universities, such as environmental initiatives or educational programs but there is no comprehensive approach to integrating these components into a single transformation strategy. In addition, mechanisms for adapting international experience to the national context are not sufficiently developed, which complicates the practical implementation of successful models. This creates a scientific niche for research into a unified concept of environmentally oriented transformation of universities, which would take into account both global trends and the specificity of the local educational environment.

3. The aim and objectives of the study

The aim of our study is to devise a comprehensive model of environmentally-oriented transformation of universities,

which integrates the principles of sustainable development into all aspects of their activities, including educational, scientific, and management processes. This will enable universities to effectively adapt international experience to national conditions, raise the level of environmental awareness among students and teachers, and also facilitate their integration into the European educational space, strengthening the competitiveness and sustainability of higher education.

To achieve the goal, the following tasks were set:

– to analyze the paradigm of ecological transformation of universities;

– to devise a concept for building a model of ecologically-oriented transformation of universities;

– to propose mechanisms for adapting European practices of sustainable development to the national educational environment;

– to assess the effectiveness of the proposed model and formulate recommendations for its implementation at Ukrainian universities.

4. The study materials and methods

The object of our study is the processes of ecological transformation of university activities, aimed at integrating the principles of sustainable development into the educational, scientific, and managerial aspects of their functioning.

The formation of CMEOT is based on modern approaches to sustainable development management, which ensures a balanced combination of educational, scientific, and social aspects of university activities. It is expected that the implementation of this model could contribute to the transformation of universities into centers of innovative environmental policy.

A set of methods combining empirical and theoretical approaches has been applied. The main methodological tools include SWOT analysis, analysis of political and regulatory acts, comparative analysis, expert surveys, and methods of system analysis. Based on the results obtained, a conceptual model of environmentally oriented transformation of universities has been formed, which takes into account the identified gaps in policy, legislation, programs, and plans in eight key areas of activity identified by the UN. The integration of various methodological approaches provided scientific substantiation for the proposed model and made it possible to compile practical recommendations for educational and political leaders.

The need to form a conceptual model of environmentally oriented transformation of universities (CMEOT) is due to several global challenges. In particular, we are talking about the growing role of higher education in the formation of environmental awareness of society and the training of specialists capable of implementing the principles of sustainable development. At the same time, there are problems of institutional fragmentation of approaches to the greening of the educational process and the lack of a single conceptual framework for the integration of environmental guidelines into the activities of universities. The need to adapt international experience in sustainable development to the national educational environment and bring educational standards in line with international requirements was also identified. To solve the outlined problems, the study used a set of methods that combine empirical and theoretical approaches: SWOT analysis of policy and legislative gaps, analysis of regulatory and legal acts, comparative analysis, expert surveys, and methods of system analysis. The integrated application of these methods has made it possible to substantiate scientific approaches for the development of CMEOT and formulate practical recommendations for educational and political leaders.

5. Results of investigating the environmentally oriented transformation of universities

5. 1. Analysis of the paradigm of ecological transformation of universities

In connection with the adoption of 17 global Sustainable Development Goals for the period up to 2030 at the UN Summit on Sustainable Development, there was a need to deepen and update the paths of sustainable development of universities. Therefore, the path to a high ecological culture lies through effective sustainable education. The level of economic development and well-being of the population under current conditions does not correspond to the natural, scientific, and technical, agrarian, and industrial potential of each individual country and the qualification and educational level of the population, socio-historical and cultural traditions.

The new worldview paradigm of sustainable development is a political and practical model of development of the global university network, which must meet the needs of the current generation without prejudice to the ability of future generations to meet their own needs. This model is focused on achieving an optimal balance between the three components of development – economic, social, and environmental (Fig. 1). The transition to sustainable development is a process of changing the value orientations of many people. The internationally recognized fundamental values of development are freedom, equality, solidarity, tolerance, respect for nature, and shared responsibility. National sustainable development goals are based on political, economic, social, environmental, moral, and cultural values inherent in society. They determine the implementation of innovative transformation of higher education in order to focus on caring for the common good and protecting the national interests of each country in the world through the search for optimal models of concepts for sustainable development of universities.

The conceptual vision of the University's CMEOT includes the vectors defined in the Green Roadmap for Universities from the European University Association (EUA) [1]:

1. Development vector – ensuring sustainable development of the university, carrying out structural reforms, ensuring economic growth in an environmentally friendly way, creating favorable conditions for conducting economic activities.

2. Security vector – ensuring the safety of the university, its activities, employees, and higher education applicants, protection from risks, academic integrity. The priority is the safety of human life and health, and obtaining proper education, which is impossible without an effective system of providing educational services, protection of socially vulnerable groups of the population, a safe environment and access to information.

3. The responsibility vector is to provide guarantees to every citizen, regardless of race, skin color, political, religious, and other beliefs, gender, ethnic, and social origin, property status, place of residence, language, or other characteristics. This guarantees access to high-quality education for all.

4. Vector of pride – ensuring mutual respect and tolerance in society, pride in one's own state, its history, culture, science, sports.

5. The conceptual vision of the University's CMEOT is based on ensuring national interests and fulfilling Ukraine's international obligations regarding the transition to sustainable development. Such development involves taking into account the large-scale ambitions of the European Green Deal, which provide a political basis for integrating the scientific, educational, and institutional dimensions of the contribution of universities to the "green" transition.

Four key areas were selected in which universities need to reorient themselves for the green transition. These areas also provide opportunities for reforms and cultural and behavioral changes that go beyond purely green topics. Areas:

1. Research & innovation.
2. Education & students.
3. Staff & operations.
4. Public engagement & societal impact.

The transition will entail varying degrees of relevance and urgency for internal optimization and external interventions, as well as varying levels of engagement and coordination depending on the target groups.

Area "Research & innovation". The main goal of the university's activities in this area is to be consistent with the Green Deal and the Zero Emission Industry Act. This highlights the importance of broadening approaches and partnerships that are more global, interdisciplinary and intersectoral. Embracing EU policy priorities requires a specific approach to science. This also requires universities not only to collaborate with other universities but also to develop joint implementation roadmaps with a wider range of stakeholders.

Shifting the focus from developers to users is necessary to align innovation with social perceptions, needs, and concerns about job creation or destruction. While the economic context and heightened concerns about energy security play a role in the scaling up of technologies, this should not distract from broader questions about social benefits, or the diversity of innovation required. Nor should innovation be reduced to inputs and outputs. Processes are equally important for achieving equitable and desirable social outcomes and for addressing the voices of marginalized groups.

