PART 2.
ENVIRONMENTAL ASPECT OF ESG IN UNIVERSITIES

Chapter 3.
Green university initiatives for a sustainable future: a case study of Taras Shevchenko National University of Kyiv

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Introduction

The concept of a "green university" is a key component of sustainable higher education institutions (HEIs), encompassing teaching, research, community engagement, and campus operations. The first steps toward energy efficiency and waste reduction in HEIs emerged in the early 1990s. However, since then, the focus has significantly broadened, incorporating various aspects of university life through an increased emphasis on innovation and technology. Green initiatives have become integral to university development strategies, forming a crucial part of reporting aligned with the Sustainable Development Goals (SDGs) and Environmental, Social, and Governance (ESG) principles. Taras Shevchenko National University of Kyiv (TSNUK) has actively embraced the global trend

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of greening universities, demonstrating remarkable resilience despite the unprecedented challenges posed by ongoing the Russian Federation aggression against Ukraine. The university faces significant financial constraints, yet attempts to build green campus initiatives. In addition, the destruction of buildings due to shelling and the high staff turnover further complicate its efforts. Nevertheless, TSNUK remains committed to sustainability, prioritizing green initiatives as a strategic response to align with SDGs.

"Green University" Concept

The concept of a "green university" is a relatively new approach to higher education that has quickly gained popularity and become one of the priority areas of development for universities. Currently, more than 1,000 universities worldwide actively participate in the Higher Education Sustainability Initiative (HESI), which fosters sustainable development efforts in collaboration with various United Nations entities (UN, 2024). This involvement demonstrates that universities are focusing not only on enhancing the quality of education but also on achieving a competitive edge by cultivating environmentally sustainable campus environments. Additionally, it is important to recognize that sustainability investments can yield long-term advantages for universities, including notable cost savings over time (Atici et al., 2021).

In this chapter, the "green university" concept will be examined across four dimensions: campus operations, teaching, research, and community engagement (Fissi et al., 2021). The integration of the "green university" concept is illustrated in Figure 3.1.

Campus initiatives of HEIs are crucial not only for reducing their environmental footprint but also for cultivating a culture of sustainability within their communities. These initiatives play a key role in shaping "green" knowledge, behavior, and attitudes among three essential groups:

1. *Students as future leaders and policymakers*. By embedding sustainability principles into campus operations and student life, HEIs equip students with the tools and mindset to prioritize environmental stewardship in their professional and personal lives.

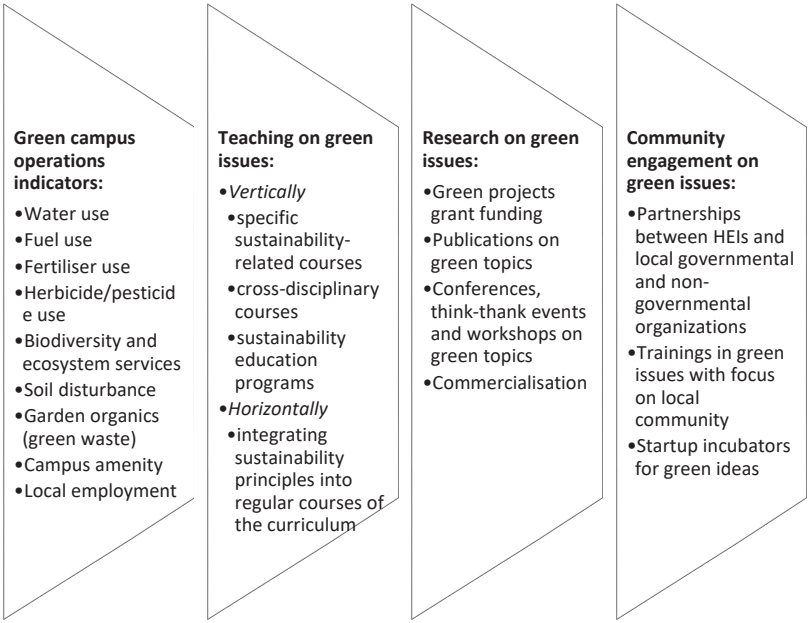

Fig. 3.1. Dimensions of green university

Source: created based on Fissi et al., 2021; Stough et al., 2018; UNEP, 2014, p. 41–42

2. *Faculty as role models*. Faculty set an example for students and the broader academic community through their teaching and research. By integrating green practices into everyday actions, they demonstrate the feasibility of sustainability and actively promote the dissemination of knowledge about green initiatives.

3. *Administrative staff as facilitators*. Administrative personnel are critical in operationalizing sustainability within campus infrastructure and services. Their actions directly impact the efficiency and effectiveness of green initiatives, from energy management to waste reduction, ensuring that sustainability is a core component of institutional practices.

Through these efforts, HEIs not only contribute to environmental preservation but also foster a generation of sustainability-minded individuals capable of driving global change.

Green initiatives on campus typically include (Leal Filho et al., 2019; Fissi et al., 2021):

- *Green building* involves the design, construction, maintenance, renovation and demolition of buildings based on sustainability principles. This includes improving energy efficiency, using renewable energy sources (use of solar panels and wind turbines) and incorporating non-toxic and environmentally sustainable materials (creating green roofs to improve the microclimate) (Fernández et al., 2023).
- *Waste management* involves the processes of collecting and handling different types of waste generated across campus. This includes materials such as office waste (e.g., paper, folders, and printer cartridges), furniture, laboratory and clinical waste (chemicals, equipment, wastewater), food waste from canteens, and general waste.
- *Sustainable procurement* focuses on acquiring goods and services that align with eco-friendly public procurement standards. The goal is not merely to select the least expensive options but to prioritize products and services that are produced responsibly, minimizing environmental harm to the greatest extent possible.
- *Sustainable mobility*, which means ensuring that both business travel and the commuting of staff and students is cheaper and more environmentally sustainable (for instance, encouraging the use of bicycles, electric vehicles, public transport and car sharing). This area also includes accessibility for disabled people.

Teaching on green issues include two interconnected levels. The vertical level involves the development of specific sustainability-focused courses or cross-disciplinary programs, culminating in comprehensive sustainability education programs. The horizontal level integrates sustainability principles into regular curriculum courses by embedding topics related to green issues. For example, sustainability concepts can be introduced into courses like “Marketing” (e.g., exploring green marketing strategies), or “Engineering” (e.g., designing energy-efficient systems). This approach ensures a broader reach across disciplines, making sustainability a fundamental part of diverse fields of study.

Research on green issues are not limited to environmentally focused studies; their highest expression lies in the practical implementation of

findings. The following sections will present specific examples of applied research conducted at TSNUK.