Project proposals for external funding should reflect a commitment to sustainability as a value, for example by prioritizing design that is aligned with the Sustainable Development Goals (SDGs) and by cross-fertilizing parallel research streams on related topics.

The challenges for realizing the transformation of the current field are outlined in Table 1.

The next area of transformation, called "Education & students", aims to integrate a minimum set of interdisciplinary skills into existing material, without necessarily leading to the creation of a new curriculum. Strong analytical skills can be complemented by interpersonal skills such as communication and teamwork (for comprehensive collaboration) or out-of-the-box thinking (for cross-disciplinary communication).

Students should also acquire the critical ability to use evidence-based approaches when verbalizing their thoughts and to distinguish between disinformation, unfounded opinions, populism, and "greenwashing". Education for sustainable development should be accessible to all staff and students, and different modules will enable them to understand management and decision-making processes, socio-cultural phenomena, and economic systems. A balance needs to be found between specialization and general knowledge so that graduates are more flexible in the workplace and learn to appreciate the value of other perspectives. Curricula should be based on problem-based learning, live labs, and other experiential learning opportunities.

Intercultural and interdisciplinary aspects can be further added by jointly implementing such programs with partners from the EU and other countries representing industry, public administration, and the non-profit sector. More flexible accreditation processes will also facilitate and guide the development of new programs.

The main tasks for universities to implement the transformation are:

1. Examine curricula for necessary changes. This can be done by bringing together staff and students from different faculties, holding workshops with stakeholder analysis. It is also important to identify topics of common interest for the green transition and find ways to translate them into learning objectives. This can be integrated with ongoing processes of pedagogical innovation and increasing inclusiveness in learning and teaching.

2. Manage the programs, for example by appointing an institutional leader and a leader to identify activities that bring together all parties with common interests. This should also help to clarify when interdisciplinarity is preferable to monodisciplinarity or can exist side by side with it. Sustainable development is a powerful tool for developing interdisciplinary programs, but such programs need to be robustly managed.

3. Align horizon scanning with emerging student and faculty interests and demands to propose and optimize curricula and elective modules on sustainability. These should include research, innovation, education, and an appropriate focus on skills development. They should also allow, where possible, for individual student-led journeys

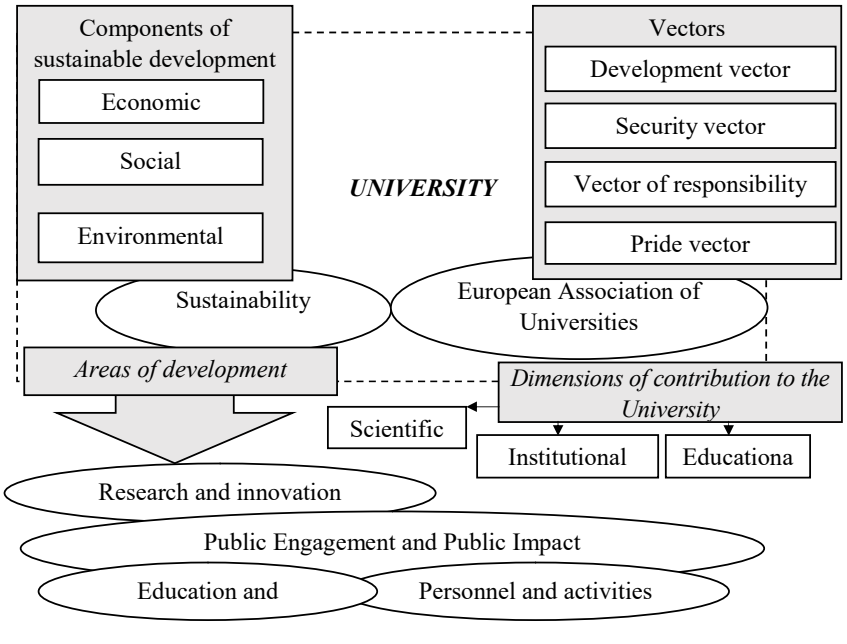

Fig. 1. Conceptual vision of the University's CMEOT

so that course participants can design their own learning package. Horizon scanning in terms of the labor, industrial and societal transformations that will soon impact local and national contexts.

4. Promote international cooperation by identifying educational programs that are jointly implemented by partners in different countries, especially those significantly affected by climate and environmental challenges. Erasmus Mundus can serve as a model for international, interdisciplinary, and intercultural programs, together with other networks and alliances such as the European Universities Initiative.

5. Identify key preconditions for the success of interdisciplinary programs that can be adopted by members of the organization according to their local context. Organize information exchange events to discuss lessons learned from new curricula, structures and graduate profiles that reflect the transformations taking place in the relevant sectors.

6. Advocate with national and transnational university funding agencies to ensure greater and more flexible funding for new interdisciplinary and experimental curricula at all levels of education.

7. Support universities in conducting strategic analyses of individual opportunities for sustainability topics and developments, for example by examining megatrends and relevant Green Deal policies. Such analyses can identify the relationship between such changes and long-term patterns of student enrolment, course choice, career outcomes and socio-economic status.

8. Promote the dissemination of best practices in foresight that would allow universities to anticipate institutional transformations geared towards sustainable development. These can be integrated into a more sustainable use of different scenario methodologies, as outlined in the EUA report "Pathways to the Future" and inspire debates about the place of the university sector in different geopolitical, technological, and societal constellations.

Regarding the area of "Staff & operations", the aim is to create a motivational framework. Sustainability strategies should clearly define roles and allocate responsibilities across the institution, with a broad indication of what is expected in practice on a daily basis. Commitment to sustainability as a value and to tackling the climate emergency as a shared cause is essential for developing an inclusive, equitable and supportive culture in universities. It also enables the whole sector to collaborate and speak with one voice.

Universities should be seen as a holistic community, with all members able to contribute to the goals of the Green Deal. Universities are already recognizing the reputational benefits they gain from their greening activities.

Ethically consistent positioning on climate and environmental challenges will further enable institutions to become attractive to students, academics, and professional staff.

Institutional growth and student numbers may be aligned with political discourses and funding models in some countries but this needs to be balanced with an awareness of the impact of campus expansion on surrounding communities.

Alternative growth models that favor the renovation and redevelopment of existing facilities or the sharing of facilities off campus should also be proposed. The evolution from the principle of "lowest price" to the principle of "highest value" shows that social and environmental criteria are taken into account in university procurement. The procurement of goods and services that have a lower environmental impact throughout their life cycle should continue to be encouraged.

In order to achieve the objective of the area, the following tasks are considered appropriate:

1. Address sustainable functioning in synergy with the commitments to equality, diversity, inclusion, and belonging (EDIB) in the institutional strategy. Through a sustainability committee reporting to senior management, the strategy should address issues related to the management of the building stock and surrounding green spaces, food and dining supply, procurement, etc. Examples such as the Green Office movement also show that direct student participation in the management of the strategy can facilitate and enrich the university's green transition.

2. Examine the rationale for high-carbon travel and mobility and develop codes of conduct that can help employees choose lower-emission alternatives.

3. Rethink the institution's internal processes, involving both leaders and staff. Following the Green Deal is not just a question of costs and funding but also of optimizing what universities are already doing. Moreover, even large funding for much-needed capital investment can be wasted if processes, incentives, and culture remain the same.

4. Assess the need for sectoral and cross-departmental training for staff on sustainability issues so that the university community can act as multipliers and facilitators of the Green Deal beyond the campus. Human resources policies can be a key tool for embedding sustainability principles into the identity of the institution, starting with induction training for staff at all levels.

5. Implement measures to make laboratory research more sustainable, such as the 1point5 lab initiative in France, Green Labs in Ireland, and Green Lab Associates in the UK.

6. Identify examples of university-wide approaches to effective sustainability performance and engagement with the entire university community. Supplement this with data on perceptions of the positive and negative impacts of ongoing or anticipated institutional transformations.

7. Create and accumulate resources to support university leaders responsible for sustainability to ensure the successful transition of operations in their institutions.

8. Raise awareness of the role of procurement in managing the green sustainable transition in universities.

9. Develop indicators of the holistic impact of greening initiatives based on the survey "Greening at Ukrainian Higher Education Institutions" and further collection of quantitative and qualitative data. Disseminate this data as part of advocacy campaigns aimed at countering the over-emphasis of existing funding models on performance indicators at the expense of holistic impact.

The final transformation area "Public engagement & societal impact" aims to articulate a clear vision for successful implementation. Staff who actively advocate for the necessary measures and actively participate in sometimes very controversial public discussions should benefit from the support of their institutions and the commitment of the university sector to reasoned debate.

Universities play an important role in ensuring a just transition at the local level. This can make them very influential, and local partnerships can often be more appropriate than national or international ones. However, this requires trusting relationships with diverse communities and indigenous groups, businesses, policymakers, and decision-makers, rather than a purely instrumental, funding-oriented mindset. Knowledge brokering training should be widely available to enable researchers to co-create, transfer, and evaluate knowl-

edge at the interface between science and policy, using the most appropriate methods. As the example of the SSH Centre funded by Horizon Europe and UKRI shows, such training could include modules on integrating knowledge from different epistemic communities and co-producing evidence to drive complex local transformations. Accreditation of training programs by public or independent bodies should provide an additional basis for promoting community outreach and sustainability.

Necessary aspects to be considered for the University's CMEOT:

1. Value in career assessment engagement in civic engagement and policy contributions alongside research and education. This can encourage staff to apply for membership of advisory committees, working groups and other policy-making bodies, and can also improve the communication skills of doctoral students. It can also strengthen the institution's media presence in cases where only certain departments or individuals are visible.

2. Develop public science projects on topics of local interest, where urban innovation is needed to achieve the Sustainable Development Goals. They should reflect a desire not only to promote and demonstrate new solutions but also to contribute to a broader understanding of how large-scale climate and environmental challenges can have specific local consequences. With nearly 70% of the world's population expected to live in cities by 2050, partnerships with initiatives such as the Covenant of Mayors can be particularly valuable in this context.

3. Mobilize and exercise collective influence by joining networks of stakeholders engaged in advocacy at local and national levels, as well as at EU and global levels. Consider partnering with think tanks and NGUs that have significant experience as intermediaries between academia and policy and ensure that governance and support structures allow for the sharing of liaison roles across multiple staff.

4. Develop stronger links with alumni as part of a shared commitment to increasing the university's social impact. Use their expertise to drive new initiatives, for example in support of groups and individuals affected by climate and environmental challenges.

5. Promote greater learning and exchange of experience between universities, in particular through programs such as "Strengthening ties with local communities". This includes partnerships at the local level, when geographically defined communities participate in the joint development of socially significant research and innovation projects. The strength of university ties with local communities varies across Ukraine and Europe, depending on the governance systems and the degree of their centralization.

6. Encourage policymakers to cooperate with universities, familiarize them with the challenges they face, to participate in scholarship programs for civil servants. Examples of programs with joint study trips for early-stage researchers and policymakers should also be identified and promoted.

Analyzing the current methodological basis for the implementation of sustainable development goals in higher education, we have developed an optimal mechanism for implementing innovative European practices. This mechanism involves the implementation of CMEOT in a network of universities and was piloted during the implementation of an international project within the framework of the Erasmus+ program (action-sectoral higher education KA220-HED-cooperation-partnership in higher education). Project title: Transformational Learning Network for Resilience – Assistance to Ukrainian Higher Education to Ensure Sustainable and Reliable Reconstruction of (Post-War) Ukraine [13].

CMEOT pilot was implemented on the basis of a network of Ukrainian universities – project partners and associated partner universities. 8 working groups personalized CMEOT through visualization and explored gaps in policies, legislative acts, programs, and plans in the areas of UN activities. The processing of the results showed the need for unification of CMEOT of universities of various profiles from technical to humanitarian. We have decided, by using SWOT analysis data, to develop an algorithm for a flexible system of unification of CMEOT of universities. This will be done through the adaptation and implementation of ongoing national voluntary institutional reviews. The reviews will take into account the criteria and processes for determining the priorities of CMEOT.