Community engagement on green issues represents a vital dimension of a university's role in addressing societal challenges. Modern universities have increasingly embraced collaboration with external agencies and stakeholders, fostering greater societal involvement. This shift, often described as the "third mission" (Benneworth & Jongbloed, 2009), reflects a strategic evolution in the relationship between higher education institutions (HEIs) and their surrounding communities.

In the context of green university initiatives, community engagement encompasses several key areas. Firstly, partnerships with governmental and non-governmental organizations to address environmental challenges, share knowledge, and implement sustainable practices. Secondly, training on green issues, when universities offer specialized training programs focused on sustainability topics, aimed at raising awareness and building capacity within local communities. Thirdly, universities can establish incubators to support innovative green projects, fostering entrepreneurship and driving practical solutions to environmental issues.

Green Campus Initiatives

When any kind of initiatives undertaken by Ukrainian HEIs are considered, the current situation is significantly impacted by the aggression of the Russian Federation against Ukraine. Due to frequent missile and UAV (Unmanned Aerial Vehicle) drone attacks targeting Ukraine's energy and civil infrastructure, many projects are focused on achieving energy independence, reducing energy consumption, and integrating renewable energy sources. These efforts aim to enhance resilience against electricity cutoffs and blackouts while promoting sustainable energy use. The first total blackout occurred on November 23, 2022, leaving Kyiv residents without electricity, water, heating, mobile communication, and internet access for over 15 hours. In some areas of Kyiv, power outages exceeded 50 hours (Mind.ua (n.d)). Since then, rolling blackouts have been implemented to stabilize the power grid. It has become common in Kyiv to experience 4–8 hours without electricity, although water and heating remain available.

Meanwhile, numerous projects have been initiated to establish spaces for remembrance and psychological relief, providing support to students, faculty, and administrative staff deeply affected by the ongoing war.

The first initiative to highlight is the "Place of Silence", which, at first glance, may appear to be a typical green project–a cluster of trees providing oxygen, shade, and landscape design near the city center. However, it is much more than a new green area; it carries profound symbolism and serves essential ecological and psychological purposes. This initiative can be classified as both a campus amenity and a contribution to biodiversity and ecosystem services. The symbolism of this space is particularly significant, serving as a poignant reminder that the best representatives of the university community stood up to defend their country. The "*Place of Silence*" *is a memorial dedicated to the students and cadets of TSNUK who sacrificed their lives for Ukraine*. The space is located in the Central Campus, within the park surrounding the main academic building, and features young thuja and viburnum trees. Viburnum (known as *kalyna* in Ukrainian) holds deep cultural significance. According to tradition, planting *kalyna* brings health and good fortune, while its red berries symbolize Ukrainian nationhood and independence (Arboretum, n.d.). The trees were planted through the collective efforts of students, cadets, and faculty, further emphasizing the unity and resilience of the TSNUK community (Fig. 3.2).

This initiative, known as the "Place of Silence", was fully conceptualized and implemented through the collaborative efforts of the TSNUK administration, the KNU Botanical Garden, the Department of Plant Biology, the Student Parliament of TSNUK, and the Virtual Memorial to the memory of the fallen students, faculty, staff and graduates (TSNUK, n.d.). By the end of 2024, the TSNUK community had mourned the loss of over 100 students, faculty, staff, and graduates. To honor these profound losses, the Virtual Memorial preserves detailed profiles of the fallen and advocates for their lasting recognition. Among these tributes is the renaming of a street in Kyiv after Yuliia Zdanovska, a student of the Faculty of Mechanics and Mathematics at Taras Shevchenko National University of Kyiv. Yuliia, a promising mathematician with the potential to make groundbreaking discoveries, was killed by the Russian Federation.

Fig. 3.2. "Place of Silence"

"Place of Silence" has become a powerful symbol of remembrance, representing the enduring spirit of the university's youth, whose resilience and courage have transcended the hardships of war. It stands as a space of gratitude, embodying the highest ideals of "Utility, Honor, and Glory".

Another notable initiative was carried out by students of the educational programs "Landscape Design and Decorative Gardening" (bachelor level) and "Urban Landscape Designe" (master level) in collaboration with staff from the Department of Plant Biology. Together, they contributed to a project aimed at improving the courtyard of the Ukrainian Physics and Mathematics Lyceum of Taras Shevchenko National University of Kyiv. This initiative aligns with the categories of Biodiversity, Ecosystem Services, and Campus Amenities. The project involved developing original design proposals that enhanced the area's aesthetic appeal, promoted psychological relief for students, and fostered ecological thinking. The designs achieved this by harmoniously combining active zones with spaces for relaxation (TSNUK, 2024a).

The third initiative to be considered is the modernization of Centers for Collective Use of Scientific Equipment (CCSEE), a project supported by the

Ministry of Education and Science of Ukraine. In 2024, TSNUK was among 19 centers selected through a competitive process to receive funding for implementing energy-efficient solutions. These measures aim to reduce energy costs and ensure the uninterrupted operation of scientific equipment, even during energy crises. This project falls under the Fuel Use and Campus Amenity categories of Campus Initiatives, focusing on the procurement and integration of alternative energy supply systems and equipment modernization and maintenance. Key components include the installation of solar panels, electrical energy storage systems (batteries), hybrid inverters, BMS controllers, and other devices essential for ensuring smooth operation. The initiative also involves adding new modules and systems to improve equipment efficiency and addressing the need for spare parts for technically worn or damaged equipment. Additional upgrades include sample preparation devices, optical and mechanical components, 3D printers, and networking facilities, collectively enhancing campus infrastructure and scientific capabilities.

TSNUK is home to numerous historic buildings of significant cultural and architectural value. These structures not only represent the rich heritage of the university but also pose unique challenges and opportunities when integrating sustainability initiatives, as preservation efforts must balance modernization with respect for historical integrity (Fig. 3.3).

Despite the inherent challenges of greening older university buildings, several strategies can be employed to effectively incorporate sustainability. Conducting comprehensive energy audits helps identify areas where improvements are needed, enabling targeted retrofitting of critical components such as windows, insulation, and HVAC (Heating, Ventilation, and Air Conditioning) systems to enhance energy efficiency. Integrating renewable energy solutions, such as solar panels, adds to energy independence while reducing environmental impact.

Water conservation measures, including low-flow fixtures and rainwater harvesting systems, can address inefficiencies in water usage. Repairs and renovations should prioritize the use of sustainable materials, aligning with broader environmental goals. Pursuing certifications provides a structured framework for implementing sustainable practices and benchmarks for success.

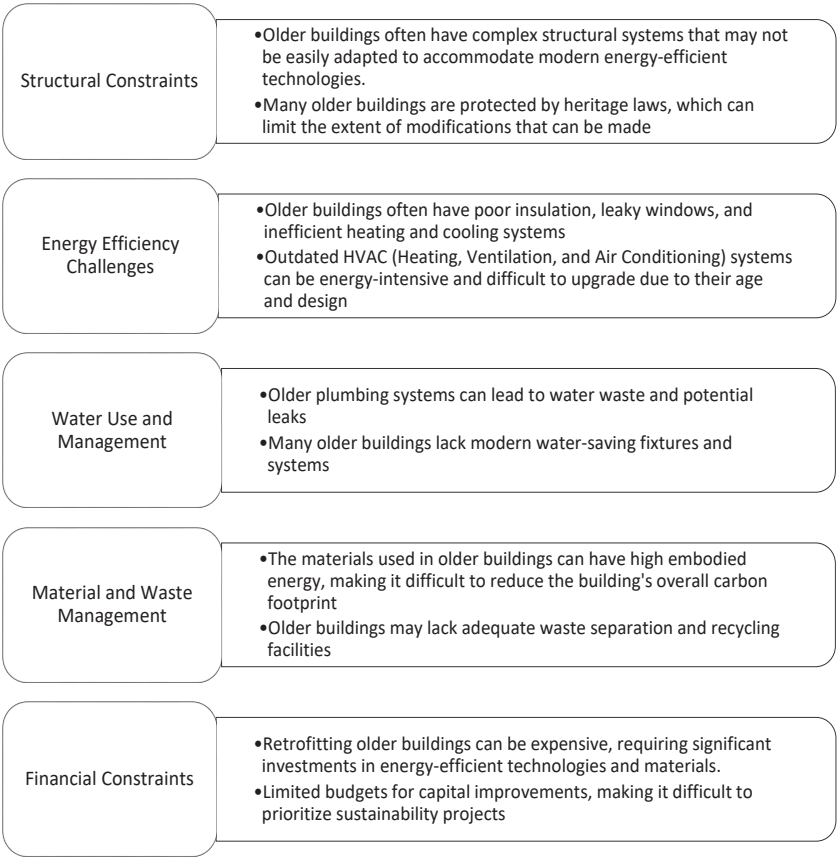

Fig. 3.3. Challenges of greening historic university campuses

Encouraging behavioral change among building occupants, such as promoting energy-saving habits and responsible water use, complements physical upgrades. To fund these initiatives, innovative financing mechanisms, such as energy performance contracting, can be explored, ensuring that sustainability goals remain achievable despite financial constraints. Through these measures, older university buildings can transition into environmentally sustainable spaces while preserving their historical significance.

Teaching on Green Issues

Teaching initiatives can be related to both the research and community engagement lines of the "Green University" concept. However, their contribution to campus operations is often less visible.

Erasmus+ project KA220-HED "Green roofs in higher education institutions as sustainable research centers for engagement, environmental awareness and O2 production" (GREENO2) in addition to its research component, also covers the teaching dimension on green issues. As a result of this initiative, several teaching goals were fulfilled. English-language training course on ecology and sustainable development, which will become an open educational online resource on the Open Education platform. The course will help participants understand the importance of green roofs and assess their benefits, challenges, threats, and sustainability. Students will be able to analyze the need for professional green roof design for their universities and critically evaluate their typology and diversity. The GREENO2 mobile application will be created as an interactive tool for virtual training and promotion of green roof practices as an additional outcome of the project. The app will allow for broader use of the GREENO2 digital toolkit and its materials, such as a new textbook created by one of TSNUK participants (TSNUK, 2024e).

Another project is Erasmus+ KA2 level (higher education capacity building) DOMANI project – Developing Micro-credentials Ecosystems in Ukraine and Mongolia for Competitive and Resilient Green Economies. This project is led by the Estonian University of Natural Sciences, with a consortium of partners, including TSNUK alongside the National Agency for Quality Assurance in Higher Education of Ukraine, V. N. Karazin Kharkiv National University, the Ukrainian Hydrometeorological Society, and partners from Italy, Estonia, Hungary, and Mongolia. The initiative's main idea is to build an educational partnership between participants to launch micro-qualification ecosystems in Ukraine and Mongolia for a competitive and sustainable green economy.

One more notable initiative involves third-year students majoring in "Landscape-Gardening Farm" who actively participated in field research and practical classes across various locations in Kyiv. As part of the "Greening Urban Areas" course, these students conducted in-depth examinations of

green spaces in the city's historic districts, explored innovative strategies for greening public spaces, and analyzed modern methods for developing green infrastructure. This hands-on approach not only enriched their academic experience but also contributed valuable insights to the sustainability and improvement of Kyiv's urban environment.

As part of the “Phytopathology” course”, students conducted monitoring of the sanitary and phytopathological condition of plantings in various locations, including Shevchenko Park, Mariinsky Park, Volodymyrska Hill, and the courtyard of the university's main building. Collected samples were analyzed in the laboratory to identify plant diseases and their underlying causes. This initiative aligns with the categories of biodiversity, ecosystem services, and soil disturbance within the broader scope of Campus Initiatives (TSNUK, 2023). By combining fieldwork with laboratory research, the project not only contributes to the ecological health of urban green spaces but also enhances students' practical skills and ecological awareness, fostering a deeper understanding of sustainable plant management practices.

Research on Green Issues

Research initiatives are often closely interconnected with other components of green university concept. Theoretical findings derived from research can frequently be adapted and scaled to enhance campus infrastructure or integrated into teaching practices. TSNUK is actively engaged in numerous international and local research initiatives. These initiatives demonstrate the university's capacity to bridge scientific exploration with practical applications, contributing to its broader sustainability goals.

The first initiative is Erasmus+ project KA220-HED “Green roofs in higher education institutions as sustainable research centers for engagement, environmental awareness and O2 production” (GREENO2). This project is coordinated by the University of Tuscia (Italy), while TSNUK (Ukraine) alongside with the University of Cadiz (Spain), Pantheon University of Social and Political Sciences (Greece), University of Social and Media Culture in Toruń (Poland), and three research and consulting organizations Xenios Polis Culture, Science and Action (Greece), LIM Srl Unipersonale (Italy), SG Gripen Europe s.r.l. (Romania) are partners (Fig. 3.4).

Fig. 3.4. GREENO2 meeting

This initiative focused on exploring technologies for implementing green areas on university rooftops, designed to create comfortable spaces for study and recreation. The Universities of Cadiz and Tuscia have already gained practical experience in this field, serving as valuable references for similar projects. Green roofs offer significant advantages, including the potential to reduce energy consumption by normalizing heat exchange throughout the year. Additionally, rooftops, which are often underutilized spaces, can be transformed into multifunctional areas. These spaces provide benefits such as recreation zones for students and staff, as well as biodiversity laboratories that support environmental research and sustainability education (TSNUK, 2024b).