Table 1

Tasks for implementing the transformation of the current field of activity

No. of entry	Action	Task
1	Development	Building on international projects such as AGERA (Agenda 2030 and the Global Sustainable Development Goals as a Framework for Collaboration) in Sweden, a national paradigm for promoting interdisciplinary research has been developed. It supports the interconnected implementation of the SDGs, bringing together economics, politics, environment, and society
2	Support	Realizing the SDGs by creating a culture in which collaboration and mutual support between existing research structures can help address the challenge of sustainable development. This cultural change should also encourage experimentation and risk-taking, for example within new structures such as interdisciplinary "institutions without walls"
3	Promotion	Collaborative research and alignment of research strategies and philosophies allow for a shift in the approach to internal funding. Instead of a single principal investigator, funding can shift to a co-principal investigator approach, for example, one from the social sciences and humanities and another from the natural sciences, technology, engineering, and mathematics
4	Development/ Adoption	Innovation impact methodologies (e.g., the SDG Impact Assessment Tool) that consider both technical and local social factors for successful implementation of solutions. Translate lessons learned into implementation roadmaps that can be co-created with innovation partners for better strategic alignment
5	Impact	Procedure for the systematic recognition and assessment of interdisciplinarity in research and innovation projects, e.g., as part of the career assessment reform
6	Implementation	Examples of interdisciplinary research methodologies that have enabled the development of new research and innovation projects, such as the UK Research and Innovation co-champion approach
7	Modification and Adaptation	based on the EUA SDG program provisions, develop an information package for national elites that highlights the university's significant contribution to research and innovation within the framework of the Green Deal

5. 2. Development of a concept for building a model of environmentally oriented transformation of universities

Given the different actions and processes, it is advisable to implement a Concept of Sustainable Development of the University, which would define the horizon of opportunities for the model of sustainable development of the University (Fig. 2). The concept is an expression of the transition of society to sustainable development. Many institutions are already strategically considering and acting on some or all of these issues. However, the development of a unified version of the Concept of Sustainable Development of the University by 2030 would ensure a "green" transition [14]. This would also stimulate the optimization of the integration of internal strategies and the alignment of incentives for the entire university community.

Ultimately, the roadmap should serve as an inspiration and a model of how universities can confront climate and environmental challenges in the long term, while contributing effectively, and also serve as an example of sustainable communities. The concept is focused on innovative development, based on the active use of knowledge and scientific achievements. It stimulates innovative activity, updating of material and technical base and formation of interdisciplinary educational programs for various branches of economy. The concept is also aimed at increasing energy efficiency, balanced growth of university potential and attraction of investments in renewable energy sources, environmentally friendly production and "green" technologies.

The basis for the development of the Concept were the 17 global Sustainable Development Goals for the period up to 2030, the Sustainable Development Strategy "Ukraine – 2030", the Updated EU Sustainable Development Strategy, and the Green Roadmap for Universities from the European University Association (EUA).

The Concept is based on a SWOT analysis and an analysis of gaps in policies, legislative acts, programs, and plans in eight areas. It is aimed at achieving the goal of university development. The methodological basis for the implementation of the Concept is the University Action Plan (roadmap) for the transition of the university to sustainable development. This plan should be adopted after the development and approval of the Concept of Sustainable Development of the University.

The Concept establishes a holistic system of strategic and operational goals for the transition to integrated economic, social, and environmental development of the potential of the country's universities by 2030. It also defines the institutional principles for implementing the Concept, the directions of interdisciplinary and inter-sectoral interaction, the main driving forces, and tools for its implementation.

Institutional principles, coordination, inter-sectoral interaction, driving forces and partnerships. The overall responsibility for implementing the Concept lies with the university's self-governing bodies and leading administrative bodies. The University administration independently decides on the distribution of powers and areas of responsibility. This concerns the coordination of actions, strategic planning, implementation of the Concept and monitoring of its implementation. Responsibility lies with the departments involved in planning the transition to sustainable development, coordinating interdisciplinary interaction, and integrating economic, social, and environmental policies. Monitoring the implementation of the Concept is carried out within the framework of academic freedom and in compliance with the principles of academic integrity.

Thus, the concept of building a model of environmentally oriented transformation of universities of sustainable development combines the use of certain implementation tools.

Regulatory and legal instruments. Strengthening the regulatory and legal framework is a necessary condition for the proper implementation of the Concept, through:

1) ensuring the development of the University Action Plan for Sustainable Development and its implementation and the transition from socio-economic planning to ecological-socio-economic planning of university development (to sustainable development planning);

2) ensuring regular examination of the university's regulatory documentation for compliance with the principles of sustainable development in order to create an appropriate legal framework and stimulating financial and economic mechanisms.

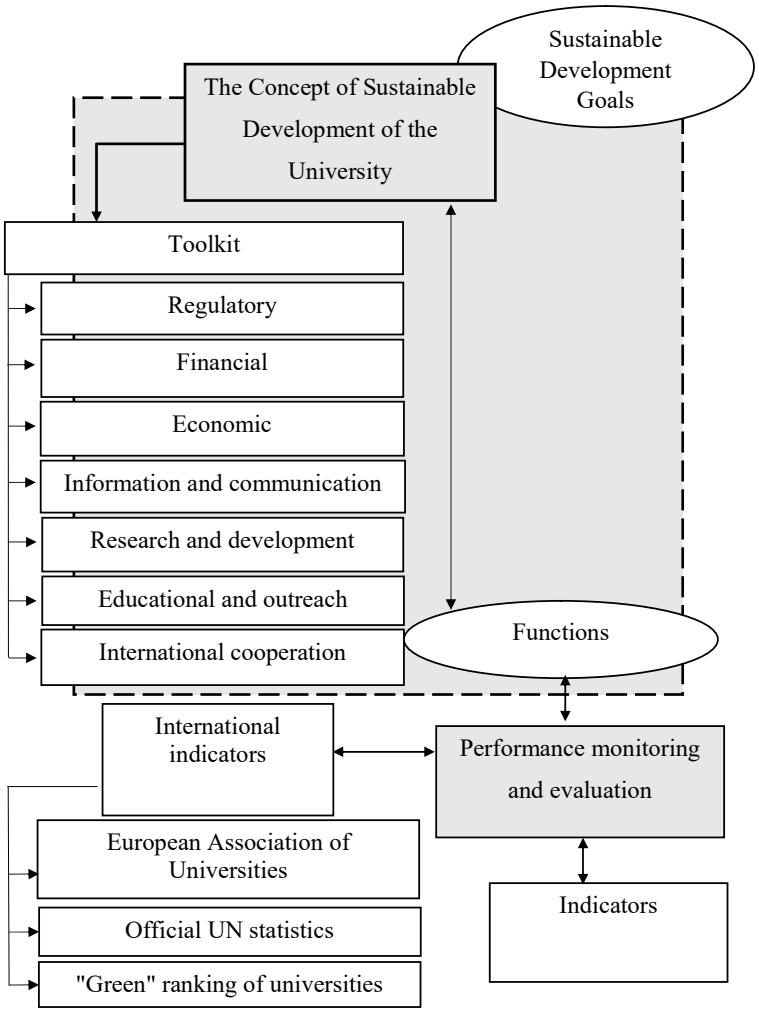

Fig. 2. The concept of building a model of ecologically oriented transformation of universities

The proposed concept of building a model of environmentally oriented transformation of universities of sustainable development ensures the integration of environmental, social, and economic aspects at all levels of the educational process. This becomes possible thanks to an interdisciplinary

approach that allows universities to flexibly adapt to global challenges and take into account national characteristics.