Another notable research initiative from a TSNUK faculty is the project led by Serhii Kondratenko, Professor of the Department of Optics at the Faculty of Physics. His work focuses on the development of flexible substrate solar panels, which can be easily applied to various surfaces. For instance, these innovative panels could transform walls into energy generators without the need for additional mounting attachments, opening up new opportunities for green energy solutions. Currently, the research team is in the process of developing and testing laboratory prototypes. These

advancements pave the way for the potential establishment of domestic production in Ukraine, contributing to the growth of renewable energy technologies and fostering energy independence (TSNUK, 2024c).

Several projects and initiatives have spearheaded by the GreenLabsKNU Center for Sustainable Solutions. Among them, the Faculty of Geography at TSNUK is actively engaged in various environmental initiatives, including the installation of bat houses and participation in the National Forest Inventory of Ukraine. These projects aim to expand the university's research capabilities in key areas of environmental study. Furthermore, they are practical applications of sustainability principles, bridging research efforts with on-campus implementation. Such initiatives enhance the university's ecological footprint and provide valuable opportunities for experiential learning and practical engagement for students and researchers (TSNUK, 2024d).

Community Engagement on Green Issues

Most of the initiatives related to this aspect of the “Green University” concept have been discussed in previous sections, as it is rare for initiatives to be explicitly designed to enhance community engagement.

One notable exception is “Place of Silence”, which stands out as the most symbolic and meaningful initiative. This project serves as a poignant reminder that the best representatives of the university community rose to defend their country. It embodies the shared respect and gratitude of every member of TSNUK’s community for the heroes who made the ultimate sacrifice during the Russian Federation’s invasion of Ukraine (Arboretum, n.d.).

Another mentioned initiative will be GREENO2. As a part of this project GREENO2 MOOC (massive open online course) was developed. It can be used for both locals and governmental entities to train new experts and share existing knowledge. Also, mobile application can be used as a part of community cooperation and networking, adding territory diversification and experience spread (TSNUK, 2024e).

And the last to mention is Erasmus+ DOMANI project. This initiative can be considered as the only one directly aimed on Community Engagement, showing and improving possible partnerships between HEIs and local governmental and non-governmental organizations. Also, the planed outcome, micro-qualification ecosystems in both Ukraine and Mongolia for

a competitive and sustainable green economy, can be considered as a part of trainings in green issues implementation with focus on both local and global communities.

TSNUK is enlarging its presence in different green oriented community engagement initiatives and is always ready to adopt some research or teaching projects.

Conclusions

Taras Shevchenko National University of Kyiv actively incorporates the principles of a green university across all four dimensions: green campus, teaching, research, and community engagement. Three key aspects deserve particular attention. First, the case of TSNUK exemplifies the effective integration of sustainable development principles through international projects, showcasing a successful adaptation of the "Green University" concept. Second, the implementation of faculty research advancements in energy efficiency has been integrated into the development of TSNUK's green campus. Third, the university demonstrates a unique combination of social and environmental initiatives, exemplified by the creation of "Place of Silence".

This experience highlights TSNUK's resilience during wartime, as the university continues to align its educational and research activities with sustainability objectives. By combining education, scientific inquiry, and sustainable practices, TSNUK serves as a meaningful example for advancing environmental and social sustainability in higher education.

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Chapter 4.
Integrating environmental sustainability into education and practices of Chernihiv Polytechnic National University

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Introduction

Under global environmental challenges, universities are positioned to lead the way in implementing sustainable practices and fostering ecological responsibility. Integrating environmental considerations into university activities is an essential aspect of the ESG approach, which seeks to create resilient institutions capable of adapting to and mitigating contemporary ecological crises. By embedding sustainability into their strategies, operations, and educational initiatives, universities can contribute to reducing their environmental footprint and cultivating future leaders equipped to address environmental issues.

This chapter examines the environmental dimension of university activities within the framework of the ESG approach, focusing on how universities can ensure resilience through ecological initiatives. Specifically, it highlights the experiences of Chernihiv Polytechnic National University. This university serves as a compelling case study for understanding how ecological innovation and community engagement can transform university campuses into sustainable ecosystems and centers for ecological expertise.

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The university concentrates on creating energy-efficient campuses, demonstrating the potential of sustainable infrastructure to reduce energy consumption and promote resource efficiency. By integrating cutting-edge technologies, renewable energy sources, and energy-saving measures, the universities not only decrease their operational impact on the environment but also set a practical example for other institutions.

On the other hand, the university has focused extensively on preparing ecology specialists, emphasizing education's role in fostering a new generation of environmental leaders. The university equips students with the knowledge and skills to address pressing environmental challenges through interdisciplinary programs and research initiatives. This approach aligns with the ESG framework's emphasis on the social component, where education is critical in advancing sustainable development goals.

The university has also engaged with its surrounding communities to promote environmental awareness and foster partnerships for sustainability. Public outreach initiatives, including workshops, ecological campaigns, and collaborative projects, serve to bridge the gap between academic institutions and society. These efforts highlight how universities can act as hubs for ecological innovation and public engagement, driving progress in achieving broader sustainability goals.

Green Campus

Between 2022 and 2024, Chernihiv Polytechnic National University faced severe challenges due to missile and bombing attacks, resulting in repeated damage to its academic buildings and dormitories. The destruction included shattered windows and doors, damage to walls and roofs, and the loss of centralized heating during the winter of 2022, which caused the heating system in three buildings and a dormitory to fail. The university's infrastructure has been restored with a focus on energy efficiency, guided by an energy audit conducted following the European Parliament and Commission Directive 2010/31/EU on the energy performance of buildings, dated May 19, 2010. The audit identified critical areas for improvement (DSTU ISO 50002:2016, 2016):

1. Enhancing insulation for walls and windows. The university buildings' walls, damaged by debris, currently exhibit low thermal insulation

properties, with an average heat transfer coefficient of 1.10 W/m²K. The application of 10 cm thick mineral wool insulation on the external walls is projected to reduce the heat transfer coefficient to 0.33 W/m²K, aligning with regulatory standards (DSTU B EN ISO 13790:2011., 2011; DSTU B V.2.6-101 ISO:2010, 2010) and decreasing heat loss by 16.7 %.

2. Insulating flat roofs. Most flat roof areas lack insulation, with the combined roof and ceiling structure currently showing a heat transfer coefficient of 1.12 W/m²K. By applying 25 cm thick mineral wool insulation, the coefficient will be reduced to 0.16 W/m²K, in compliance with regulatory requirements (DSTU B EN ISO 13790:2011., 2011; DSTU B V.2.6-101 ISO:2010, 2010), resulting in a 17.4 % reduction in heat loss.

3. Replacing damaged wooden windows with modern metal-plastic ones. The energy audit before 2022 showed an average heat transfer coefficient of 1.99 W/m²K for the existing windows. Installing double-glazed, argon-filled energy-saving windows (4i-14Ar-4-14Ar-4i) has reduced this coefficient to 1.10 W/m²K, in line with current standards. Similar improvements (DSTU B EN ISO 13790:2011., 2011; DSTU B V.2.6-101 ISO:2010, 2010) were achieved by replacing damaged wooden doors with metal-plastic ones, collectively reducing heat loss by 11.7 %.

4. Modernizing the heating system. Radiators and most thermal distribution pipes were replaced, hydraulic balancing was performed, and thermal distribution pipes were insulated. Additionally, thermostatic regulators were installed (EN 15316., 2013), contributing to a 5.6 % increase in energy efficiency.

5. Upgrading the ventilation system. Installing ventilation openings in windows and exhaust devices with heat recovery systems has resulted in energy savings of 11.2 % for heat and 18.4 % for electricity while also reducing indoor noise levels (DBN V.2.5-67:2013, 2013).

6. Implementing energy-efficient lighting. Transitioning to LED lighting fixtures reduced electricity consumption by 60 kW. The installation of motion sensors and dimmer switches further decreased electricity use by 44.2 kWh/year (EN 15193, 2019).

These energy efficiency measures have also had a significant environmental impact, reducing annual CO_2 emissions by 283.7 kg.

Renewable energy research has been a strategic focus for Chernihiv Polytechnic National University, with several projects since 2011 aimed at improving semiconductor converters for photovoltaic power stations. These initiatives were conducted in collaboration with international institutions, including Tallinna Tehnikaülikool (Estonia), Hochschule Bonn-Rhein-Sieg (Germany), Politechnika Gdańska (Poland), Wrexham Glyndŵr University (United Kingdom), and Universidad de Extremadura (Spain). Key findings have been published in numerous scientific works (Husev, et al., 2015; Tytelmaier, et al., 2016; Husev, et al., 2019; Voytenko, et al. 2015; Roncero-Clemente, et al., 2013; Prystupa, et al., 2022).

A 5 kW solar power station was installed on the roof of the university's third building as a research facility, showcasing the institution's commitment to integrating renewable energy solutions into its operations (Fig. 4.1).

By addressing immediate infrastructure needs and long-term sustainability goals, Chernihiv Polytechnic National University demonstrates resilience in the face of adversity while aligning with the ESG approach to create a sustainable and energy-efficient campus.

Fig. 4.1. Photovoltaic power station at Chernihiv Polytechnic National University

During the military actions in the spring of 2022, the photovoltaic power station charged communication devices for local residents. At the same time, in the context of frequent power outages caused by significant destruction of energy infrastructure, the station's capacity proved insufficient to supply electricity to the university's critical facilities.

To enhance the reliability of the university's power supply, an energy storage system, Tesla Powerwall, was installed with the support of the governments of Ukraine and Poland. This system is a critical addition to the existing infrastructure, ensuring greater resilience in the face of ongoing energy challenges (Fig. 4.2).

Fig. 4.2. External view of the Tesla power wall system and information application

Currently, Chernihiv Polytechnic National University operates a Tesla Powerwall energy storage system with a capacity of 54 kWh. This system provides power for servers essential to supporting online educational processes and the university's automated management system. After the war, the Tesla Powerwall system is expected to play a critical role in optimizing energy costs in a dynamic electricity tariff environment. It will store energy during periods of low tariffs and utilize the stored energy during peak load times, significantly reducing electricity expenses (Fig. 4.3).

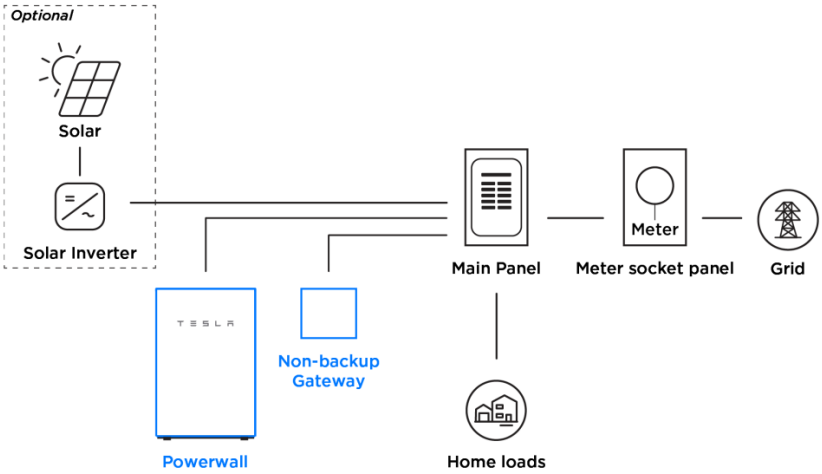

Fig. 4.3. Structural diagram of the Tesla power wall connection

To enhance the university's energy independence, efforts are currently underway to increase the capacity of the photovoltaic power station at Chernihiv Polytechnic National University to 30 kW. This initiative is supported by the Ministry of Education and Science of Ukraine and GiZ. The university has also accumulated valuable experience integrating renewable energy sources into autonomous energy supply systems. Notably, the implementation of a monitoring station for the Dnipro River, carried out between 2017 and 2019, was a part of the Eastern Partnership program co-financed by the European Union (Prystupa, et al., 2022). The university organizes various educational initiatives to popularize renewable energy within the Chernihiv community. It has installed art installations on campus (Fig. 4.4) to engage the public and raise awareness about sustainable energy solutions.

Chernihiv Polytechnic National University actively promotes energy-efficient technologies across various sectors of daily life by implementing a range of educational projects with financial support from the EU. Notable initiatives include the Erasmus+ international projects UNICITIES, which focuses on unlocking the transformative potential of Ukrainian

universities for building climate-neutral and sustainable cities, and BRIDGE, which aims to bridge the gap between academia and industry by developing an innovative master's program supporting green jobs and digital skills in Ukraine's construction sector (UNICITIES, 2021; The BRIDGE Project, 2021).

Fig. 4.4. Art installation “Energy Tree”

As part of these projects, the university conducts training sessions, workshops, and summer schools, providing students from disciplines such as Ecology, Architecture and Urban Planning, Environmental Economics, Civil Engineering, Electrical Engineering, and Software Engineering with opportunities to learn about best practices and enhance their skills in using modern technologies for real-world projects.

One notable example was a summer school in July 2024, where students worked on a project to rebuild a student dormitory and its surrounding area using sustainable urban principles. Mentors and consultants included architects, ecologists, and engineers from Spain, Chile, and Sweden (UNICITIES, 2024).

Since September 2024, Chernihiv Polytechnic National University, as part of the WIN2EDIH consortium, has secured funding to establish a digital innovation hub. This hub will be integrated into the pan-European network of innovation hubs (European Digital Innovation Hubs, 2020), offering services to small and medium enterprises and startups to implement modern energy-efficient technologies and improve digital skills to support sustainable development.