The devised concept for building a model of environmentally oriented transformation of universities for sustainable development contains an algorithm for unifying ecological transformation for universities of various profiles, which makes it possible to effectively consider the specificity of educational institutions and their environment.

Research that focuses on environmental initiatives without their integration into the educational process limits the effectiveness of implementing sustainable development. The proposed concept for building a model of environmentally oriented transformation of universities for sustainable development, on the contrary, provides for a systematic approach that contributes to the formation of students' environmental awareness and improving the quality of education.

This concept for building a model of environmentally oriented transformation of universities for sustainable development offers effective mechanisms for integrating universities into global educational networks, which contributes to increasing their competitiveness at the international level.

Thanks to support at the state level and the implementation of financial mechanisms for ecological transformation, the concept of building a model of environmentally oriented transformation of sustainable development universities ensures the sustainability of changes, which makes it more effective compared to approaches that do not provide for specific financial and management strategies.

5. 3. Mechanisms for adapting European sustainable development practices to the national educational environment

Financial tools.

One of the most important conditions for the proper implementation of the Concept is the coordination of the goals and objectives of the Concept with the national and university budget process. One of the tools is a comprehensive analysis of expenditures in terms of implementing the goals and objectives of the Concept. Integrating sustainable development principles into existing development planning mechanisms is another means of harmonizing the Concept with the budget process.

The transition from taxation based on labor use to resource consumption and environmental pollution criteria should be considered. This will contribute to achieving the goals of the Concept. In order to properly finance the measures, it is necessary to conduct continuous activities and look for new opportunities. It is also important to recommend effective solutions to the relevant sectoral authorities:

1. Increase the efficiency of the tax system by improving the taxation system and implementing European principles of good governance in the field of university taxation.

2. Ensure an improvement in the investment climate and introduce measures to encourage foreign and domestic investors to invest, giving priority to investments aimed at implementing the goals of the Concept.

Economic tools.

These tools help form transparent mechanisms for attracting international financial assistance to address systemic development issues, primarily the restoration and restructuring of the economy of Eastern Ukraine. The goal is to consistently implement the provisions of the Association Agreement between the countries and the EU member states. This applies to educational services, non-discrimination, and the reduction of tariff barriers in trade. It also provides for bringing the state aid system and public procurement into line with WTO requirements.

Information and communication tools.

These tools form the ability to consistently implement information and communication technologies, ensuring their general accessibility, integration into the educational process and the e-governance system for sustainable development. For this purpose, it is considered necessary:

1. Create a system of objective information for all stakeholders about the political, economic, social, and environmental aspects of the sustainable development of universities in Ukraine and the world.

2. Cooperate with and support the work of information and analytical centers, educational and research institutions on sustainable development issues and centers of best practices on sustainable development.

Research and development.

This tool provides for the priority development of educational programs that provide interdisciplinary training of specialists. They should be knowledgeable in the implementation of environmentally friendly technologies, in particular energy-saving and low-carbon ones. On this basis, the principles of sustainable development of traditional sectors of the economy should be implemented, the efficiency of the energy sector should be increased, and the energy intensity of life support systems should be reduced. The use of this tool will strengthen the scientific validity of decisions in the field of ensuring sustainable development, promote the advanced development of research that provides an assessment of the natural resource potential of Ukraine, spatial planning of its effective use.

Educational and knowledge-building tools.

A balanced society is a knowledge society. To solve numerous development problems, new knowledge, skills, and competencies will be required, necessary for a deep understanding of complex problems and solving interrelated issues of public life. The implementation of these tools will allow for the following:

1. To ensure integration with research and information and analytical centers to study and substantiate ways to solve regional environmental, social, and economic problems.

2. Promote the implementation of the UNECE Strategy on Education for Sustainable Development in the education system of Ukraine by introducing into the Education Standards of all levels and specialties general competencies for understanding the issues of society's transition to sustainable development. Universities and other educational institutions should ensure the training of qualified specialists with the necessary competencies for the development and use of the latest technologies that ensure society's transition to sustainable development.

3. Integrate sustainable development issues into the system of professional education of civil servants and educators. Education is one of the prerequisites for achieving sustainable development and the most important tool for effective management and informed decision-making.

4. Promote the integration of sustainable development issues into the system of preschool, school, out-of-school, secondary, higher, and non-formal education.

International cooperation.

In the field of international cooperation on sustainable development, the following tasks are priority:

1. Stimulate the implementation of international projects in the field of sustainable development.

2. Strengthen cooperation with international organizations, in particular EU institutions, to ensure the implementation of the Concept.

3. Ensure the protection of Ukraine's national interests and university freedoms when concluding international agreements.

4. Expand international cooperation in the field of science and technology, focused on capitalizing the country's scientific and technological sector, structural modernization of the national economy and balanced environmental management.

5. Strengthen partnership cooperation at the international level in order to achieve global sustainable development goals, in particular in the regional dimension on the basis of cross-border cooperation.

5. 4. Assessing the effectiveness of the proposed model and formulation of recommendations for its implementation at Ukrainian universities

The Conceptual Model of Sustainable Development of the University includes "Monitoring and Evaluation of Performance". To ensure comprehensive and in-depth monitoring of the entire set of goals and objectives of the Concept, it is necessary to:

1. Develop and implement (taking into account the indicators of the global "green" ranking of universities) indicators of sustainable development in the internal statistical reporting of all university departments, in particular in a regional context.

2. Ensure the formation of an array of accessible structured statistical data by improving the system of university statistics, in accordance with the requirements of the Basic Principles of Official Statistics of the UN and the European University Association on Sustainable Development.

3. Based on the indicators (Table 3), an open and publicly available system for monitoring the university's activities by key indicators (Table 2) of sustainable development is proposed. The indicators are listed in order of ranking by priority groups for sustainable development.