Promoting green transportation is another crucial step toward achieving campus sustainability. During the war, significant fuel shortages impacted mobility for the Chernihiv community. To address this, the NGO Ekomisto, comprised of students and alumni from Chernihiv Polytechnic, launched the "Bike Kitchen" project (Ekomisto, 2023) as part of the international initiative #BikesForUkraine. This project involved setting up a bike repair workshop on campus, where dozens of bicycles imported from Europe were repaired and donated to the Chernihiv community.

In addition to traditional bicycles, the university is fostering the development of electric vehicles. The "Bayka" startup (Bayka Bikes, 2021), which has joined the Ukrainian Association of Electromobility, showcases its products at international exhibitions and has already produced more than 1,500 models. The campus now features convenient parking spaces equipped with charging stations to support this green transportation initiative.

Students of Chernihiv Polytechnic National University developed the charging devices, which can power batteries from 12 to 96 volts. These facilities enhance the campus infrastructure and promote the widespread adoption of green transportation (Fig. 4.5).

A key aspect of sustainable development at Chernihiv Polytechnic National University is reusing and recycling waste on campus. In collaboration with the NGO Ekomisto, the university is implementing the Plastic Fantastic project (Ekomisto, 2021).

Fig. 4.5. Charging and parking station for portable electric transport

As part of the project, educational activities are organized for children to raise awareness about sustainability and the importance of recycling.

Additionally, a creative workshop operates on campus, where various items are crafted from recycled plastic, showcasing the potential of turning waste into functional and artistic products (Fig. 4.6). Through these initiatives, Chernihiv Polytechnic continues to integrate sustainability into campus life, fostering environmental responsibility within the university community and beyond.

Fig. 4.6. Results of the Plastic Fantastic Project

In addition to plastic recycling, the creative workshops at Chernihiv Polytechnic National University also focus on repurposing wood and metal. Startups developed in these workshops were presented this year at the Way to Success startup competition, an annual event hosted by the university.

Chernihiv Polytechnic is actively involved in numerous educational, scientific, and social initiatives as part of the "University in the Life of the Region" program. These activities not only significantly reduce the university's environmental impact but also serve as practical examples of sustainable solutions for students, empowering them to apply these practices in their future endeavors. These initiatives contribute to resource conservation, reduce campus financial expenditures, and enhance its appeal and comfort for all university community members.

Fostering Environmental Awareness

Global problems always have their individual dimensions. In this context, it is urgent and essential to foster environmentally conscious thinking among current and future generations – every decision and activity must have an ecological foundation. To achieve this, it is necessary to develop environmental competencies, skills, and abilities at all stages of education: preschool, school, extracurricular, vocational, and higher education. The outcomes of applying these competencies include:

1. A qualified assessment of the environmental impact of activities.
2. Minimizing the use of raw materials and energy, waste generation, and all forms of pollution.
3. Choosing optimal solutions from an ecological and economic perspective.
4. Conducting a critical analysis of the consequences of actions and inactions, both in the short and long term, including their impact on human health.
5. Understanding the priority of actions aimed at improving the state of the environment, among other outcomes.

Environmental competencies form the foundation of a person's safe existence in today's urbanized world, where most of the population resides in cities. Preparing citizens with a high level of environmental knowledge,

awareness, and culture, based on new criteria for evaluating the relationship between human society and nature, has been identified in the Concept of Environmental Education as one of the main tools for addressing the acute environmental and socio-economic problems facing modern Ukraine (Cabinet of Ministers of Ukraine, 2001).

The urban environment creates a set of negative factors that impact humans and pose risks to their health. These factors include air pollution, poor-quality drinking water, significant amounts of household and industrial waste, noise pollution, and electromagnetic fields. In this regard, a standardized assessment of environmental risks in cities, considering both the direct impact of ingredient and energy pollution and its indirect effects on potentially hazardous sources, becomes critically important.

As part of the TEMPUS project "Establishing Modern Master-level Studies in Industrial Ecology," environmental experts at Chernihiv Polytechnic National University developed and implemented a methodology for assessing the ecological condition and risks of technonatural systems as human habitats. As a result of this project, a master's program in Environmental Economics and Natural Resources, specializing in "Industrial Ecology," was launched. Today, the university offers a bachelor's program in Ecology and a master's program in Environmental Safety.

An innovative approach to achieving sustainable development involves the formation of climate-neutral city concepts. One of its components must include the monitoring of factors that ensure comfortable living conditions for humans. Chernihiv Polytechnic National University, in partnership with leading European and Ukrainian universities, is working on this concept within the framework of the Erasmus+ KA project (Project 101083099 – UNICITIES): Unlocking the Transformative Potential of Ukrainian Universities Towards Climate-neutral and Sustainable Cities (Chernihiv Polytechnic National University, 2023).

Currently, an interdisciplinary educational module, "Smart Cities and Climate Adaptation and Mitigation Strategies", has been developed and integrated into the curricula of master's programs such as Environmental Safety, Environmental Economics and Natural Resources, Electrical Power Engineering, Electrical Engineering, and Electromechanics, and Computer Engineering.

The formation of environmental consciousness cannot be fully ensured through formal education alone. Non-formal education also plays a vital role in providing comprehensive environmental competencies for informed individuals. Chernihiv Polytechnic National University is actively developing non-formal education courses as part of the "Ukrainian-German Teaching Network for a Digital Transformation of Environmental Education" project. This initiative will include training on the methodology for assessing the ecological risks of technonatural systems developed by university experts.

The developed methodology includes an analysis based on two subsystems (Fig. 4.7).

Applying comprehensive environmental protection measures at sources of pollution formation can produce a positive synergistic ecological effect across nine components (SEE 1-9) in ensuring the environmental safety of technonatural systems. The unification of an integrated assessment of technogenic impacts on technonatural systems is aimed at monitoring the ecological safety status of both biotic and abiotic components of the environment. It also includes technological safety evaluations for potentially environmentally hazardous objects.

The project's implementation facilitated constructive inter-university collaboration, expanded the academic network, and provided new experiences for instructors of environmental disciplines, fostering professional development and broadening the audience. The use of the Moodle distance learning system allowed for the creation of a shared educational space, enabling students and instructors to choose from various courses, exchange their findings, and refine teaching methodologies.

In partnership with collaborators, a platform for electronic courses based on the Moodle system was developed and successfully launched. This serves as a vivid example of inter-university cooperation, where instructors not only master modern tools for digital teaching and learning but also create, publish, and adapt their electronic courses for use by students across all partner higher education institutions.

This approach significantly expands access to quality education and contributes to the development of innovative teaching methodologies within universities.

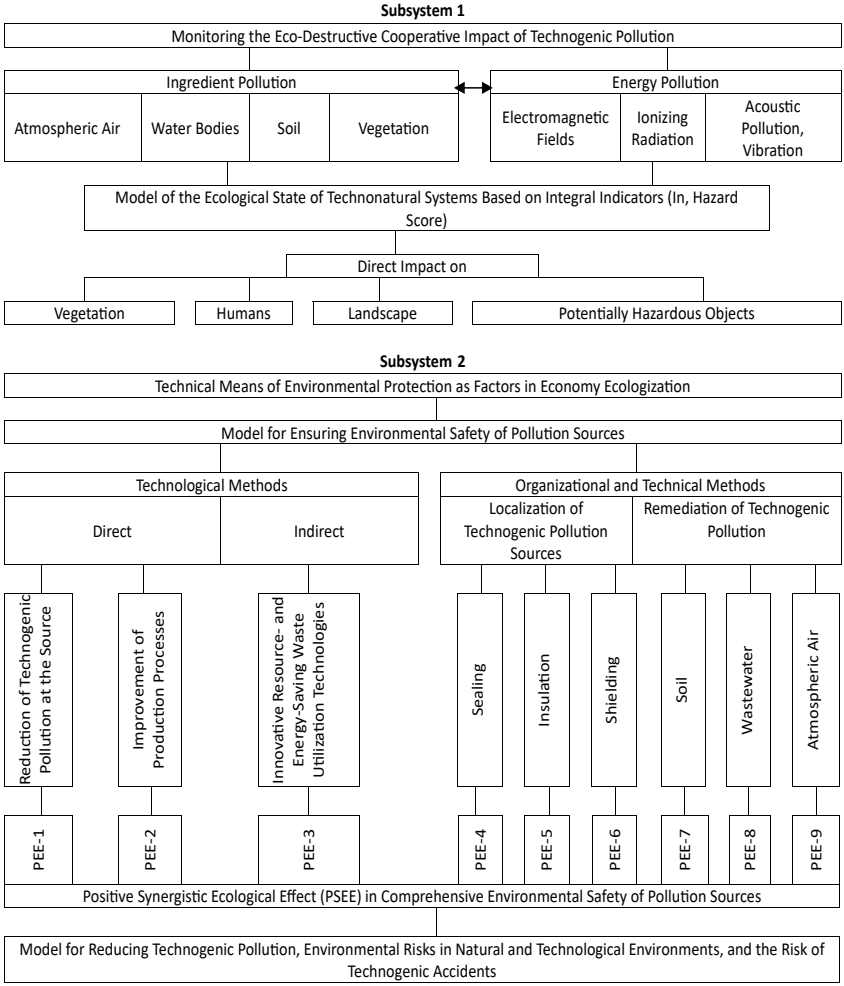

Fig. 4.7. Methodology for assessing the ecological state and environmental risks of technonatural systems as human habitats

Systematic environmental education will help establish the foundation of ecological thinking in society, which is the cornerstone of fundamental changes in the "human-nature" relationship.

Drivers of Social Cohesion and Community Resilience

Social cohesion in Ukraine is currently a cornerstone of the EU's social and educational policy. The relevance of this phenomenon for Ukrainian society has been emphasized by numerous EU donor programs and structures (UNDP, the Council of Europe, etc.) (Education – Free Encyclopedia Search Engine, 2023). As noted by Nesterova, Delini, and Zamozhskyi, Ukraine today strives to practically implement the doctrine of social cohesion across all spheres of societal life. "Social cohesion must become a guarantee of social stability and tolerant relations between the authorities and citizens in conditions of economic instability, large-scale organizational, structural, and financial-economic transformations that have become everyday occurrences due to globalization and the need to gain competitive advantages; to minimize the risks of mistrust among social partners in the context of global instability" (Kolomoiets, 2023).

It is known that social cohesion operates on two levels. The first is the relationship between citizens and the state. It is critically important for people to trust the authorities, feel that their voices are heard, and believe their interests are protected. When individuals are confident that their voice can influence change, they take responsibility for their country and act for its future benefit. The second level is the relationship we have with each other. We must support one another, show solidarity, and help those in need. Solidarity and mutual support are what help overcome any challenges and unite society into a cohesive whole.

How can we recognize the existence of social cohesion? There are several key indicators: a sense of responsibility for the country and actions aimed at its future well-being; respect for and acceptance of diversity, one of the most critical signs of cohesion; and pride when someone says, "I belong to this country". This sense of belonging and responsibility is the true manifestation of social cohesion.

Thus, social cohesion is what makes a community a genuine community. It is when everyone feels they can actively participate in the life of their country, enjoying equal opportunities and rights. It is the force that helps us build a future together, no matter the challenges.

We also see a growing sense of civic responsibility in Ukrainian society, where people realize their ability to influence changes in the country and

take responsibility for its fate. This reflects a deep understanding of shared civic duty. Together, by uniting efforts at all levels–from individual to state–the Ukrainian community can build a strong, cohesive, and resilient society that will not only overcome the challenges of war but also ensure development and prosperity for future generations.

Unfortunately, as Nesterova and Zamozhskyi note, even in societies considered to be civil and developed, the balance between "harmony" and "discord" increasingly tilts toward the latter. "This has led many researchers and political leaders to believe social cohesion is threatened. In any case, there is every reason to assert that among the main contradictions observed daily by society across different parts of the globe are those between the decline in social cohesion–under the influence of numerous factors highlighted above–and the need to ensure the resilience of economic and societal development, and consequently, the necessity for a new level and quality of social cohesion" (Kolot, 2009).

The social role of education in fostering social cohesion, especially in times of war, is of paramount importance today. HEIs have taken on an even more significant role–they have become centers of transformation that help Ukraine persevere and rebuild.

One of the critical tasks of universities during the war is fostering collaboration among different sectors of society. Universities are not just places for learning but also serve as social hubs for shaping the country's future.

It can confidently be stated that during times of crisis, Ukrainian universities have maintained their functionality and become pillars of society, promoting community cohesion, supporting scientific research, and creating new educational formats. Universities continue to build communities among students, faculty, researchers, local populations, governmental bodies, and international partners.

Modern Ukrainian universities are taking on the roles of visionaries and integrators, helping communities develop growth strategies. This is achieved through academic programs and participation in project offices that coordinate collaboration between businesses, governments, and communities.

Thus, universities have evolved into not just educational centers but also drivers of local community development. In wartime, they assist communities in adapting to the new challenges facing Ukrainian society, such as energy independence, environmental issues, local business development, and social sector challenges. For instance, Chernihiv Polytechnic National University has become an integral part of social and economic initiatives in the Chernihiv region.

One of the most pressing challenges for the Chernihiv region is preserving human capital, particularly within local communities. The war has caused significant migration abroad, threatening the region's future potential. Therefore, the university is tasked with retaining young people by creating conditions for their continued education. Active implementation of social action projects facilitates this goal.