Table 2

University performance monitoring indicator system

Rank based	Key indicators	Characteristics
1. Climate		
1. 1	University sustainability startups	Quantitative and qualitative indicators
1. 2	Organic production	To introduce green areas occupied by organic production to meet the needs of the university and local communities
1. 3	Surface water quality	To improve the quality of natural waters by reducing the discharge of pollutants and materials, reducing the volume of untreated wastewater
1. 4	Waste	To reduce the volume of waste
1. 5	Climate change	To limit greenhouse gas emissions in all sectors of economic activity
2. Energy		
2. 1	Renewable energy sources	Increase the share of energy produced from renewable sources in total final energy consumption
2. 2	Efficiency of use of resources	Ensure a reduction in resource intensity
3. Infrastructure		
3. 1	Development vector	Scientific directions by economic sector
3. 2	Economic growth	Quantitative/qualitative indicators
3. 3	Transport infrastructure	Develop high-quality, reliable, balanced, and sustainable infrastructure
3. 4	Industrial development	Cooperation with enterprises and businesses, branches of government, communities on the development and implementation of projects that take into account sustainable development goals
3. 5	Modernization of the infrastructure and material base of the university	Quantitative and qualitative indicators
3. 6	Development planning	Ensure the development of university campuses, territories, and buildings exclusively on the basis of comprehensive and sustainable planning (based on master plans) and management with public participation based on the principles of sustainable development
4. Educational and scientific		
4. 1	Scientific research	Intensification of scientific research
4. 2	Structure of international export of educational services	Number of educational programs, courses offered for study in other languages
4. 3	Security vector	Access to justice and enforcement of academic integrity standards. Ensure access to justice and protection of rights for all segments of the educational process
5. Social		
5. 1	Countering corruption	Regulatory basis
5. 2	Reducing gender-based violence	Reduce the level of gender-based and domestic violence
5. 3	Road safety	Conduct comprehensive agitation, educational activities on the rules of behavior of road users in order to reduce mortality in road accidents
5. 4	Social support programs	Promote the increase in educational activities on the possibilities of covering the population with targeted social support programs
5. 5	Employment	Increase the employment rate of graduates through constant monitoring of the employment of university graduates
5. 6	Reducing inequality	Reduce inter-settlement disparities in access to educational services
5. 7	Gender equality	Ensure equal opportunities for women and men to receive educational services

The significance of determining indicators can be characterized by the following inherent features and properties:

– indicators are the starting point for planning the organization's activities;

– indicators determine both the structure and mechanisms for implementing internal and external organizational relations;

– based on the system of indicators, a motivational system is developed and supported, which is used in the university to achieve goals;

– indicators are a tool for the control system;

– indicators can be considered as criteria for assessing the performance of individual employees, departments, and the university as a whole.

General indicators must take into account the goals set, which are formed and established on the basis of the organization's general mission and certain values and goals of top management. Goals must have a certain number of characteristics in order to make a real contribution to the success of the organization. There are well-known basic characteristics and requirements for goals (Fig. 3).

The diagram shows the main characteristics that should be taken into account when forming the goals of the organization. Each sector corresponds to one of the requirements, equally distributed:

1. Attainability – goals should be realistic and achievable, taking into account the available resources.

2. Measurability – there should be specific criteria for assessing progress and achieving the goal.

3. Specificity – goals should be clearly formulated to avoid ambiguity.

4. Flexibility – goals should be adapted to changing environmental conditions.

5. Compatibility – the goals of the organization should not contradict each other.

6. Time orientation – each goal should have a time limit for achievement.

Each of the sectors in the diagram is of the same size, indicating the equivalence of these characteristics for the success of the organization.

Coordination of monitoring the implementation and performance assessment of the Concept will be carried out by the university unit/units responsible for the implementation of the Concept and will perform the following functions:

1. Annually conduct an analysis of the implementation of tasks from the point of view of achieving the goals of the Concept and, if necessary, provide proposals on the priorities of the sustainable development policy and the means and instruments for implementing the Concept.

2. Check the results of the implementation of the Concept, in particular the achievement of planned target indicators.

3. Prepare and publish the "University Report on Sustainable Development", which will present information on progress in the implementation of the Concept, and which will include the current values of indicators of balanced development.

4. Develop University Action Plans for the transition to sustainable development at all levels of activity, monitor their implementation and, if necessary, propose changes and additions.

For informative and complete monitoring, a system of indicators was proposed as a tool for influencing the development of processes that will most fully reflect the university's activities in the direction of the "green" transition. This will provide the opportunity to introduce a procedure for ranking university structural units in order to adjust their activities according to individual indicators, thus influencing the university-wide target indicators.

Each sector is characterized by a certain number of unified indicators (from 6 to 10). For quantitative assessment, a scoring scale was proposed with points from 1 to 100 assigned to each indicator. It was proposed to rank units with the same total score according to the most significant indicators. Initially, the indicator "Energy and Climate Change" (EC, Energy and Climate Change) is taken into account. Next are the aggregate indicators of Waste (WS), Transportation (TR), and Education (ED). Subsequently, it will be based on the assessment of Setting and Infrastructure (SI), which will depend on the assessment of Water (WR) (Fig. 4).