The “Voices of Youth for Social Cohesion and Peace in the Community” project united the efforts of youth leaders and workers from Sumy, Chernihiv, Cherkasy, and Zaporizhzhia regions. It facilitated experience exchange, cooperation with regional youth policy providers, and strengthened the resilience and capacity of youth leaders by involving them in decision-making processes within communities. The project amplified youth voices in the social cohesion sphere by developing and presenting regional strategies titled “Youth. Peace. Security”.

As part of the project, training sessions were held on civic participation, social cohesion, inclusion, non-discrimination, and equality, further strengthening participatory youth policies and enhancing youth work during wartime in line with the “Youth. Peace. Security” agenda in Ukraine. Social cohesion among youth has been identified as a key priority in the National Action Plan for Ukraine’s Recovery. Enhanced cooperation and sustainable partnerships among youth organizations, councils, media, and youth policy providers are among the project’s notable achievements.

The “Voices of Youth for Social Cohesion and Peace in the Community” project was implemented from June 1 to October 31, 2024, by the NGO “Human Rights Foundation” with financial support from the European Youth Foundation of the Council of Europe. Chernihiv Polytechnic National University participated in the project in collaboration with the Gender Education Center NGO. Such collaboration between the university and the

community in project activities mobilizes and combines academic expertise and community experience to address social issues and promote the idea of a fair society.

Another critical challenge, not only for the Chernihiv region but for all of Ukraine, is supporting veterans and their reintegration into peaceful life. To raise awareness among veterans and their families, an information center for legal assistance was established in Chernihiv, Ivanivka, Snovsk, Mena, Korop, Mykhailo-Kotsiubynske, and Ripky territorial communities.

The "Legal Compass" project was implemented with technical administration by ISAR Ednannia and facilitated by the United Nations Development Programme (UNDP) in Ukraine, with financial support from the European Union under the "EU4Recovery – Empowering Communities in Ukraine" project.

135 individuals were the direct beneficiaries of this project, while 23 147 others benefited indirectly. As a result, community residents gained access to justice, and veterans and their families increased their legal awareness regarding their rights and protections.

Ukrainian universities today play a crucial role in strengthening the social fabric of the country. As aptly noted in the materials of the Alliance of Ukrainian Universities, they have become spaces where representatives of different societal sectors meet, discuss pressing issues, and seek solutions (Nesterova & Zamozhskyi, 2021). This positions universities as key hubs of civil society, helping to shape a new model of social interaction. An essential tool for fostering this interaction is active collaboration with international partners, organizations, and foundations.

One such example is the "Women as Agents of Social Cohesion and Community Recovery" project, implemented in the Chernihiv, Ripky, and Horodnia territorial communities by the NGO "Gender Education Center" (Chernihiv Polytechnic National University) with support from the United Nations Development Programme (UNDP) in Ukraine and financial backing from the Government of France under the "Funding Windows" initiative.

The project aims to enhance young women's capacity to participate in community recovery processes through training on conflict-free communication, facilitation, combating gender-based violence during and after the war, integrating gender perspectives into community planning documents

(including recovery plans), advocacy, and implementing gender initiatives. The project also includes gender analysis of target communities and monitoring opportunities for gender mainstreaming in recovery processes.

The project targets representatives of community organizations and informal initiative groups, local government employees collaborating with NGOs, and youth interested in community activities. Forty female participants have the opportunity to attend a series of educational training sessions to improve their competencies in gender equality, leadership development, advocacy, and building resilient communities.

These efforts aim to empower women to become active agents of change in their communities, fostering social cohesion and sustainable development. Additionally, the project promotes informational support and the dissemination of UNDP's "10 Steps to Advance Gender Equality in Crisis", including principles, goals, and methodologies for localizing UN Resolution 1325 and integrating the "Women, Peace, and Security" agenda into local development plans.

The project aligns with the objectives of the Eighth Ukrainian Women's Congress (Kyiv, 2024), where speakers emphasized the changing attitudes toward women's rights and roles in Ukrainian society and the economy. Joint planning for women's involvement in recovery processes is critical not only for the nation's overall reconstruction but also for the development of individual communities.

Today, universities understand their mission as combining local and global approaches to address social responsibilities. This includes tackling social challenges such as economic development, poverty alleviation, public health improvement, and the advancement of sustainable development goals.

This shift has also led to reevaluating the role of academic research. University research now often focuses on global challenges, such as combating diseases, disaster management, and the development of new energy sources. However, universities are also directly working with their communities to improve quality of life and address everyday issues.

For example, in the Chernihiv region, Chernihiv Polytechnic National University has become involved in addressing social and economic challenges, such as preserving human capital and supporting veterans. Projects like

"Voices of Youth for Social Cohesion and Peace in the Community" and "Legal Compass" demonstrate how universities mobilize knowledge and community experience to resolve pressing issues and promote the idea of a fair society.

As European literature highlights, Ukrainian universities traditionally emphasize training high-quality professionals and conducting academic research. However, leading universities worldwide provide students with opportunities to collaborate with social enterprises, address social problems, and improve lives (Education–Free Encyclopedia Search Engine, 2023; Hodges & Dubb, 2012).

Ukrainian universities are increasingly adopting this approach. Viewing the university as a "social enterprise" allows students to develop entrepreneurial skills applicable across business sectors, showcase them to potential employers, and provide staff opportunities to create solutions within their areas of interest. It also enables universities to collaborate with local businesses and communities to address regional challenges.

Universities serve as unique platforms for dialogue among government representatives, territorial communities, active citizens, and NGOs in areas of mutual interest. This role positions them as educational centers and drivers of societal transformation and sustainable development.

Conclusions

Chernihiv Polytechnic National University demonstrates how environmental principles can be integrated into university activities to achieve sustainability and reduce negative environmental impacts. The restoration of infrastructure after damage was accompanied by the implementation of energy-efficient solutions: insulation of walls and roofs, window replacement, and modernization of heating systems significantly reduced energy consumption and carbon emissions.

The use of renewable energy sources has become a crucial step in strengthening energy autonomy. The photovoltaic power station and energy storage system meet part of the university's energy needs and serve as an example of implementing innovative technologies. Training specialists in ecology and sustainable development also plays a key role. Students participate in projects related to waste recycling, sustainable urban planning, and the development of climate strategies.

Special attention is given to engaging with the local community: from educational activities to environmental initiatives, such as plastic recycling projects and the promotion of eco-friendly transportation. These efforts contribute to improving environmental literacy and public involvement. International cooperation through programs like Erasmus+ allows for adopting best practices and advancing the environmental agenda on a global scale.

Through these initiatives, the university demonstrates that sustainable development is achievable even under challenging circumstances. This serves not only as an example for other educational institutions but also as a contribution to addressing global environmental challenges.

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