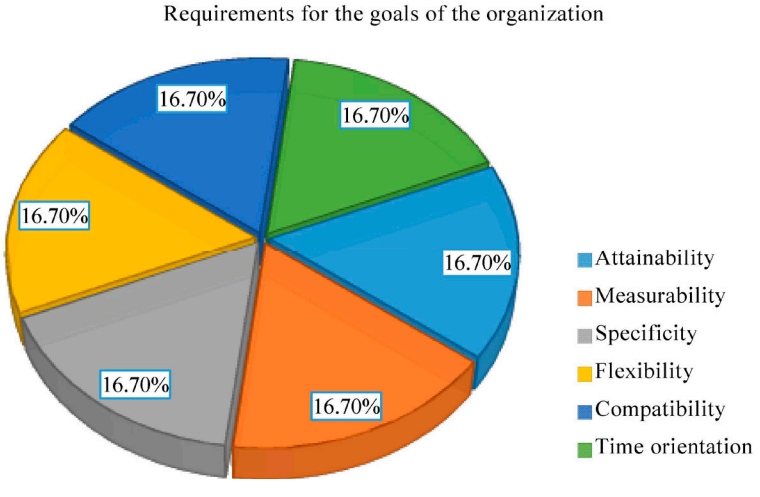

Fig. 3. Sectoral characteristics of the organization

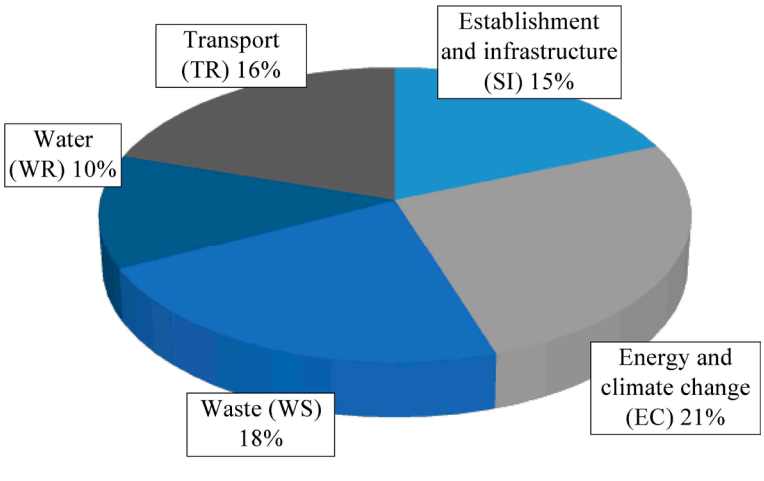

Fig. 4. Prioritization of "green" development sectors (proposed by Authors)

For the representativeness of the comparative assessment, we selected identical departments of two universities, the terms of the assessment were taken identically standard for universities during reporting: the fourth quarter of the current year. The instrumental assessment of the University's CMEOT was tested on the basis of the ecology departments at the Kharkiv National Automobile and Road University (KhNARU) and

the National Aerospace University "Kharkiv Aviation Institute" (KHAI). The study was carried out using the example of the indicator "Education" (ED, Education & Research). A comparative assessment was also conducted between the departments of these universities. (Fig. 5, 6). Educational and research information of the university departments constitutes the main information about the university's policy and actions in forming and maintaining awareness of students, academic and non-academic staff on sustainable development issues. This criterion also encourages universities to report on their activities, strategies, and goals in the field of sustainable development to stakeholders.

Based on the results of the comparative assessment, we can draw the following conclusions: the activities of the units are identical, which is due to the same functional tasks at the universities that were selected for testing.

Table 3 gives indicators for the target indicator Education (ED, Education & Research) and their scores.

The results of the assessment of the environmental activities at the ecology departments of KhNARU and KhAI indicate a high level of involvement of both universities in sustainable development processes. Both institutions demonstrate stable indicators in the field of events and initiatives related to environmental sustainability.

At the same time, analysis of individual indicators indicates a difference in the financing of sustainable development research: KhAI pays more attention to this aspect (15 points versus 10 at KhNARU). KhAI also has a higher level of student involvement in public environmental initiatives (54 points versus 50 at KhNARU). At the same time, KhNARU demonstrates slightly higher indicators in the field of cultural events (75 versus 70 at KhAI).

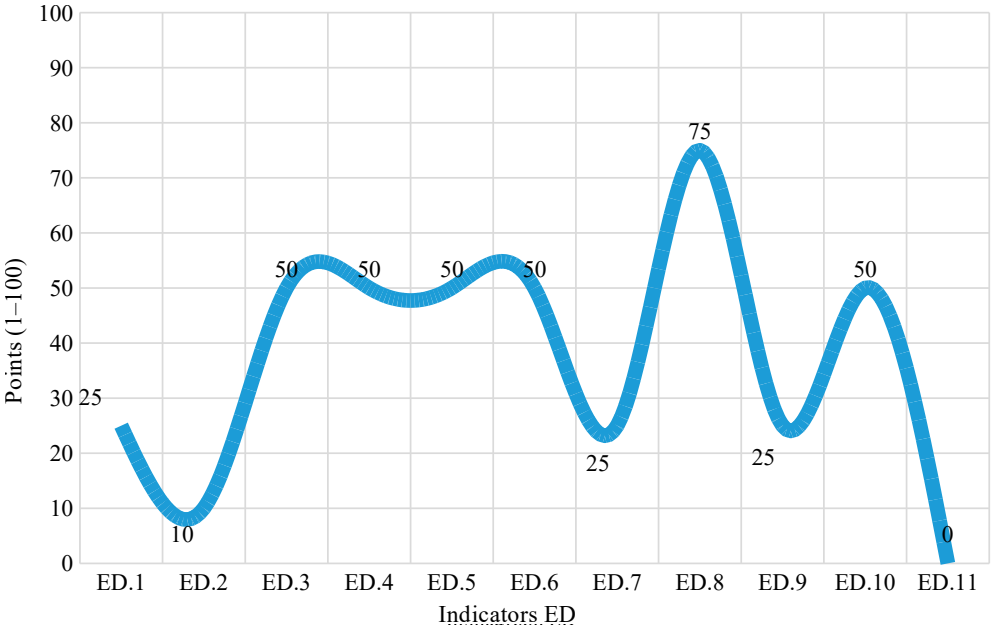

Fig. 5. Modeling by indicators of the Education (ED, Education & Research) indicator, subdivision – Department of Ecology, Kharkiv National Automobile and Road University

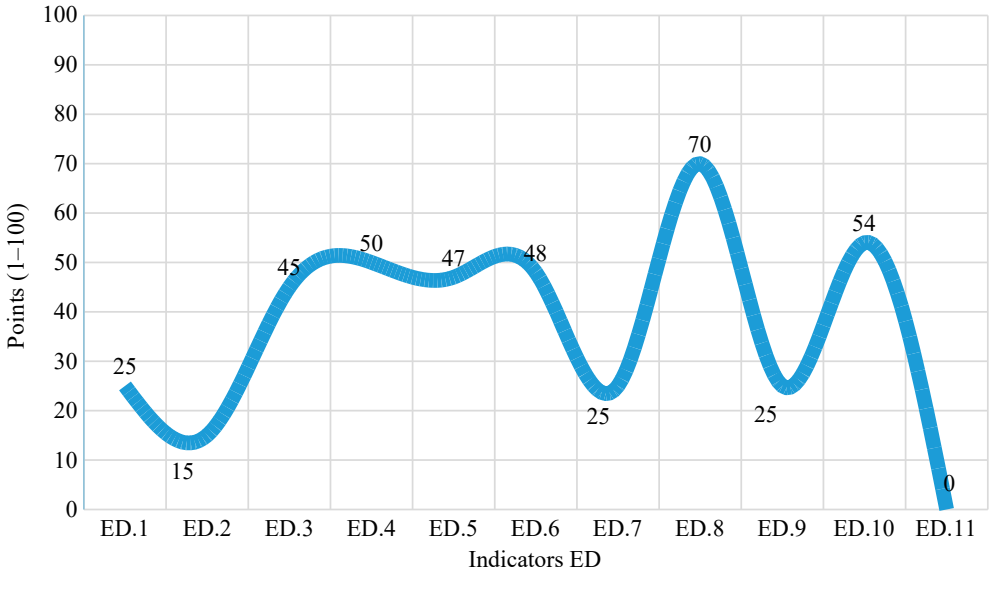

Fig. 6. Modeling by indicators of the Education (ED, Education & Research) indicator, subdivision – Department of Ecology and Technogenic Safety at the National Aerospace University "Kharkiv Aviation Institute"

Table 3

Indicators and scores for the "Education" indicator

ID	Indicator	Points, Ecology Department at KhNADU	Points, Department of Ecology at KhAI
ED.1	The ratio of sustainability	25	25
ED.2	The ratio of sustainability research funding to total research funding	10	15
ED.3	Number of scholarly publications on sustainability	50	45
ED.4	Number of events related to sustainability (environment)	50	50
ED.5	Number of activities organized by student organizations related to sustainability per year	50	47
ED.6	University-run sustainability website	50	48
ED.7	Sustainability report	25	25
ED.8	Number of cultural activities on campus	75	70
ED.9	Number of university sustainability program(s) with international collaborations	25	25
ED.10	Number of community services related to sustainability organized by university and involving students	50	54
ED.11	Number of sustainability-related startups	0	0

In general, the results in the table confirm the need for further research to improve the strategies of environmental management of universities, in particular regarding funding, student initiatives, and the integration of international experience in the field of sustainable development.

6. Discussion of results based on the study of the model of environmentally oriented transformation of universities

During the study, a set of tasks was solved, which allowed us to form a holistic model of environmentally oriented transformation of universities (CMEOT).

The conceptual vision of CMEOT is shown in Fig. 1. A feature of the result of such a representation is the identification of four key vectors of university development in the context of sustainable development: development, safety, responsibility, and pride. These vectors provide a comprehensive approach to ecological transformation, which makes it possible for educational institutions to form an environment of sustainable development.

The proposed concept of building a model of environmentally oriented transformation of universities of sustainable development provides a structured interaction of strategic and operational elements (Fig. 2). An important feature is the construction of a roadmap for the university's transition to sustainable development, which takes into account internal and external factors of influence. This makes it possible to close the gaps associated with the lack of comprehensive mechanisms for strategic management of ecological transformation.

Table 1 gives tasks for implementing transformational processes in the field of research and innovation. The use of international experience (for example, the AGERA and EUA SDG initiatives) allows for flexible adaptation of the best European practices to the conditions of Ukrainian universities, which ensures the model's relevance to the local context.

Finally, the effectiveness of the proposed model was assessed by building a system of monitoring indicators (Table 2). The assessment confirmed the model's ability to ensure real integration of sustainable development principles into the activities of universities. A feature of the developed system is its focus not only on environmental aspects but also on infrastructure, energy, and educational and scientific components. This comprehensive coverage allows for long-term sustainability and increased competitiveness of higher education institutions.

The study has a number of limitations that determine its application limits:

– the reproducibility of results depends on the characteristics of each university, the level of funding, and readiness for environmental changes;

– the sustainability of solutions may vary depending on political and socio-economic conditions;

– the ranges of input data (for example, the current level of environmental culture in universities) may affect the final results of the implementation of CMEOT.

The main drawback of the study is the insufficient testing of the model at technical and medical universities, which limits its universality. To eliminate this deficiency, it is necessary to expand the experimental base and adapt the methodology to different profiles of higher education institutions.

Further research may focus on expanding the use of the conceptual model of environmentally oriented transformation of universities (CMEOT) at institutions of various profiles to test its flexibility and adaptability to the specificity of different educational environments. It is also important to devise a methodology for long-term monitoring of the implemented changes to assess their effectiveness and compliance with the goals of sustainable development.

It is advisable to pay special attention to the comparative analysis of the impact of environmental transformation on the competitiveness of universities in the international educational space, which would make it possible to substantiate the strategic priorities for the development of higher education in Ukraine in a globalized world.

Further research is needed to expand the methodological tools for monitoring the effectiveness of CMEOT and determine its long-term impact on the sustainability of educational institutions. In particular, the introduction of an automated system for collecting and analyzing data on the environmental efficiency of universities could increase the accuracy of the assessment, ensure transparency of processes, and contribute to further improvement of the model in accordance with changes in international standards of sustainable development.

7. Conclusions

1. As a result of our analysis of the paradigm of ecological transformation of universities, it was established that the greening of the educational space is a necessary condition

for the integration of higher education institutions into global processes of sustainable development. The latest global trends demonstrate the importance of an interdisciplinary approach, a combination of environmental, economic, and social components in the formation of an ecological culture and a new educational paradigm focused on long-term sustainability.

2. Based on the results of our study, a concept for building a model of environmentally oriented transformation of universities (CMEOT) was devised, which combines the principles of sustainable development in all areas of university activity: educational, scientific, managerial, and public. The concept provides for the creation of an integrated system for managing environmental initiatives and contributes to the development of the innovative potential of the university network in the face of global challenges.

3. The proposed mechanisms for adapting European practices of sustainable development to the national educational environment are based on a flexible combination of international experience with the specificity of the local context. Key areas identified include reforming curricula, developing environmental management, increasing energy efficiency, involving the student community in implementing environmental projects, and expanding international academic cooperation.

4. The assessment of effectiveness of the proposed model has shown its high adaptability for universities of various profiles, which is confirmed by the results of testing within the framework of international projects. The proposed recommendations for the implementation of CMEOT at Ukrainian universities include the need to strengthen regulatory and legal support, state support, financing of environmental initiatives, improve the sustainable development monitoring system and intensify cooperation with national and international stakeholders.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study, as well as the results reported in this paper.

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Data availability

All data are available, either in numerical or graphical form, in the main text of the manuscript.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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